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Are central bank balance sheets in Asia too large?

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Foreword

This volume is a collection of the speeches, background papers and presentations from a conference on “Central bank balance sheets in Asia and the Pacific: the policy challenges ahead”. The event was co-hosted by the Bank of Thailand (BOT) and the Bank for International Settlements (BIS) and was held on 12–13 December 2011 in Chiang Mai, Thailand. Senior officials from central banks, as well as academic scholars and economists from the BIS attended the conference. The formal addresses included those from Prasarn Trairatvorakul, Governor of the Bank of Thailand, and Jaime Caruana, General Manager of the BIS. The conference marked the culmination of a two-year research programme at the BIS Representative Office for Asia and the Pacific focused on central bank balance sheets, addressing the domestic and international implications of the large expansion of central bank balance sheets worldwide, with particular emphasis on Asia. This two-year research programme is a flagship activity of the BIS Representative Office; the activities in the office are guided by the Asian Consultative Council, comprising the Governors of the 12 BIS shareholding central banks in the region.[1]

[1] Those of Australia, China, Hong Kong SAR, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore and Thailand.

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Monday 12 December 2011

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Prasarn Trairatvorakul (Bank of Thailand)

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Athanasios Orphanides (Central Bank of Cyprus)
Randall Kroszner (University of Chicago)

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List of participants

Central banks

Australia	Reserve Bank of Australia **Chris Aylmer** Head of Domestic Markets Department
Colombia	Central Bank of Colombia **Hernando Vargas Herrera** Deputy Governor
Cyprus	Central Bank of Cyprus **Athanasios Orphanides** Governor
Czech Republic	Czech National Bank **Vladimír Tomšík** Vice Governor
ECB	European Central Bank **Alain Durré** Principal Economist
Hong Kong SAR	Hong Kong Monetary Authority **Dong He** Executive Director, Research Department **Qianying Chen** Economist
India	Reserve Bank of India **Sanjay Hansda** Director, Internal Debt Management Department
Indonesia	Bank Indonesia **Budianto Soenaryo Mukasan** Head of Bureau (of Monetary Operation)
Japan	Bank of Japan **Ryuzo Miyao** Member of the Policy Board **Hiroaki Kuwahara** Director, Deputy Head of Center for Monetary Cooperation in Asia **Shinichiro Okawa** Director and Executive Secretary

Korea	Bank of Korea **Myung Hun Kang** Monetary Policy Committee Member	
Malaysia	Central Bank of Malaysia **Ooi Sang Kuang** Special Advisor	
New Zealand	Reserve Bank of New Zealand **Michael Wolyncewicz** Chief Financial Officer **Dean Ford** Manager Forecasting, Economics Department	
Philippines	Bangko Sentral ng Pilipinas **Jasmin Dacio** Bank Officer V	
Singapore	Monetary Authority of Singapore **Teo Kok Ming** Executive Director (Finance)	
Thailand	Bank of Thailand **Prasarn Trairatvorakul** Governor **Suchada Kirakul** Deputy Governor **Paiboon Kittisrikangwan** Assistant Governor, Monetary Policy Group **Chantavarn Sucharitakul** Senior Director, International Department **Supawadee Punsri** Senior Director, Northern Region Office **Somsak Wongpanyathaworn** Director, Northern Region Office **Parisun Chantanahom** Director, Economic Research Department **Roong Mallikamas** Director, Monetary Policy Office **Piti Disyatat** Division Executive, Monetary Policy Strategy **Pornvipa Tangcharoenmonkong** Division Executive, International Economic Policy	

United States	Federal Reserve Bank of San Francisco **Mark Spiegel** Vice President

Academic and policy institutions

Australia	Lowy Institute for International Policy **Stephen Grenville** Visiting Fellow
Hong Kong SAR	Fung Global Institute **Andrew Sheng** President
	Hong Kong University of Science and Technology **Jonathan Batten** Professor of Finance
Japan	Japan Center for Economic Research **Kazumasa Iwata** President
	Osaka University **Shinji Takagi** Professor of Economics
Korea	Korea Development Institute **Dongsoo Kang** Director and Vice President, Department of Macroeconomic and Financial Policy
United Kingdom	University of Kent **Jagjit Chadha** Professor of Economics
	Cass Business School **Alec Chrystal** Professor of Money and Banking
United States	University of Chicago Booth School of Business **Randall Kroszner** Norman R Bobins Professor of Economics
	Peterson Institute for International Economics **Joseph Gagnon** Senior Fellow
BIS	Bank for International Settlements **Jaime Caruana** General Manager
	Philip Turner Deputy Head of Monetary and Economic Department

Eli Remolona
Chief Representative for Asia and the Pacific

Andrew Filardo
Head of Economics for Asia and the Pacific

James Yetman
Senior Economist

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Welcome remarks

Prasarn Trairatvorakul[1]

Mr Jaime Caruana, General Manager of the BIS, Distinguished Participants, Ladies and Gentlemen:

It is a pleasure to extend my warmest welcome to all of our distinguished participants to Chiang Mai. The Bank of Thailand is honoured to have the opportunity to co-host the Research Conference with the BIS on the most topical and timely issue of "Central Bank Balance Sheets in Asia and the Pacific: The Policy Challenges Ahead".

The global financial crisis prompted central banks in major advanced economies to undertake unprecedented policy actions that not only tremendously expanded the size of their balance sheets, but also dramatically changed their composition. With a few exceptions, the central banks of Asia and the Pacific did not need to move beyond traditional policy tools during this time. That said, our experience with policy actions that entail similar impact on central bank balance sheets predates the global financial crisis. For much of the second half of the last decade, several central banks in the region have seen rapid expansions of their balance sheets as foreign reserves were built up steadily. While the primary intention of the policy actions differ, the end result in terms of balance sheet impacts are quite similar to the broad spectrum of unconventional policies undertaken by the major central banks recently. As such, I believe there is much to share and discuss in terms of our mutual experiences with such policies. One of the most prominent issues that we have all faced is the political economy challenges that come with substantial run-ups in our balance sheets, not only in terms of prospective losses but also in terms of pressure to mobilize central bank resources in order to support targeted constituents.

Against this backdrop, the Conference today provides an opportunity for in-depth discussions on these very important challenges for the purpose of (1) better understanding the implications of unconventional policies for central bank balance sheets and (2) discussing the lessons learnt, in terms of both the effectiveness of the policy options and the possible spillover effects. The discussions are even more pertinent to Asia as we deepen our economic and financial integration – of course not to the extent of, or as ambitiously as, Europe.

I would like to thank the BIS Representative Office for Asia and the Pacific for their continued support and contribution to the central banking community of Asia and the Pacific. I am confident that the policy implications drawn from debates today between leading academics and experienced central bankers will provide a basis for our deeper understanding and preparation for future challenges, regionally and globally.

I wish you fruitful discussions and a successful conference.

[1] Governor, Bank of Thailand.

Why central bank balance sheets matter

Jaime Caruana[1]

1. Introduction

Let me begin by thanking Governor Prasarn for co-hosting this joint Bank of Thailand-BIS conference here in this historic city of Chiang Mai. And on behalf of all those present, I would like to extend our deepest sympathies to our Thai colleagues and offer encouragement as you and your nation continue to address the challenges arising from the devastating floods this year.

Today, we take up the important subject of central bank balance sheets. This may sound arcane, but it has often proved crucial in designing and understanding policies pursued in the wake of financial crises in recent years. I need hardly tell this audience that balance sheet stocks are just as important as income flows. Indeed, one of the lessons of the recent crisis is that more attention must be paid to balance sheets than was the case before the crisis. This is true for all economic agents.

As you know, Governor, you and your fellow governors of the BIS's Asian Consultative Council encouraged the economists in our Hong Kong office to think hard about the balance sheets of central banks. We have invited a number of leading international experts here to help us by telling us about their research. We hope that this conference, and the research reported, will contribute to our better understanding of the difficult and controversial issues now facing the central banking community.

To set the stage for our discussions over the next day and a half, I'd like to start with some observations about the special role that central bank balance sheets have played historically in ensuring monetary and financial stability. Then I will outline how policy responses to recent crises have transformed central bank balance sheets. Central banks have been ready to buy a wide range of financial assets on a large scale in order to further major macroeconomic and financial stability objectives. Because the scale and persistence of the world-wide expansion in central bank balance sheets is unprecedented, we need to pay special attention to possible medium-term risks. I will pose four questions about such risks and mention work by BIS economists on these questions.

2. The historical power of central bank balance sheets

The central bank's deliberate use of its balance sheet has played a salient role in financial history, especially during crises. From very early on, central banks were given the monopoly of note issue, and the role of lender of last resort naturally fell to them. Bagehot (1873) clearly understood this privileged position vis-à-vis the rest of the financial sector in the 19th century. During times of financial distress, only the central bank could be a credible lender of last resort. Its ability to create monetary liabilities could be used to provide liquid assets to a bank in difficulty.

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[1] General Manager, Bank for International Settlements.

During the Gold Standard period, time and again central banks took centre stage in preserving the integrity of the international monetary system. Central banks provided essential liquidity at times when gold convertibility came into question. And it became increasingly well understood during this time that a central bank could play the pivotal role in responding to periodic financial crises. Indeed, it was the deep financial crisis in the United States in 1907 that prompted the US Congress to finally set in motion the creation of the Federal Reserve System. The explicit understanding was that the Fed would use its balance sheet to promote a currency that would be "elastic" in meeting the needs of a growing economy. The idea was also that it would address the forces behind the periodic financial panics that had plagued the United States up to that time.

We should not forget, of course, that mistakes have been made over the years. Lessons were learned along the way. In the 1930s, for example, the deepening of the Great Depression was due in part to the failure of the major central banks to fully grasp the consequences of debt deflation. Central banks in the 1930s failed to use their balance sheets sufficiently to lower long-term rates and to counter a cascading sequence of bankruptcies. The lessons learned from that crisis have guided many central banks in dealing with the recent crisis.

A stylised central bank balance sheet can be helpful in clarifying the various transmission channels (Table 1). Any accumulation of assets implies an increase in corresponding liabilities. In addition, the purchase of domestic assets will directly affect their prices, and therefore credit spreads, term premia and long-term interest rates. An increase in monetary liabilities – eg reserve money – will have implications for the liquidity of the banking sector in the short run, and this may undermine price stability in the medium term. But an increase in long-term liabilities could also crowd out lending to the private sector.

Table 1

A central bank balance sheet

Assets	**Liabilities and capital**
Net foreign assets	Reserve money
Net domestic assets	*Currency in circulation*
	Reserves of commercial banks
	Non-monetary liabilities
	Central bank securities
	Others
	Equity capital

Taking into account these transmission channels, it is quite clear that large expansions of central bank balance sheets have implications both for the real and financial sectors of the economy. They do create risks – and we must watch these closely. In some historical episodes, central banks did expand their balance sheets too much in order to finance profligate government spending. This often had inflationary results. On other occasions, central banks were too slow in reversing expansionary policies when conditions improve.

3. Crisis-induced revival of a policy focus on balance sheets

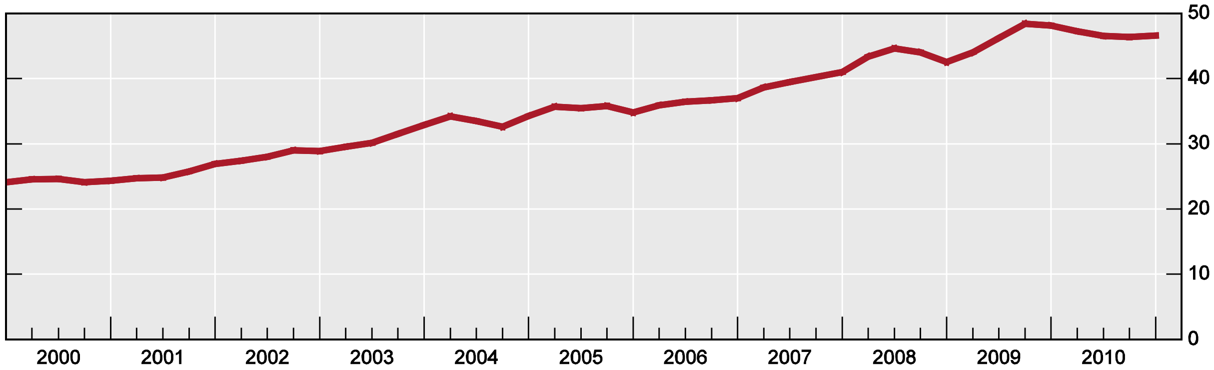
In normal periods of stability and prosperity, however, interest in central bank balance sheets tends to wane. Indeed, by the end of the 1990s, the policy focus of most central banks in the advanced economies had moved away from their balance sheets. Monetary policy frameworks came instead to focus almost exclusively on policy interest rates. This was the time of what we once called the "Great Moderation". Inflation worldwide had fallen to low levels and become more stable. The variability over time in the level of assets and liabilities of central banks declined. Balance sheets took a back seat in the formulation of monetary policy, even though they continued to play an important role on the operational side of central banks in the implementation of policy.

Two major shocks have changed this. The first was the Asian financial crisis of 1997/98. This convinced the authorities in Asia that they needed to build up foreign exchange reserves to protect themselves against future crises. But nobody in the mid-2000s expected such a large increase: forex reserves held by central banks in emerging Asia rose from $2 trillion at the beginning of 2006 to over $5 trillion now – exceeding 45% of GDP (Graph 1).

Graph 1

Foreign reserves in Asia[1]

As a percentage of GDP



[1] Aggregate of China, Chinese Taipei, Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand. Japan is excluded.

Sources: IMF, *IFS*; national data.

The motives for the further accumulation of forex reserves changed as time progressed. Increasing foreign exchange reserves became more and more the by-product of the exchange rate regimes adopted in the region. This policy choice often reflected the export-oriented growth strategy pursued by many countries. This has had major international implications, but these are not the subject of my speech today.[2]

The sizable build-up of the asset side of central bank balance sheets also required a comparable increase in domestic liabilities. Since such liabilities are the assets of banks and other financial institutions, the process of domestic financial intermediation has been altered.

The potential implications of such changes for monetary and financial stability meant that central banks had to be very careful in structuring their local liabilities as their foreign assets increased. As we will discuss at this conference, central banks used many instruments – reserve requirements, the issuance of sterilisation bonds, etc – to neutralise the liquidity associated with the massive rise in their forex reserves.

The second shock was the recent financial crisis that originated in the advanced economies. A loss of confidence in banks and in many financial products in the advanced economies disrupted global financial markets. This occurred in large part because the normal operations

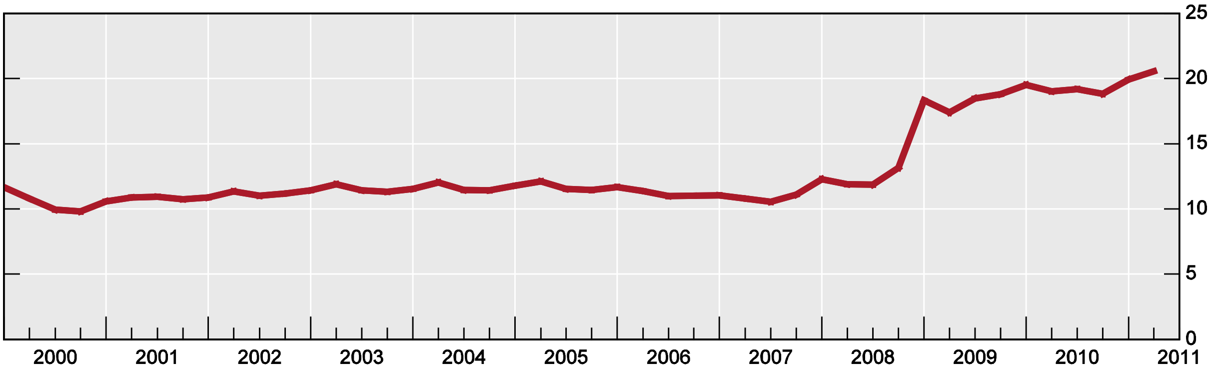
[2] CGFS (2009): Capital flows and emerging market economies, *CGFS Papers*, No 33, January.

of financial markets became impaired – blocking the transmission of lower policy rates to the real economy. Central banks countered this by buying "unconventional" assets on a large scale. They started by short-term lending or by buying short-term assets, but progressively moved towards buying long-term paper. At present, the aggregate size of central bank balance sheets in the advanced countries is nearly $8 trillion, the equivalent of more than 20% of GDP (Graph 2). In some cases, balance sheets are still growing. In addition, as the effective zero lower bound for policy rates was reached, large-scale asset purchase programmes became the primary tools in efforts to prevent any renewed financial meltdown. With short-term interest rates near zero, such policies also sought to provide additional monetary stimulus by lowering the long-term interest rate on government bonds.

Graph 2

Total central bank assets in advanced economies[1]

As a percentage of GDP



[1] Aggregate of Canada, the euro area, Japan, Sweden, Switzerland, United Kingdom, United States.

Sources: IMF, *IFS*; national data.

4. Four questions about policy risks

This global expansion of central bank balance sheets is unprecedented. Central banks showed commendable imagination and skill in using their balance sheets to prevent what could have been an even worse crisis. An unprecedented crisis required unprecedented measures. Even so, many central banks feel distinctly uncomfortable about the longer-term implications of such large balance sheets.

This sustained expansion means that the central bank's balance sheet becomes more exposed to market developments: a fall in the value of foreign assets or a rise in long-term interest rates could reduce the value of their assets while leaving the value of their liabilities intact. At some point, the capital of the central bank could be put at risk. This could in some circumstances raise unwarranted political questions and may even undermine the central bank's credibility. A country is better off if the central bank has the financial strength needed to carry out its functions. It is of course the macroeconomic and financial stability of the country that should determine policy decisions of the central bank. It is not profit or loss implications for the central bank's balance sheet.

But this risk to the central bank's own balance sheet is already well understood. Today, I would like to consider whether balance sheets of the current size could create broader policy risks. Such risks could include: inflation, financial instability, distortions in financial markets and conflicts with government debt managers. There is of course nothing inevitable about such risks materialising. But it is prudent never to lose sight of the risks created by expanding balance sheets. Analysing balance-sheet-related risks can also help design suitable "exit strategies". So let me outline four questions that are commonly raised about central bank balance sheets.

Inflation risks

The first is: Does the expansion of central bank balance sheets risk creating inflation? A preliminary answer is "not necessarily". Central banks today have clearly been able to increase the size of their balance sheets without losing their credibility for price stability. A good track record of low inflation has given central banks some leeway. There has been little correlation in recent years between the expansion of central bank balance sheets and inflation. This is true both for emerging economies and for advanced economies. That is the good news.[3]

But the ultimate answer to this question about inflation might be "not yet". Much will depend on whether governments in the advanced countries take decisive action in the years ahead to curb future fiscal deficits in a durable way. The very high and growing levels of public debt in many countries raise uncomfortable questions for central banks not only about the creditworthiness of the sovereign but also about fiscal dominance. I discussed those risks in a recent speech in India.[4]

In any event, the large expansion of central bank balance sheets has brought about a substantial rise of base money relative to GDP. The banking systems in many countries have become very liquid. Bringing central bank balance sheets back to more normal levels in these economies will, at some point, require the intensive and timely use of tools for draining liquidity. Central banks face no significant technical difficulties in doing this. At present, the financial markets appear to expect a smooth exit once the time is ripe. But the road ahead may still prove to be rather bumpy. A drain of excess bank reserves on this scale is going to be unprecedented. It will require not only judgement about uncertain and evolving financial conditions, but also skill in managing market expectations. Sensitivity to the political economy dimensions of restrictive policies is always wise. Fortitude in the face of political pressures is part of the duty of a central bank.

Financial stability risks

A second question is: How large an impact will central bank balance sheets have on domestic financial intermediation? Could financial stability risks be introduced? Several papers written in our Hong Kong Office address this important question.

One risk is excessive credit expansion. This could be stimulated by the increase in the banks' local currency assets, which are the major counterpart of the increase in the foreign currency reserves. And there does seem to have been some correlation between credit growth and foreign exchange asset accumulation in recent years. A recent analysis by Cook and Yetman (2012) argues that there is growing evidence of incomplete sterilisation which is reinforcing this risk. The threat to financial stability from an increase in bank lending is greater when credit growth is already robust and inflation pressures are picking up.

Are there implications for financial stability from the choice of tools to limit the expansion of bank credit? Some central banks have relied on reserve requirements. Such measures act as a tax on domestic bank intermediation. Indeed, Ma, Yan and Liu (2011) document China's use of reserve requirements to withdraw excess liquidity. They estimate that the higher

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[3] BIS (2011): *81st Annual Report*, chapter 4, June.

[4] See http://www.bis.org/speeches/sp111118.pdf.

reserve requirements impose a burden on banks equal to 0.3% of GDP. Such measures may also drive intermediation out of the regulated sector into the unregulated sector. A number of central banks are grappling with the growth of "shadow banking" in their countries.

Could central bank issuance of longer-dated paper have financial stability implications? Mehrotra (2012) notes that Asian central banks have relied heavily on central bank paper to sterilise the build-up of foreign reserve assets. The need to limit the refunding risks of short-term paper has led central banks to extend the average maturity of outstanding sterilisation bonds. The advantage of issuing higher-yielding, longer-term debt is that it makes sterilisation more effective. The disadvantage is that increased bank holdings of such paper may, in the short run, tend to crowd out bank loans to the private sector. Some call such paper "lazy" assets because they give banks a yield without much effort. Moreover, the presence of large holdings of these relatively low-yielding, liquid securities by banks tends to depress retail deposit rates. A medium-term risk is that the very liquid balance sheets may influence bank lending behaviour in ways that are difficult for policymakers to predict.[5] Filardo and Grenville (2012) argue that the build-up of 'lazy assets' (eg government bonds) in banks may encourage banks to eventually take on excessive risks.

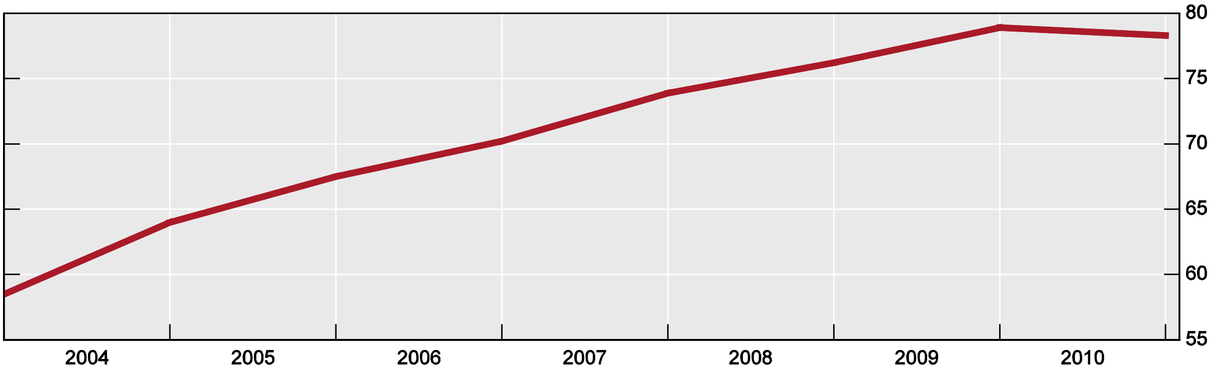
Financial market distortions

My third question is: could the increased size of central bank balance sheets relative to private domestic capital markets have unintended adverse consequences for the functioning of capital markets? For example, foreign official institutions now account for almost 80% of aggregate foreign holdings of US Treasury securities (Graph 3). In the years before the recent financial crisis, the preference of foreign central banks for US Treasuries tended to depress US yields and boost bond and other asset prices. More recently, large-scale asset purchases by the Federal Reserve have lowered US long-term yields, tending to push down yields in overseas markets as well.[6] The paper by Chen, Filardo, He and Zhu (2012) to be presented later in this conference documents the significant spillover of Quantitative Easing on Asian financial markets.

Graph 3

Long-term us treasury securities held by foreign official institutions

As a percentage of total foreign holdings



Source: US Treasury International Capital System.

[5] M S Mohanty and P Turner (2006): Foreign exchange reserve accumulation in emerging markets: what are the domestic implications?, *BIS Quarterly Review*, September.

[6] Also see BIS (2011) for a discussion of the distortions arising from ultra-low interest rates.

Should we be concerned about such international spillovers at the current juncture? When financial markets are subject to elevated uncertainty, central bank actions (actual and expected) on asset markets can play a disproportionate role in influencing financial market outcomes. And this could create a potent cross-border feedback loop: large-scale asset purchases in the West depress the domestic yield curve, which tends to widen the interest rate gap with emerging Asia; the threat of capital flows encourages more foreign reserve accumulation in emerging Asia and easy monetary policy; and this puts additional downward pressure on US treasury yields as the demand in Asia for US treasury securities rises. Anticipating such a dynamic, investors can become overly sensitive to expected central bank policies.

Sovereign debt management conflicts

My final question is: how are large changes in a central bank's balance sheet coordinated with sovereign debt managers? The management of sovereign debt has taken on increased importance as government debt has risen and central bank balance sheets have expanded. The much-increased official holdings of financial assets (forex reserves or domestic assets acquired under Quantitative Easing) will have implications for the management of the corresponding liabilities. Increased issuance of short-term debt – either by the government or by the central bank – affects conditions in money markets, and this influences monetary transmission mechanisms.

Could conflicts arise between the central bank's actions and debt issuance policy? If a central bank is trying to take duration out of the market by buying longer-term sovereign debt, there may be a temptation for debt managers to take advantage of a temporary decline in the cost of issuing new bonds by increasing issuance of long-term paper. When central banks want to sell government bonds – and so reverse extraordinary policy accommodation – what will be the reaction of debt managers who are anxious to place their own new issuance? Strong coordination across institutions will be needed to make sure sovereign debt managers do not inadvertently work at cross-purposes to the monetary authorities both in crisis conditions and during the exit phase.

5. Conclusions

Policy tools that involve the active use of central bank balance sheets – both the assets and the liabilities – can help monetary authorities to navigate the policy challenges during times of financial stress and when interest rates are close to zero. And they can be vitally important, as these times of financial strain have shown. The increased use of these tools in recent years reminds us that central banks do not need to rely merely on short-term interest rates in order to achieve their policy goals.

But the judgement that such and such a policy was the right choice in current exceptional circumstances should not make us complacent about possible medium-term risks arising from such a significant shift in the size and composition of central bank balance sheets.

With the economic and financial world constantly changing, we need to continuously re-evaluate the appropriate role of central bank balance sheets in the formulation of policy. In other words, we need to continue researching how changes in central bank balance sheets affect financial markets and thus the real economy – not only now, but also in the future. Let me reiterate a lesson from the recent crisis that I mentioned at the beginning: we cannot afford to ignore the implications of balance sheet developments.

Let me remind you too about the considerable fiscal risks that many countries face – risks that could at some point confront central banks with extremely difficult choices. It is very useful to share our central bank experiences with each other at events like this one. I am also very happy to welcome those of you from the academic world and from policy think-tanks to help us think critically about the issues before us.

It is the right time to be thoughtfully considering the various roles of central bank balance sheets. Exit strategies from these enlarged balance sheets will be an issue that will pre-occupy us for some years to come. Doing it right is important. I look forward to the progress we will make over the next two days in our understanding not only of the wider economic implications of increased central bank balance sheets, but also of how to address the potential risks.

Thank you very much for your attention.

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Key facts on central bank balance sheets in Asia and the Pacific

Andrew Filardo and James Yetman

1. Introduction

Central bank balance sheets in emerging Asia have been expanding rapidly over the past decade. Most of the increase is accounted for by the unprecedented rise in foreign reserve assets. Some of this expansion reflects efforts to bolster buffer stocks of reserves in the aftermath of the Asian Financial Crisis in the late 1990s. Increasingly over the past decade, however, the reserve accumulation has been the by-product of monetary policy frameworks focused on resisting exchange rate appreciation. The funding of this asset accumulation across the region has been diverse, including extensive use of required and excess reserves, and the issuance of central bank paper.

This paper briefly lays out the key facts and policy issues associated with the expansion of central bank balance sheets in Asia and the Pacific, drawing extensively on the research done in the BIS Asian Office over the past year. Section 2 highlights the salient trends in both central bank assets and liabilities, and the various central bank policy challenges. Section 3 discusses some of the risks that the expansion of central bank balance sheets may pose for the region. Section 4 notes the implications of expanding central bank balance sheets for debt management, briefly revisiting the traditional debate about the potential conflict between central banks and debt managers. Finally, section 5 highlights the initial progress being made to introduce central bank balance sheets into conventional monetary policy models.

2. Expanding central bank balance sheets

The expansion of central bank balance sheets in Asia and the Pacific has been unprecedented (Graph 1). While China has been the single largest contributor to this regional trend, the trend has been widely present across emerging market economies in Asia.

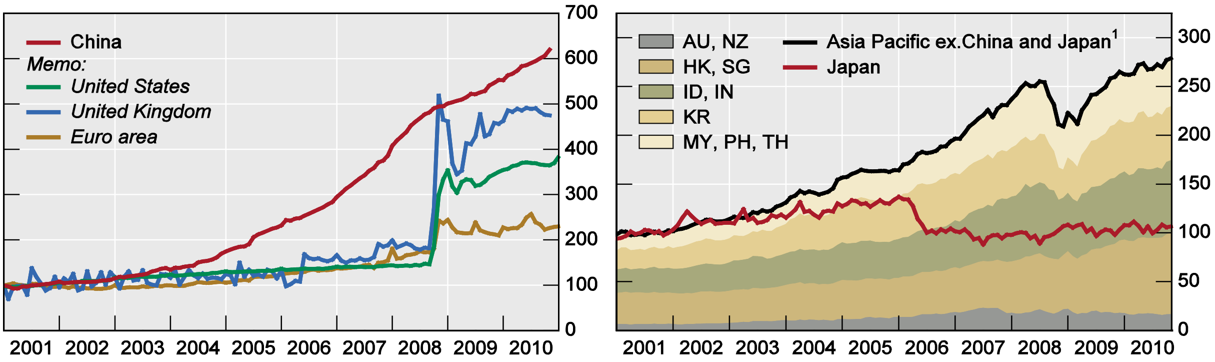
Of course, part of the expansion is consistent with the fundamental role of central banks in accommodating secular increases in currency demand fuelled by rapid economic growth. But the massive expansion goes well beyond currency demand. It is also important to note that the size of central bank balance sheets in Asia today as a percentage of GDP is far greater than in the advanced economies (Annex, Table A1).

There is a temptation to conclude that the mere fact that central bank balance sheets are unprecedentedly large translates into clear and present policy dangers. But it is important to note that the underlying policy frameworks, rather than the outcome in terms of balance sheets per se, are the source of policy risks. So one might ask, when thinking about policy risks, what the role of central bank balance sheets is. In other words, how should we view central bank balance sheets?

First, central bank balance sheets are a means to policy ends. They represent the available financial resources with which central banks pursue their policy objectives. In this sense, the special nature of central bank balance sheets gives central banks the unique ability within the broader government sector to take on such policy mandates as lender of last resort status and price stability. And since the beginning of the International Financial Crisis, there has been greater awareness of the potential role that central banks have in using their balance sheets in crisis resolution (eg through large-scale asset purchase programmes).

Graph 1

Central bank total assets (2001 = 100)



AU = Australia; HK = Hong Kong SAR; ID = Indonesia; IN = India; KR = Korea; MY = Malaysia; NZ = New Zealand; PH = Philippines; SG = Singapore; TH = Thailand.

[1] Sum of listed economies.

Sources: IMF, International Financial Statistics; national data.

Second, the size and structure of central bank balance sheets can provide useful information about policy risks – especially when assessing the unintentional consequences of policies. The sheer size of a central bank's balance sheet can signal potential imbalances in the macroeconomy and financial system, regardless of the particular policies driving the burgeoning balance sheets. The imbalances arise because the financial sector's balance sheets are the natural counterparts to that of the central bank. In other words, the size and structure of a central bank balance sheet can provide a valuable bird's eye view of growing risks across the financial system; in contrast, focusing narrowly on the marginal impact of central bank actions on a policy-by-policy basis may be misleading. Traditionally, inflation risks have been thought to be correlated with central bank balance sheet size. Now we need to add financial stability risks to this perspective. And just as central bank balance sheets may alert us to risks in the economy as they are arising, they also provide a key input for designing exit strategies from current policies.

Central bank assets and liabilities: the facts

The assets and liabilities of a central bank differ from those of private sector banks. A simplified central bank balance sheet is shown in Table 1. Central bank assets consist of net foreign reserves and domestic assets; its liabilities comprise currency in circulation, bank reserves, deposits of other institutions (including government), its own securities and other liabilities, and equity capital. Equity capital represents accumulated profits and losses as well as transfers of resources from the government.

Table 1

A central bank balance sheet

Assets	Liabilities and capital
Foreign assets	Reserve money
Domestic assets	Currency in circulation
Claims on government & public enterprises	Reserves of commercial banks
Claims on the private sector	Foreign liabilities
Claims on domestic money banks	Other deposits of commercial banks, etc
Claims on other financial sector entities	Central bank securities, etc
	Government deposits
	Others
	Equity capital

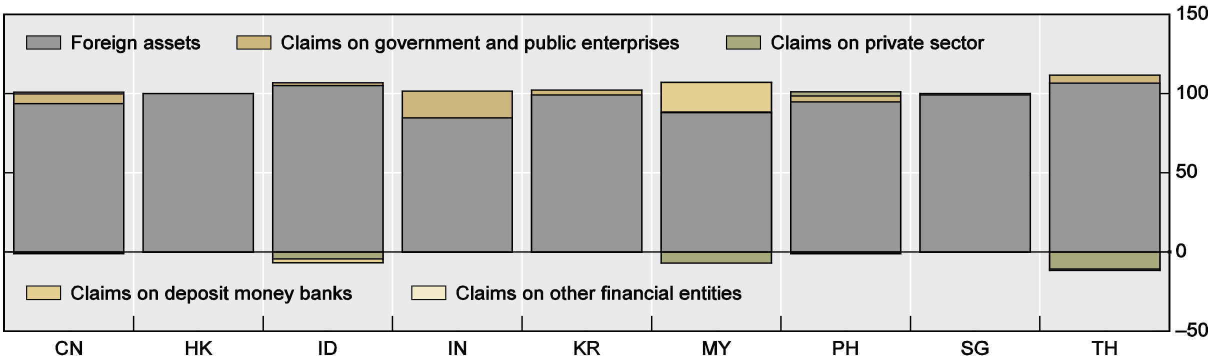
Assets

In emerging Asia, the remarkable increase in central bank assets has been dominated by growth in net foreign assets (Graph 2), with most of the accumulation of foreign assets being in US-dollar-denominated bonds.

Graph 2

Change in composition of central bank assets in Asia, 2002–10

As a percentage of change in total assets



CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand;

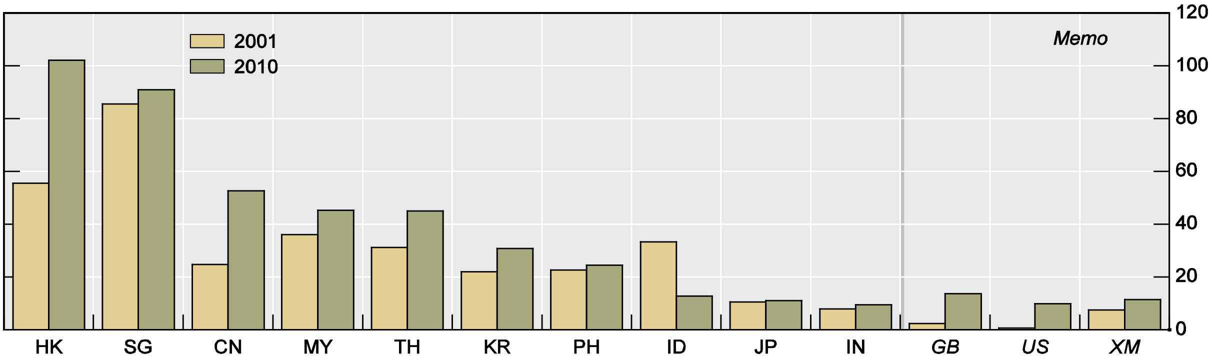
Source: IMF, International Financial Statistics.

After a decade or more of these policies, many economies are sitting on large foreign exchange reserve holdings. Singapore and Hong Kong SAR, for example, have reserves of around 100% of GDP; China, Malaysia and Thailand have reserves equal to around half of GDP. To put these figures in perspective, the ratios are far in excess of the pre-crisis ratios in the advanced economies, and exceed the advanced economy ratios even now, after the substantial expansion of their balance sheets during the crisis (Annex, Table A1).

Graph 3

Central bank assets[1]

As a percentage of GDP



CN = China; HK = Hong Kong SAR; GB = United Kingdom; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United Kingdom; XM = euro area.

[1] Net of currency in circulation.

Sources: IMF, International Financial Statistics; national data.

Some policymakers point out to their critics that the rapid accumulation of foreign exchange reserves has not always been one-sided (Graph 4). Some central banks experienced a sharp transitory reduction during the international financial crisis. For example, the Bank of Korea shrank its balance sheet at the end of 2008, as did the Central Bank of Malaysia and the Reserve Bank of India. Thus, even though the growth in foreign assets has been large and mainly one-sided over the past decade, there is some openness to running down assets when there are depreciation pressures. An open question is whether the accumulation/decumulation process will be more symmetric going forward.

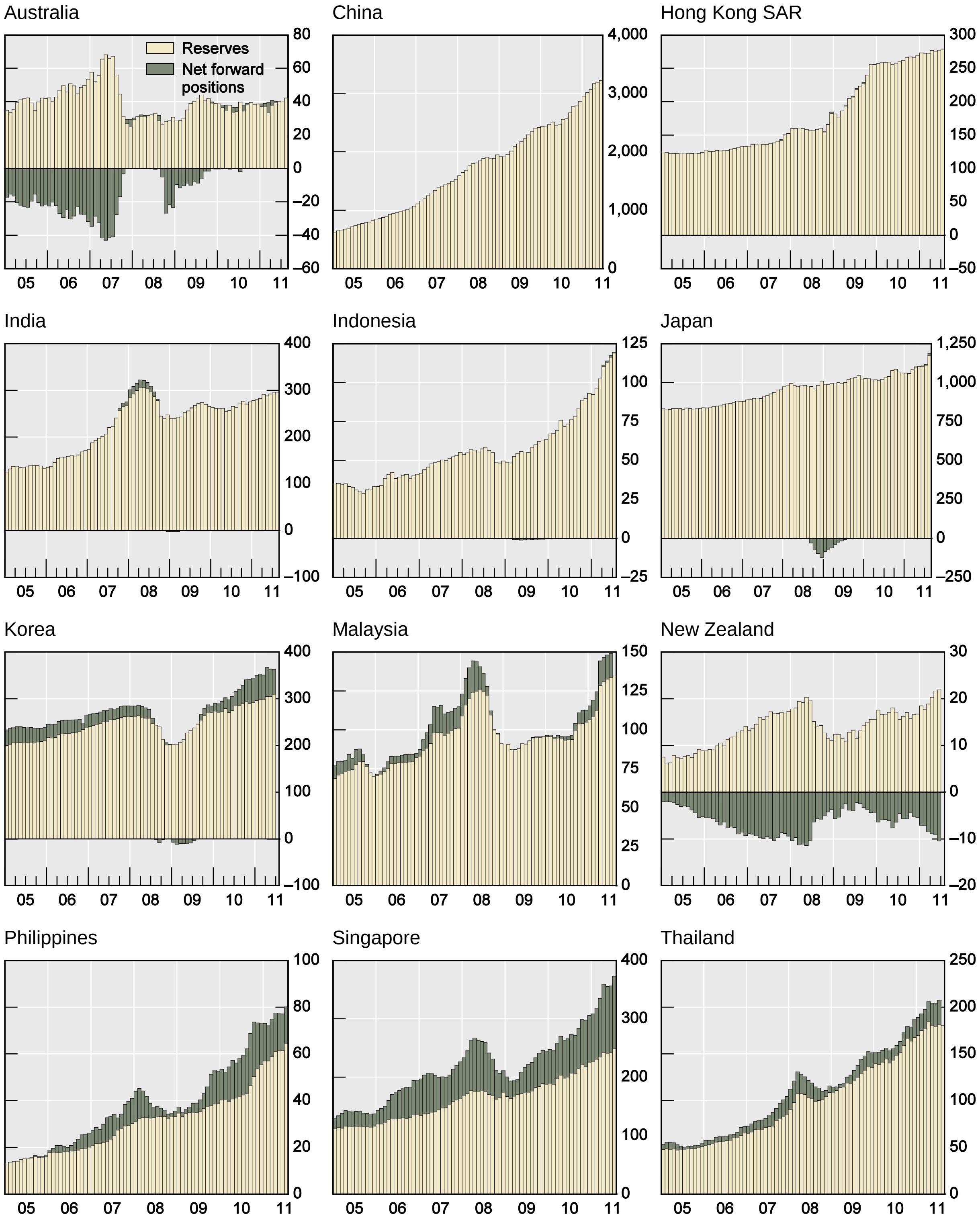
The policy factors driving the expansion in the region have changed over time. Early in the post-Asian crisis period, Asia-Pacific policymakers took to heart the importance of having a sufficient war-chest of reserves that could be used in the event of a run on the currency. Reserve adequacy also helped to assure markets that the exchange rate regime was sound in an ex ante sense. Indeed, credit rating agencies took reserve holdings as one of the key factors determining an economy’s credit rating, thus influencing the cost of local currency borrowing.

By the second half of the 2000s, however, Asia as a whole was seen as having ample reserves, based on conventional import and external debt metrics (Annex, Table A2). With adequate reserves, the further accumulation of reserves was primarily motivated by the policy aim of resisting exchange rate appreciation. Again, economic history in the region weighed on the minds of policymakers. One of the central lessons of the Asian Financial Crisis in the late 1990s was that fixed exchange rates are hard to defend in the face of large volatile foreign capital flows and substantial changes in sentiment. But authorities did not accept the argument that those countries which could not credibly peg indefinitely should float freely. Instead, with the notable exception of Hong Kong SAR’s currency board, many policy makers sought out the middle ground of a managed float. While there were times of heavy intervention to resist sharp depreciations, notably in Korea and Indonesia during the recent international financial crisis, the more typical mode has been ‘leaning against the wind’ in the face of appreciation pressure, which helps to account for the trend of foreign reserves accumulation.

Graph 4

Foreign exchange reserves[1] and net forward positions[2]

In billions of US dollars



[1] Official reserves excluding gold, in billions of US dollars. Includes SDRs and reserve positions in the IMF. [2] Long positions in forwards, and futures in foreign currencies vis-à-vis the domestic currency, minus short positions.

Sources: IMF, International Financial Statistics; IMF, International Reserves and Foreign Currency Liquidity; national data.

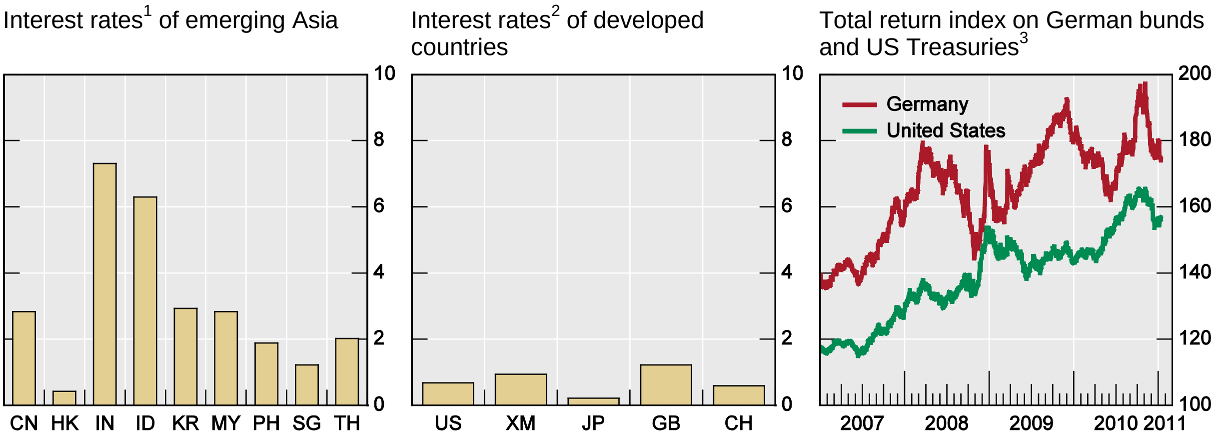
Finally, the return on the foreign currency assets on central bank balance sheets has been low (Graph 5). These foreign assets, dominated by US and euro fixed-income instruments, have relatively low yields in a global sense. In recent years the decline in yields in the US has led to paper gains on a mark-to-market basis. Going forward, however, if the securities are held to maturity, the paper gains will be offset by lower future returns.

In addition, the domestic currency return on such foreign-currency-denominated assets is influenced by swings in the exchange rate. Appreciation of domestic currencies lowers the effective return and can even result in losses. Questions remain about the policy importance of such losses when the reserves are being held primarily to protect against sudden stops and rapid currency depreciations in the future.

Graph 5

Interest rates and total bond returns

In per cent / index



CH = Switzerland; CN = China; HK = Hong Kong SAR; GB = United Kingdom; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

[1] Latest observed yields of available three-month, six-month, one-year, five-year and 10-year government bills and bonds; weighted average based on amount issued in 2010. [2] Simple average of one-year to three-year government bonds. For Switzerland, average of one- and two-year bonds. [3] GBI global traded total return index level, seven-to-10 year, in US dollar terms; 2000–06 = 100.

Sources: Bloomberg; Datastream; JPMorgan Chase; national data; BIS calculations.

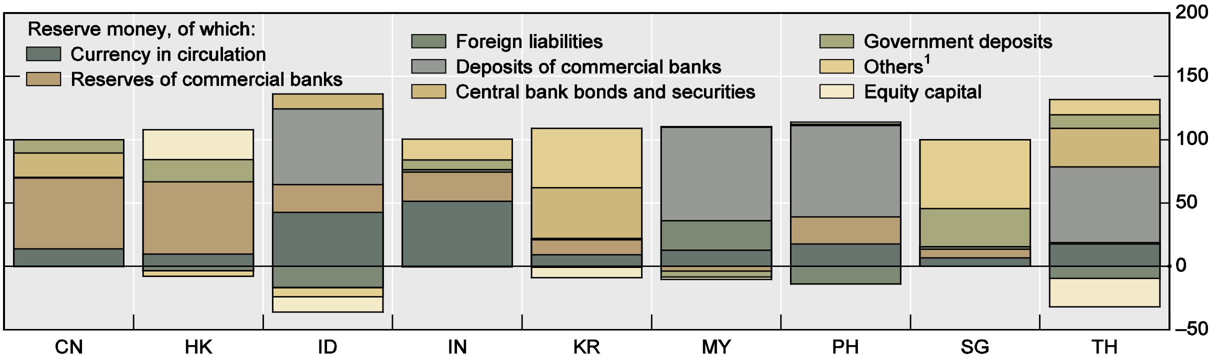
Liabilities

The liability side of a central bank's balance sheet provides insight into the selection of central bank policy instruments that have been used to finance the purchase of the foreign reserve assets (Graph 6, and Annex, Table A3). The impact of the liability-side expansion of Asian central bank balance sheets has been more diverse across the region than the impact of the asset side. Though it is difficult to generalise, the choice of liabilities across economies reflects two factors: historical reliance on particular policy tools in each jurisdiction, and the relative cost of each tool in the policymaker's toolbox.

Graph 6

Change in composition of central bank liabilities in Asia, 2002 - 10

As a percentage of change in total assets



CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand.

[1] Including loans and other items (net).

Source: IMF, International Financial Statistics.

First, let us briefly review the diverse trends. Currency and reserve money have risen sharply across most of the region, reflecting the strong underlying economic growth in Asian economies. The rise in reserve money is partly due to the growth in commercial bank deposits with central banks as financial systems deepen. In addition, several central banks have imposed higher reserve requirements in order to curb the growth of bank lending.

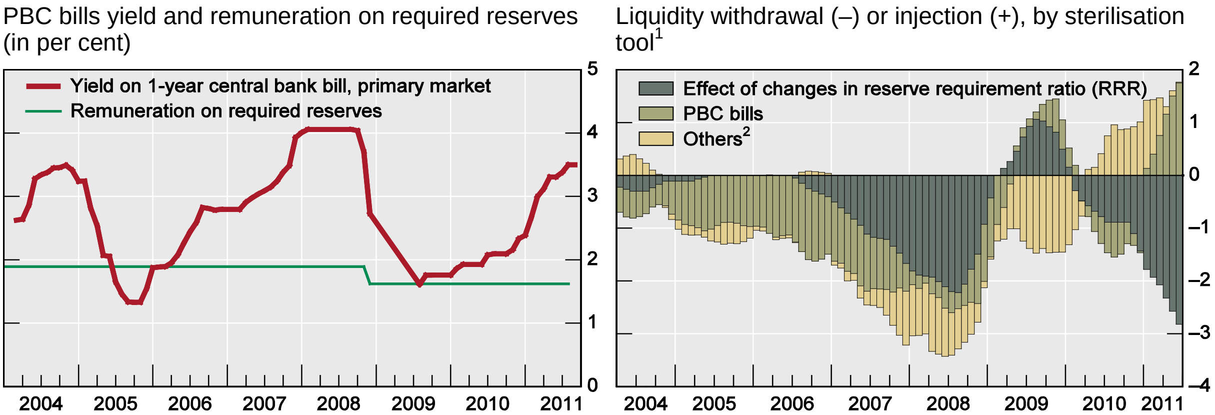
Greater issuance of central bank paper and the use of deposit facilities at central banks also show up significantly. Changes in government deposits are an additional important explanatory variable in some economies, reflecting both the traditional mandate of central banks as the government's banker and the use of government deposits as a means to sterilise foreign exchange intervention.

Second, the diverse trends reflect the historical use of particular tools in a given jurisdiction and the relative costs of the various tools in the toolkit. For example, two instruments that are used heavily in Asia are required reserve ratios and issuance of sterilisation securities. These tools have different costs and benefits that determine their attractiveness. Compared with central bank securities, required reserve ratios tend to remove liquidity from the banking system on a more permanent basis and are typically low-cost tools for the central bank because either little or no interest is paid. However, the below-market interest rate acts as a tax on domestic banks. One concern is that this increases incentives to borrow in the unregulated shadow banking system. A related concern is that high-quality borrowers are the most likely to find alternatives to banks as sources of funding, precipitating a decline in the credit quality of banks' loan portfolios. In the case of China, as the interest costs of sterilisation bonds have risen, the reliance on low-yielding reserve requirements has increased, as Ma, Yan and Liu (2011) discuss (Graph 7).

Another option for central banks in Asia is to sell off their domestic bond holdings in open market operations. However, the limited size of domestic bond markets provides a disincentive to sterilise the large accumulation of foreign reserve assets. Paying interest on excess reserves is also a possibility. However, the interest costs could be quite high owing to the large amounts of liquidity to be drained, and fine-tuning operations using excess reserves are more difficult than those based on issuing central bank bills.

Graph 7

Sterilisation tools and costs in China



[1] Components of net domestic assets; year-on-year change of three-month moving average; in trillions of RMB; positive (negative) indicates injection (withdrawal) of liquidity. [2] Net domestic assets other than effect of changes in RRR and PBC bond issue.

Source: Ma, Yan and Liu (2011).

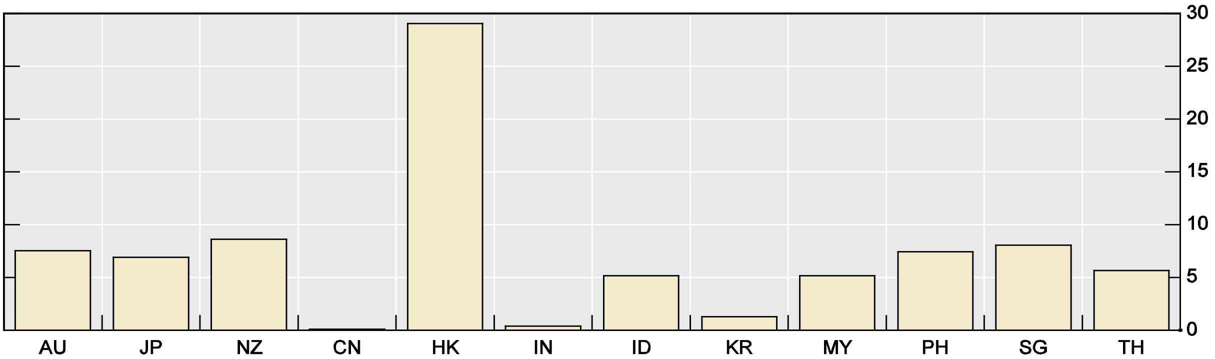
Equity capital

Central bank equity issues have taken on increased importance in recent years. In part, central banks have faced balance sheet losses owing to appreciating currencies and because of taking on quasi-fiscal costs. These losses have eaten into central banks' equity capital buffers, raising questions about how best to replenish capital (Graph 8). The greater emphasis on private sector capital adequacy naturally raises the question of what capital standards central banks should be subject to. While much of this discussion goes beyond the scope of our conference, these central bank financing issues may take on increasing importance in future.

Graph 8

Central bank equity, 2010

As a percentage of total assets



AU = Australia; JP = Japan; NZ = New Zealand; CN = China; IN = India; ID = Indonesia; KR = Korea; MY = Malaysia; PH = the Philippines; SG = Singapore; TH = Thailand.

Sources: IMF, International Financial Statistics; national data.

A critical policy issue is whether a central bank retains its ability to act if it has negative equity. Both in theory and in practice, the answer is yes. Central banks are very different institutions to private sector banks, primarily because central banks cannot be illiquid, given their ability to print money. This does not mean that negative equity positions over the long term do not create problems. Issues of credibility and loss of central bank independence cannot be ruled out. These possibilities suggest that there is a premium on central bank governance designs that put funding rules in place to ensure that a central bank has a sound recapitalisation plan and other indemnities from the general government to prevent the perception that short-term, opportunistic pressures might influence central bank policy decisions.

3. Macroeconomic and financial stability risks

The expansion of central bank balance sheets in the region raises concerns about three types of risks: inflation risks, financial stability risks, and credibility and independence risks. We briefly highlight each of these in turn.

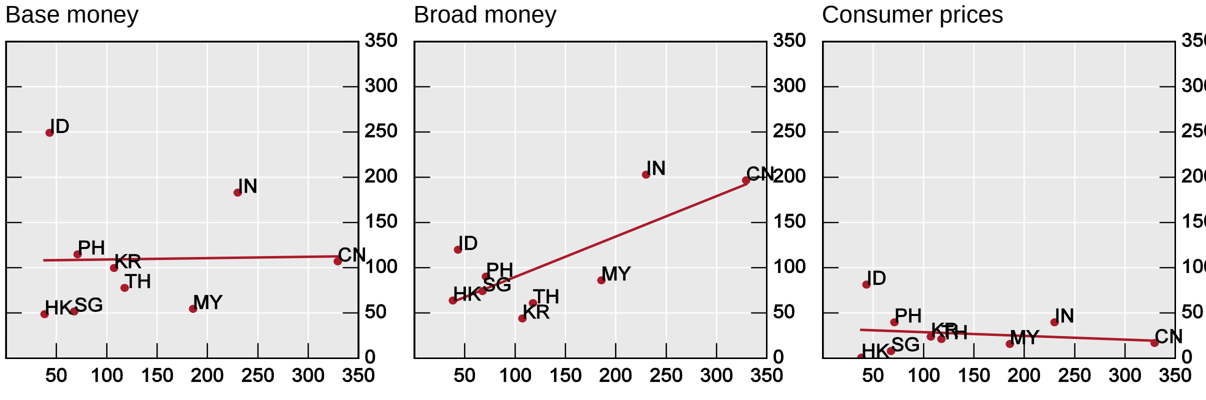
Inflation risks. Traditionally, the rapid expansion of central bank balance sheets has gone hand-in-hand with the growth of the monetary aggregates. This additional liquidity in the economy served as stimulus that eventually pushed inflation rates higher.

In emerging-market economies, central banks could reduce the chances of such an outcome if they sterilised foreign exchange purchases by draining reserves from the financial system. In this way, Asian central banks have been able to control inflation despite the massive accumulation of foreign reserve assets. Graph 9 shows that there has so far been little correlation between base money growth, broad money growth and consumer prices. It is also important not to overlook the fact that central banks in some Asian economies have built strong price stability credibility over the past two decades, despite some backsliding recently in some jurisdictions. This credibility has also helped to keep inflation rates well-anchored even in cases where broad money and credit growth did accompany foreign exchange intervention trends. For these reasons, a significant deterioration in inflation performance is not likely a consequence of the growth in central bank balance sheets.

Graph 9

Growth of central bank assets relative to the growth of money and consumer prices[1]

2001–07; in per cent



[1] The horizontal axis show percentage change in central bank total assets; the vertical axis represents the percentage change in the variables shown in the panel title.

Source: Filardo and Grenville (2012).

Financial stability risks. Despite the relatively benign assessment of the inflation risks associated with the trends in central bank balance sheets, the financial stability risks are a greater concern for several reasons (Graph 10).

In the short run, an acceleration in the rate of foreign reserve accumulation would be likely to crowd out domestic investment in the region. In the case that downside risks in Europe and the United States materialise, appreciation pressures on Asian exchange rates may thus lead to less near-term investment.

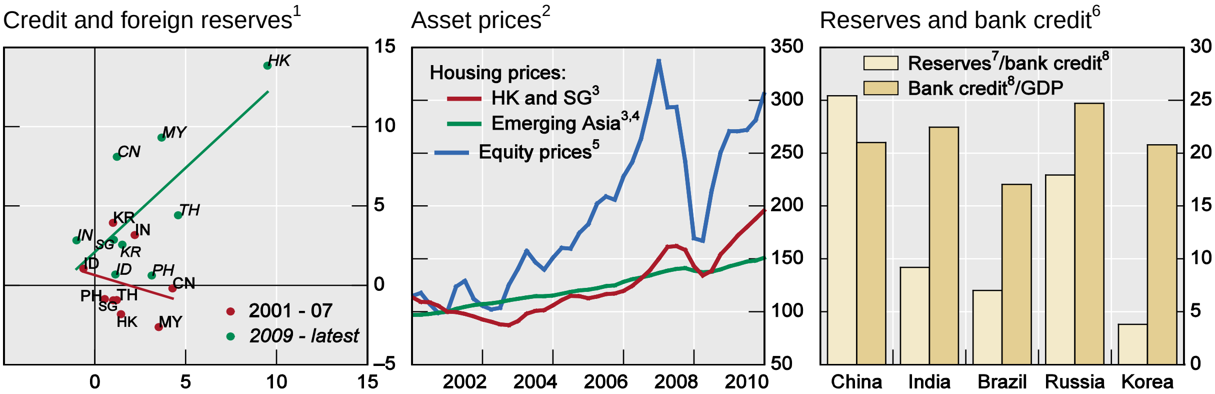
Indeed, Cook and Yetman (2012) estimate the potential impact for each 1% increase in the level of reserves to be a decline of approximately 1% in the growth of the quantity of loans relative to assets for the banks. This impact reflects the bank-dependent lending channel in emerging Asia. Emerging Asia is characterised by the following three traits: 1) bank intermediation is crucial to capital formation; 2) banking activity is limited by bank capital; and 3) central bank asset accumulation influences the size and structure of bank balance sheets. Empirical evidence from balance sheet data for 55 banks in Indonesia, South Korea, Malaysia, the Philippines and Thailand indicates that banks finance the accumulation of reserves through a combination of measures: holding reserves at the central bank and/or purchasing sterilisation bills. This in turn reduces resources for loans in the short run.

Of course, this may not be the end of the story. Over time, the massive accumulation of foreign reserve assets at the central bank will generally result in an increase in "lazy assets" on the books of private sector banks. The liabilities of the central bank are claims of the private sector banks. The accumulation of these generally low-yielding assets on the banks' balance sheets provides growing incentives to expand credit at some (possibly future) point in time.

When global risk aversion is high, as it has been in Asia for some time now, banks may be content sitting on these lazy assets. The concern is that when the global recovery begins to gain traction and global risk aversion falls, these banks will attempt to sell or leverage these highly liquid securities on their balance sheets in the form of loans. This behaviour is consistent with correlations between credit and foreign reserves in the past. Of course, this risk-taking channel can be offset by monetary policy actions (and macro-prudential tools). However, if the surge in lending is sufficiently strong and the monetary authorities get behind the curve, the credit expansion has the potential to be a "credit boom gone bad", with well-known negative consequences for economic and financial instability.

Graph 10

Foreign reserves, credit and asset prices



[1] Horizontal axis shows foreign reserves as percentage of GDP; the vertical axis represents credit to the private sector as percentage of GDP; the points show annual average change in the ratios. [2] End-2001 = 100. [3] Weighted average based on 2005 GDP and PPP exchange rates. [4] China, Hong Kong SAR, Indonesia, Korea, Malaysia, Singapore and Thailand. [5] MSCI emerging Asia in local currency. [6] Increase in percentage points; end-2002 to latest available data. [7] Foreign exchange reserves minus currency in circulation. [8] Bank credit to the private sector.

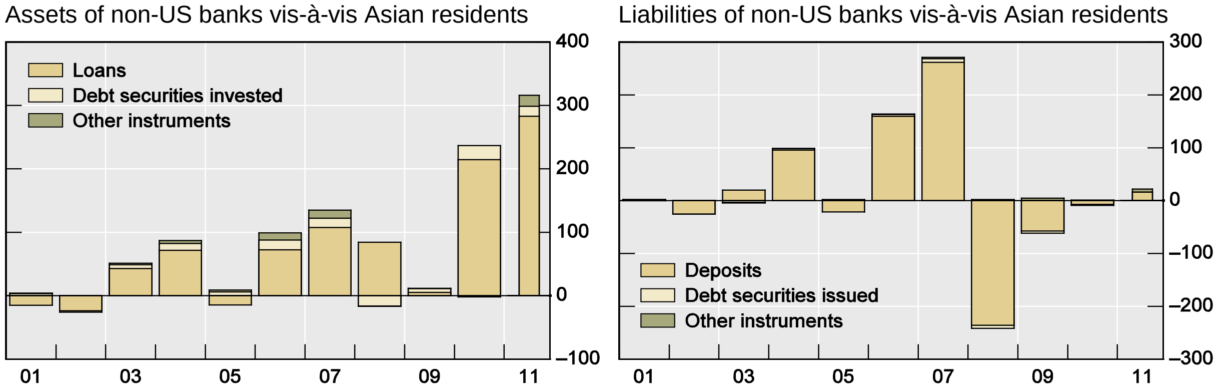
Source: Filardo and Grenville (2012).

Finally, the expansion of central bank balance sheets, particularly in the West, appears to be contributing to financial stability concerns today. Graph 11 illustrates the sharp pickup in offshore dollar lending in Asia over the past couple years. Admittedly, some of the recent anecdotal evidence suggests that some of this credit growth has eased as European banks have withdrawn from Asian markets.

Graph 11

USD flows outside US[1, 2]

(in billions of USD)



[1] 2011 figure based on annualised Q1 data. [2] Estimated-exchange-rate-adjusted changes of total positions of BIS reporting banks outside the US vis-à-vis all sectors in emerging Asia-Pacific.

Source: BIS locational banking statistics.

The expansion of central bank balance sheets in the West, as part of their response to the international financial crisis, was initially thought of as a big push factor behind capital flows to the region. Such aggressive capital flows were seen as a risk to sustainable growth in the region. But low policy interest rates in Asia and high global risk aversion appear to have prevented such destabilising carry trades. Chen, Filardo, He and Zhu (2012) find evidence that the central banks that adopted large-scale asset purchase programmes were successful in lowering the yield curve in their economies, but that these programmes also had spillover effects on Asia. Asian yield curves shifted downward contemporaneously with those in the West.

The lower interest rates in the region have helped to pump up credit and asset prices in a number of economies. In addition, the low interest rates in the United States and the dollar-based Asian economies have created a new channel of credit growth in Asia – the offshore dollar market. In this market, non-US banks are willing to lend US dollars at low rates of interest to Asian residents. Without an increase in their US dollar deposits on the books of these offshore banks, they may be taking on a currency mismatch if the loans are funded by selling local-currency assets. If funded by FX swaps, the currency mismatch may be less worrisome, but this type of funding does entail counterparty risks – which, in today's global financial world, cannot easily be dismissed. To assess these risks, more complete data on offshore bank balance sheets is needed. The only point here is that the unintended consequences of the massive accumulation of foreign reserve assets in Asia are beginning to be seen in regional credit developments. These need to be tracked closely.

Sustained, large balance sheet losses and credibility and independence risks. The average running cost ('quasi-fiscal costs' represented by the differential between domestic and foreign interest rates, Graph 5) of reserve-holding has been relatively modest over the past decade, and the benefits of substantial foreign reserve holdings were demonstrable during the international financial crisis (especially for Korea, Malaysia and Indonesia). But this interest differential is only one component of the cost of reserve-holding; the central bank incurs a capital loss when the domestic currency appreciates, which has been the case for most economies in emerging Asia (Filardo and Grenville, 2012; Cook and Yetman, 2012). For most economies in emerging Asia, investing in USD loses around 2 percent per year, calculated in terms of the domestic currency of these economies. For India and Indonesia, the capital appreciation cost has been smaller than the group average, but the interest-differential cost has been higher. For the others (except for Hong Kong SAR with its fixed rate), taking into account the currency appreciation cost roughly doubles the overall cost of reserve holdings.

Capital losses of this nature do not limit a central bank's ability to intervene to restrain an appreciation, and to sterilise the effect of the intervention, but they do cause asset valuation losses which weaken their profit-and-loss accounts. The capital losses on appreciations either diminish profits or are taken into the balance sheet in the form of reductions to reserves.

A major concern is that the public reporting of the weakened state of the central bank's balance sheet may diminish the central bank's reputation. And if the central bank has to go cap-in-hand to the Ministry of Finance and Parliament to approve capital replenishment, the reputational damage may be accompanied by a weakening of independence.

A series of factors seem likely to raise the net cost of reserve-holding in the future, thereby raising questions about how much longer the current trends can be sustained (Filardo and Grenville, 2012). First, the greater size of the foreign exchange reserves relative to GDP will increase costs. Second, the funding-interest differential between domestic and foreign rates seems likely to widen, with interest rates in the reserve-currency countries likely to stay low for quite some time, while regional domestic rates are likely to rise as more vigorous economic activity resumes. Thus, the differential will widen from the abnormally narrow levels seen over much of the past decade. A large inflow will be attracted by this wider interest differential, accelerating the accumulation. In addition, there is the prospect of further upgrades from the credit-rating agencies, belatedly adjusting to the region's stronger prospects. Lastly, to the extent that exchange rates will unwind any existing undervaluation, the phenomenon will make reserve holding more costly in terms of capital losses.

4. Central bank balance sheets and debt management

In the past few decades, advanced economy central banks became less active as market makers for government debt, and new agencies were set up to take over sovereign debt management (Turner, 2011). Moreover, debt managers were generally given relatively narrow mandates in order to minimise the expected cost of funding for the government over the medium to long term while ensuring prudent risk management practices.

Emerging market economies saw less drift in such mandates. Where financial systems were less fully developed, central banks retained a bigger role in promoting deep and liquid financial markets, especially for government bonds. At the same time, some central banks, such as the Reserve Bank of India, retained some functions related to sovereign debt management.

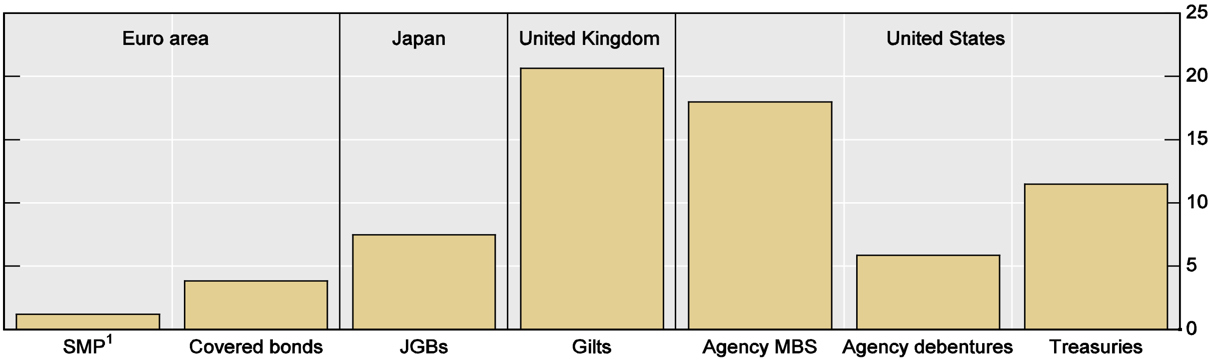
However, many central banks have had to increase their issuance of central bank bills as part of sterilisation operations, as central bank balance sheets have expanded. Mehrotra (2012) notes that the outstanding stock of central bank paper now amounts to over 10% of GDP in some Asian economies. And the average maturity of central bank paper is still relatively short, but has risen during 2010-11. This could help to lock up excess liquidity for longer periods of time, which is especially relevant in an environment of strong capital inflows.

These trends have created an elevated possibility of conflict between debt managers and central banks. As major advanced economy central banks implemented large-scale asset purchase programmes to take duration out of the markets, for example, longer-term interest rates came down. Graph 12 shows that these central banks now hold substantial quantities – 10% to 20% – of domestic government debt outstanding. This action was meant to stimulate the economy (at the zero lower bound of nominal interest rates) by lowering the cost of long-term borrowing. It also meant that long-term borrowing by the government looked increasingly attractive. If debt managers, in their efforts to minimise financing costs, were to issue more long-term debt, this would work at cross-purposes to the goals of the central bank.

Graph 12

Central bank outright holdings of selected debt securities

Per cent of total market; as at end-December 2010



[1] Securities Markets Programme holdings include private and public debt securities.

Sources: Bloomberg; Datastream; European Covered Bond Council; SIFMA; UK Debt Management Office; US Treasury; central banks.

While sovereign debt management choices do not appear to have constrained central banks' ability to ease monetary conditions significantly in the advanced economies so far (see CGFS, 2011), the possibility cannot be ruled out for the future. This would be especially true if concerns about the cost of short-term debt financing continue to intensify at the same time as new large-scale asset purchase programmes are contemplated. And for emerging markets this would be true as long as there was a need to finance the large and growing stock of foreign reserve assets.

Such possibilities raise the issue of enhancing coordination between debt managers and central banks. To manage the potential tensions arising from sovereign debt management, it is essential that debt managers and central banks understand each other's motives for their respective actions. Moreover, it is important that markets also share this understanding. Helpful steps in this regard include stable and predictable issuance, with issuance calendars announced well in advance of auctions and central banks spreading their purchases over a range of maturities to avoid squeezes in particular market segments. For emerging markets, central banks may also need the authority to lengthen the maturity of their central bank bill issuance and to provide incentives for domestic and international investors to hold longer maturities, as Bank Indonesia has been doing in recent years.

5. Modelling challenges

In recent years, there has been renewed interest in modelling the role of central bank balance sheets in macroeconomics generally, and for monetary policy deliberations in particular. Previously, central bank balance sheets were treated mainly as a sideshow of little real consequence. The crisis in the West and the build-up of foreign exchange official reserves in Asia have underscored the importance of bridging the gap between theory and practice.

The canonical model used in most policy analysis can be reduced, in essence, to three central relationships: (1) a Phillips curve that relates inflation to inflation expectations and output, (2) an IS curve that relates output to real interest rates, and (3) and a Taylor rule that describes monetary policy as a function of deviations between macroeconomic variables – typically inflation and output – and their targets.

$$p_t = f(p^e_{t-1}, y_{t-1}) \tag{1}$$

$$y_t = g(i_{t-1} - p^e_{t-1}) \tag{2}$$

$$i_t = h(p_{t-1} - p^*, y_{t-1} - y^*_{t-1}) \tag{3}$$

The model may be complicated in many realistic ways without fundamentally changing its essence. For example, for an open economy we might add exchange rates to all of the equations: to the Phillips curve (to allow for pass-through from exchange rates to inflation); to the IS curve (to capture the relationship between external demand and exchange rates); and perhaps even to the Taylor rule (to allow for a policy response to exchange rate movements). But fundamentally, we would still have a model with a three-equation reduced form.

Where do central bank balance sheets fit into this model? The short answer is that they do not. Within most of the benchmark macroeconomic models used in recent decades, there is no role for central bank balance sheets, or even for the information that they contain.

From a pragmatic point of view, ignoring central bank balance sheets may have been a reasonable simplification until recently, at least for most advanced economies. Before the international financial crisis, monetary policy was centred on a paradigm in which policymakers set short-term interest rates and offered signals about the likely future path of policy rates. The size and composition of central bank balance sheets tended to be passive and merely reflected the underlying demand for different central bank liabilities. Central bank balance sheets also tended to be limited in size, and their composition stable.

For emerging economies, failing to take explicit account of the role of central bank balance sheets in policy analysis in the past may have been less benign. In the lead-up to the Asian financial crisis, for example, many national currencies in emerging Asia were overvalued, leading to a decline in foreign currency assets on central bank balance sheets, as foreign exchange intervention was used to support the value of these currencies. The expectation of currency depreciation due to the loss of foreign currency assets precipitated currency crises in a number of economies. The situation faced by many emerging Asian economies today is the mirror image of this, with the rapid accumulation of foreign currency assets bloating central bank balance sheets as a result of action to resist exchange rate appreciation.

Recent events in advanced economies pose a further challenge to the canonical model. Central bank balance sheets have been growing rapidly, driven primarily by purchases of domestic currency assets. The composition of the balance sheets has also changed, in part reflecting extraordinary policy actions intended to stimulate the economy and offset the recessionary effects of deleveraging within the private sector.

Analysing the effects of such policies, along with the macroeconomic risks and policy challenges that large balance sheets might pose, requires new analytical frameworks that depart from the canonical model in ways that provide a meaningful role for central bank balance sheets.

The key to generating a role for central bank balance sheets in models is ensuring that changes in their balance sheets are not automatically offset by the decisions of other actors in the economy. Underlying the irrelevance of balance sheets is the idea that the balance sheets of taxpayers, governments and central banks are intertwined, since taxpayers are residual claimants on public sector wealth – or, equivalently, residual payers of public sector liabilities. An influential paper by Wallace (1981) demonstrated that changes in the official sector's balance sheet will not affect the risk-return profile of households or change equilibrium financial-asset prices when markets are complete. Effectively, optimal decision-making by residual-claimant taxpayers/investors will result in changes in private sector balance sheets that exactly offset the effects of changes in the official sector.

There are a number of plausible ways to proceed to overturn the Wallace (1981) result: removing perfect substitutability between different types of assets; assuming that actors in the private sector face leverage constraints; and modelling possible links between monetary policy and fiscal policy. We briefly discuss each in turn.

For central bank balance sheet irrelevance to hold, different types of assets must be perfectly substitutable at the margin. Eggertsson and Woodford (2003) have shown that if private agents have a liquidity preference for central bank monetary liabilities, for example, then the size and composition of central bank balance sheets will have equilibrium effects. They argue that such a liquidity preference is likely to be especially relevant when interest rates are constrained by the zero lower bound.

The Eggertsson and Woodford result may be viewed as a special case of portfolio balance theory (see Branson and Henderson, 1985, for a literature review). Portfolio balance theory focuses on the imperfect substitutability of domestic and foreign bonds in the portfolios of private investors due to frictions in financial markets. As a result, financial markets are not efficient, and investors will prefer some assets over others – hence these models are sometimes referred to as "preferred habitat" models. Changes in the asset and/or liability composition of the central bank balance sheet will then imply changes in the balance sheet of the private sector that may influence private sector decisions to spend, save and invest. In this framework, even sterilised foreign exchange interventions by the central bank may have important real effects on the economy.

An alternative means to ensure that central bank balance sheets play an important role is to assume that other economic actors face leverage constraints, as in Bernanke, Gertler and Gilchrist (1999), and as in Woodford (2011). A key condition for the irrelevance of central bank asset purchases is that investors be unconstrained in the purchase of individual assets; otherwise their limited ability to purchase assets may prevent them from fully offsetting changes to the balance sheet of the central bank.

A number of papers provide examples of how targeted central bank lending in the presence of leverage constraints on asset purchases by private investors may have important real effects. For example, Curdia and Woodford (2011) construct a model with heterogeneous consumers, in which borrowers may have less than full access to the pool of private savings. In their model, the level of direct central bank lending to credit-constrained private sector borrowers can improve societal welfare. Ashcraft, Gârleanu and Pedersen (2011) construct a model in which only a fraction of bank assets are pledgeable as collateral. Central bank lending, which demands lower collateral "haircuts", can relax credit conditions efficiently by lending at lower margins. And Reis (2009) describes a model in which financial intermediation is plagued by pledgeability concerns which, together with information costs, may reduce the funding for profitable investment projects when central bank balance sheets expand.

Chadha, Corrado and Meaning (2012), in this conference, also develop a model along these lines, in which there are two effective leverage constraints: households face a leverage constraint based on the level of their collateral, and banks face a leverage constraint due to required reserve ratios. They show that these constraints ensure an important role for asset purchases by the central bank as a policy tool for improving economic welfare.

The above examples of models with leverage constraints all apply to the purchase of domestic currency assets by the central bank. Applying leverage constraints in an open economy context, Cook and Yetman (2012) consider the effects of a central bank's accumulating foreign exchange reserves that are financed, or equivalently sterilised, via the sale of central bank paper to the banking system. If banks do not face leverage constraints, foreign exchange intervention may be accomplished without changing real allocations of private sector agents, as per Wallace (1981). But in the presence of binding leverage constraints on banks, the acquisition of foreign currency assets crowds out investment – to the detriment of long-run growth, and with an exacerbation of current account imbalances.

A final route to ensuring a role for central bank balance sheets is to model the interrelationship between inflation and fiscal policy. Durré and Pill (2010) provide an example of such a model. It builds on the fiscal theory of the price level (Woodford, 1995), wherein the path for prices may be ultimately determined by fiscal policy. Underlying this is the assumption that if governments fail to respect their intertemporal budget constraints, but by assumption cannot default, fiscal considerations will drive price development in equilibrium. Durré and Pill (2010) show that credit policies, which are quasi-fiscal in nature, may therefore be used by a central bank to support price stability objectives.

There is no consensus on the best way to incorporate central bank balance sheets into policy analysis, but current efforts suggest the likely shape of analytical frameworks to come. And different approaches to ensuring a role for central bank balance sheets are likely to be more appropriate in different circumstances.

For example, portfolio balance approaches may be most appropriate for assessing the role of policies whose objective is to adjust the balance sheet of the financial system so as to stimulate some sectors, as with "Operation Twist." Based on historical estimates, it may be possible to assess the likely degree of substitutability of different assets, and therefore the degree of stimulus to the macroeconomy from a given change in the central bank's balance sheet.

Models incorporating binding leverage constraints may find the greatest currency in circumstances in which the private sector is deleveraging – for example during crises, and when the counterparty to transactions that change the size or composition of the central bank's balance sheet is domestic banks that face regulatory barriers to increasing the size of their own balance sheets. In the former case, such models may allow for a careful analysis of the degree to which expansion of the central bank's balance sheet will offset the contraction of private sector balance sheets, and in the latter case they may provide a way of assessing for the wider economy the trade-offs posed by central bank balance sheet expansion.

Finally, models incorporating explicit links between fiscal and monetary policy may be especially helpful for assessing balance sheet expansions in economies facing fiscal distress that have independent currencies and may in principle use expansion of the monetary base to prevent fiscal default, although there remains some work to be done on the relevance of this class of models (for example, see the discussion in Buiter, 2002).

In sum, most economists agree that central bank balance sheets may, in principle, play a significant role in the economy and reveal important information about monetary policy. However, standard macroeconomic models leave little role for central bank balance sheets – a conceptual simplification consistent with the assumption of complete markets. In recent times, macroeconomic events have demonstrated the inadequacy of this assumption for several reasons. First, during crisis periods the degree of market completeness inevitably declines. Second, central bank balance sheets have seen dramatic changes in both their size and composition compared with historical norms. And third, recent changes in central bank balance sheets appear to have had important macroeconomic effects.

We have briefly outlined a number of ways to incorporate a role for central bank balance sheets in standard models used in central banks for policy analysis. But the development of these models remains nascent. In the discussions during the remainder of this conference, we will hear more about the kind of dynamics that these models need to incorporate.

Table A1

Central bank total assets

	In billions of USD		As a percentage of quantity indicated							
			GDP		Currency in circulation		M2[1]		Bank credit[2]	
	01	**11[3]**	**01**	**11[3]**	**01**	**11[3]**	**01**	**11[3]**	**01**	**11[3]**
Australia	32	81	8	5	217	152	12	5	10	4
China	514	4425	39	62	271	621	27	36	35	49
Hong Kong SAR	126	315	75	129	966	1063	33	40	50	65
India	85	394	18	22	178	192	31	27	62	43
Indonesia	61	161	38	19	690	352	75	53	211	72
Japan	892	1847	24	29	160	162	12	12	21	28
Korea	131	417	26	35	922	1177	37	48	33	37
Malaysia	39	165	42	59	590	836	31	43	33	52
New Zealand	5	25	9	16	492	867	11	16	8	11
Philippines	22	79	31	36	464	631	50	61	78	124
Singapore	70	245	82	92	1091	1256	72	68	70	85
Thailand	47	207	41	58	426	580	35	48	42	58
Memo:										
Euro area	*718*	*2994*	*11*	*24*	*285*	*227*	*17*	*23*	*11*	*15*
United Kingdom	*72*	*391*	*5*	*16*	*192*	*523*	*4*	*9*	*4*	*8*
United States	*663*	*2857*	*6*	*19*	*108*	*288*	*9*	*21*	*12*	*32*

[1] Money plus quasi-money. [2] Bank credit to private sector. [3] Latest available data.

Sources: IMF, *International Financial Statistics*; national data.

Table A2

Foreign reserve adequacy[1]

Outstanding year-end reserves position

	In billions of USD				As a percentage of:									
					GDP	Imports	Short-term external debt[2]				Broad money			
	1997	2009	2010	2011	2010	2010	1997	2009	2010	2011	1997	2009	2010	2011
Australia	16	33	33	33	3	17	23	16	13	11	5	3	2	2
China	140	2,399	2,847	3,262	48	214	394	1,594	986	841	13	27	26	27
Hong Kong SAR	91	245	258	270	115	59	53	251	167	147	25	29	28	27
India	24	259	268	286	17	74	305	304	201	192	12	23	19	19
Indonesia	16	60	90	117	13	71	45	198	213	209	22	27	33	38
Japan	208	997	1,036	1,135	19	162		200	176	173	5	12	11	11
Korea	20	265	287	296	28	68	30	174	191	182	6	20	20	19
Malaysia	20	93	102	132	43	65	133	545	394	342	19	31	29	34
New Zealand	4	14	15	20	11	52	45	61	89	91	22	25	27	31
Pakistan	1	10	13	15	8	42	56	428	558	609	4	16	18	21
Philippines	7	37	54	66	28	88	55	292	353	377	22	43	53	66
Singapore	72	188	226	249	101	73	40	164	148	142	73	69	72	69
Thailand	26	134	166	178	52	92	66	1,026	1,034	915	22	42	42	41
Memo items:[3]														
Asia[4]	*645*	*4,733*	*5,394*	*6,060*	*37*	*83*	*104*	*404*	*348*	*325*	*19*	*28*	*29*	*31*
Latin America[5]	*154*	*468*	*547*	*639*	*13*	*81*	*112*	*305*	*253*	*234*	*70*	*46*	*42*	*42*
Central Europe[6]	*39*	*164*	*180*	*203*	*25*	*47*	*274*	*224*	*232*	*222*	*37*	*36*	*40*	*41*
Other[7]	*36*	*521*	*558*	*612*	*17*	*88*	*56*	*335*	*332*	*328*	*22*	*38*	*33*	*33*

[1] For the outstanding year-end position, regional aggregates are the sum of the economies listed; for percentages, simple averages. For 2011, latest available data. [2] Consolidated cross-border claims to all BIS reporting banks on countries outside the reporting area with a maturity up to one year plus international debt securities outstanding with a maturity of up to one year. [3] Sum (reserves in USD billions) or simple average (other indicators) of the economies listed. [4] Economies shown above. [5] Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela [6] The Czech Republic, Hungary and Poland. [7] Russia, South Africa and Turkey.

Sources: IMF; Datastream; BIS, *Consolidated banking statistics*; BIS, S*ecurities statistics*; national data.

Table A3

The composition of central bank liabilities[1]

As a percentage of total assets

	Reserves of commercial banks[2]		**Deposits of commercial banks**		**Central bank bonds**		**Government deposits**		**Others**[3]	
	2001	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**
China	56.5	55.9	…	0.3	…	16.1	6.7	9.6	–2.0	–0.3
Hong Kong SAR	15.6	40.3	…		…	…	46.3	29.1	–16.1	–9.2
Indonesia	14.3	17.8	8.9	32.3	…	5.4	14.9	7.9	8.5	1.3
India	20.5	22.5	…	…	…	…	0.0	5.7	20.3	17.4
Korea	8.7	10.4	0.0	0.0	57.4	47.9	4.5	1.7	0.6	26.1
Malaysia	9.8	1.4	38.1	60.1	…	…	16.9	3.7	1.1	0.8
Philippines	7.2	16.6	10.2	50.3	…	…	7.9	3.5	1.5	0.4
Singapore	5.6	6.1	…	…	…	…	58.2	44.0	27.1	41.0
Thailand	2.6	1.6	10.9	41.7	5.5	21.3	1.4	7.3	–20.8	0.0

[1] Data less than 0.05 are shown as 0.0; unavailable data is shown as '…'. [2] Reserves money other than currency in circulation. [3] Including loans and other items (net).

Source: IMF, *International Financial Statistics*.

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Expanding central bank balance sheets in emerging Asia: a compendium of risks and some evidence

David Cook and James Yetman[1]

Abstract

Foreign exchange reserves have grown dramatically in emerging Asia over the past decade. Many of these reserves have been sterilised, via the issuance of non-monetary liabilities by central banks, with the sterilisation instruments held largely by domestic banks. We investigate the effects of this process on emerging Asian economies. We find evidence that long run economic performance may suffer, due to resource mis-allocation and reduced investment. We also find that while reserves appear to have helped to protect banks during periods of crisis, they have had little effect during more normal times. Finally, we examine the effect of reserves on central banks and monetary policy. We find that sterilisation appears to be incomplete in some cases, with reserves accumulation leading to higher levels of broad money, inflation and credit. Further, sterilisation costs, and losses due to currency appreciation, are a potential threat to central bank independence and may bias policy away from raising interest rates or allowing currency appreciation.

Keywords: Central bank balance sheets, reserves accumulation, sterilisation

JEL classification: E58, E61

[1] Cook: davcook@ust.hk, Hong Kong University of Science and Technology. Yetman: james.yetman@bis.org, Bank for International Settlements. The views expressed here are those of the authors and do not necessarily reflect those of the Bank for International Settlements. We thank Lillie Lam, Garry Tang and Eric Chan for providing excellent research assistance, and seminar participants at Bank Negara Malaysia, the Reserve Bank of New Zealand and City University of Hong Kong for comments.

1. Introduction

Over the last decade, many central banks in emerging Asia have seen large balance sheet expansions. Graph 1 shows that there have been substantial increases in overall central bank assets relative to GDP in eight of nine major emerging market economies in Asia. The exception is Indonesia where the central bank was reducing its holdings of assets acquired as a legacy of the Asian Financial Crisis of the late 1990's. These asset expansions were primarily due to the build-up of foreign exchange reserves. With the exception of Indonesia, foreign exchange reserves constituted more than 80 percent of central bank assets for these nine in 2008, with a median share of 91 percent. Even in Indonesia, foreign exchange reserves have constituted more than half of central bank assets since 2006.

What induces central banks to accumulate large foreign exchange reserves? Arguably, central banks hold reserves as a precaution against the possibility of sudden stops of international capital flows. If emerging markets finance long-term projects with short-term external borrowing, precautionary reserves of foreign currency might allow the economy to avoid liquidating projects in the face of a cut-off of international lending (see Jeanne, 2007). Another possibility is that central banks were engaging in competitive exchange rate management for mercantilist motives. Aizenman and Lee (2007) find that the evidence favours precautionary, rather than mercantilist, motives, especially in the period immediately following the Asian Financial Crisis. Cheung and Qian (2009) argue that the precautionary motives were strengthened as emerging Asian countries sought to avoid becoming the most attractive targets for speculative attacks.

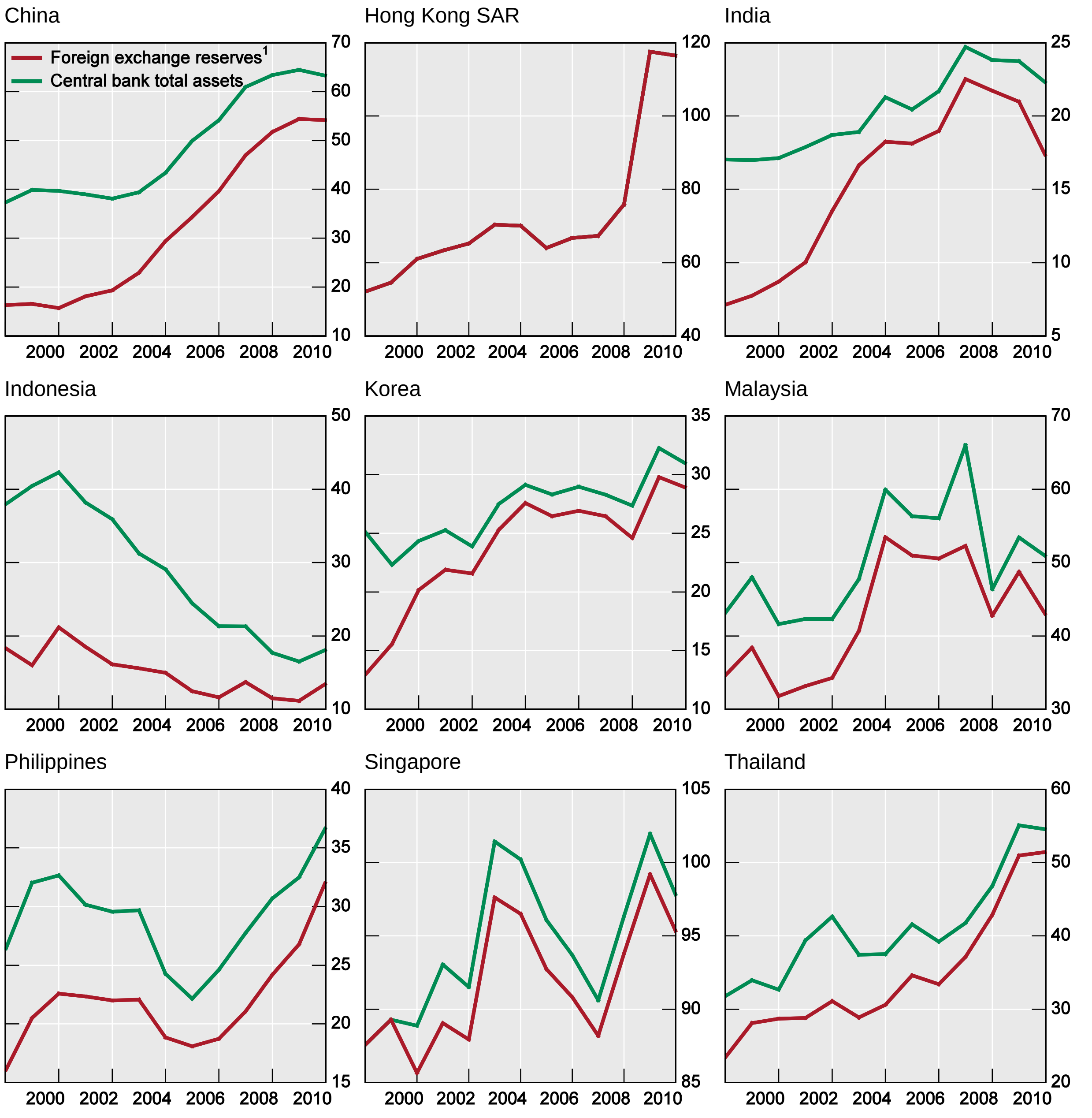
What, then, are the implications of high levels of reserves on economies in emerging Asia? This paper will catalogue some of the potential benefits and costs of accumulating large reserve positions on emerging economies. The benefits of exchange rate reserves may include reducing risks associated with external shocks. The costs include the direct financing costs of holding reserves (see Rodrik, 2006). In addition to these direct costs, we explore the potential for some other types of indirect costs. Beyond some level, reserve accumulation may be excessive. The over-accumulation of reserves may cause distortions in the economy and crowd out the accumulation of other sorts of assets important for long-run economic growth at a cost to the economy that exceeds any benefits from reduced risks. Potentially, the riskiness of the domestic financial system may also be influenced by the build up of its own balance sheet positions in the process of reserves accumulation. Finally, the concentration of financial wealth on the balance sheet of central banks may reduce the independence of monetary policy. Large stocks of foreign reserves may expose the central bank to possible credit and solvency risks and restrict monetary policy flexibility. We will investigate aggregate and firm-level evidence for each of these possible effects.

Traditionally, foreign exchange reserves were thought to play an important role in protecting the economy from volatile capital flows. To that end, a variety of benchmarks have been suggested of what constitutes "adequate" reserves related to international trade and international finance. A traditional rule of thumb related to international trade has recommended holding foreign reserves equal to 3-4 months of imports; in terms of international finance, the more recent Greenspan-Guidotti rule suggests holding reserves equal the total stock of outstanding short term debt (see IMF, 2011). Complying with the Greenspan-Guidotti rule allows the economy access to foreign funds to avoid liquidation during a sudden stop. Obstfeld, Shambaugh and Taylor (2009) argue that the role of foreign reserves may be broader during a "twin" crisis featuring both a domestic banking panic and a sudden stop in international capital flows (see Kaminsky and Reinhart, 1999). If domestic depositors attempt to switch domestic bank deposits into hard currency when international demand for the domestic currency is limited, central banks with ample excess foreign reserves may be able to provide this hard currency and limit exchange rate depreciations. Obstfeld, Shambaugh and Taylor (2009) argue that emerging economies therefore use broad monetary aggregates as a benchmark for reserves.

Graph 1

Foreign exchange reserves and central bank total assets

As percentage of GDP



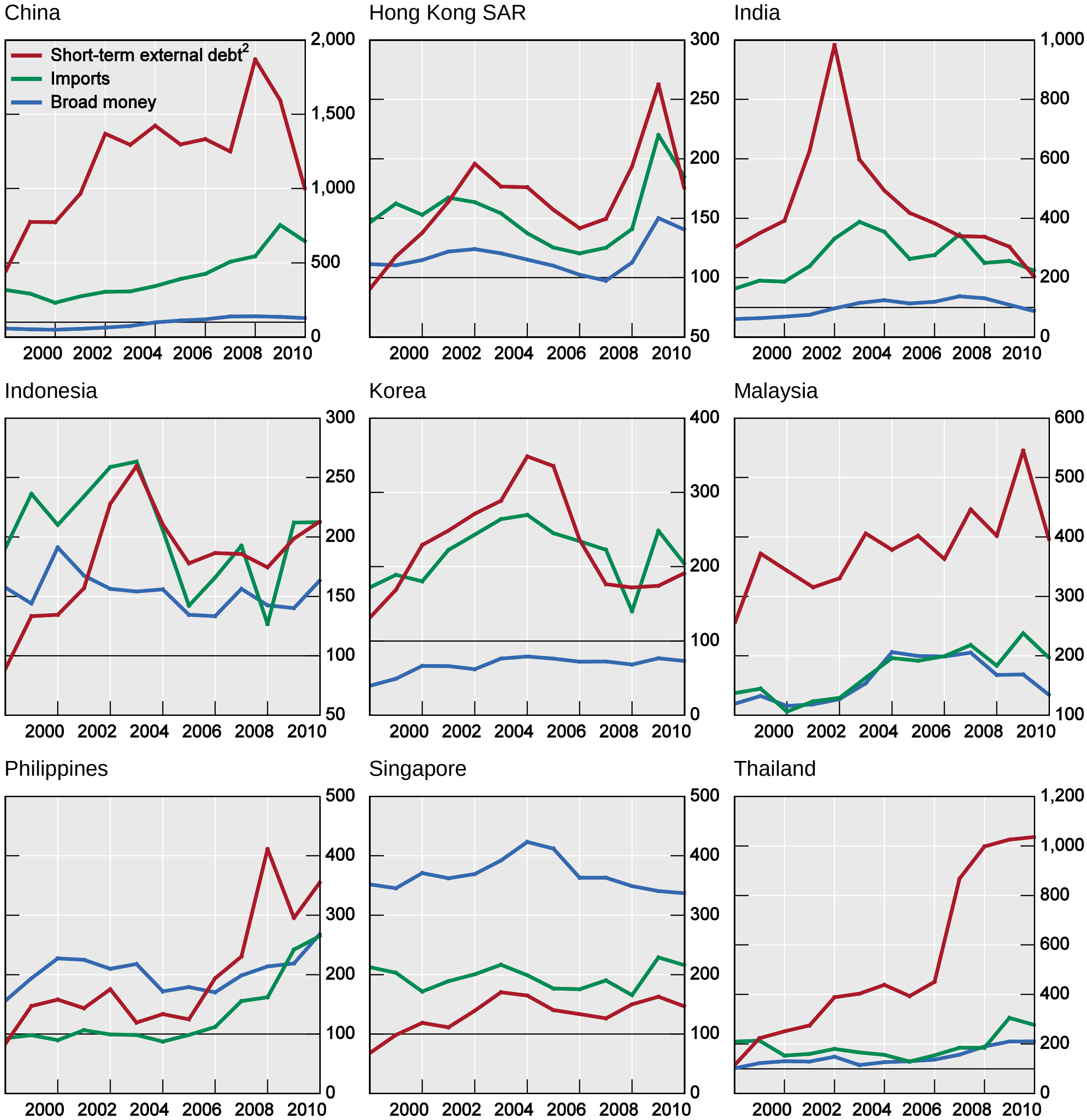
[1] Central bank foreign assets. For Hong Kong, domestic assets are not recorded in the IFS.

Source: IMF *IFS*.

Graph 2 plots reserve levels relative to three standards for adequacy using a level of 100 to indicate reserve levels corresponding to levels cited as being prudent (4 months of imports, 100% of outstanding short term debt and 20% of broad money). At present, these prudent standards are generally well exceeded by most economies in Emerging Asia.

Graph 2

Measure of adequacy of foreign reserves[1]



[1] 100 corresponds to "Adequate reserves", defined as 4 months of imports, total short term external debt and 20% of broad money respectively. [2] Short-term external debt comprises consolidated international claims of BIS reporting banks with a maturity up to and including one year, plus international debt securities outstanding with a maturity up to one year.

Sources: IMF *WEO*; Datastream; national data; BIS.

The implications of a large expansion in foreign exchange reserves may depend crucially on the nature of financing involving. When the central bank acts in foreign exchange markets to purchase foreign currency, there are two main ways in which it can finance these purchases (see Table 1 for a stylised representation). First it can increase the quantity of domestic money ("monetary liabilities") in circulation. However, ongoing increases in the domestic money supply would tend to result in a loss of domestic monetary policy control. The alternative is to sterilise the monetary effects of the accumulation of foreign exchange reserves.

Table 1

Central bank balance sheet

Assets	**Liabilities**
Net foreign assets · foreign reserves Net domestic assets · government securities	Monetary liabilities · currency · reserves Non-monetary liabilities · central bank securities Equity

Focusing on emerging Asia's experience with foreign reserves accumulation, Aizenman and Glick (2009) find that the monetary base does not vary with the size of foreign exchange reserves, indicating that central banks have generally matched increasing reserves accumulation with increased sterilisation.[2] Similarly, Ouyang, Rajan and Willett (2007) find that China successfully sterilised around 90% of its reserves accumulation over the 1999-2005 period. The instruments used for sterilisation vary across economies, but generally consist of selling market instruments or sterilisation bills; increasing required reserve ratios; using swaps or repurchase operations; or transferring Government deposits from commercial banks to the central bank.[3] For example, Greenwood (2008) argues that China's foreign exchange reserves are substantially sterilised using a combination of sterilisation bills and required reserves. Other measures can also play an important role in sterilisation. Yeow and Ying (2007), for example, argue that Singapore's compulsory Central Provident Fund, with a stock of approximately 60% of GDP and net contributions of around 3.5% of GDP per year, effectively sterilises a significant portion of reserves accumulation by withdrawing liquidity from the domestic banking system.[4]

Graph 3 gives an indication of how prevalent these methods are for central banks in emerging Asia. It displays the total stock of foreign exchange reserves and total non-monetary liabilities of the central banks, both measured in domestic currency units. Focusing on the link between reserves and non-monetary liabilities, defined as total liabilities less both the monetary base and foreign liabilities, there are strong links along at least two dimensions. For Hong Kong, Indonesia, Korea, the Philippines, Singapore and Thailand, non-monetary liabilities are of approximately the same magnitude as reserves. The same is also true for China until 2008, after which required reserve ratios played a larger role in sterilisation. Further, the correlation between the two series over 1999-2009 exceeds 0.95 for all economies except Hong Kong (0.91), Malaysia (0.74) and Indonesia (0.68).

[2] See, also, Filardo and Grenville (2011).

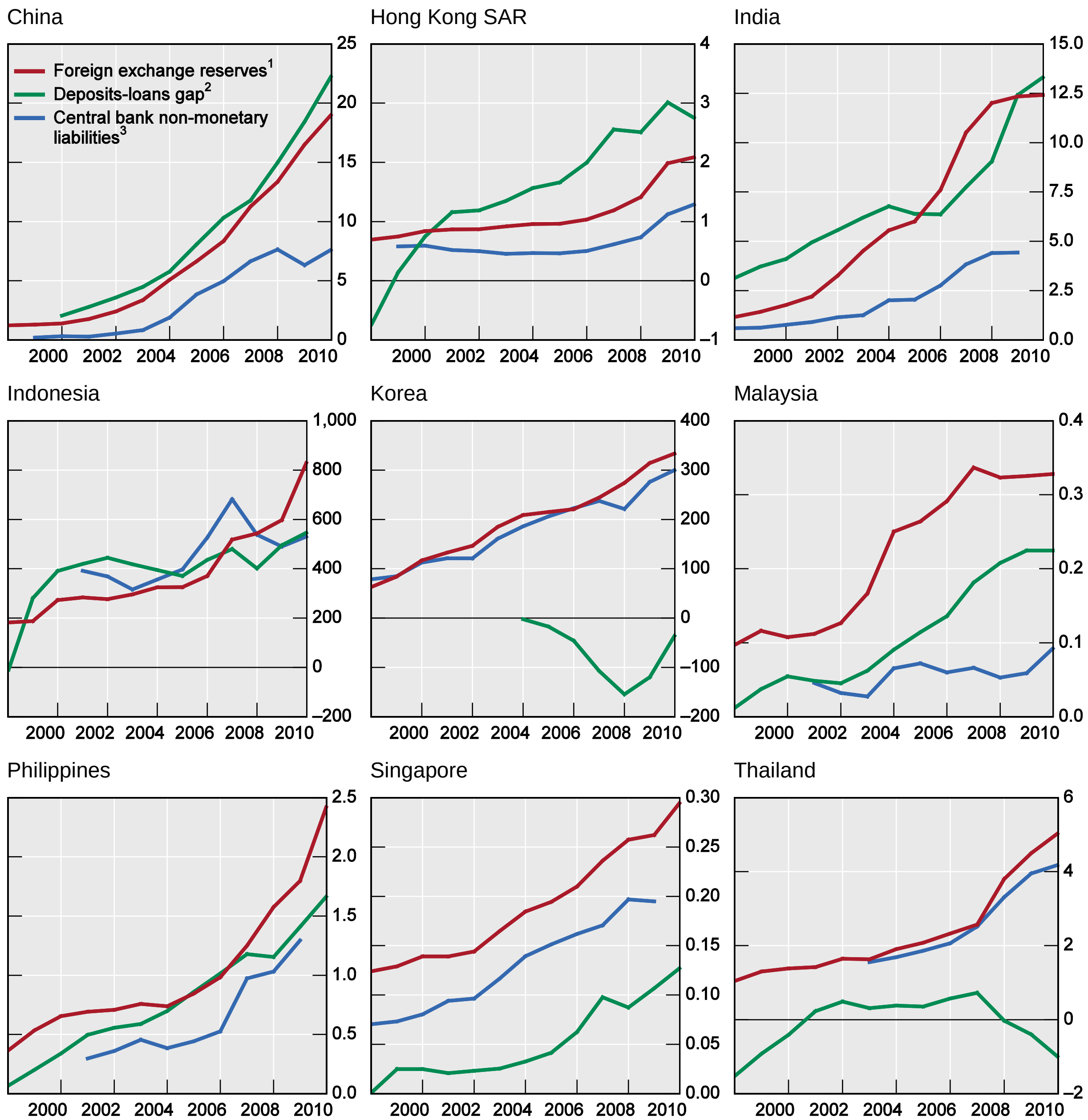
[3] See Mohanty and Turner (2005, 2006) for a more complete list and a discussion of the relative merits of different instruments.

[4] It is also possible to finance reserves accumulation via a reduction in assets instead, by selling government securities, for example. Given the large size of reserves accumulation seen in many economies in emerging Asia relative to the stock of saleable assets on central bank balance sheets, it is clear that most purchases must have been financed via the expansion of central bank liabilities rather than the sale of assets.

Graph 3

Foreign exchange reserves, deposits and loans and central bank non-monetary liabilities

In trillions of national currency



[1] Total reserves minus gold. [2] Deposits minus loans. [3] Total liabilities minus base money and foreign liabilities.

Sources: Bloomberg, CEIC, IMF IFS, national data.

To the extent that banks buy sterilisation bills or reserve requirements are raised, this drives a wedge between bank deposits and loans in the economy. Graph 3 also shows the deposit-loans gap, the difference between aggregate deposits and aggregate loans of the banking system, for the nine countries. There are strong links between reserves accumulation and the deposits-loans gap. For China, Indonesia, India and the Philippines banks had sufficient excess capacity on their balance sheets, beyond their loan portfolios, to approximately buy up the full stock of sterilisation bills, assuming complete sterilisation of the foreign reserves. And for all economies in our sample except Indonesia, Korea and Thailand the correlation between these two series exceeds 0.80.

The relationship between reserves and the deposits-loans gap is easy to explain. One characteristic shared by most methods of sterilisation is that they drive a wedge between loans and deposits in the banking system. For example, both increasing the required reserve ratio and issuing sterilisation bills, if the latter are purchased by banks, reduce the quantity of funds available for banks to extend credit for any given level of deposits. Graph 3 suggests that the effects of sterilisation are borne primarily by the banking system in this way, especially in those economies with relatively underdeveloped financial systems. Thus non-monetary liabilities of the central bank may be a good proxy for sterilisation for most emerging Asian economies.

The policy choice to hold a large stock of sterilised reserves changes both the balance sheet positions of the domestic banking system and the central bank. In this paper, we explore the impacts of some of these balance sheet changes over the last decade.

First, we examine some of the effects on the domestic banking system. In section 3, we explore the first order effects of reserve accumulation on bank balance sheets. We will develop a simple macroeconomic model embedding a relationship between sterilisation and bank balance sheets. This may have broader macroeconomic implications as banks are the key channel for credit creation in many Asian emerging markets. If purchases of sterilisation bonds by banks crowd out bank lending, the financing of sterilisation bonds may impinge on investment, increase global imbalances and reduce the long-term growth potential of the economy. Consistent with this, we find that there is a negative relationship between increases in foreign reserve holdings and the growth rate of bank lending for banks in some emerging Asian economies. Banks that have used their deposit bases to buy liquid sterilisation bonds appear to have reduced the credit that they make available to customers.

In section 4 we examine the second order effects of reserve holdings on the domestic banking system. Mohanty and Turner (2010) report that the risk exposures of the Asian banking system are lower now than at the time of the Asian crisis, due to a combination of favourable macroeconomic circumstances and improved regulatory performance. An important aspect of changing risk exposures of Asian banks is the degree to which they have increased their holdings of government debt reducing their perceived riskiness.

Hard currency reserve holdings may be most effective in extraordinary times. At the height of the recent crisis, in late 2008, the retrenchment of international capital flows was an external shock to emerging market banks (see Milesi-Feretti and Tille, 2010, and Blanchard, Faruqee and Das, 2010). We examine the effect of sterilised reserves holdings on the equity value of emerging Asian banks. We find that large central bank holdings of sterilised reserves appear to have mitigated the effects of the crisis on banks that rely on non-deposit funding.

We assess the degree to which foreign exchange reserve holdings more broadly influence banks' risk performance, focusing on the sensitivity of bank equity prices to different types of risks and how this sensitivity varies with the size of sterilised foreign exchange reserves. Generally, however, we find no strong evidence that holdings of sterilised reserves have protected emerging Asian banking systems from a variety of risks, including exchange rate risk, during more normal periods.

In section 5, we examine the macroeconomic policy impact of changes to central bank balance sheets entailed in the large holdings of sterilised reserves. Sterilised intervention can impose heavy financing costs on monetary authorities (Mohanty and Turner, 2005) which we quantify. Additionally, the process of sterilization, if incomplete, may undermine central bank objectives regarding price and monetary stability. There may thus be inflationary consequences as well. We provide evidence based on vector auto-regressions consistent with this: for some economies, increases in non-monetary liabilities tend to be followed by expansions in broad money and moderate increases in inflation.

Reserves accumulation may also negatively affect the functioning of the central bank. Financing the purchase of foreign assets with domestic liabilities incurs costs and exposes the central bank to exchange rate risk. A currency appreciation would lead to large capital losses that might threaten central bank independence, for example. Such risks might affect the behaviour of central banks or the credibility of their policy choices. A central bank worried about an appreciating currency may be a central bank unable to fully confront inflation, for example. Consistent with this, we find evidence suggesting that long-run inflation expectations respond less to short-term policy tightening in countries with substantial foreign reserves in a panel data study of the impact of policy rates on the yield curve.

2. Background: The Role of Central Bank Balance Sheets in Monetary Policy

Historically, the role of central bank balance sheets in macroeconomic models has concentrated on the liquid liabilities constituting the monetary base. In both the Keynesian and Monetarist theories which dominated post-war monetary economics, central banking affects the economy through the liquidity preference of households and businesses for money. The Keynesian school, as exemplified by Baumol (1952) and Tobin (1956), isolated this liquidity preference as governing the trade-off between holding monetary assets and short-term bonds. Central bank activity is felt mainly through its impact on the relative price of these assets: the short-term interest rate.[5] Monetarist theory focused on the role of money as a (highly liquid) financial asset, part of the larger portfolio of households. Private agents make trade-offs between holding money and a wide variety of other assets. The demand for money is determined, not only by the short-term interest rate and the level of transactions as in the Keynesian theory, but also by the level of wealth and the return on alternative assets in the portfolio (see Friedman, 1956). Central bank operations to adjust the level of the money supply change the relative availability of various assets and therefore their yields (including those of physical capital and consumer durables; see Cagan, 1987), not just the short-term interest rate.[6]

Some strands of the international macroeconomics literature pointed specifically toward a role for asset holdings in central bank balance sheets. Portfolio balance theory (see Branson, 1977 and Dooley and Isard, 1982; Branson and Henderson, 1985 provide a literature review) focuses on the imperfect substitutability between domestic and foreign bonds in the portfolios of private investors due to their different risk properties. Sterilised and unsterilised interventions which change the asset composition of central bank balance sheets also change the relative supply of bonds, the relative prices of such assets and the currencies they are denominated in. Acquisition of foreign exchange reserves and its sterilisation would therefore have an impact on asset prices, exchange rates and the wider economy.

In more recent times, the trend toward general equilibrium modelling has reduced the focus on central bank balance sheets. In the New Classical school, central bank assets and liabilities are explicitly modelled as parts of the government balance sheets (see Sargent and Wallace, 1981). Moreover, intertemporal budget constraints of taxpaying wealth holders are intertwined with the wealth position of the government (see Barro, 1974). An influential paper by Wallace (1981) demonstrated that changes in the composition of the government's asset portfolio (which includes central bank balance sheets) would not affect the risk/return profile

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5 Various strands of Keynesian theory have minimised the role of money either because money demand was thought to be so price elastic that changes in the money supply had little effect on the interest rate or aggregate demand was relatively unresponsive to changes in the interest rate

6 Due to the complicated nature of the myriad transmission mechanisms, monetarist theory has tended to focus on the (purportedly) relatively stable relationship between aggregate money balances and aggregate spending.

of households nor change equilibrium prices of financial assets when markets are complete. This is because investors as taxpayers are the ultimate claimants on the government asset portfolio. Therefore, a change in the government's portfolio does not alter the risk profile of the representative or marginal investor or their willingness to hold assets at the margin. Investors optimise their portfolios such that private asset demand offsets changes in the government's positions. This Modigliani-Miller type result also implies that the manner in which a central bank chooses to finance reserves accumulation is irrelevant.

In an economy where the logic of Wallace (1981) holds true, central bank balance sheets are only important insomuch as the stock of money influences the economy through the liquidity preference channel. More recently, Eggertsson and Woodford (2003) have used this logic to show that in circumstances in which private agents have no effective liquidity preference for central bank monetary liabilities (in their case, at the zero lower bound for interest rates) then changes in the size and composition of central bank balance sheets have no equilibrium effects.

Wallace (1981) has immediate implications for understanding the portfolio balance effects of foreign exchange rate interventions since the foreign exchange reserves on central bank balance sheets are part of the overall government portfolio of which investors are the ultimate claimants. Obstfeld (1982) shows that the foreign currency denomination of central bank assets does not affect exchange rates. Backus and Kehoe (1989) show that equilibrium asset prices are only affected by the currency composition of government portfolios if the portfolio choice affects fiscal policy. Changes in the money stock may impact interest rates due to liquidity preference, but the composition of central bank assets and non-monetary liabilities are irrelevant for policy.

Woodford (2011) points out that a key condition for the irrelevance of central bank asset purchases is that investors are unconstrained in the purchase of individual assets. Conversely, in the presence of leverage constraints, central bank actions which allow the purchase of assets unattainable by private investors may have important effects. The financial crisis of 2008 brought new attention to the role of financial market constraints in the economy. A number of papers examine the effects of targeted central bank lending in the presence of constraints on asset purchases. Curdia and Woodford (2011) construct a model with heterogeneous consumers in which borrowers may have less than full access to the pool of private savings due to market segmentation. In their model, the level of direct central bank lending to credit-constrained private sector borrowers can affect real societal welfare. Ashcraft, Gârleanu and Pedersen (2011) construct a model in which only a fraction of bank assets are pledgeable as collateral. Central bank lending which demands lower collateral "haircuts" can relax credit conditions efficiently by lending at lower margins. Similarly, Reis (2009) describes a model in which financial intermediation is plagued by pledgeability concerns and information costs may reduce the funding for profitable investment projects.

3. Reserve Holdings and International Imbalances

In this section we develop a simple model of a small open economy, consistent with the stylised facts for emerging Asian economies outlined in the introduction, to examine the effect of sterilised reserves accumulation on the real economy. We then compare the empirical implications of our model with actual data. At the foundation of our model is a central bank accumulating foreign assets which must be financed through some channel. In the absence of borrowing constraints, this may be accomplished without changing real allocations of private sector agents. In the presence of borrowing constraints, however, the acquisition of foreign currency assets may crowd out other assets.

3.1 Model

Results in Graph 3 and Greenwood (2008) suggest that domestic banking systems play a central role in financing sterilised reserves, while Sheng (2008) notes that banks still play a dominant role in East Asia's financial system. The natural place to examine the effects of imperfections for Asian economies is therefore within the banking system. The following model describes one such possible interaction, focusing on the interactions between the financing of sterilised reserves and credit activities within a constrained banking system.

The model modifies a standard intertemporal approach to the current account along three dimensions: 1) bank intermediation is crucial to capital formation; 2) banking activity is limited by bank capital; and 3) central bank asset accumulation is financed through bank balance sheets.

Consider a two period neo-classical small open economy. There is a single freely traded numeraire good in the economy that may be used for consumption or capital investment. The good is produced in the economy by competitive firms. The economy is populated by a representative household that consumes, provides labour and is the residual claimant of firms' profits. Firms are assumed to finance investment through financial intermediaries. The central bank may also finance balance sheet expansions through the banking system. In one version of the model, bank funding will be limited to a multiple of its equity holdings.

Households

Consumers in the economy are endowed with L units of labour each period, normalised to $L = 1$. The households maximise the standard utility function:

$$\ln C_t + b \ln C_{t+1} .$$

Households face an external interest rate $R = 1/b$ at which they can save or borrow. Households gain income from wages, W_t , and, as residual claimants of the profits of firms, P_t. There are no taxes in the first period. In the second period, they pay taxes or transfers based on any losses or gains of the central bank. In addition, the household begins with some initial debt which we assume satisfies $DEBT = b\left(ab\right)^{\frac{1}{1-a}}$ for normalisation purposes.[7] Their budget constraint is:

$$C_t + \frac{C_{t+1}}{R} = W_t + P_t + \frac{W_{t+1} + P_{t+1} - TAX}{R} - DEBT .$$

The first order condition assures consumption smoothing over time: $C_t = C_{t+1}$.

Firms

Firms have access to a Cobb-Douglas production function in capital, K_t, and labour, L:

$$Y_t = K_t^{a} L^{1-a} .$$

Capital depreciates fully every period. We assume that the initial stock of capital is equal to the optimal steady state level, $K_t = (ab)^{\frac{1}{1-a}}$. To finance capital for the second period, firms

[7] The initial endowment of capital generates wealth that encourages the running of a current account surplus. The initial debt level is set to offset this.

borrow funds from domestic financial intermediaries at a rate of R_t^L. Profits in each period are:

$$\Pi_t = Y_t - W_t L \, ; \; \Pi_{t+1} = Y_{t+1} - W_{t+1} L - R_t^L K_{t+1} .$$

The first order conditions are:

$$W_t = (1-\alpha)\left(\frac{K_t}{L}\right)^{\alpha} ; \quad W_{t+1} = (1-\alpha)\left(\frac{K_{t+1}}{L}\right)^{\alpha} ; \quad R_t^L = \alpha\left(\frac{K_{t+1}}{L}\right)^{\alpha-1} .$$

Financial intermediaries

Financial intermediaries begin with some wealth, EQ_t, and get utility from consuming at time *t+1*. For the purposes of normalisation we assume that $EQ_t = \frac{1}{1+\chi}(\alpha\beta)^{\frac{1}{1-\alpha}}$. Financial intermediaries raise funds, D_t, in international financial markets at rate R and lend to domestic firms at rate R_t^L. They also hold central bank bonds paying return R_t^B. Their budget constraint it given by:

$$K_{t+1} + B_t = D_t + EQ_t ,$$

and they earn profits of:

$$R_t^L K_{t+1} + R_t^B B_t - RD_t .$$

We consider two cases for banks. In the *unconstrained banks* case, financial intermediaries can borrow freely. The first order profit maximisation condition in this case is $R_t^L = R_t^B = R$. In the *constrained banks* case, we assume there is a borrowing constraint imposed exogenously for reasons similar to Kiyotaki and Moore (1997) so that $D_t \le \chi EQ_t$. If this is a binding constraint, the first order conditions are $K_{t+1} = (1+\chi)EQ_t - B_t$ and $R_t^L = R_t^B$. [8]

Central bank

The central bank buys foreign assets in the international financial markets, FX_t, which are financed with the issuance of bonds. The budget constraint is $B_t = FX_t$. The central bank imposes a tax in period 2 to cover its losses on its holdings of foreign reserves of $TAX = \left(R_t^B - R\right)B_t$. The central bank's reserves holdings are defined as a fraction of initial capital holdings, $FX_t = \rho K_t$.

Equilibria

<u>Unconstrained banks:</u> when banks face no constraints, $R_t^L = R_t^B = R = 1/\beta$. The central bank takes no losses, so $TAX = 0$. In this case, consumption, capital, output and wages are all smooth across time:

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[8] From a regulatory perspective, there is typically no capital charge against banks for holding sterilisation bills, though this is at the discretion of national regulators under Basel II, and will remain so under proposed Basel III standards. We are therefore implicitly assuming that financing constraints are due to market imperfections.

$$K_{t+1}=K_t=(\alpha\beta)^{\frac{1}{1-\alpha}};\ Y_{t+1}=Y_t=(\alpha\beta)^{\frac{\alpha}{1-\alpha}};\ W_{t+1}=W_t=(1-\alpha)(\alpha\beta)^{\frac{\alpha}{1-\alpha}}.$$

Inserting these conditions and the debt equation into the households' intertemporal budget constraint, we obtain:

$$(1+\beta)C=W_t+\Pi_t+\frac{W_{t+1}+\Pi_{t+1}}{R}-DEBT_t,$$

Or:

$$\begin{aligned}C_t&=Y_t(1-\alpha\beta)\\&=Y_t-K_{t+1}\end{aligned}$$

There is no trade imbalance ($NX_t\equiv Y_t-C_t-K_{t+1}=0$), and the equilibrium outcomes of all variables are invariant to the level of foreign reserve holdings, ρK. In effect, the central bank is financing the purchase of foreign assets using foreign borrowings. This increases gross capital flows, but the net impact on the trade balance or any other real variables is nil. This is the world envisaged by Sargent and Wallace (1981), discussed in section 2, in which central bank balance sheets are perfectly offset by the decisions of other actors in the economy.

Constrained banks: in the case of constrained banks, bank lending is limited by bank capital, so the financing of foreign reserve holdings crowds out future capital accumulation and $K_{t+1}=(1-\rho)K_t$. Reduced capital accumulation reduces future income: $Y_{t+1}=(1-\rho)^{\alpha}Y_t$, and the lack of available funds pushes up the lending rate in the domestic economy:

$$R_t^L=R_t^B=\alpha\left(K_{t+1}\right)^{\alpha-1}=(1-\rho)^{\alpha-1}/\beta.$$

Given that $R=1/\beta$, this implies a mark-up of the lending rate over the international cost of capital, raising the cost of central bank balance sheet expansion by:

$$TAX=\frac{(1-\rho)^{\alpha-1}-1}{\beta}\rho K_t.$$

Inserting these conditions, along with the consumption smoothing condition, into the budget constraint, we obtain:

$$(1+\beta)C_t=(1+\beta(1-\rho)^{\alpha})(1-\alpha)Y_t+\alpha Y_t-\beta TAX-\alpha\beta^2Y_t,$$

so that:

$$C_t=\left[\frac{1+\beta(1-\rho)^{\alpha}}{1+\beta}(1-\alpha)+\alpha-\alpha\beta+\frac{\left(1-(1-\rho)^{\alpha-1}\right)\alpha\beta\rho}{1+\beta}\right]Y_t.$$

Now there are also implications for other variables as well. We can write the trade balance, $NX_t\equiv Y_t-C_t-K_{t+1}$, as:

$$\begin{aligned}NX_t&=\frac{\beta}{1+\beta}\left[1-\alpha+\alpha\beta\rho+(1-\rho)^{\alpha-1}(\alpha+\rho-1)\right]Y_t\\&=\frac{1}{\alpha(1+\beta)}\left[1-\alpha+\alpha\beta\rho+(1-\rho)^{\alpha-1}(\alpha+\rho-1)\right]K_t.\end{aligned}$$

Clearly, when $\rho=0$, the trade balance is zero. Further, we can see that, for $0<\rho<1$:

$$\frac{dNX}{d\rho} = \frac{1}{1+\beta}\left[\beta + (1-\rho)^{\alpha-2}(2-\alpha-\rho)\right]K_t > 0$$

Thus, in the case of credit-constrained financial intermediaries, the financing of the acquisition of bonds will have a positive impact on the current account. Central bank balance sheet expansion therefore increases global imbalances through three channels: 1) the direct impact of borrowing from the domestic banking system will reduce investment; 2) low investment will in turn reduce future income which will reduce current consumption due to intertemporal consumption smoothing; and 3) the cost of central bank balance sheet expansion increases future taxation, further reducing current consumption.

3.2 Evidence

We test whether reserve accumulation acts to crowd out other types of assets, as predicted by our model, using data on balance sheets of 55 individual banks (Source: S & P Global Compustat) over the period year-end 2003 to year-end 2007 in five economies including Indonesia, South Korea, Malaysia, the Philippines and Thailand. These countries provide a useful test case as they had accumulated reserves to varying degrees over the sample period, yet they experienced roughly similar average real GDP growth over, from a low of 4.6% in Korea to a high of 5.9% in Malaysia (Source: World Bank World Development Indicators).

In Table 2, we report the results of regressions of growth rates in the asset positions of banks on a number of regressors including foreign reserves accumulation.[9] In column 1, we report the results of a regression of the percentage growth of the loan-to-asset ratio on the percentage growth of foreign reserves in US dollar terms, controlling for initial bank-specific factors at the end of 2003. We find that banks with relatively low leverage in 2003 had relatively higher growth in loans compared to deposits. Also, there is evidence of mean reversion in the sense that banks with relatively high levels of loans-to-assets in 2003 had lower rates of growth in loans-to-assets in the subsequent four years. Further, there is little evidence that the relative size of the banks was associated with growth in this ratio. More important for the predictions of our model, for each 1% increase in the level of reserves there is an approximately 1% decline in the growth of the quantity of loans relative to assets.

Columns 2 and 3 show that this result is driven by the effect of reserves growth on loans. The elasticity of real loan growth (i.e. deflated by the local CPI) with respect to growth in foreign reserves is approximately -1.25% while the accumulation of foreign reserves has relatively low association with growth in real assets by domestic banks. These results show that high initial capitalisation is significantly associated with subsequent growth in real banking assets, and especially with growth in real loans to customers. They suggest an association of reserve accumulation with significant crowding out of bank lending, as the banks finance the sterilisation of reserve purchases instead of providing credit.

[9] See the appendix for data definitions and sources.

Table 2

Impact of Reserve Accumulation on Bank Balance Sheets

	(1)	(2)	(3)	(4)	(5)
Dependent variable: % Growth in	**Loan/Asset Ratio**	**Real Loans**	**Real Assets**	**Loan/Deposit Ratio**	**Liquidity/ Asset Ratio**
% Growth in Reserves	-0.952*** (0.176)	-1.254*** (0.409)	-0.302 (0.342)	-1.527*** (0.214)	1.264** (0.508)
<u>Initial Levels:</u>					
Size	0.014 (0.016)	-0.045 (0.064)	-0.059 (0.058)	0.079*** (0.028)	-0.154*** (0.049)
Capitalisation	1.051** (0.478)	2.766*** (0.860)	1.715** (0.815)	2.313*** (0.840)	-2.521 (1.686)
Loan/Asset Ratio	-0.715** (0.284)	-0.316 (0.391)	0.399 (0.280)		
Loan/Deposit Ratio				-0.187*** (0.037)	
Liquidity/ Asset Ratio					-2.747*** (0.625)
Constant	0.881*** (0.222)	1.508* (0.669)	0.627 (0.616)	0.329 (0.333)	1.565* (0.764)
Adj. R^2	0.509	0.297	0.114	0.769	0.487
Obs.	55	55	55	55	55

Heteroskedasticity Robust Standard Errors in Parentheses. ***, **, * indicates significance at 1%, 5%, 10% level respectively.

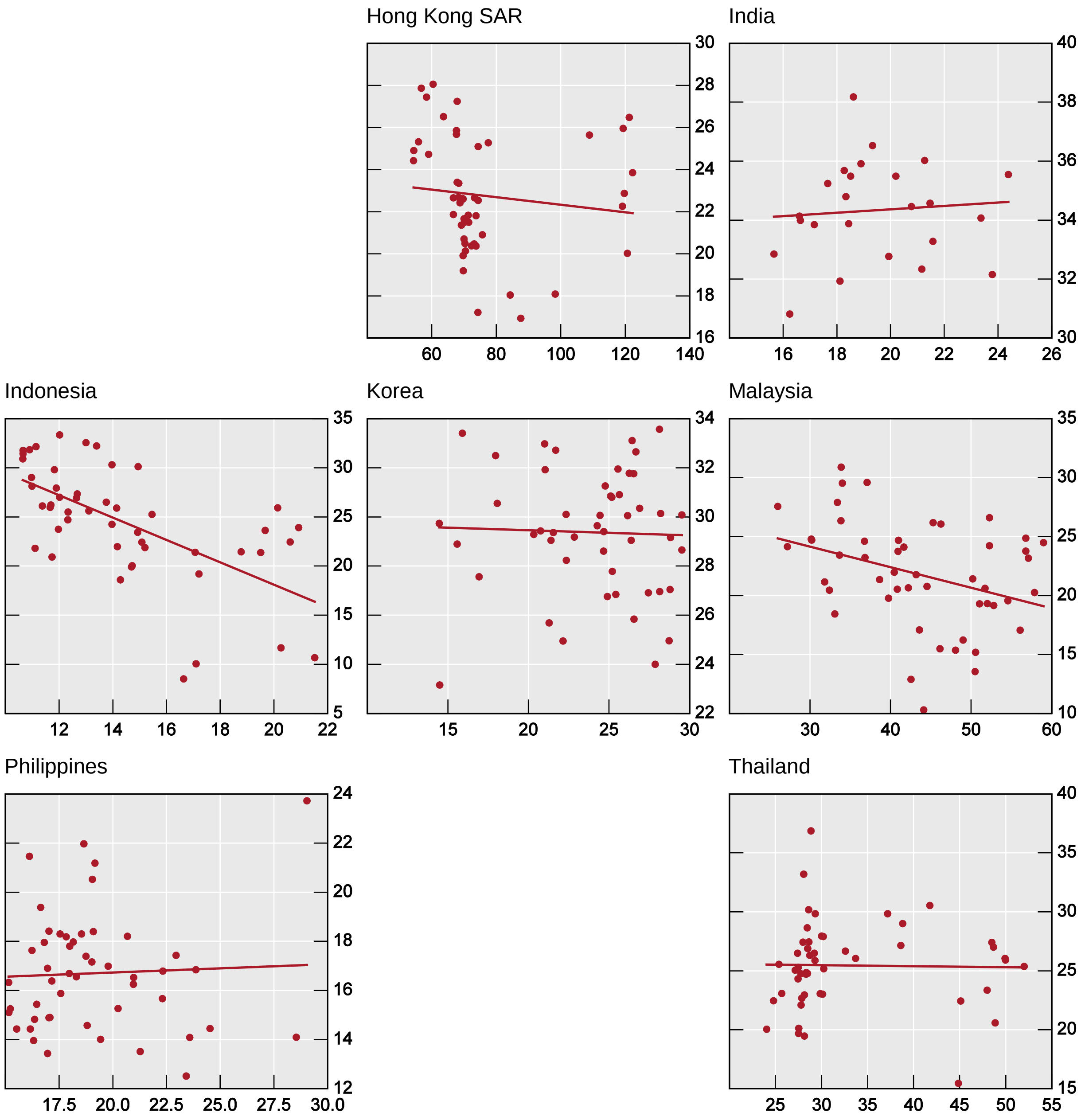
Column 4 reports the result of a regression of the loan-to-deposit ratio on foreign exchange accumulation and other bank specific factors. The results suggest that accumulation of foreign reserves is significantly associated with a decline in the loan-to-deposit ratio, consistent with deposits being used to purchase sterilisation instruments. Also, banks that were highly leveraged in 2003 subsequently reduced their loan-to-deposit ratio, arguably consistent with prudent management. Interestingly, relatively large banks were significantly more likely to increase their loan-to-deposit ratio.

Column 5 shows the flip side of column 1, reporting the association between the accumulation of foreign exchange reserves by the central bank and increases in the share of liquid assets held by banks. In this case, we define liquid assets as the sum of cash plus investment securities. We see that each percentage point increase in central bank foreign reserves is associated with an approximately 1.25% *increase* in the ratio of liquid assets to total assets. This is consistent with banks' increased holdings of sterilisation instruments (a liquid asset) coming at the expense of loans (an illiquid asset).

Graph 4

Reserves and investment[1]

As a percentage of GDP



[1] Horizontal axis: foreign exchange reserves as percentage of GDP; vertical axis: investment as percentage of GDP.

Source: IMF *IFS*.

The results in Table 2 are not driven by any single country. For each regression we drop, in turn, one of the five countries in the sample. In each case, the significant coefficient on the growth in reserves observed in columns 1, 2 and 4 are significant at the 5% level. The results in column 5 are slightly less robust. The statistically significant association between changes in the liquid asset ratio and foreign reserves accumulation is significant at the 10% level when Korean or Philippine banks are dropped but is not significant when Malaysian banks are dropped. However, in each of these cases the coefficient remains economically large and is comparable in size to the results reported in Table 2.[10]

We also check whether the results are driven by other macroeconomic factors. We estimate versions of the regression in column 2 replacing the initial loan-to-asset ratio with some macroeconomic observation including: 1) the average CPI inflation rate between 2003 and 2007 (Source: IMF *IFS*); 2) the average real GDP growth rate between 2003 and 2007 (Source: World Bank *WDI*); 3) the average ratio of the current account to nominal GDP from 2003 and 2007 (Source: IMF *IFS*); and 4) the log of the 2003 in GDP per capita in 2005 PPP equivalent US dollars (Source: World Bank *WDI*). In each case, the association between central bank reserves accumulation and commercial bank lending growth is negative and significant at the 5% level. We also check whether the result is robust to our choice of start and end dates. We repeat the regression in column 2 using 1) growth rates over the period end-year 2003 to end-year 2006 and initial values at end-year 2003 and 2) growth rates over the period end-year 2004 to end-year 2007 and initial values at end-year 2004. In each case, we find the negative relationship between reserves accumulation and real loan growth is significant at the 5% critical value.

We briefly examine these possibilities further by plotting the relationship between reserves and investment, defined as a percent of GDP, for all economies for which data is available. Graph 4 illustrates indications of a negative relationship between investment and reserves accumulation, which is statistically significant for Indonesia and Malaysia.

4. The effect of large reserves on risks in the financial system

Accumulating foreign exchange reserves, largely financed through the issuance of non-monetary liabilities, may affect the stability of the financial system in a variety of ways. Some of these are positive and intentional. After all, one of the prime motives for central banks to accumulate foreign exchange reserves is precautionary. The capital outflows during the 1998 crisis confronted a number of emerging Asian economies with a shortfall of foreign currency. By accumulating large reserves, the central banks in some of these countries may hope to avoid such external constraints in future times of crisis. Using macroeconomic evidence, Aizenman and Hutchison (2010) show that countries that had accumulated substantial foreign exchange reserves (relative to international liabilities) were best able to avoid exchange rate depreciations during the international financial crisis. On a microeconomic level, Tong and Wei (2011) show that manufacturing firms that were intrinsically dependent on external sources of liquidity suffered worse equity outcomes during the crisis of 2008, suggesting that central banks' ability to alleviate liquidity constraints could be important during a crisis.

Other effects, however, may be less positive. If reserves are sterilised largely through increased reserve requirements or issuing sterilisation bills that are purchased by banks, offsetting decisions by those banks could in principle increase the overall riskiness of the financial system. For example, successful sterilisation may result in persistent interest rate differentials, and

[10] Results are robust to including the 9 largest banks from Chinese Taipei in the sample. Including 12 major Indian banks changes the results qualitatively unless one controls for differences in growth rates of real GDP, perhaps because India experienced greater reserves accumulation in part due to higher growth rates. Full results are available from the authors.

therefore persistent capital inflows, which have been identified as a contributory factor to the Asian Financial Crisis (Cavoli and Rajan, 2006; Takagi and Esaka, 2001).

In this section, we will provide evidence on the sign and size of the impact of foreign exchange reserves accumulation on the financial system. Primarily using bank-level data, we will examine the degree to which central bank reserves were able to alleviate liquidity constraints amongst emerging Asian financial intermediaries during the most recent crisis. We then further examine whether foreign reserves affected the risk profiles of these intermediaries prior to the crisis.

4.1 Crisis risk

To test the success of foreign exchange reserves as a means to alleviate liquidity shortages, we examine the relative performance of banks during the international financial crisis. We construct a weekly series of stock returns, R_t^j, defined as the log first difference of end-of-week stock prices, for a sample of banks for which equity price and balance sheet data were available for at least 6 years during the decade 2001-2010. In Table 3 we report the average (annualised) return on the shares of 46 emerging Asian banks from Indonesia, Korea, Malaysia, the Philippines and Thailand over the period 1 September 2008 to 30 April 2009. We see from the first column that in each country there is a large decline in the stock prices of the banks, ranging from 17% in Malaysia to nearly 60% in Korea, for an average of 40% across the five countries. In the second column we report the average difference between the returns on the individual banking stocks and the average market return for each of these countries. In Malaysia and Thailand the banking shares on average tracked the market. In the Philippines banking shares performed worse than the market and in Korea much worse. In Indonesia, banking shares actually outperformed the market.

Table 3

Bank equity performance

1 September 2008 – April 30 2009

	Average Return	**Average Excess Return**
Indonesia	-0.276	0.151
Korea	-0.590	-0.441
Malaysia	-0.170	-0.037
Philippines	-0.496	-0.151
Thailand	-0.556	-0.015
Total	-0.402	-0.081

In Table 4 we estimate a regression that specifies bank level determinants of crisis period excess returns (relative to the market). The bank level determinants from end of year 2007 balances sheets we examine are:

1. *Size*: The logarithm of total bank assets (AT from S & P Global Compustat) in US dollar terms converted from local currency using end of period exchange rate from the IMF *IFS*;

2. *Loan/Assets*: For each bank, the ratio of Loans/Claims/Advances-Customers-Total (LCUACU) to Total Assets (AT);

3. *NonCore*: The ratio of non-core deposits to assets defined for each bank as total liabilities (LT) less total customer deposits (DPTC) divided by total Assets (AT).

Table 4

Bank equity performance

1 September 2008 – April 30 2009

	Average Excess Returns					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Size	-0.094*** (0.034)	-0.104 (0.102)	-0.099*** (0.034)	-0.078*** (0.028)	-0.081** (0.033)	-0.066*** (0.024)
Loan/Assets	-1.164*** (0.375)	-1.177*** (0.409)	-1.912** (0.804)	-1.254*** (0.408)	-1.194*** (0.395)	-0.893* (0.502)
Non-Core	-1.139** (0.459)	-1.128** (0.434)	-1.220*** (0.431)	-4.828** (2.307)	-4.102* (2.177)	-6.034*** (2.174)
*NML*Size*		0.053 (0.433)				
*NML*Loan/ Assets*			4.460 (4.365)			
NML NonCore*				15.487* (8.613)		19.155** (8.441)
FR NonCore*					10.595 (7.196)	
NML						-1.015 (1.103)
PC GDP						0.072 (0.059)
R^2	0.422	0.406	0.415	0.446	0.436	0.385
N	46	46	46	46	46	46

Heteroskedasticity consistent standard errors report in parenthesis. ***, **, * signify significance at the 1%, 5%, 10% level respectively.

The results in column 1 of Table 4 show the relationship between bank-level excess returns and these balance sheet indicators. The regression includes country dummies to abstract from country-level effects on the banking system. The coefficients on all three indicators are negative and statistically significant at the 5% level indicating that all of these were associated with relatively worse performance during the crisis period. Large banks are likely to have more international exposure than smaller banks, so it might not be surprising that the relatively larger banks had worse returns, given that the crisis was external to these economies. Banks with relatively greater quantities of loans on their balance sheets might have faced worse performance due to greater credit risk or greater liquidity risk during the crisis. Also, banks that financed their assets through channels other than core deposits had relatively worse performance. The contraction in international money markets that occurred during the crisis may explain this result.

The above results are not strongly driven by any one country. We repeat the regressions in column 1 dropping banks from each of the five countries in turn. When Korean banks are dropped from the sample, non-core deposits are significant only at the 10% level. When either Malaysian or Indonesian banks are dropped from the sample, the coefficient on the loan to asset ratio is not statistically significant. However, in both of these cases the p-value is less than 0.15 and the coefficient estimates are comparable to the full sample. In all other cases, the coefficients are significant at the 5% level.

We next consider how the balance sheets of central banks in these countries might have affected these risk factors. In columns 2-4 we report the results of regressions that include an interaction between *NMR* (defined as the ratio of non-monetary domestic liabilities of the central bank to GDP in year 2007) with each of the three risk factors. We find that the interaction between sterilised reserves and either *Size* or *Loan*/*Assets* is insignificant at the 10% level. However, we find that the interaction between *NMR* and *NonCore* is positive and significant at the 10% level. Thus, banks with exposure to money markets tended to perform somewhat less poorly during the crisis if the central bank had large quantities of sterilised reserves. Central banks with substantial amounts of foreign reserves might have been able to use these to mitigate the double drain of foreign currency and domestic credit during the crisis.

In column 5 we report the results using the interaction between the ratio of total foreign assets (sterilised and unsterilised) to GDP and *NonCore*. Though this coefficient is positive, it is small and not statistically significant. In column 6, we report results of a regression that drops country dummies and includes a control for the natural logarithm of per capita GDP in PPP-converted 2005 US Dollars (from the World Bank WDI database) as well as the level of *NMR*. Interestingly, the adjusted R^2 in this regression is similar to the regression including country dummies. Here we see that the interaction term between *NMR* and *NonCore* is significant at the 5% critical value. These results provide some evidence that the acquisition of sterilised foreign reserves may have played some positive role in mitigating the effects of the crisis relative to what was seen during the Asian financial crisis of 1998.

4.2 Reserves and the Crisis

To see how sterilised foreign currency reserves are used in a crisis, it is interesting to examine the response of the Bank of Korea to the events of the autumn of 2008. During this season, Korean banks experienced capital outflows as foreign lenders withdrew their short-term funds (see Shin and Shin, 2011). Because of the reliance of Korean banks on foreign currency financing, this had some potential for damaging the Korean financial system (see Kim, 2010). Table 5 reports the response of the Bank of Korea’s balance sheets during the second half of 2008, with month-by-month figures for foreign assets, the monetary base and non-monetary domestic liabilities. First, we see that there was a drain on the foreign reserves of the central bank, which declined from 294 trillion to as low as 227 trillion Won in November. Outflows were temporary and began reversing by December (and reserves have since risen to new highs). At the same time, the drain on reserves had very little impact on domestic liquidity. In October 2008 the domestic monetary base fell briefly but quickly recovered. Instead, the decline in the foreign assets of the central bank was balanced by a decline in non-monetary liabilities. In particular, the deposits of foreign exchange by the Ministry of Finance and Economics, which had been financed by the issuance of stabilisation bonds, were withdrawn. The holdings of excess reserves of foreign currency allowed policy makers to intervene in an illiquid foreign currency market without draining liquidity from the domestic market.

Table 5

Bank of Korea balance sheet

In trillions of won

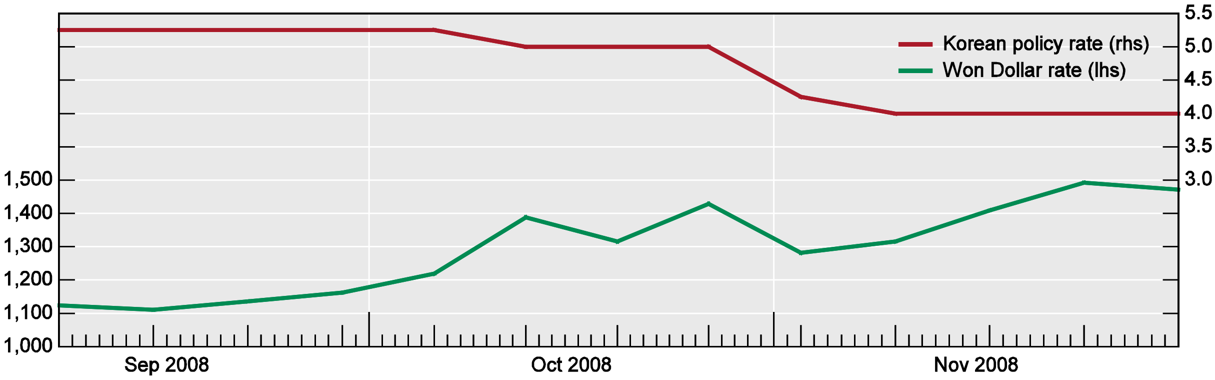
Date	Monetary base	Foreign assets	Non-monetary liabilities	Foreign exchange stabilisation funds
6/2008	52.271	294.938	246.355	59.975
7/2008	53.255	286.627	235.793	58.192
8/2008	55.071	285.282	237.227	58.118
9/2008	56.590	272.762	229.336	55.966
10/2008	51.113	240.181	207.510	25.491
11/2008	55.364	227.746	194.110	17.693
12/2008	61.335	257.970	221.248	20.938

Source: CEIC

Indeed, the Korean Won depreciated from 1000 won per dollar on 11 July 2008 to nearly 1500 by 23 November that year. At the same time, the Bank of Korea was able to reduce its policy rate (see Graph 5).

Graph 5

Korean exchange rate and policy rate



Source: Datastream

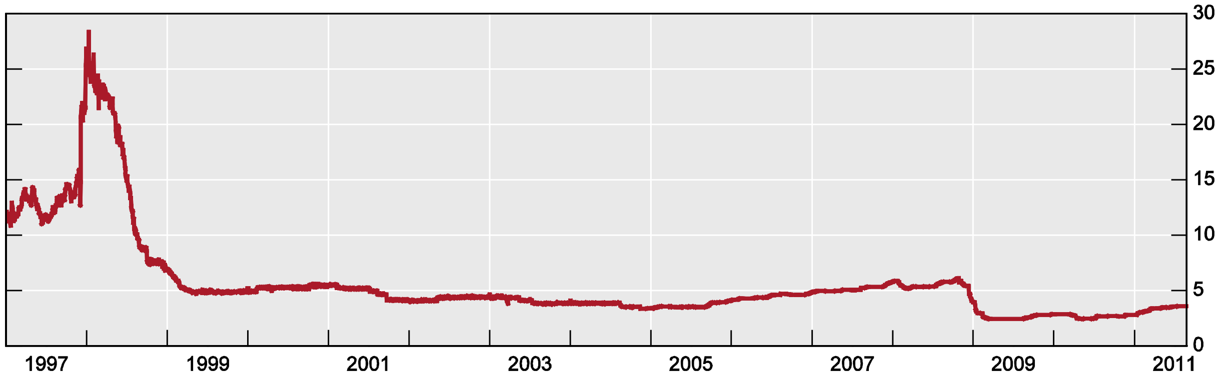
In fact, interbank interest rates actually declined during this period (Graph 6). Capital outflows in economies whose central banks smooth exchange rates can have a negative double drain effect. First, outflows drain loanable funds from capital markets. Second, they put downward pressure on exchange rates, inducing the central bank to drain money from the domestic economy through foreign exchange intervention. As shown in the Korean example, careful use of sterilised reserves may mitigate these risks. Indeed, Aizenman and Sun (2009) show that countries with high levels of international reserves relative to GDP did allow the greatest depletion of those reserves during the initial stages of the crisis.

The degree to which foreign exchange reserves serves to protect financial institutions during a crisis may depend on the institutional arrangements governing the use of sterilisation instruments. As argued in the introduction, foreign exchange reserves are generally financed using sterilisation instruments. Many sterilisation instruments are assets which, for the purposes of the commercial banking system, might be highly substitutable for monetary instruments. However, like government bills that traditionally play the role of secondary reserves, sterilisation instruments may not always be perfectly substitutable, particularly in a crisis situation, as we can illustrate using data from 1998 for Hong Kong.

Graph 6

Korean three-month interbank rate[1]

In per cent



[1] KORIBOR rate extended backwards beyond 2004 using the overnight call rate for interpolation.

Sources: Bloomberg; BIS calculations.

The Hong Kong currency board system requires that the monetary base, including bank notes and commercial bank reserves held at the central bank, be fully backed with US dollar assets. There are no reserve requirements in Hong Kong, but funds in the clearing accounts are used for the real-time settlement of interbank payments. In addition, the Hong Kong Monetary Authority intermittently exchanges non-interest paying reserves for liquid interest-bearing securities of varying maturities referred to as Exchange Fund paper (bills and notes). Though any parties can hold Exchange Fund paper, it is largely held by banks for liquidity purposes.[11] Meanwhile, clearing balances are typically small relative to the quantity of Hong Kong dollars being exchanged. At the end of 1998, the size of the clearing balances was approximately HK$2.5 billion relative to a GDP level of HK$1,293 billon in that year. Table 6 reports the size of Clearing Balances and Exchange fund paper in Hong Kong during the 1990's.

Given the small size of reserves held by banks and the operation of the currency board, relatively small quantities of capital flight may lead to significant interest rate volatility in the interbank market. Following the depreciations of some emerging Asian currencies during the financial crisis of 1998, market sentiment reflected a view that a similar devaluation in Hong Kong was possible, despite the fifteen-year continuous operation of the currency board. It is surmised that, in August 1998, some international hedge funds played on this sentiment by engineering large-scale short-selling of Hong Kong dollars by borrowing funds from Hong Kong banks and selling the funds in foreign exchange markets.[12] By the operations of the currency board, these sales reduced the aggregate amount of Hong Kong dollars available in reserve accounts. The resulting liquidity shortage caused extreme spikes in the interbank rate (HIBOR).

[11] Between 1999 and 2007, an average of 83% of Exchange Fund paper was held by banks (Source: HKMA Monthly Statistical Bulletin).

[12] See Goodhart and Dai (2003).

Table 6

Clearing balances and exchange fund paper in Hong Kong

In millions of HK dollars

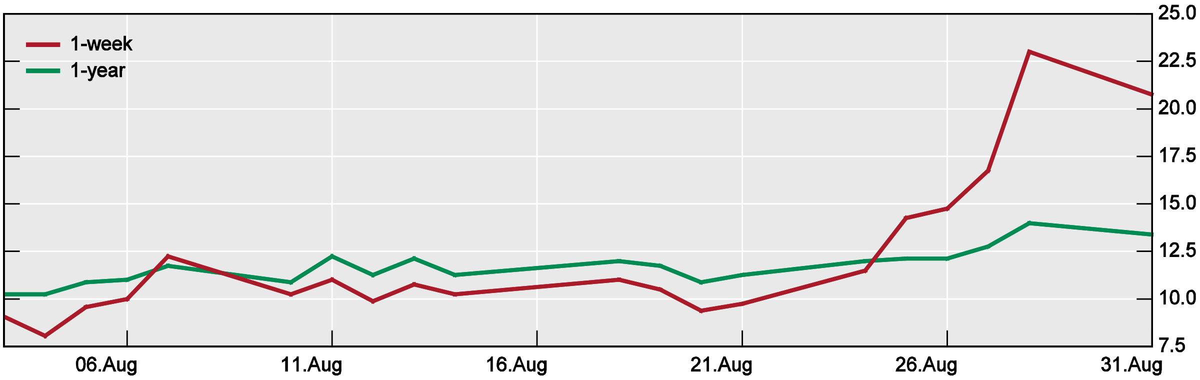
Year	Clearing balances	Exchange fund paper
1993	1,385	25,157
1994	2,208	46,140
1995	1,762	53,311
1996	474	83,509
1997	296	89,338
1998	2,527	98,334
1999	7,960	101,828
2000	669	109,288

Sources: HKMA Monthly Statistical Bulletin

Graph 7

Daily Hong Kong Interbank Offered Rates (HIBOR)

August 1998



Source: HKMA Monthly Statistical Bulletin.

Graph 7 shows the daily average interest rate for 1 week HIBOR during August 1998 along with 1 year HIBOR for comparison. Rates were already high during this period, relative to the US, reflecting fears of a future devaluation. In the final week of the month, we observe a large spike in weekly interest rates to above 22% on an annual basis with little movement in the longer rate, suggesting that this spike was the result of a deficit of short-run liquidity.

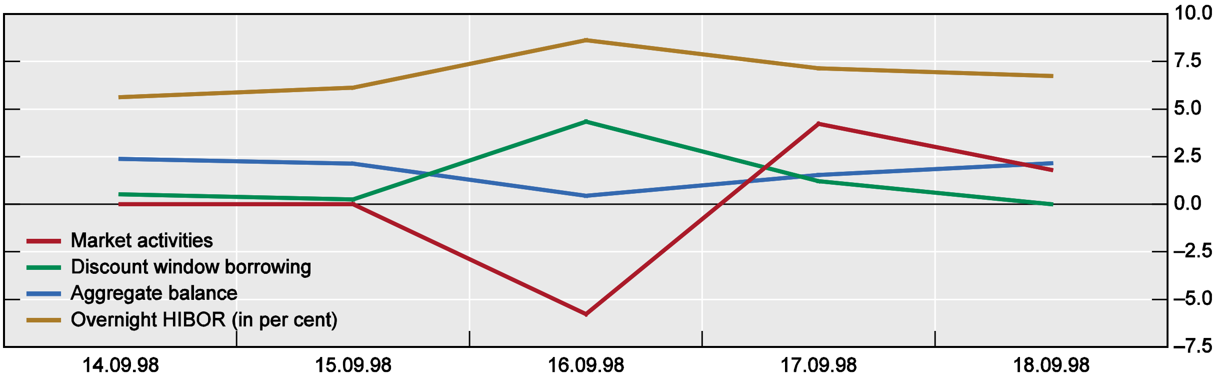
The Hong Kong government responded with a number of measures including an intervention in the domestic stock market. Perhaps as interesting were some technical changes in the monetary arrangements announced on September 5th (HKMA, 1998). In particular, the monetary authority announced that they were "removing the restriction on repeated borrowing in respect of the provision of overnight Hong Kong dollar liquidity through repo transactions using Exchange Fund Bills and Notes." From that point on, banks were able to use up to 50% of their Exchange Fund paper as collateral to borrow overnight Hong Kong dollar clearing balances from the discount window at a rate similar to a longer term average HIBOR rate. By sharply increasing the substitutability between Exchange Fund paper and clearing balances, this procedural change markedly improved the liquidity of the Hong Kong dollar interbank market.

The results of this new regime may be seen in Graph 8. On September 16 1998 there was another sharp capital outflow, amounting to HK$5.8 billion, larger than the entire clearing balances at the outset of that week. This resulted in a large net drain from the system. However, this was offset by an increase in discount window borrowing of approximately HK$4.4 billion. The inflow of funds from the discount window limited the rise in the overnight interbank rate which increased by only 250 basis points (annualised) for a single day before reverting to normal levels. Thus, with the new institutional arrangements, large stocks of sterilisation bills served as a source of stability for the financial system during a period of extreme stress.

Graph 8

Hong Kong dollar interbank market

In billions of HKD unless otherwise specified



Source: HKMA Monthly Statistical Bulletin.

4.3 Exchange rate risk

It is possible that a large stock of sterilisation instruments could also help to insulate the banking system from currency risk. For each individual bank j in market m we estimate the OLS regression:

$$R_t^j = a_0 + g^S ds_t^m + e_t ,$$

where R_t^j is the log first difference of the equity price of bank j and ds_t^m is the log first difference of the exchange rate (domestic currency per USD) of market m. We estimate the equation by OLS using a series of rolling regressions with three years of data starting in 2001 and running through 2008. The exchange rate exposure coefficient, g^S, measures the unconditional co-movement between exchange rates and stock prices. A negative estimate of g^S indicates that a banks' stock price tends to fall when exchange rates depreciate. For four of the five markets we report the mean estimate (across the banks in the sample) of g^S for each of three year period between 2001 and 2009. However, as Malaysia operated a fixed exchange rate through 2005, we report the mean unconditional exposure using regressions based on one year samples to identify trends over the period 2006-2009.

For all of these countries and periods, the relationship is negative (Table 7). For Thailand the negative relationship seems to lessen over time, while the reverse is true for the Philippines. For Korea, the relationship shows a pronounced diminution in the period 2001-2006, with a reversal once the international financial crisis is included in the same period. Perhaps because of the shorter sample, the estimate for Malaysia appears unstable.

Table 7

Estimates of unconditional bank equity sensitivity to exchange rate movements (g^S)

Sample Period	Indonesia	Korea	Philippines	Thailand	Sample Period	Malaysia
2001-2003	-0.27	-1.43	-0.42	-1.26		
2002-2004	-0.99	-1.36	-0.35	-2.00		
2003-2005	-1.15	-1.04	-0.57	-1.61		
2004-2006	-0.99	-0.67	-1.12	-2.20	2006	-0.79
2005-2007	-0.98	-0.72	-1.30	-0.77	2007	-1.83
2006-2008	-0.60	-1.08	-1.24	-0.89	2008	-0.74
2007-2009	-0.83	-1.30	-1.27	-0.62	2009	-1.08

There are two potential interpretations for the negative relationship between stock prices and exchange rates. First, exchange rate shocks from external sources might have a negative impact on the value of bank equity. Second, domestic macroeconomic shocks which have a negative impact on the stock market may also lead to decline in the value of the domestic currency. To abstract from the second effect we re-estimate controlling for broader market movements. For each individual bank j in market m we estimate the OLS regression:

$$R_t^j = a_0 + bR_t^m + f^S ds_t + e_t ,$$

where R_t^m is the log first difference of a broad market index for market m. The exchange rate exposure coefficient, f^S , now represents the conditional correlation between exchange rates and an individual firm's stock price. Table 8 reports the estimates of coefficient f^S .

Table 8

Estimates of conditional bank equity sensitivity to exchange rate movements (f^S)

Sample Period	Indonesia	Korea	Philippines	Thailand	Sample Period	Malaysia
2001-2003	0.04	0.04	0.22	-0.11		
2002-2004	-0.39	0.05	0.31	-0.18		
2003-2005	-0.57	0.23	-0.11	-0.15		
2004-2006	-0.28	0.42	-0.36	-0.30	2006	0.17
2005-2007	-0.12	0.66	-0.24	0.03	2007	0.23
2006-2008	0.16	0.07	-0.01	-0.03	2008	0.06
2007-2009	0.06	-0.20	-0.28	0.31	2009	0.32

Here we see much less negative exchange rate exposure overall, with banks in Korea and Malaysia showing a positive response to exchange rate movements after broad market movements are controlled for. This suggests that the financial system may be relatively less exposed to exchange rate movements than the stock market as a whole. We also see a pattern where the positive exposure of the Korean banking system increases until it reaches the period of the international financial crisis after which exposure turns relatively negative, while the negative exposures observed early in the decade amongst the banks of Indonesia and Thailand diminish, particularly in the period after 2005.

To understand the relationship between stock returns and exchange rate depreciation, we regress our estimates of conditional and unconditional exchange rate exposure on some market and bank specific factors. We estimate a fixed effects regression of g^S for each bank in each period on country-period specific factors including the level of nom-monetary liabilities relative to GDP, real GDP growth and bank-period specific factors including the size of the bank assets and the degree of leverage. Each regression includes a bank-specific dummy variable, which soaks up all country effects, as well as year-specific dummies. Since the exchange rate exposures are calculated with overlapping samples, we estimate standard errors that are robust to heteroskedasticity and auto-correlation of unknown form. We report coefficients and standard errors in Table 9.

Table 9

Exchange rate exposure

	Unconditional exposure (g^S)		**Conditional exposure (f^S)**	
	(1)	**(2)**	**(3)**	**(4)**
Period	**2001-2009**	**2001-2007**	**2001-2009**	**2001-2007**
Non-monetary liabilities	6.19***	4.14**	-0.64	0.16
	(2.02)	(1.76)	(1.52)	(2.32)
Capitalisation	-0.18	3.00	1.83	4.68**
	(2.25)	(1.99)	(1.58)	(1.77)
Size	0.39	0.53**	0.40**	0.56***
	(0.40)	(0.22)	(0.18)	(0.20)
GDP growth	0.89	-24.23***	2.39	-9.44
	(10.03)	(8.28)	(6.34)	(10.51)
Obs.	317	215	317	215
Banks	55	53	55	53

Standard errors in brackets. ***, **, * indicates significance at 1%, 5%, 10% level respectively.

The first column reports the determinants of unconditional equity sensitivity to exchange rates. In this unbalanced sample there are 55 banks and 317 observations. Here the only statistically significant determinant is the ratio of non-monetary liabilities to GDP, implying that a high level of this measure of sterilised reserves is associated with a less negative exchange rate exposure. Possible explanations are that sterilised reserves allow the central bank to insulate the exchange rate from domestic shocks or the central bank to protect the value of domestic banks' equity from negative external shocks that weaken the exchange rate.

In column 2 we report results using data preceding 2008, before the height of the international financial crisis. We see that in these pre-crisis years, the effect of sterilised reserves on unconditional exposure is smaller but still significant at the 5% level. We are also able to detect that relatively large banks tend to have less negative exchange rate exposure in this period. Large banks might be able to use their size to overcome the fixed costs of using derivative instruments to protect against various currency mismatches or other financial exposures, for example. Exchange rate exposure is also cyclical, with more negative exposure during periods of rapid economic growth.

Columns 3 and 4 show the determinants of conditional exchange rate sensitivity. We see that controlling for aggregate stock market movements eliminates the significance of the country-level variables. The quantitative effect of non-monetary liabilities, in particular, is much reduced and insignificant at standard significance levels. These results suggest that a large stock of sterilised foreign exchange reserves offers no stronger protection from exchange rate shocks to banks than to the stock market as a whole. One interpretation is that sterilised reserves can help to insulate the economy from shocks but does not protect the financial system from external shocks beyond that. We also observe that exchange rate depreciations have smaller negative effects on the shares of large banks and (especially in the pre-crisis sample) well capitalised banks. This suggests that exchange rate shocks present risks to the financial systems in these markets that can be mitigated through conservative leverage or risk management.

4.4 Duration risk

Sterilisation involves risk transformation: banks are left holding sterilisation bills in exchange for some other asset. This risk transformation itself could increase the risk profile of the financial system. While credit risk and currency mismatch are unlikely to be negatively affected, since sterilisation instruments are issued by the central bank and in the same currency as most other assets and liabilities of domestic banks, banks may face heightened interest rate risk, or increased maturity mismatch, especially if sterilisation instruments are issued at longer maturities.

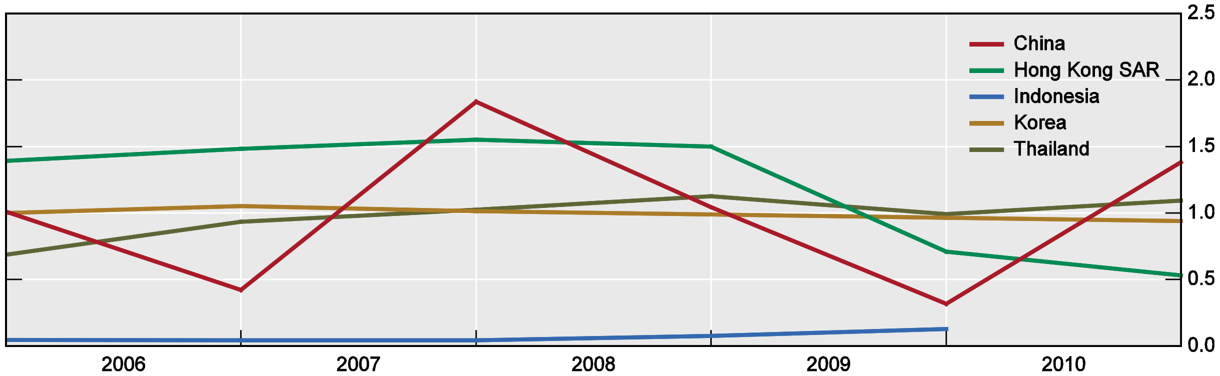
Graph 9 provides estimates of the average maturity of the outstanding stock of sterilisation bills for five economies for which data is available. For Indonesia only sterilisation bills at short maturities (up to 6 months) are issued, although the average length is increasing gradually. For Hong Kong, despite the rapid expansion of Exchange Fund paper issuance in recent years and a maximum maturity of 15 years, a growing share of paper is issued at 3 and 6 month maturities so that the average term to maturity is falling. For China, Korea and Thailand sterilisation bills have an average duration of approximately 1 year, and this has been stable for the past five years except in the case of China. Given the rapidly growing stock of sterilisation bills on bank balance sheets, and the historically low levels of interest rates globally, this could represent a growing source of interest rate risk within the banking system, although the risk appears to be small at this time.

Some central banks, including those in Malaysia, Singapore and Thailand, sterilise their reserves accumulation at least in part using foreign exchange swaps. While there is no publically available break-down on the maturity of these swaps, central banks are likely to be active at maturities where swaps markets are most liquid – that is, at maturities less than one year. This would limit concerns about effective interest rate risk due to swaps-based sterilisation.

Graph 9

Average maturity of outstanding sterilisation bills[1]

In years



[1] Average maturity is computed as a weighted average where the weights are outstanding bills of a given maturity as a share of total outstanding bills. The share is estimated based on the assumption that bill issuances are spread evenly over the year, and no bills are repurchased by the central bank before maturity. Thus the stock of sterilisation bills issued with maturity of 1 month are estimated as total issuance of such bills for the year divided by 12, and these are assumed to have an average time to maturity of 0.5 months. For bills with maturity exceeding one year, data for previous years is used to construct the stock of outstanding bills. For example, for bills issued with a maturity of 2 years, bills issued in the previous year with a maturity of 3 years are added, and the average time to maturity for the combined stock is assumed to be 1.5 years. For Indonesia, approximately 2% of all issued bills are SWBIs for which no term structure data is available. These are excluded from the calculations.

Sources: Dealogic; national data.

We can also use stock price data to test the market perception of the relationship between the stock of central bank non-monetary liabilities and the sensitivity of commercial banks' net worth to interest rates. We construct a measure of the yield curve as $yc_t = i_t^{10} - i_t^{Pol}$ where i_t^{10} is the 10 year sovereign yield from Datastream and i_t^{Pol} is the policy rate.[13] For each individual bank *j* in market *m* we estimate the OLS regression:

$$R_t^j = a_0 + b_j R_t^m + h_j^Y dyc_t + e_t ,$$

where dyc is the first difference of the yield curve and R_t^m is the return (i.e. log first difference) on a market index. We estimate this regression for the 50 banks using data from the beginning of 2005 to the end of 2009.

A standard notion is that bank assets tend to be of longer maturity than their liabilities (see English, 2002). Thus, a steeper yield curve will tend to improve the balance sheets of the bank. However, this is not the case in emerging Asia. Table 10 shows that the average level of h_j^Y is negative for each country indicating that, on average, banking stocks do worse than the broader market when the yield curve steepens. In addition, we find that the coefficient h_j^Y is negative and significant at the 5% level in 10 of the 50 banks. A number of explanations might account for this. First, Asian banks tend to issue floating rate mortgages (see Zhu, 2006) indicating more short-term interest sensitive asset income. Second, Asian banks raise a high level of their funds from customer deposits (see Mohanty and Turner, 2010). If costs

[13] For the Philippines, 10 year sovereign yield this series ends on June 22, 2007. Beginning in July, we substitute a 10 year government yield also from Datastream.

of deposits are primarily non-interest related, then, a drop in interest rates might have a negative impact on balance sheets.

Table 10

Bank equity exposure

2005 – 2009

Exposure to:	**Yield curve** h_j^Y	**VIX** j_j^V
Indonesia	-1.263	
Korea	-3.784	-0.97
Malaysia	-1.121	-1.07
Philippines	-0.170	-0.34
Thailand	-1.056	0.20
Total	-1.40	-0.98

In Table 11, column 1 we report the results of a regression of the exposure to yield curve risk on some bank level determinants (along with country dummies). We find that large banks have relatively more negative yield curve exposure. We might expect this to be positive, since large banks may be more able to use derivative instruments to eliminate interest rate risk. However, given the central importance of commercial banks in emerging markets, large banks may play a role as a counter-party for other players in swap markets. We also see that banks that are funded in large part through non-core liabilities have relatively less negative exposure to a steepening of the yield curve. Since the costs of funds raised in money markets are primarily interest rate-related, such banks might tend to benefit the most from a reduction in market interest rates relative to long-term rates.

To check the robustness of these results to the specifics of different countries, we re-estimate the regression in column 1 dropping each of the countries in turn. We find that when we drop the Philippines, the coefficient on bank size is significant only at the 10% level; when we drop banks from Korea, the coefficient is not significant at the 10% level. However, even in this latter case the coefficient is similar to the estimate in the total sample. Regardless of which country is dropped, the coefficient on *NonCore* is negative and significant at the 5% level.

To test whether central bank balance sheets affect the relationship between risk determinants and yield curve exposure, we include some interaction terms between the measure of non-monetary liabilities relative to GDP and the risk determinants (columns 2 and 3). We find no evidence that yield curve risk is impacted by the level of sterilised reserves, suggesting that the market does not perceive banks to be more risky in countries where there is a large stock of sterilised reserves.

Table 11

Explaining bank exposure to the yield curve, h_j^Y

	(1)	**(2)**	**(3)**
Size	-0.339**	0.191	-0.373**
	(0.152)	(0.582)	(0.170)
NonCore	8.593***	8.008***	14.986
	(2.023)	(2.215)	(10.297)
*NML*Size*		-2.855	
		(3.123)	
*NML*NonCore*			-27.009
			(41.136)
Adj. R^2	0.386	0.385	0.375
N	50	50	50

Heteroskedasticity consistent standard errors report in parenthesis. ***, **, * signify significance at the 1%, 5%, 10% level respectively.

4.5 Market risk

We also use equity prices to examine whether the acquisition of non-sterilised reserves modifies exposure to market risk. First, we examine exposure to a generalised level of market volatility, as measured by the VIX (following Milesi-Ferretti and Tille, 2010), an implied options volatility measure from the Chicago Board Options Exchange. For each individual bank *j* in market *m* we estimate the OLS regression:

$$R_t^j = a_0 + b_j R_t^m + j_j^V dvix_t + e_t ,$$

where R_t^j is the log first difference of the equity price of bank *j*; R_t^m is the log first difference of a broad market index for market *m*; and $dvix_t$ is the first difference of the VIX index. The regression is estimated over the period 2005-2009. We find that for most of the Asian countries in the sample, negative exposure to market volatility is apparent. Table 10 above reports the average estimate of j_j^V (scaled by 1000). We see that in Indonesia, Korea and Thailand this estimate is near -1, while it is closer to zero in Malaysia and positive in the Philippines. We find that in 12 out of 50 cases the coefficient estimate is negative and significant at the 5% level (most of these cases are concentrated in Korea and Thailand) indicating banking systems that are more exposed to international volatility than the stock market as a whole.

We also assess the bank-level determinants of exposure to international volatility, focusing on bank size and holdings of investment securities, as follows:

1. *Size*: The logarithm of total bank assets (AT from S & P Global Compustat) in US dollar terms converted from local currency using end of period exchange rate from the IMF *IFS*;
2. *Securities/Assets:* The ratio of total investment securities (IST) to total assets (AT) from S&P Global Compustat measured in 2007.

Table 12, column 1 reports the results of a regression of the estimate of relative volatility exposure, j_j^V, on these determinants. We find that large banks face relatively large negative exposure to international volatility. Given that large banks will tend to have relatively large international positions, this may not be surprising. Possibly more surprisingly, we find that banks with large holdings of investment securities have less negative responses to an increase in market volatility. This may indicate that bank holdings of investment securities are concentrated in relatively lower risk areas. One interpretation is that holdings of sterilisation bonds in emerging Asian banks reduce overall risk exposure.

Table 12

Explaining bank exposure to the VIX, j_j^V

	(1)	**(2)**	**(3)**
Size	-0.278*	-0.789	-0.360**
	(0.150)	(0.574)	(0.151)
Securities/Assets	4.820**	5.607*	18.056**
	(2.301)	(2.564)	(7.049)
*NML*Size*		2.717	
		(3.370)	
*NML*Securities/Assets*			-65.658*
			(36.551)
Adj. R^2	0.111	0.113	0.146
N	50	50	50

Heteroskedasticity consistent standard errors report in parenthesis. ***, **, * signify significance at the 1%, 5%, 10% level respectively.

To test whether central bank balance sheets make any significant difference to risk exposures, we report results from regressions which include an interaction term between central banks holdings of non-monetary liabilities relative to GDP and the determinants of risk in Table 12. We do not find significant evidence that heavy central bank holdings of sterilised reserves limit the exposure to the VIX index. However, we do find a significant association (at the 10% level) between sterilised reserves and the relationship between securities holdings and volatility exposure. We find that in economies with high levels of sterilised reserves, banks with large securities portfolios have relatively less positive exposure to the VIX than in countries with relatively smaller holdings. Perhaps this is because banks which hold securities in countries with high sterilised reserves tend to hold relatively safe sterilisation bonds, rather than more risky investments with returns that are highly correlated with the VIX. Thus the accumulation of sterilised reserves may reduce banks exposure to market risk.

4.6 Moral hazard risk

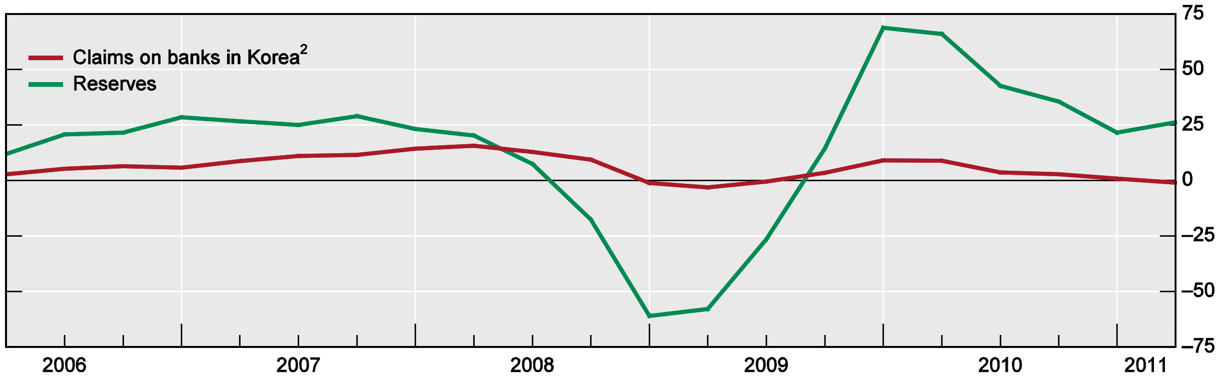
One source of increased risk for banks might result if banks are forced to finance their large holdings of sterilisation bills through international money markets. In practise, this may not be a major concern since most banks in the region are funded primarily from a broad deposit base. However, in the most financially developed economies, such as Korea, banks have the ability to access wholesale markets. There may be increased risks for those economies in which banks' foreign currency exposure and sterilised intervention are highly correlated, as would occur if the banking system's marginal funding comes from accessing international markets. The net effect of these transactions for the banks would be to increase their foreign currency liabilities and their domestic currency assets (sterilisation bills).

We can assess this risk for Korea, an economy in which domestic banks borrow in international markets, by comparing changes in non-won claims on Korean banks, using BIS locational banking statistics, with changes in reserves. As Graph 10 shows, there is some co-movement between the two series, but it is far from complete. Thus either banks' marginal funding does not come from international markets, intervention is not fully sterilised, sterilisation instruments are substantially sold to others besides domestic banks or some combination of these factors holds for Korea.

Graph 10

Korean foreign reserves and claims on Korean banks[1]

In billions of US dollars



[1] Year-over-year changes. [2] Unconsolidated claims on banks resident in South Korea which may include interoffice positions.

Sources: IMF IFS; BIS locational banking statistics.

5. The effect of large reserves on the central bank and monetary policy

We now outline some of the risks of foreign exchange reserves accumulation for the central bank and the conduct of monetary policy.

5.1 Central bank balance sheet risk

As argued in Calvo (1991) and Filardo and Grenville (2011), sterilised intervention, especially based on the issuance of sterilisation bills, is typically costly for two reasons. First, sterilisation bills typically pay a higher interest rate (since they are in domestic currency) than the return on foreign reserves (which may be largely in USD instruments). Second, this effect has been compounded historically by an even larger cost in terms of currency appreciation – a "carry trade" effect.

Table 13 offers estimates of sterilisation costs and the valuation losses from a 10% appreciation of the domestic currency. Note that while sterilisation costs tend to be small, at least as a percent of GDP, it is in some cases of the same order of magnitude as central bank equity and total central bank revenues.[14] Further, sterilisation costs are small relative to the mark-to-market valuation losses from even a moderate appreciation of the domestic currency. One risk is that these costs reduce the effective independence of the central bank, due to the need for recapitalisation by the government.

Table 13

Estimates of sterilisation costs and valuation losses from domestic currency appreciation

	As of December 2010		Central bank equity[1,2]	Central bank revenues[1,2]	100 % Sterilisation cost[1,3]	Valuation loss for a 10% appreciation of domestic currency (%)[1]
	FX reserves (USD bn)	Short-term rate (%)				
China	2,667	3.1			0.6	4.6
Hong Kong SAR	266	0.3	34.2	6.9	(1.0)	11.8
India	272	6.7			0.7	1.8
Indonesia	83	0.2	1.7	0.5	0.7	1.1
Korea	290	2.8	0.6	1.9	0.8	3.0
Malaysia	99	3.0	7.1	1.4	0.7	4.2
Philippines	46	0.7	3.2	1.1	0.5	2.4
Singapore	215	0.3	10.9	-3.1	(0.6)	9.8
Thailand	159	1.9	-0.9	0.7	0.0	4.8

[1] As a percentage of nominal GDP. [2] 2009 annual report total equity and revenue figures reported by respective central banks. [3] Assumes entire FX reserve is invested in 1–3 year US government bonds and the funding rate is the domestic deposit rate.

Sources: IMF; Bloomberg; Datastream; BIS calculations.

A related possibility is that the risk of valuation losses from currency appreciation may encourage policymakers to resist currency appreciation with foreign exchange intervention even more strongly. However, if the prospects of eventual appreciation remain, and capital flows are sufficiently elastic to these prospects, the end result would be even larger losses from the eventual appreciation.

5.2 Incomplete sterilisation risk

A standard argument in open economy macroeconomics is that exchange rate stability, capital mobility and domestic monetary control are not all simultaneously achievable (Mundell 1963 is a classic reference). We now consider evidence of a loss of domestic monetary control in emerging Asia, a region that appears to be reasonably open to capital and where targeting exchange rates via large scale foreign exchange intervention is

[14] See, also, Table 4 in Mohanty and Turner (2005). Zhang (2010) argues that the cost of China's sterilisation to-date has been more than covered by income earned from reserves.

common. Equivalently, we are examining whether the expansionary effects of reserve accumulation on the domestic economies in emerging Asia have been fully sterilised.

Correlations suggesting deterioration in domestic monetary control due to foreign exchange intervention in emerging Asia are easy to find. For a number of regional economies, higher foreign exchange reserves as a percent of GDP are significantly correlated with higher consumer price inflation[15] (China, Hong Kong, Korea and Malaysia; see Graph 11); higher broad money as a percent of GDP (China, Hong Kong, India, Indonesia, Korea, Philippines and Singapore; see Graph 12) and greater credit to the private sector as a percent of GDP (China, India and Korea; see Graph 13).[16] Curiously for Indonesia, Malaysia and Thailand the final correlation is reversed: credit to the private sector appears to decline as reserves increase.

Much of the reserves accumulation has been sterilised, specifically to avoid increasing the monetary base. However, even if the monetary base is stable, it is possible that sterilisation is incomplete. For example, if sterilisation bills and money are near substitutes, then increased bank holdings of sterilisation bills may not offset the expansionary effects of foreign exchange intervention. Or in an economy in which banks have ready access to wholesale funding, banks may offset the need to hold sterilisation bills by increased wholesale funding so that credit growth remains expansionary despite sterilisation.

To explore the effects of sterilised intervention on the economies of emerging Asia further, we follow Moreno (1996) and Takagi and Esaka (2001) in considering vector auto-regressions on a subset of the economies in our sample for which the monetary policy regime over the 1999-2010 period has been relatively stable, namely Indonesia, Korea, the Philippines and Thailand.[17] Using available monthly data from the post Asian Financial Crisis period, defined as January 1999 to August 2010, we estimate a vector auto-regression in the vector X_t where $X_t = \left[cpi_t, i_t^{MM}, m2_t, s_t, nm_t \right]$ and cpi_t is the natural logarithm of the domestic consumer price index, i_t^{MM} is the domestic money market interest rate, $m2_t$ is the logarithm of broad money, M2, s_t is the logarithm of the spot exchange rate defined as the number of units of domestic currency per US dollar and nm_t is the level of non-monetary liabilities measured in domestic currency, our proxy for sterilised intervention. For each economy we estimate a vector auto-regression with six lags.

Impulse responses are identified using the Choleski decomposition. The ordering of the variables reflects the view that prices are sticky in the short run but inflation impacts monetary policy responses; these in turn contribute to broad money, and all three variables influence exchange rates. The crucial identification assumption in our estimation in the ordering of s_t and nm_t. If sterilised intervention is used to offset exchange rate shocks, then these two series are likely to co-move at high frequencies. To be conservative, we identify all

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[15] Statistical significance at the 5% level based on country-specific regressions on quarterly data. Regressions for the region as a whole, incorporating country fixed effects, also indicate statistically significant relationships between reserves as a percent of GDP and both higher inflation and higher broad money. For Singapore, the 1-month interbank offered rate is used as a proxy for the policy rate. Full results are available from the authors.

[16] Filardo and Grenville (2011) note that emerging Asian economies that have seen large run-ups in credit as a share of GDP in the region were typically those with relatively poorly developed credit markets, who were therefore starting from a low base in terms of credit availability.

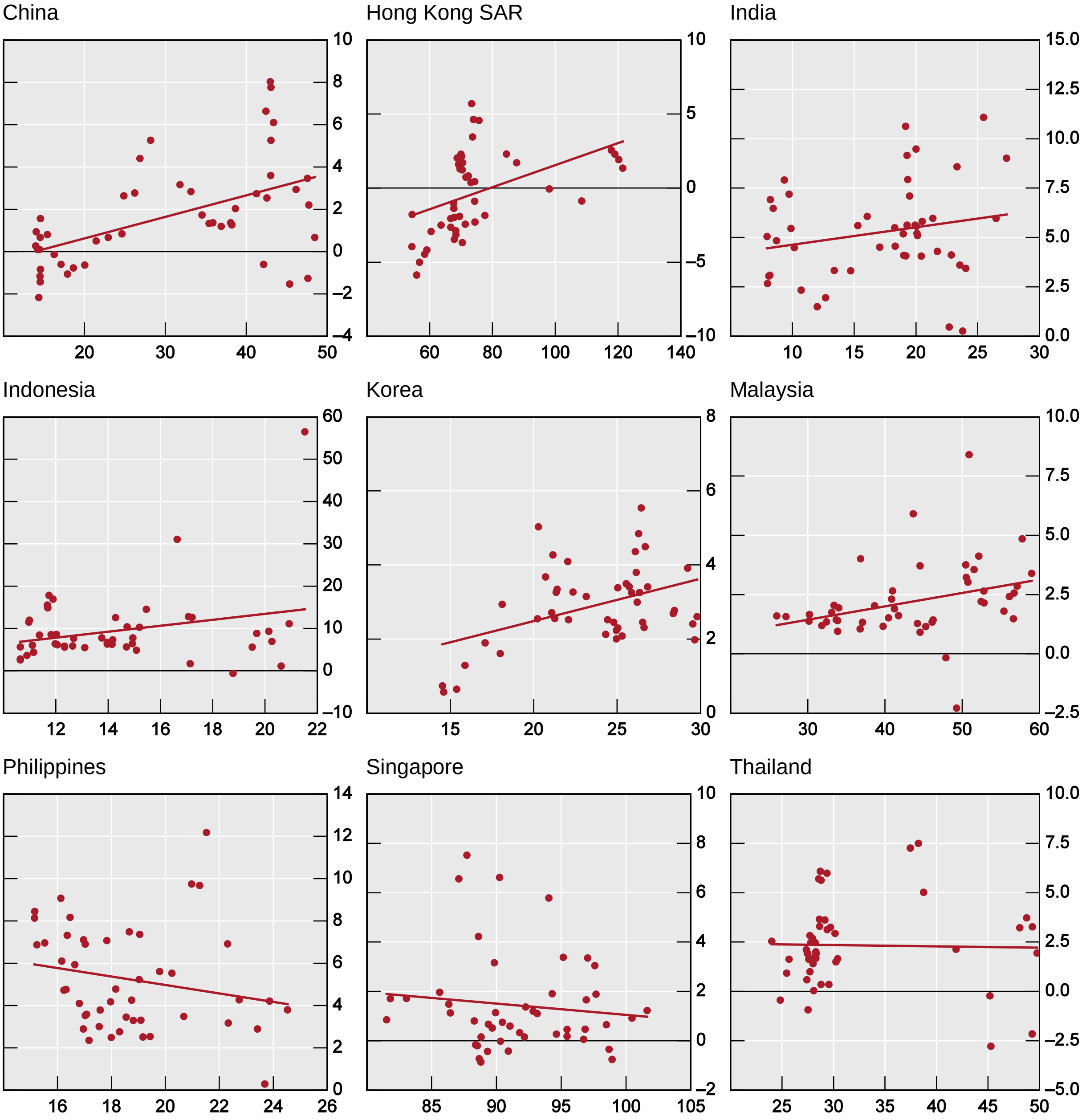
[17] Malaysia is excluded because it switched from a fixed exchange rate to a flexible exchange rate in 2005, leaving too short a sample for our analysis.

short-term co-movement between the two series as the endogenous response of sterilised reserves to exchange rate shocks. By contrast, *exogenous* shocks to non-monetary liabilities are identified as having no contemporaneous effect on exchange rates.

Graph 11

Inflation and reserves as percentage of GDP[1]

In per cent



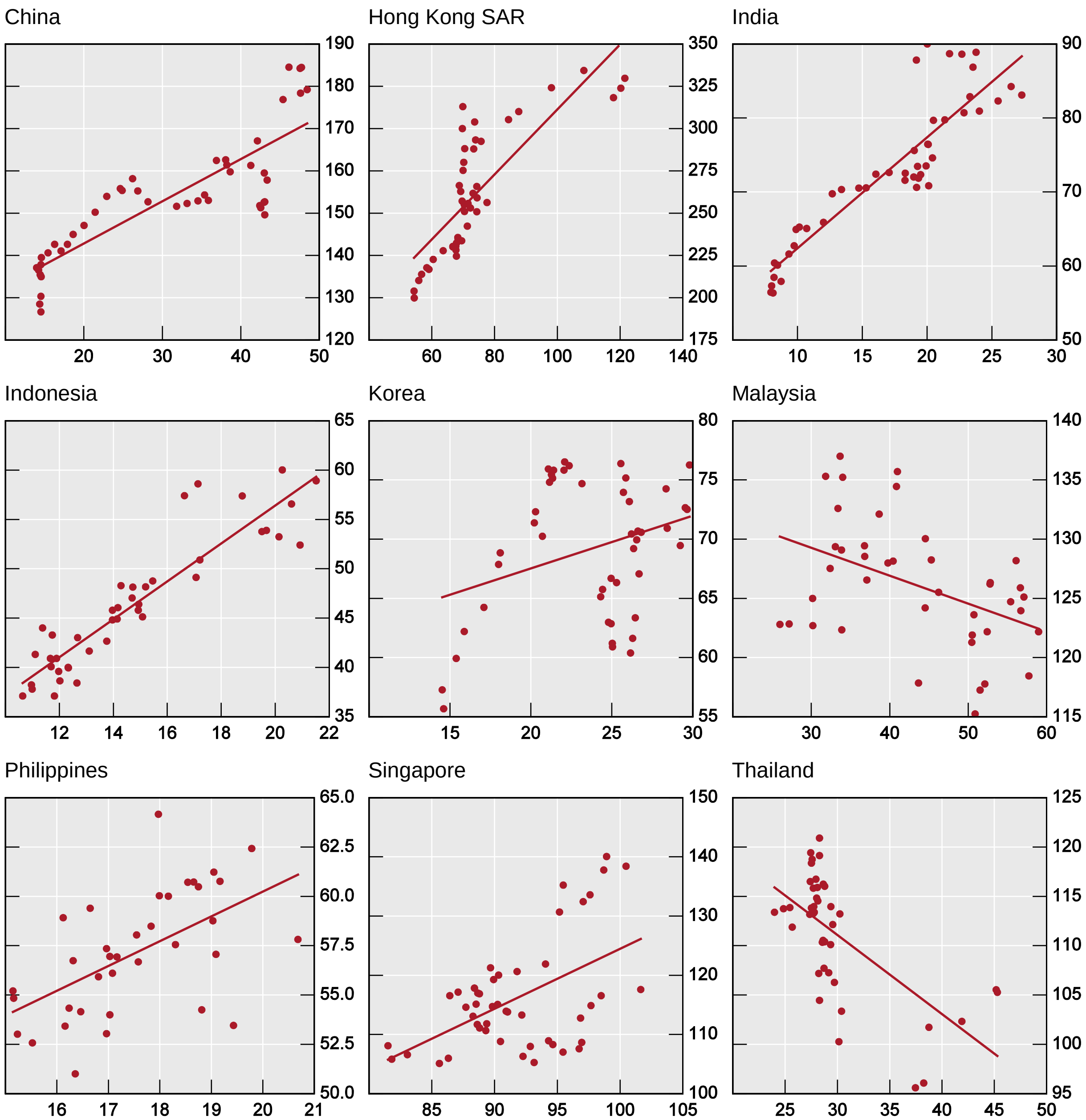
[1] Horizontal axis: foreign exchange reserves as percentage of GDP; vertical axis: year-on-year change on producer prices index for India; year-on-year change of CPI for others.

Sources: IMF *IFS*; national data.

Graph 12

Broad money and reserves as percentage of GDP[1]

In per cent



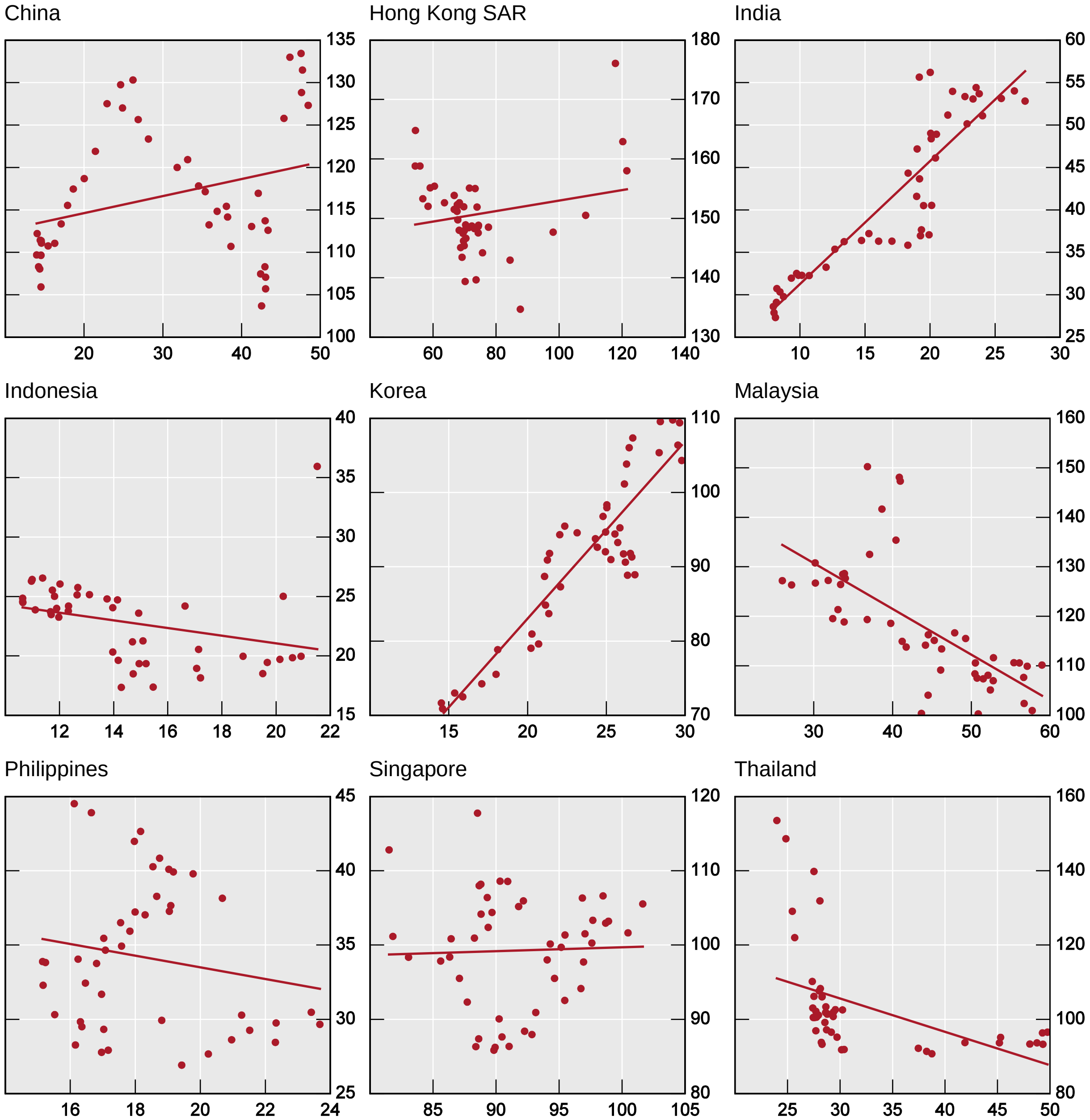
[1] Horizontal axis: foreign exchange reserves as percentage of GDP; vertical axis: money plus quasi money as percentage of GDP.

Source: IMF *IFS*.

Graph 13

Credit and reserves as percentage of GDP[1]

In per cent

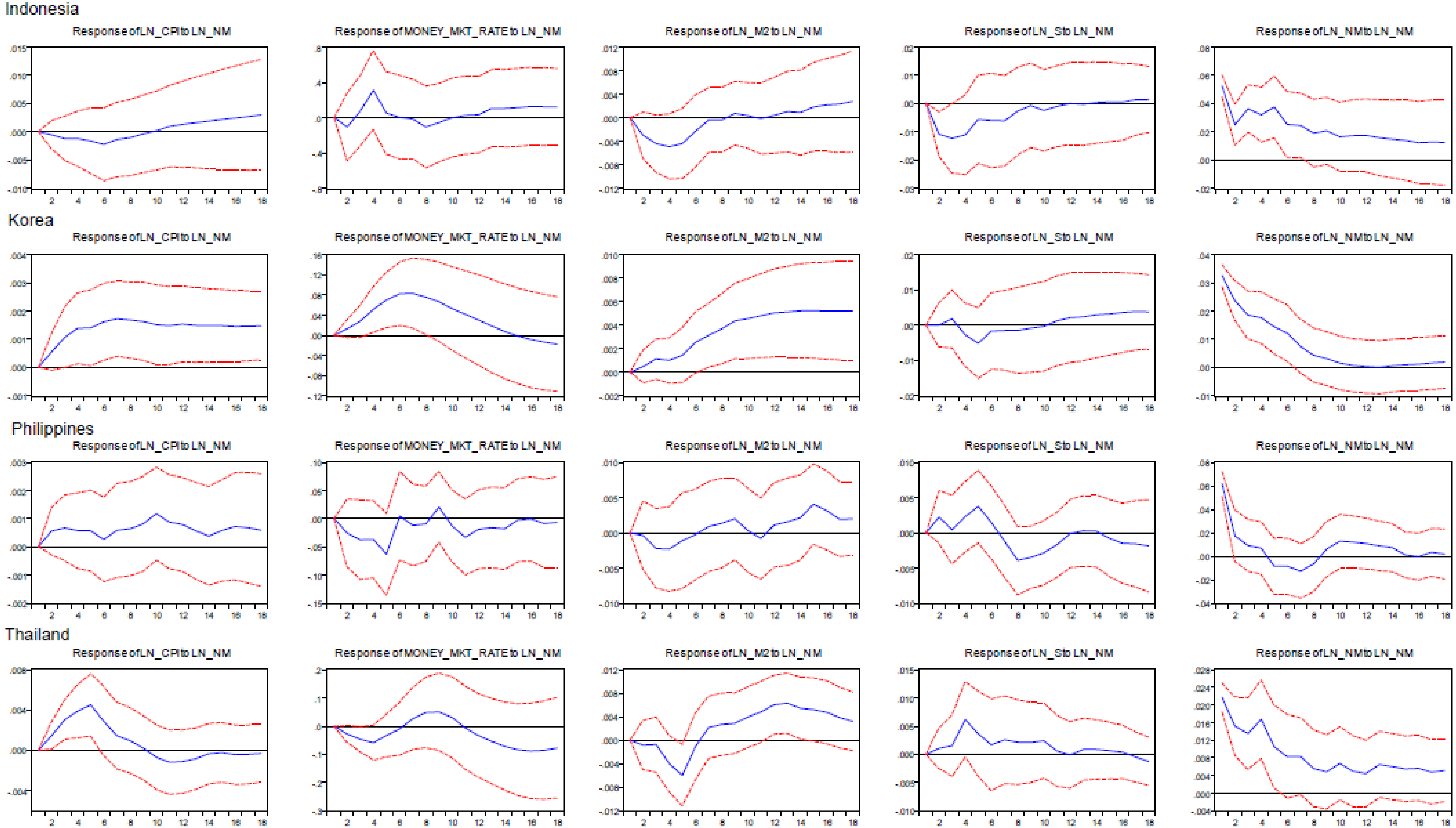


[1] Horizontal axis: foreign exchange reserves as percentage of GDP; vertical axis: credit to private sector as percentage of GDP.

Source: IMF *IFS*.

Graph 14

Impulse responses from vector auto-regression[1]



[1] Red lines indicate 2-standard deviations around impulse responses

Graph 14 illustrates the estimated impact of a one-standard deviation shock to non-monetary liabilities, our proxy for sterilised intervention, on key nominal variables for each economy. For Indonesia and the Philippines the estimated effects of the shock are small, except for an exchange rate appreciation – almost immediate in the case of Indonesia and lagged in the case of the Philippines. For Korea there are significant and persistent increases in consumer prices and broad money, and policy rates also rise, perhaps reflecting the monetary policy response to higher inflation, while the net effect on exchange rates is more muted. Finally, for Thailand, short-lived price increases and exchange rate depreciations follow the shock, while broad money contracts in the short term, but expands over longer horizons.

Overall, the VAR evidence is mixed. For Korea and Thailand, the two economies in the sample with relatively well developed financial markets, "sterilised" intervention does not appear to be fully sterilised, although quantitatively the inflationary effects of sterilised intervention are relatively small: a one-standard deviation increase in sterilised reserves, equivalent to between 2% and 5%, leads to a maximum increase in prices of less than 0.5%. Further, we see in all countries a limited impact of sterilised reserves on exchange rates themselves. Note, however, that the vector auto-regression evidence is based on relationships between the variables over the last 10 years, a period over which reserves grew rapidly. It is possible that risks posed by sterilised intervention have grown steadily worse as reserves have increased, in which case the estimates presented here may understate the true underlying risks.

Together, the results in this section provide some evidence that a number of central banks may have failed to fully sterilise the expansionary effects of reserves accumulation on the domestic economy, implying a growing risk of a loss of effective monetary policy control if the recent rapid accumulation of reserves were to continue. This risk is most clearly visible for China, Hong Kong, India and Korea.

5.3 Policy credibility risk

A lack of domestic monetary control could in principle occur via a number of different channels. For example, a large stock of sterilised foreign exchange reserves may result in reluctance on the part of the central bank to tighten policy in the face of inflationary pressures, since the costs of sterilising reserves are increasing in the spread between local and foreign interest rates. This channel would imply that monetary policy will tend to be relatively expansionary when reserves are larger. There is some evidence of this: in China, Hong Kong, India, Korea and Malaysia there is a significant correlation between higher foreign exchange reserves as a percent of GDP and lower real policy rates- see Graph 15.

To more formally assess the implications of reserves for the conduct of monetary policy, we consider regressions of the form:

$$\Delta YC_{it} = \beta_0 + \beta_{1t}\Delta i_{it} + \beta_{2t}\Delta i_{it}\left(\frac{\text{Reserves}}{GDP}\right)_{it} + \varepsilon_{it}$$

on monthly data where *YC* is the yield spread between 2 and 10 year government bonds and *i* is the policy rate.[18] The interactive term between policy rates and reserves as a percent of

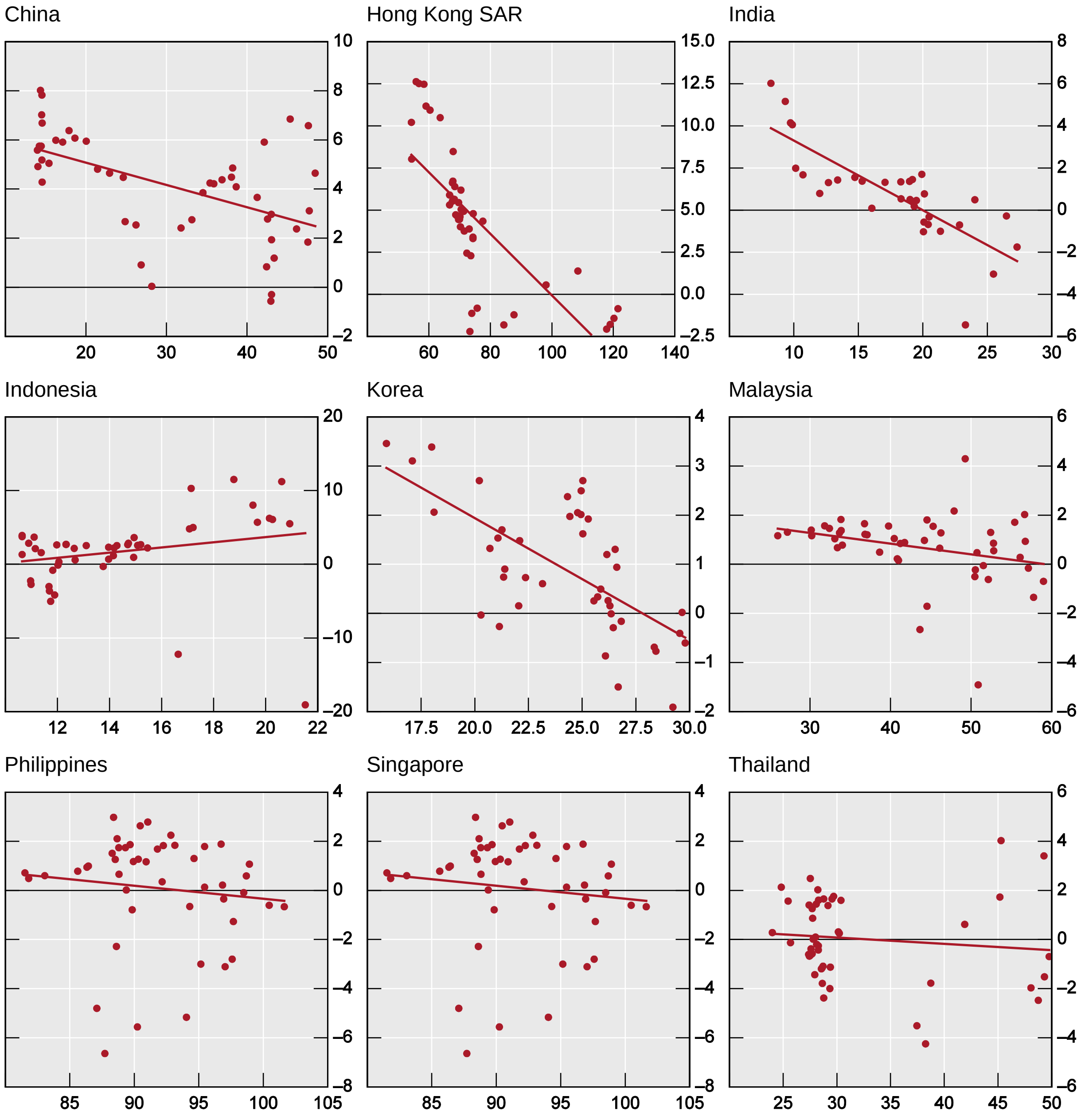
18 The policy rates are 1-year lending rate (CN), Bank Indonesia rate (ID), 1-day reverse repo rate (IN), overnight call rate target (KR), overnight policy rate (MY), overnight reverse repo rate (PH) and 14-day repo rate (TH). For HK and SG the discount window base rate and 1-month interbank offered rate are used as proxies for the policy rate respectively. The one-year rate is used to construct *YC* for MY and PH starting in July 2007 due to data availability. GDP data is interpolated to monthly frequency to construct a measure of (Reserves/GDP).

GDP allows us to assess changes in the relationship between policy rates and the yield curve.

Graph 15

Real policy rate and reserves as percentage of GDP[1]

In per cent



[1] Horizontal axis: foreign exchange reserves as percentage of GDP; vertical axis: real policy rate which is the policy target rate or its proxy minus the 12-month change in the CPI. For China, one-year lending rate; for Hong Kong, base rate; for Indonesia, one-month SBI rate; for India, reverse repo rate; for Korea, overnight call rate; for Malaysia, overnight policy rate; for Philippines, overnight reserve repo rate; for Singapore, 3-month interbank offered rate; for Thailand, 14-day repo rate before 17 January 2007; overnight repo thereafter.

Sources: Bloomberg; IMF *IFS*.

Table 14 presents the results for a number of different specifications: with and without year fixed effects, and including or excluding data from the period of the international financial crisis. The results indicate that an increase in the policy rate tends to decrease the term spread, consistent with a drop in longer term inflationary expectations. However, this effect is smaller the greater are foreign exchange reserves as a share of GDP.

Table 14

Transmission mechanism

Term spread is the dependent variable

Period	(1) 2001-2010	(2) 2001-2007, 2010	(3) 2001-2010	(4) 2001-2007, 2010
Policy rate	-2.43**	-2.43**	-1.19***	-1.13**
	(0.93)	(0.97)	(0.32)	(0.34)
(Policy rate) x (Reserves)	0.027**	0.028**	0.011**	0.013*
	(0.012)	(0.013)	(0.004)	(0.007)
Economy fixed effects	Y	Y	Y	Y
Year fixed effects	N	Y	N	Y
Obs.	927	927	711	711

Standard errors in brackets. ***, **, * indicates significance at 1%, 5%, 10% level respectively.

There are at least three possible explanations for this phenomenon. First, given the potential loss of domestic monetary control as reserves grow (see sections 5.1 and 5.2), an increase in policy rates may not be perceived as having the same anti-inflationary effects for an economy with large reserves. Second, given that monetary policy tightening is likely to result in capital losses for central banks with large reserves due to exchange rate appreciation, the credibility of any anti-inflationary stance may be compromised. Thus a rise in policy rates may be less likely to bring down inflationary expectations and long-term interest rates, so that any narrowing of the term spread is reduced. Third, given that the balance sheets of financial institutions are likely to be distorted by large-scale holdings of sterilisation instruments, banks may effectively hold a large stock of secondary reserves. Thus the supply of credit may be less responsive to short term rates as more foreign exchange reserves are accumulated.

Regardless of the mechanism, one conclusion is clear. The monetary policy transmission mechanism appears to vary with the size of sterilised foreign exchange reserves. Hence a substantial built-up of reserves requires a recalibration of monetary policy to reflect the changed macroeconomic environment.

6. Conclusions

Reserves in emerging Asia have grown dramatically over the past decade. Many of these reserves have been sterilised, via the issuance of non-monetary liabilities by the central banks in the region, with the sterilisation instruments being held primarily by domestic banks. We have used aggregate and bank-level data to explore some of the potential costs and benefits of such policies. We do find some evidence of benefits precisely where they might be intended: the performance of emerging market banking systems during an external crisis. During the East Asian crisis of 1997 and 1998, banks with foreign currency financing faced large losses in value and high likelihood of default (see Chue and Cook, 2008). The desire to avoid this financial damage may drive foreign reserves accumulation. Further, we find evidence that holdings of excess foreign reserves mitigated the financial losses of banks during the financial crisis of 2008. Foreign exchange reserves appear to play little role mitigating risk in more normal times.

We also document some of the costs of reserves accumulation. The holding of a large stock of foreign exchange reserves may negatively impact on the long-run prospects for the economy, even if the inflationary effects of the reserves are fully sterilised. In the presence of financial imperfections such as leverage constraints, a distorted central bank balance sheet (holding too much or too little of some asset) also distorts the private sector's balance sheet in a mirroring manner that can in theory have either positive or negative welfare effects (see Curdia and Woodford, 2011). We provide evidence that the accumulation of excessive levels of reserves has had negative effects on bank lending and investment. There is a concentration of sterilisation instruments, used to finance the accumulation of foreign exchange reserves, in economies with limited financial markets. This may have reduced the level of domestic investment, thereby contributing to global imbalances.

Finally, we examine the effect of reserves on central banks and monetary policy and find evidence that sterilisation appears to be incomplete in some cases, with reserves accumulation leading to higher levels of broad money, inflation and credit.

Appendix 1: central bank balance sheet data

China: foreign liabilities are from the CEIC database. Total liabilities are the sum of reserve money plus foreign liabilities plus bonds plus deposits of government plus other liabilities. Total assets are the sum of total liabilities plus net worth. Domestic liabilities are total liabilities minus foreign liabilities. The monetary base is reserve money.

Hong Kong: total assets, liabilities, and foreign liabilities are from the HKMA Monetary Bulletin. The monetary base is the sum of notes and coins, certificates of indebtedness and clearing balances.

India: total assets are from the CEIC database. Total liabilities are the sum of deposits at the Banking Department plus other liabilities of the Banking Department plus notes in circulation plus notes held in the Banking Department. Foreign liabilities are from the IMF's IFS. The monetary base is reserve money from the IMF's IFS.

Indonesia: total assets are from the CEIC database. Total liabilities are reserve money plus central government accounts plus other liabilities plus foreign liabilities. The monetary base is reserve money. Domestic liabilities are total liabilities minus liabilities to non-residents from IMF's IFS.

Korea: total assets, total liabilities and domestic liabilities are all from the CEIC database. The monetary base is the sum of notes and coins issued and reserve deposits of deposit money banks. Non-monetary liabilities are the difference between domestic liabilities and the monetary base.

Malaysia: total assets are from the CEIC database. Total liabilities are currency in circulation plus deposits plus Bank Negara bills/bonds plus allocation of SDR plus other liabilities. The monetary base is currency in circulation plus deposits of commercial banks, finance companies and merchant banks. Domestic liabilities are total liabilities minus liabilities to non-residents from the IMF's IFS.

Philippines: total assets are from the CEIC database. Total liabilities are total assets minus net worth. The monetary base is currency issued plus deposits: banks and other financial institutions. Domestic liabilities are total liabilities minus liabilities to non-residents from the IMF's IFS.

Singapore: total assets and liabilities are annual data from the CEIC database. Foreign liabilities are foreign liabilities from the IMF's IFS. Monetary base is reserve money from the IMF's IFS.

Thailand: total assets and liabilities are from the CEIC database. The monetary base is banknotes in circulation plus deposits of other depository corporations. Domestic liabilities are total liabilities minus liabilities to non- residents from the IMF's IFS.

Appendix 2: data definitions for regressions

1. *Loan to Asset Ratio* For each bank, the ratio of Loans/Claims/Advances - Customers- Total (LCUACU) to Total Assets (AT).
2. *Real Loans:* For each bank, Loans/Claims/Advances - Customers- Total (LCUACU) deflated by the CPI (Source: IMF *IFS*).
3. *Real Assets:* For each bank, Total Assets (AT) deflated by the CPI.
4. *Loan to Deposit Ratio* For each bank, the ratio of Loans/Claims/Advances - Customers- Total (LCUACU) to Deposits-Total-Customer (DPTC).
5. *Liquidity/Asset Ratio* For each bank, the ratio of the sum of Cash (CH) plus Investment Securities-Total (IST) to Total Assets (AT).
6. *Reserves* End of Period Foreign Assets (from central bank balance sheets, various) converted into Billions of US dollars using the end of year exchange rate (IMF *IFS*).
7. *Size* For each bank, the natural log of foreign assets converted into billions of US dollars using the end of year exchange rate.
8. *Capitalisation* For each bank, the ratio of Total Assets (AT) less Total Liabilities (LT) to Total Assets.
9. *Non-monetary liabilities/GDP:* Non-monetary liabilities are computed as total liabilities less the monetary base and foreign liabilities. GDP is nominal GDP from IMF *IFS*. For each three year period, we take an average of the end of year level for the first two years.
10. *Real GDP Growth:* the log first difference of annual constant price GDP from the World Bank's World Development Indicators. For each three year period, we take an average of growth in each of the three years.
11. *Capitalisation* for each bank is the ratio of net worth to total assets from S&P Global Compustat. For each three year period, we take an average of the end of year level for the first two years.
12. *Size* is the logarithm of bank total assets in USD calculated using an end of year exchange rate from IMF *IFS*. For each three year period, we take an average of the end of year level for the first two years.

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Central bank balance sheets and foreign exchange rate regimes: understanding the nexus in Asia

Andrew Filardo and Stephen Grenville[1]

Abstract

Central bank balance sheets in emerging Asia have been expanding rapidly for the past decade, driven primarily by the accumulation of foreign exchange reserves. Some of the expansion reflects efforts to increase the buffer stock of reserves in the aftermath of the 1997–98 Asian Financial Crisis. Increasingly, however, the reserve accumulation has been the by-product of exchange rate regimes that have in practice tended to resist appreciation. At the same time, policymakers in the region have been able to achieve price stability and bolster financial stability.

This policy experience in Asia is changing the consensus about the trade-off between fixed and floating exchange rate regimes. The past decade has shown that an intermediate approach in Asia has emerged as being both feasible and, by revealed preference, desirable. But this choice however is not without its costs. The unprecedented expansion in the region's central bank balance sheets has increased the carrying cost for central banks and exposed them to significant re-valuation risks as exchange rates and interest rates fluctuate. This paper also introduces concerns about the rise of 'lazy assets' on the balance sheets of private sector financial institutions. These assets are associated with the sterilisation purchases of foreign exchange assets by central banks which, over time, could contribute to financial instability. Conclusions are drawn about the need for more sustainable Asian monetary policy and exchange rate regimes.

Keywords: Central bank balance sheets, foreign reserve assets, exchange rate sterilisation, lazy assets, fundamental equilibrium exchange rate (FEER), carrying costs, monetary stability, financial stability

JEL classification: E58, E61, F31, F33

[1] Head of Economics for Asia and the Pacific, Bank for International Settlements; Visiting Fellow, Lowy Institute, respectively. This paper was written while Stephen Grenville was visiting the Asian Office of the BIS in 2011. The views expressed are those of the authors and do not necessarily represent those of the Bank for International Settlements.

Introduction

Central bank balance sheets in emerging Asia have been expanding rapidly for the past decade, driven primarily by the accumulation of foreign exchange reserves (Graph 1). Some of the expansion reflects efforts to increase the buffer stock of reserves in the aftermath of the 1997–98 Asian crisis. Increasingly, however, the reserve accumulation has been the by-product of regimes for exchange rates that have in practice tended to resist appreciation.[2] At the same time, policymakers in the region have been able to maintain price stability and bolster financial stability.

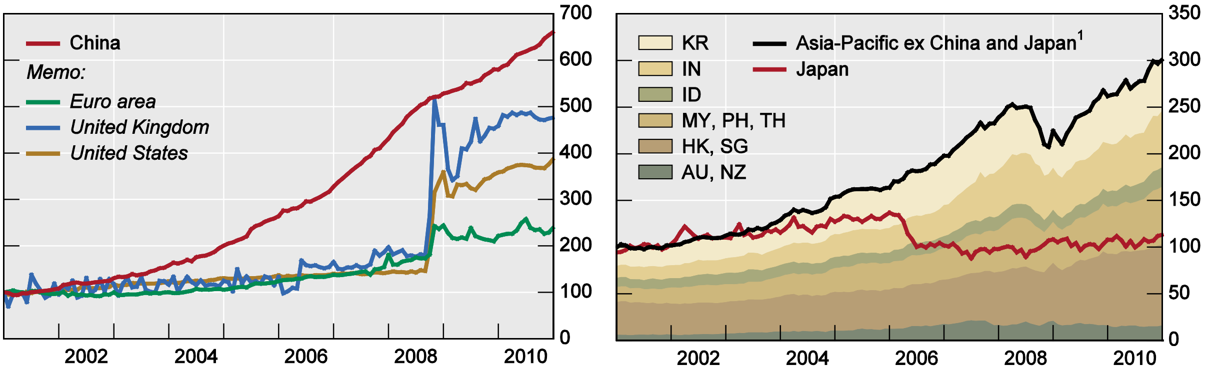
This policy experience in Asia is changing the consensus about the trade-off between fixed and floating exchange rate regimes. At one time, it was thought that the choice was binary: either freely float or fix. The past decade has shown that a third, intermediate, approach has emerged in practice as being both feasible and, by revealed preference, desirable.

However, this third way is not without its costs. The resistance to exchange rate appreciation has led to an unprecedented expansion in the region's central bank balance sheets. Concerns have risen about the implications for macroeconomic and financial stability. Looking forward, it is natural to ask how much longer this rapid and costly asset accumulation can and should go on. And, if it can't go on forever, what will happen when the accumulation stops or even goes into reverse?

Graph 1

Central bank total assets

2001 = 100



AU = Australia; HK = Hong Kong SAR; ID = Indonesia; IN = India; KR = Korea; MY = Malaysia; NZ = New Zealand; PH = Philippines; SG = Singapore; TH = Thailand.

[1] Sum of listed economies.

Sources: Datastream, IMF, *International Financial Statistics*; BIS, national data.

This paper explores the challenges that the expansion of central bank balance sheets poses for policymakers in emerging Asia. We first look at the experience of reserve accumulation, focusing on the implications for monetary and financial conditions through the lens of the size and complexity of central bank balance sheets. Then we look at the challenges in managing

[2] In the advanced economies, by way of contrast, policy actions taken in response to the recent international financial crisis account have also resulted in a sharp expansion in central bank balance sheets, but the causation has been quite different. The Federal Reserve, Bank of England and ECB, for example, have seen their balance sheets grow sharply since mid-2008, as these central banks adopted extraordinary measures to combat the effects of the international financial crisis and the sovereign debt problems in Europe. For Japan, the relevant period is in the late 1990s and early 2000s.

the assets and liabilities of these large central bank balance sheets, before drawing some conclusions about sustainable Asian monetary policy and exchange rate regimes.

I. The expansion of Asian central bank balance sheets

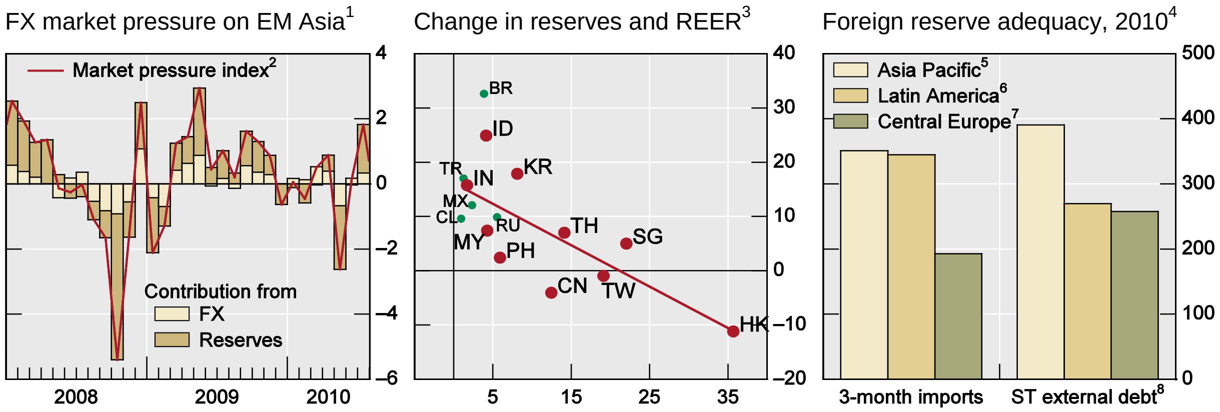
The rapid expansion of Asian central bank balance sheets has been driven primarily by exchange rate concerns. Soon after the Asian crisis, the region's policymakers took to heart the importance of having a sufficient war-chest of reserves. At least in theory, the reserves were there to deter a run on the currency and assure markets that the exchange rate regime was sound. Indeed, credit rating agencies took reserve holdings as one of the key factors determining an economy's credit rating, and thus influencing the cost of local currency borrowing.

By the second half of the 2000s, Asia as a whole was seen as having reserves that were ample according to conventional import and external debt metrics (right-hand panel of Graph 2 and Table A1 in the Annex). With adequate (or more than adequate) reserves, the rationale for continuing to accumulate them was to resist exchange rate appreciation (Graph 2, left-hand and centre panels).

Moves to resist exchange rate appreciation did not imply a reversion to fixed exchange rates. One of the central lessons of the Asian crisis was that fixed exchange rates were hard to defend in the face of large and volatile foreign capital flows coupled with substantial changes in sentiment. But nor did the authorities accept the argument that those countries which could not credibly peg indefinitely should float freely.[3]

Graph 2

Reserves and exchange rates



BR = Brazil; CL = Chile; CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; KR = Korea; MX = Mexico; MY = Malaysia; PH = Philippines; RU = Russia; SG = Singapore; TH = Thailand; TR = Turkey; TW = Chinese Taipei.

[1] China, Hong Kong SAR, Indonesia, India, Korea, Malaysia, Philippines, Singapore and Thailand. [2] Defined as sum of normalised change in nominal exchange rate against US dollar and ratio of normalised change in international reserves to narrow money. [3] Vertical axis: percentage change in real effective exchange rate (REER) from Q1 2009 to Q3 2010 (increase = appreciation); horizontal axis: change in foreign reserves from Q1 2009 to Q3 2010 as a percentage of GDP. [4] In per cent; average of the economies in the region. [5] Australia, China, Hong Kong SAR, Indonesia, India, Japan, Korea, Malaysia, New Zealand, Pakistan, Philippines, Singapore and Thailand. [6] Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela [7] The Czech Republic, Hungary and Poland. [8] Short-term external debt measured as consolidated international claims of BIS reporting banks with a maturity up to and including one year, plus international debt securities outstanding with a maturity up to one year.

Sources: IMF, *International Financial Statistics*; Datastream; BIS; national data.

[3] See Fischer (2001) for a discussion at the time of the range of views on bipolar exchange rate regimes.

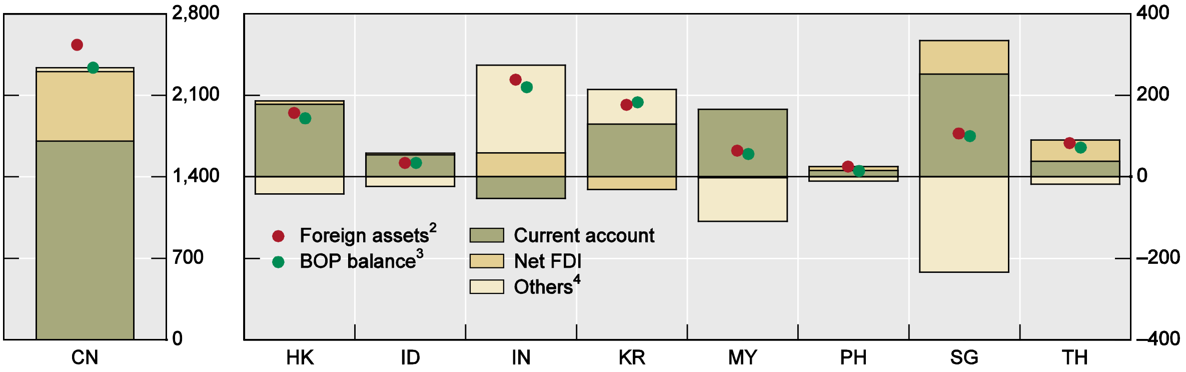
The record in Asia suggests that reality is not so simple. While Malaysia continued its peg until 2005, China had periods of fixity, Hong Kong SAR maintained a fixed rate via its currency board, and Singapore chose a targeted approach, most countries of the region adopted a flexible exchange rate framework. They did not, however, choose a purely free float. The exchange rate regime of choice was a managed float, where the degree of market-determination varied across economies and over time. There were also times of heavy intervention to resist sharp depreciations, notably in Korea and Indonesia during the recent international financial crisis. But the more typical mode was "leaning against the wind" in the face of appreciation pressure, which helps to account for the trend accumulation of reserves.

Another manifestation of this overall policy approach was the current account which, having generally been in deficit before the crisis, now moved substantially in the direction of surplus (Graph 3). While the international policy debate has raised questions about the persistence of these surpluses, the countries affected by the Asian crisis were keenly conscious of the vulnerability that accompanies external deficits. Thus the increase in foreign exchange reserves generally reflected *both* current account surpluses and strong capital inflows. There were, of course, exceptions to this generalisation. For example, India's current account was in deficit, and both Singapore and Malaysia had net capital outflows over the period.

Graph 3

Balance of payments and foreign assets, cumulative change from 2000 to 2009[1]

In billions of USD



[1] Data as of end-2008 for Indonesia, India, Malaysia, Philippines and Thailand. [2] Changes in foreign assets (line 11 IFS) over the observation period. [3] Sum of overall balance for the observation period. [4] Net sum of BOP components other than current account and direct investment.

Source: IMF, International Financial Statistics.

To explore the linkages between the expansion of central bank balance sheets and foreign exchange rate regimes, we start by reviewing how the foreign exchange intervention activities of central banks affect the size of their balance sheets and how these activities alter the composition of central banks' assets and liabilities.

Central bank assets and liabilities: the facts

How does the increase in foreign reserves affect a central bank balance sheet? A simplified central bank balance sheet is given in Table 1. Central bank assets consist of net foreign reserves and domestic assets; the liabilities comprise currency in circulation, bank reserves, deposits of other institutions (including government), the bank's own securities and other liabilities and equity capital. Equity capital represents government transfers to the central bank (plus accumulated profits and losses). Without increased equity capital, the accumulation of assets requires financing in some form. The details of the expansion of Asian central bank balance sheets, in the range of both assets and liabilities, also offer insights into the policy choices of the monetary authorities.

Table 1

A central bank balance sheet

Assets	Liabilities and capital
Foreign assets	Reserve money
Domestic assets	Currency in circulation
Claims on government and public enterprises	Reserves of commercial banks
Claims on the private sector	Foreign liabilities
Claims on domestic money banks	Other deposits of commercial banks etc
Claims on other financial sector entities	Central bank securities etc
	Government deposits
	Others
	Equity capital

Assets

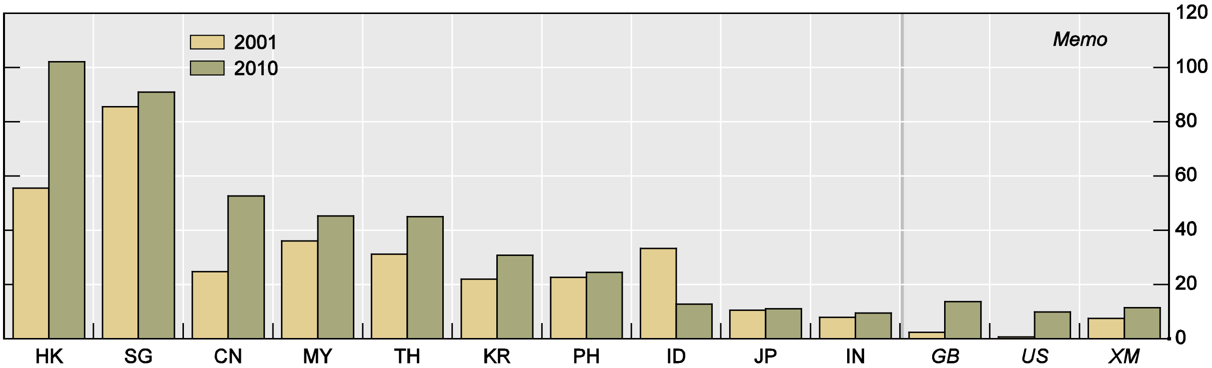
In emerging Asia, the increase in net foreign reserves has come to dominate the balance sheets of all the central banks. After a decade or more of these policies, the sheer magnitude of these foreign exchange reserve holdings now has macroeconomic implications for a number of countries in the region. Singapore and Hong Kong SAR, for example, each have reserves of around 100% of GDP; and China, Malaysia and Thailand have reserves equal to around half of GDP (Graph 4 and Table A2).

Table 2 provides a cross-country perspective on the assets on the balance sheet of the region's economies; Graph 5 illustrates quite vividly the dominant role foreign exchange assets has played in accounting for the cumulated *change* on the asset side of the central banks' balance sheet from 2002 to 2010. All other types of assets played a relatively small role in the expansion of emerging Asia's central bank balance sheets. Some view this behaviour as one-sided and as an attempt to keep exchange rates undervalued.

Graph 4

Central bank assets[1]

As a percentage of GDP



CN = China; HK = Hong Kong SAR; GB = United Kingdom; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

[1] Net of currency in circulation.

Sources: IMF, International Financial Statistics; national data.

Yet the accumulation process was not continuous through the whole period. Some of the central banks experienced a sharp transient reduction during the international financial crisis (see Graph 1, right-hand panel).[4] For example, the Bank of Korea shrank its balance sheet at the end of 2008 as did the Central Bank of Malaysia and the Reserve Bank of India. But these episodes were short-lived, as depreciation pressures rose: foreign assets still dominate the balance sheets.[5] This underscores the point that, even though the run-up in foreign assets has been large and infrequently interrupted over the past decade, the region is open to running down assets when there are depreciation pressures. This supports the view that the intervention policy in emerging Asia should be seen as symmetrical but the shocks to the exchange rate have been one-sided. On this view, foreign reserve accumulation will eventually go into reverse naturally as appreciation pressures subside, although this process may take a considerable time.

Table 2

The composition of central bank assets[1]

As a percentage of total assets

	Foreign assets		**Domestic assets; claims on**							
			Government[2]		**Private sector**		**Banks**[3]		**Others**[4]	
	2001	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**
China	46.5	85.6	6.6	6.1	0.5	0.0	26.5	3.8	20.0	4.5
Hong Kong SAR	100.0	100.0	…	…	…	…	…	…	…	…
Indonesia	48.5	74.4	42.9	24.0	5.8	1.1	2.8	0.4	…	…
India	56.1	77.6	37.5	22.0	…	…	1.7	0.3	4.7	0.1
Korea	86.7	93.4	6.3	4.5	…	…	7.1	2.1	…	…
Malaysia	78.4	84.3	1.0	0.6	18.4	2.7	2.3	12.4	…	…
Philippines	74.1	87.5	18.1	8.7	2.8	2.7	5.1	1.1	…	…
Singapore	95.7	97.5	4.3	2.5	…	…	…	…	…	…
Thailand	73.2	94.3	6.2	5.4	18.4	0.0	2.2	0.2	…	…

[1] Data less than 0.04 is shown as 0.0; unavailable data is shown as '…'. [2] Claims on government and public enterprises. [3] Deposit money banks. [4] Other financial sector entities.

Sources: IMF, *International Financial Statistics*; national data.

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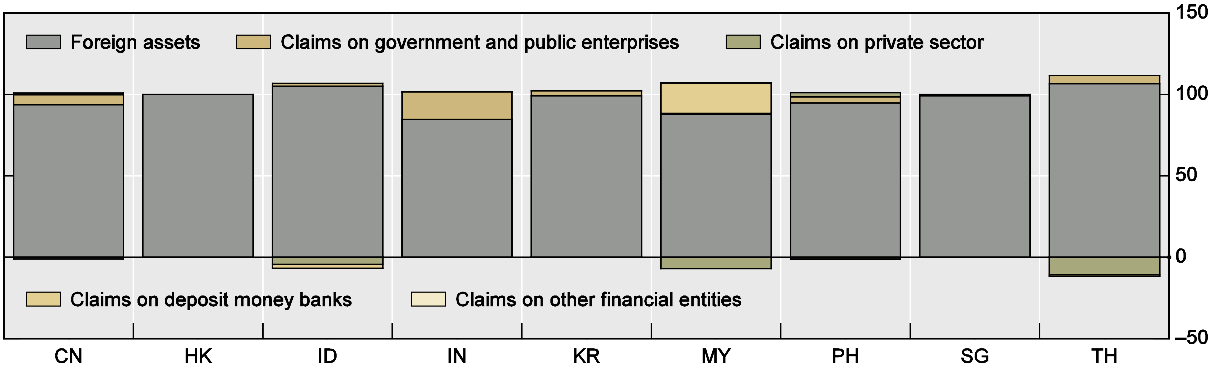
[4] In addition to reducing foreign currency assets on their balance sheet, many central banks reduced off-balance sheet foreign exchange claims. In some cases, the drawdown of net foreign exchange forward positions during the crisis was larger than the change in the on-balance sheet long foreign exchange positions (Graph A1).

[5] The one exception in the 2000s is Japan and this illustrates the role of a central bank's balance sheet in addressing the liquidity needs of the general public and financial institutions. To meet this need, central banks have traditionally relied on open market purchases of securities. From the mid-1990s to the mid-2000s, the Bank of Japan tripled the size of its balance sheet from about 10% of GDP to 30% of GDP. This expansion reflected the extreme financial conditions that first led the central bank to adopt innovative policies in the form of the zero interest rate policy in 1999 and then quantitative easing in 2001. In particular, the quantitative easing programme aimed to support financial market functioning by targeting monetary policy operations at the level of outstanding current account balances of the private sector held at the Bank of Japan. These efforts were also augmented with what is now referred to as credit easing in the form of outright purchases of Japanese government bonds, purchases of asset-backed securities and asset-backed commercial paper, commercial paper repos and equity purchases from financial institutions. While contracting somewhat since the mid-2000s, the Bank of Japan's balance sheet measured in relation to GDP is comparable to that of the Federal Reserve (not including the likely increase in size associated with the latest large-scale asset purchase programme) and larger than those of the ECB and Bank of England.

Graph 5

Change in composition of central bank assets in Asia, 2002–10

As a percentage of change in total assets



CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand.

Source: IMF, International Financial Statistics.

Liabilities

For completeness, it is useful to review the structure of the liabilities side of the balance sheet. The liability side provides a glimpse into the choice of central bank policy instruments used to sterilise the impact of the foreign exchange intervention. Across the region, central banks have looked to various instruments to drain the additional liquidity that is pumped into the economy as central banks buy foreign exchange.

Table 3

Composition of central bank liabilities[1]

As a percentage of total assets

	Reserves of commercial banks[2]		Deposits of commercial banks		Central bank bonds		Government deposits		Others[3]	
	2001	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**	**2001**	**2010**
China	56.5	55.9	…	0.3	…	16.1	6.7	9.6	–2.0	–0.3
Hong Kong SAR	15.6	40.3	…		…	…	46.3	29.1	–16.1	–9.2
Indonesia	14.3	17.8	8.9	32.3	…	5.4	14.9	7.9	8.5	1.3
India	20.5	22.5	…	…	…	…	0.0	5.7	20.3	17.4
Korea	8.7	10.4	0.0	0.0	57.4	47.9	4.5	1.7	0.6	26.1
Malaysia	9.8	1.4	38.1	60.1	…	…	16.9	3.7	1.1	0.8
Philippines	7.2	16.6	10.2	50.3	…	…	7.9	3.5	1.5	0.4
Singapore	5.6	6.1	…	…	…	…	58.2	44.0	27.1	41.0
Thailand	2.6	1.6	10.9	41.7	5.5	21.3	1.4	7.3	–20.8	0.0

[1] Data less than 0.04 is shown as 0.0; unavailable data is shown as '…'. [2] Reserves money other than currency in circulation. [3] Including loans and other items (net).

Source: IMF, *International Financial Statistics*.

Given the various options, it is not surprising that the impact of the expansion of liabilities side of Asian central bank balance sheets has been more diverse than that of the assets side (Table 3 and Graph 6). Currency and reserve money have risen sharply across most of the region, reflecting the strong underlying economic growth in Asian economies. The rise in reserve money also reflects the growth in commercial bank deposits at the central bank. In part, this reflects financial system deepening; it also suggests that commercial banks could put the funds to no better use. In addition, several central banks have raised reserve requirements to curb the growth in bank lending. Greater issuance of central bank paper (eg in China and Indonesia) and the use of deposit facilities at central banks also show up significantly. Changes in government deposits are important sources of change in some economies, reflecting both the traditional mandate of central banks as the government's banker and the use of government deposits as a means to sterilise foreign exchange intervention.

The decade in retrospect

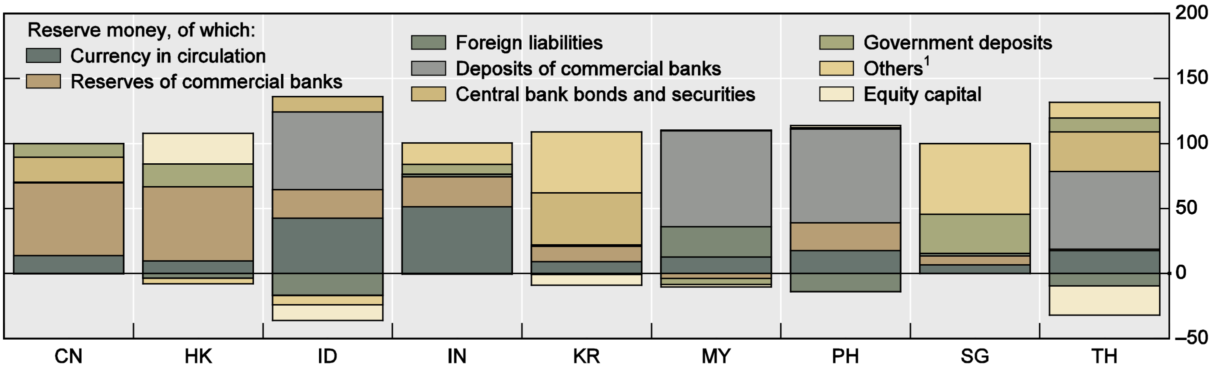
Overall, the period following the Asian crisis has been one of successful policymaking for the central banks of the region. Inflation has remained fairly low and stable, and growth has been strong. Financial stability concerns, while present as financial liberalisation continued apace, did not materialise to the extent seen in the West. It is important to note that central banks do not as a rule face any *technical* difficulty in funding the expansion of their balance sheets (when they intervene, they issue a liability which is usually acceptable in the market). Given this record, one might be tempted to conclude that the rapid expansion of central bank balance sheets via foreign exchange reserve accumulation is relatively benign.

However, such a conclusion may be premature. A number of risks may yet prove disruptive as balance sheets continue to expand. On the macroeconomic side, questions remain about the inflationary implications of a large increase in reserve (base) money. On the financial side, questions remain about whether the liabilities that central banks use to fund the purchase of foreign reserve assets can lead to greater elasticity of the credit supply from banks. In addition, concerns exist that expansion of "other liabilities" (not technically part of reserve money) could crowd out other asset holdings in the financial intermediation process. On the central bank balance sheet management side, does the huge currency mismatch between the asset and liability sides of the central banks' balance sheets raise concerns? This paper explores these issues. To a great extent, the answers to these questions are inextricably linked to the choice of exchange rate regimes in the region. We turn to this topic in the next section.

Graph 6

Change in composition of central bank liabilities in Asia, 2002–10

As a percentage of change in total assets



CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand.

[1] Including loans and other items (net).

Source: IMF, International Financial Statistics.

II. Money, credit, the Impossible Trinity and central bank balance sheets: lessons learnt and policy challenges ahead

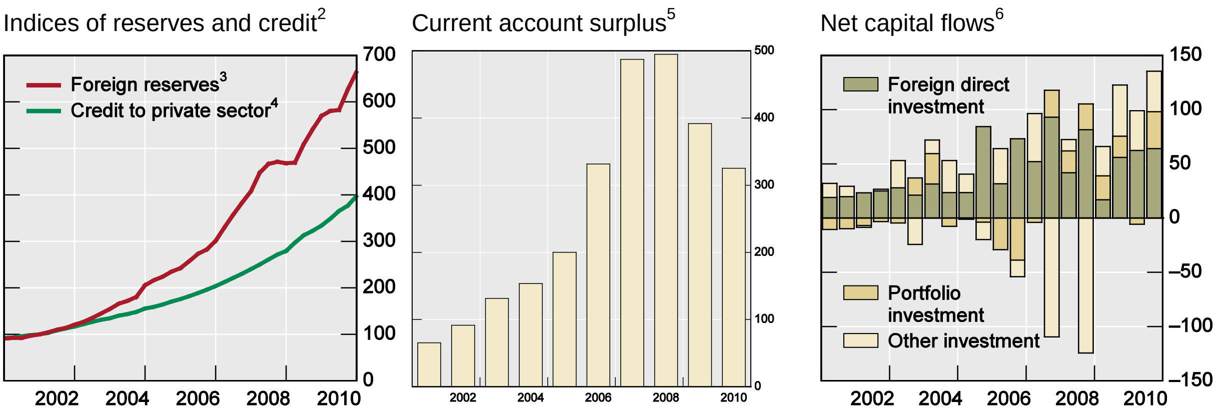
Two main arguments for free floating were heard after the Asian financial crisis. First, proponents of the "corner solutions" view argued that the middle ground of managed exchange rates was untenable. Countries had to adopt hard fixes or free floats. Second, a more general version of this argument was contained in the Impossible Trinity doctrine: countries open to international capital flows could choose a fixed exchange rate or an independent domestic monetary policy, but not both (Calvo (1991), Aizenman (2010)). The concern was that intermediate exchange rate regimes in emerging market economies ran the risk of excessive reserve money and credit creation, raising the spectres of inflation and financial instability.

At first sight, this seems a familiar story to observers of Asia over the past decade. In the region, the fourfold increase in foreign exchange reserves in the seven years shown was accompanied by a three-fold increase in credit (Graph 7). It might seem that these substantial increases were related, as the Impossible Trinity hypothesis would suggest.

However, the apparent link to the doctrine is weaker than at first meets the eye. In the rest of this section, we explore the empirical links from foreign reserve accumulation to money and credit during the past decade. As we shall see, even with the huge increase in foreign exchange reserves, the rise in reserve money was modest (weakening the direct link between foreign reserve increase and credit) and inflation remained well contained. For credit, the supporting evidence is somewhat more favourable to the Impossible Trinity doctrine but, in the end, argues for a new way of thinking about the linkages among foreign reserve accumulation, central bank balance sheets and macroeconomic/financial stability.

Graph 7

Foreign reserves, credit and capital flows in Asia[1]



1 China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. 2 End-2001 = 100. 3 In US dollar terms; sum of the economies listed. 4 Weighted average based on 2005 GDP and PPP exchange rates. 5 In billions of US dollars; sum of economies listed. 6 Positive (negative) indicates inflows (outflows).

Source: IMF, International Financial Statistics.

Central bank balance sheet expansion, money and inflation: the elusive nexus

The Impossible Trinity view envisaged that, if countries attempted to prevent their exchange rates from appreciating, current accounts would move into surplus and foreign exchange reserves would rise. This would boost reserve money and bring about credit expansion, stronger economic activity and inflation, lifting the real exchange rate and eroding international competitiveness. The prospect of this adjustment would also attract foreign capital inflows, further boosting foreign exchange reserves and reserve money. Any attempt to respond to inflationary pressures by raising interest rates would prove counterproductive, encouraging even more capital inflows.[6]

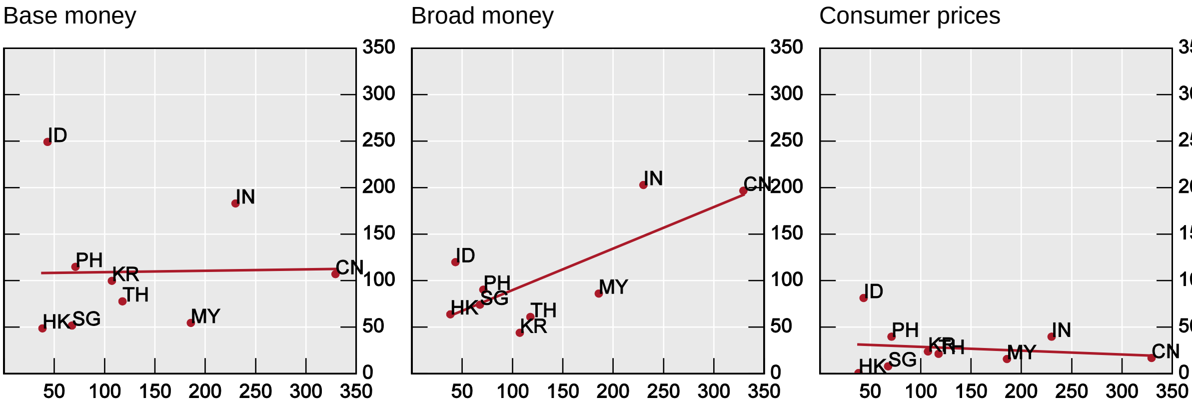
Graph 8 illustrates quite convincingly that the transmission mechanism from foreign exchange asset accumulation to reserve money growth to inflation did not function in emerging Asia during much of the 2000s. The correlation between the growth in central bank assets and reserve money was virtually zero:[7] in the centre panel of Graph 8, the broad monetary aggregates show some tendency to be positively related but, on close inspection, the slope of the line turns out to be largely determined by the observations for China and India. Finally, the correlation with inflation is, if anything, modestly negative.

Overall, these results are consistent with the findings of Aizenman et al (2008) – emerging Asian economies have been able to adopt intermediate exchange rate regimes (ie managed floats) while retaining some degree of monetary autonomy, even as greater financial openness was achieved. Sizeable international reserves have been a critical part of the success of this approach. In other words, the direct monetary effect on inflation of the increase in foreign exchange reserves was effectively sterilised in most countries.

Graph 8

Growth of central bank assets relative to the growth of money and consumer prices[1]

2001–07; in per cent



[1] The horizontal axis shows the change in central bank total assets; the vertical axis represents the change in the variables shown in the panel title.

Sources: IMF, *International Financial Statistics*; Datastream; national data.

Defying the Impossible Trinity: evolving views on the monetary transmission mechanism

How did these emerging Asian economies avoid the apparently inexorable forces of the Impossible Trinity, and successfully take the supposedly untenable middle ground of the "corner solutions" argument?[8]

In a nutshell, the key monetary transmission mechanism envisaged in the Impossible Trinity did not function. In other words, the rise in foreign exchange reserves did not cause reserve

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[6] It was assumed that foreign and domestic assets were close substitutes in this integrated world, so that there would be large inflows in response to even minor interest differentials.

[7] The correlations with net foreign assets are similar; see Graphs A2 and A3 in the Annex.

[8] Others who have looked at these issues in recent years include BIS (2009) and Aizenman and Glick (2009).

money to rise and the credit multiplier process to operate. In retrospect, maybe this should not come as a big surprise. This traditional transmission channel belongs to an earlier era where monetary policy was implemented via control over reserve money, with the growth of credit set via the credit multiplier. In that world, monetary policy operates by restricting the *supply of reserve funds* to the banking system.

Today, this monetary transmission mechanism is much less relevant, even in the emerging market economies. Central banks generally use interest rates as the policy instrument. In other words, central banks set policy interest rates and supply financial markets with the liquidity they want at that price. This has important implications for a central bank's balance sheet when sterilising the accumulation of foreign exchange sterilisation operations. In theory, any increase in domestic liquidity that is not consistent with the policy interest rate setting will flow back to the central bank via domestic liquidity management. In other words, central banks generally, and virtually automatically, sterilise any excess liquidity supplied through foreign exchange intervention.[9]

The developments on the liability side of central bank balance sheets (see Table 3 and Graph 6) illustrate this tendency, as central banks chose various means at their disposal to fund their expanding foreign asset holdings. For all these countries, strong underlying growth in activity raised the public's demand for currency, providing a source of zero interest rate funding. The extent of this currency funding was, of course, determined by the public's demand for currency, and was not under the direct control of the central bank. This funding source was especially important for India and Indonesia.

More widely apparent was the rise in the other element of reserve money – banks' deposits at the central bank. Some of this reflected the normal rise in the demand for bank reserves as the financial sector grows and broadens. It also reflects the reliance of some Asian central banks on the use of the required reserves in their monetary policy frameworks (eg Ma et al (2011) and Montoro and Moreno (2011)). For some Asian central banks, this instrument had become unfashionable during the shift towards a more market-oriented deregulatory approach. More recently, interest in required reserves has revived as a way to help neutralise the build-up of reserve money and short-term liquidity without resorting to policy rate increases.[10]

The past decade has seen two important technical developments on the liability side of central bank balance sheets. First, central banks have increasingly issued their own securities. This represents a powerful sterilisation tool. None of the central banks in our sample had enough domestic government securities on their balance sheets to run these down in open market operations – the conventional text-book liquidity-reducing practice. Thus their ability to issue sterilisation instruments has been a key element of the sterilisation story. Bank Indonesia has issued SBI for this purpose since the 1980s and central bank bonds also have a long history in Korea, but other central banks came to use them extensively only in the 2000s. Thailand's capacity to issue was progressively enlarged during the past decade; the PBC began issuing its own paper in 2003; and Malaysia's capacity to use this instrument was greatly enhanced with new legislation in 2006.[11]

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[9] It is technically relatively easy for the authorities to manage the liquidity requirements of the financial system provided the central bank has suitable instruments for sterilisation, such as the ability to issue its own bonds. The central bank's foreign exchange intervention leaves the banks with excess liquidity, so that there is a ready demand for these stabilisation instruments from the commercial banks.

[10] In addition, it has also have been justified in prudential terms, although the degree to which it has been used exceeds any prudential requirement. China, India, and the Philippines have all relied on this approach. Substantial reserve requirements distort financial intermediation by levying what amounts to a tax on the banking system. Nevertheless it is attractive as a low-cost (sometimes zero-cost) source of funding.

[11] See Glick and Hutchinson (2008) and Mehrotra (2011, forthcoming).

The other important innovation was the payment of interest on excess reserves held at the central bank.[12] This facility was put in place in Malaysia in 2004, Singapore in 2006 and Thailand in 2007 (see Ho (2008)). These two sterilisation innovations broadened the array of market-oriented sterilisation instruments and allowed central banks to avoid reliance on less market-friendly measures such as increases in required reserves. Thus the technical means of sterilisation have been substantially strengthened over the past decade. Where reserve money was not directly sterilised, the commercial banks were offered an incentive (in the form of interest paid on deposits held with the central bank) to go on holding excess reserves, rather than expand their balance sheets through lending.

Another powerful channel of sterilisation is not usually found in the textbooks. Both India and Singapore issue government securities ("overfunding the budget"), and place the cash counterpart of the issue on deposit at the monetary authority: these funds formed the bulk of the sterilisation funding in Singapore and were an important recent (2004) innovation in India. This underscores the importance of the interactions between central bank balance sheet management and sovereign debt management, a topic that has attracted particular attention recently (eg Turner (2011)).

Additional implications

Of course, this may not be the end of the story, even for countries where sterilisation seems fairly complete. The sterilisation process often involves changes in the composition of balance sheets of both central banks and commercial banks. Growth in central bank liabilities leads to growth in the balance sheets of commercial banks which might, in turn, affect their incentives for lending. In other words, as central banks sterilise foreign exchange interventions, they alter the bank lending channel and increase the incentive to expand credit.[13] For example, when sterilisation takes the form of central bank or government securities, the banks take highly liquid securities onto their balance sheets. This could at a later date be the basis for further expansion of their balance sheets if the banks choose to leverage up on this relatively safe asset by expanding credit to the private sector.[14]

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[12] It had been a key element of the credit multiplier story that reserves were unremunerated. This discouraged banks from holding excess reserves and thus gave the central bank leverage to restrain the commercial banks' balance sheets when necessary.

[13] Before addressing that question, we might also ask whether loading up the asset side of the banks' balance sheets with central bank paper might, in fact, have had the opposite effect of crowding out other lending – as banks would little incentive to expand their balance sheets through increased lending if they could instead hold this high-quality paper. It seems unlikely, however, that the sterilisation bonds crowded out credit growth that would otherwise have occurred. The initial source of the foreign exchange reserve increase added to the funding side (deposits) of the banks' balance sheets. If the source of the upward pressure on the exchange rate was a current account surplus, the net export earnings created bank deposits, at least initially. In macro terms, there was a positive savings/investment balance that was available to fund the reserve build-up. In the case of foreign capital inflows, the foreigners initially sold their foreign exchange to a commercial bank which sold it to the central bank. The commercial bank gained additional deposits and held the central bank sterilisation bond. Of course this is not the end of the story, but it suggests that the commercial banks can fund their holdings of sterilisation securities without crowding out their lending. There is the interesting case where the sterilisation bonds are sold to the non-bank public. The new purchaser pays by running down a deposit, which would, at least initially, shrink both sides of the commercial bank's balance sheet, but leave loans untouched.

[14] There would be no effects only in the case where the exporters/foreigners held all the sterilisation bonds. But if the foreigners want to hold other assets, relative prices will have to change to facilitate these shifts in asset holding, and these relative price changes may well affect credit growth. While foreigners didn't hold *all* the sterilisation bonds, they did hold some: in Indonesia, for example, foreigners hold nearly 30% of SBIs (Bank Indonesia's sterilisation instrument) and government securities.

In the absence of the traditional credit multiplier process, effects via *relative price changes* are possible within the financial sector. Relative price changes might alter banks' funding costs (and their lending margins), and their cost of raising capital (Borio and Zhu (2008) and Disyatat (2010)). While such changes no doubt have occurred, these are such subtle influences that they could be hard to disentangle from large changes in bank margins caused, for example, by the stickiness of lending rates in response to changes in the policy rate (which have been found to be on the order of 200–300 basis point changes in bank margins over the course of the business cycle in some cases).

Central bank balance sheet, credit, asset prices and financial stability

Perhaps surprisingly, given the growth in the aggregate credit data shown in Graph 7, when credit growth as a percentage of GDP is examined country by country, the picture is not particularly clear that the region's credit growth has been a persistent problem in a way that would suggest a systematic build-up of financial imbalances. In the first part of the 2000s, only two economies (Korea and India) show substantial growth (Graph 9). Korea, in particular, has seen a credit card boom gone bad during this period, and property price bubbles were a policy concern. Most of the other countries show credit expanding not much faster than nominal GDP.

Moreover, we cannot rule out special factors that could account for part of the rapid credit growth in these two economies. They began the decade with an unusually low level of credit t to GDP, by international norms. For Korea, one element of the story is that businesses obtain a substantial part of their funding from sources other than the domestic banking system. But even with this caveat, the fast credit growth in both these countries can be partly explained in terms of the transition towards a normal level of bank intermediation. This, of course, still raises important policy issues about the speed of transition, the dangers inherent in the transition process and the problem of identifying when the transition has run its course. These judgements are difficult because credit has to grow faster than GDP in order to achieve a new normal.[15]

However, recent trends suggest the relatively benign assessment for the earlier part of the decade may be too favourable. Since the business cycle trough in early 2009, credit growth in the region has been surging as has foreign reserve accumulation (Graph 9, left-hand panel). China, Malaysia, Hong Kong and Thailand stand out in this respect. At the same time, this surge in credit creation and foreign reserve accumulation has corresponded with robust growth in housing and equity prices (centre panel, Graph 9).

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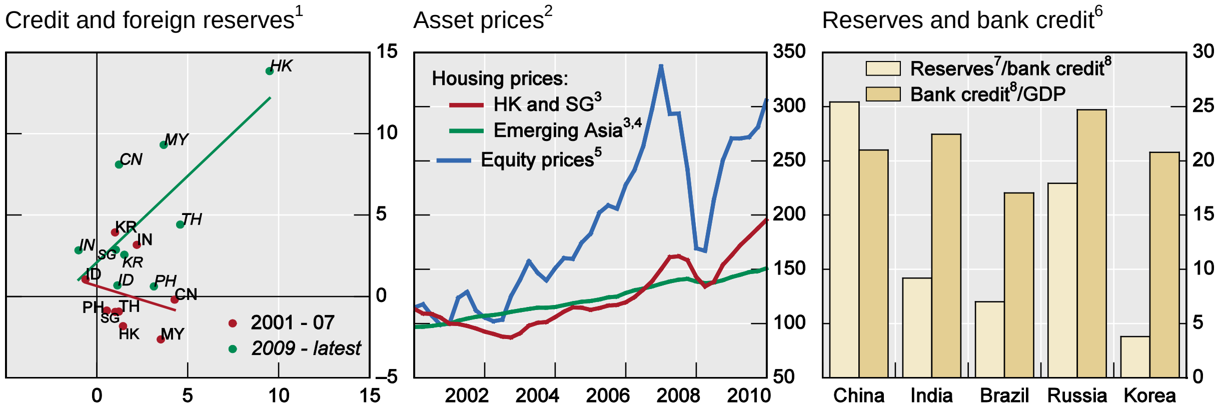
[15] In several of these countries (notably Korea and Indonesia), one of the legacies of the Asian financial crisis was that bank lending to corporations and businesses fell away (for both demand and supply reasons) and banks saw households as more bankable customers. As a result, there are policy issues in Korea relating to the growth and extent of household debt (eg Chung (2009)). Household debt grew from one quarter of total lending in 1999 to nearly one half by 2002. This took household debt from 50% of GDP to over 70%, and as a percentage of household disposable income, it rose from 80% to 130%. Since then it has levelled out as a percentage of GDP and household income. The same trends can be seen in Malaysia: banks' loans to households grew from one third of total loans in 1997 to 56% in 2007 (Endut and Hua (2009)). In Thailand, the ratio of debt to household income rose from 40% in 1998 to 58% in 2004 (Subhanij (2009)). The focus here, however, is on the development of the overall credit aggregates.

Graph 9

Foreign reserves, credit and asset prices



1 Horizontal axis shows foreign reserves as percentage of GDP; the vertical axis represents credit to the private sector as percentage of GDP; annual average change in the ratios. 2 End-2001 = 100. 3 Weighted average based on 2005 GDP and PPP exchange rates. 4 China, Hong Kong SAR, Indonesia, Korea, Malaysia, Singapore and Thailand. 5 MSCI emerging Asia in local currency. 6 Increase, in percentage points; end-2002, latest available data. 7 Foreign exchange reserves minus currency in circulation. 8 Bank credit to the private sector.

Sources: IMF, *International Financial Statistics*; Bloomberg; CEIC; national data.

The elasticity of lending *capacity* and financial stability concerns

Is it possible that the decade of rapid foreign reserve accumulation has contributed to a surge in lending activities and that vulnerabilities of the financial systems in Asia will be exposed?[16] In other words, did the increase in liquid assets associated with sterilisation operations help to shape this environment of rapid credit growth?[17]

One view is that the growth of credit during most of the decade has been determined largely by demand rather than by the availability of funding via sterilisation operations. In most Asian economies (eg Indonesia, Korea, Malaysia, the Philippines, Thailand, Hong Kong SAR and Singapore), commercial banks continuously held substantial excess reserve money and stabilisation instruments on their balance sheets. If they had expanded their balance sheets in the way envisaged by the traditional credit multiplier process, these holdings would have been taken up in the form of additions to required reserves and public currency holdings, as credit growth pushed well beyond the growth of nominal GDP.

16 Here we can see an important distinction between sterilisation by means of issuing central bank paper, and sterilisation via increased reserve requirements. The former, while more market-friendly, gives commercial banks the funding liquidity that would allow them to expand their lending, should they decide to do so, while the cruder instrument of reserve requirements exercises a more direct restraint on banks' balance sheet expansion. The large volume of "lazy assets" (in the form of low-yield sterilisation bonds) on the balance sheets of the banks in five of the countries in this group provides the funding by which these banks could expand credit. Where banks have no room to profitably increase their lending, they are captive holders of these instruments, and the authorities can use this fact to cut the interest rate on these instruments, thus reducing the cost of their sterilisation operations. But such a strategy will give banks greater incentives to find new lending opportunities. Over time, pressure will build to replace these low-return assets with high-earning loan assets. The presence of these low-risk assets may encourage banks to take on higher-risk alternative assets (offering loans to customers previously considered to be not bankable). To keep these instruments "bedded down", the authorities have to offer a full market return, and this makes the sterilisation operation more expensive. Even where the instruments offer the full policy rate, there is often a substantial margin between the policy rate and the lending rate, providing incentives to replace the sterilisation instruments with loans.

17 For a detailed discussion of these issues, see Mohanty and Turner (2006).

Another view would argue that these vulnerabilities were largely dormant during much of the 2000s but nonetheless grew. Indeed, we cannot exclude the possibility (even likelihood) that *some* of the rapid credit growth that was seen at times arose from the elastic supply of bank lending. Again, Korea's experience points in this direction. By and large, however, most of the liquidity associated with the foreign exchange intervention appears to have found a home in the form of currency or required reserves. The situation now seems more worrisome.

The critical question is whether this increased elasticity of the credit supply can quickly lead to unstable financial conditions that promote excess credit expansion, rapid asset price growth and eventually financial instability.

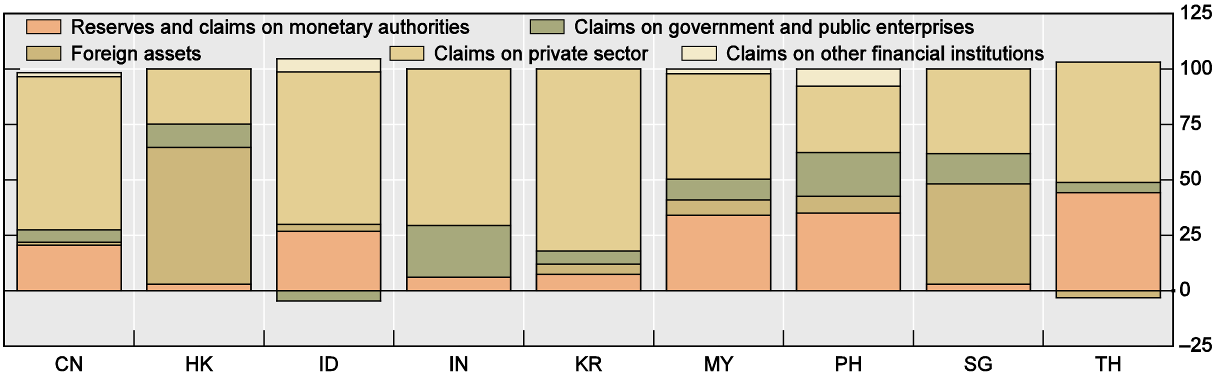
The concerns associated with this view have already taken on considerable importance given the state of Asian commercial bank balance sheets. Graph 10 shows that commercial banks in all these economies (with the possible exception of China) have accumulated substantial holdings of near-reserve-money instruments: central bank or government paper, or foreign currency.

Moreover, Graph 11 underscores the potential lending elasticity of Asian financial systems even under the new financial regulatory regime being put in place internationally. It shows that capital reserves of the Asian banking systems are well in excess of the Basel requirements (ie Asian banks on the whole are not particularly capital constrained),[18] and that for all, except for Korea and perhaps Thailand, the loan/deposit ratio suggests that bank lending is not constrained by a shortage of deposit funding.

Graph 10

Change in assets of deposit money banks, 2002–10

As a percentage of change in total assets

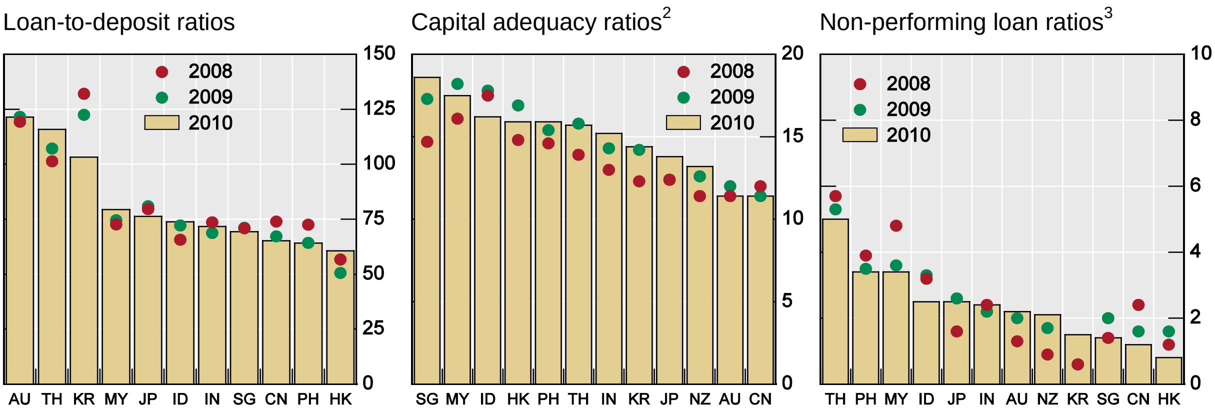


Source: IMF, International Financial Statistics.

[18] The one exception is China in 2006.

Graph 11

Bank soundness indicators[1]



AU = Australia; CN = China; HK = Hong Kong SAR; IN = India; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; NZ = New Zealand; PH = Philippines; SG = Singapore; TH = Thailand.

[1] In percent. [2] Total capital as a percentage of total risk-weighted assets. [3] Definitions may vary across countries.

Sources: IMF; Bloomberg; CEIC; national data.

Some tentative lessons learnt: four aspects of the policy trade-offs in this environment

The demise of the bipolar view associated with the canonical Impossible Trinity doctrine begs the question of what replaces it. Here we offer four important aspects of an environment in which the constraints of the Trilemma are relaxed. Though not mutually exclusive, they provide a more empirically appealing way to think about the policy trade-offs facing Asian central banks. First, foreign reserve asset accumulation may be an effective, though partially, independent policy tool. Second, macroprudential policy tools and capital flow management tools offer effective ways to constrain excessive money and credit growth. For these two possibilities, questions arise about whether they can be effective beyond the short term. Third, the greater use of monetary conditions indexes (MCIs) in the formulation of monetary policy may be warranted. Fourth, the active foreign exchange intervention implicit in intermediate exchange rate regimes may pose more significant macroeconomic-financial stability risks than have been experienced in the past decade.

1. Foreign exchange reserve accumulation: a partially independent policy tool

The Asian experience suggests that central banks in the region can intervene in the foreign exchange market and resist nominal appreciation pressures while at the same time liberalising financial markets and retaining some degree of central bank independence for considerable periods of time. In other words, foreign exchange rate intervention seems to have had some success in influencing exchange rates without sacrificing the ability of credible, low-inflation monetary policy frameworks to deliver price stability.

It is worth noting that inflation did pick up in 2008 and again recently. As in Aizenman (2010), this may suggest that while the accumulation of foreign reserves may loosen some of the constraints of the Impossible Trinity doctrine in the short term, but there are limits. Establishing those limits in practice for both price stability and financial stability may prove to be quite difficult.

2. Monetary policy is not alone: factoring in other policy tools that can constrain credit growth

One might argue that monetary policy was kept relatively accommodative over the past decade while macroprudential tools, as they are now termed, were successfully used to rein in credit. Graph 12 suggests that, judged by the real policy rate, the policy stance has been generally accommodative in recent years. This is consistent with the view that relatively conservative financial system practices were adopted in the aftermath of the Asian financial crisis in the late 1990s and that this was sufficient during much of the decade to ward off the financial instability associated with rapid credit and asset price growth.

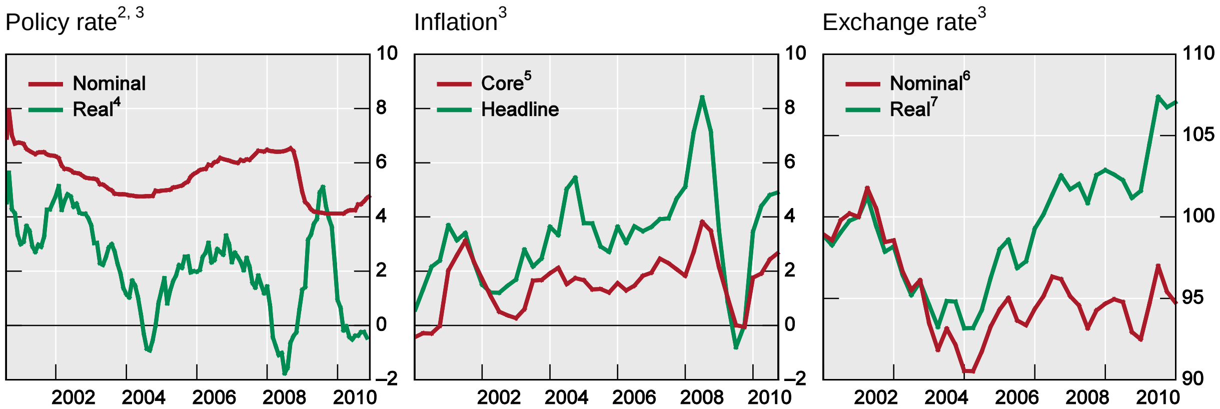
Why did policymakers choose to kept policy rates relatively accommodative and rely more heavily on non-price policy tools? Two possible explanations relate to the choice of exchange rate regime. First, authorities may have been concerned about disruptive capital inflows. A risk often mentioned by Asian central bankers in recent years is that higher interest rates would attract even larger foreign inflows, intensifying upward pressure on the exchange rate and also exposing their economies to the risk of a sudden and disruptive stop of capital flows at a later stage. Second, some central banks have argued that a real appreciation of the exchange rate would eventually achieve the external restraint in a less costly manner than would appreciation of the nominal exchange rate. The latter argument has taken on greater force in 2010–11.

Whatever the case, one view argues that macroprudential policy tools and capital flow management tools can effectively relax the constraints of the Trilemma. But can they do so over the medium and long term? The jury is still out but recent developments suggest that such tools can only buy time and are not effective substitutes over the longer term. The continued frothiness in property markets in Hong Kong SAR and Singapore underscores the limitations of macroprudential tools in fine-tuning the relationship between credit supply and credit demand.

Graph 12

Monetary policy and central bank balance sheets in emerging Asia[1]

In per cent / index



[1] China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. [2] For China, one-year lending rate; for Hong Kong SAR, base rate; for India, reverse repo rate; for Indonesia, one-month SBI rate; for Korea, overnight call rate; for Malaysia, overnight policy rate; for the Philippines, overnight reserve repo rate; for Singapore, three-month interbank offered rate; for Thailand, 14-day repo rate before 17 January 2007, overnight repo rate thereafter. [3] Weighted average of listed economies based on 2005 GDP and PPP exchange rates. [4] Policy rates or their proxies minus 12-month change in CPI. [5] Headline inflation excluding food and energy. [6] Nominal effective exchange rate; an increase indicates an appreciation. [7] Real effective exchange rate; an increase indicates an appreciation.

Sources: Bloomberg; CEIC; BIS; national data.

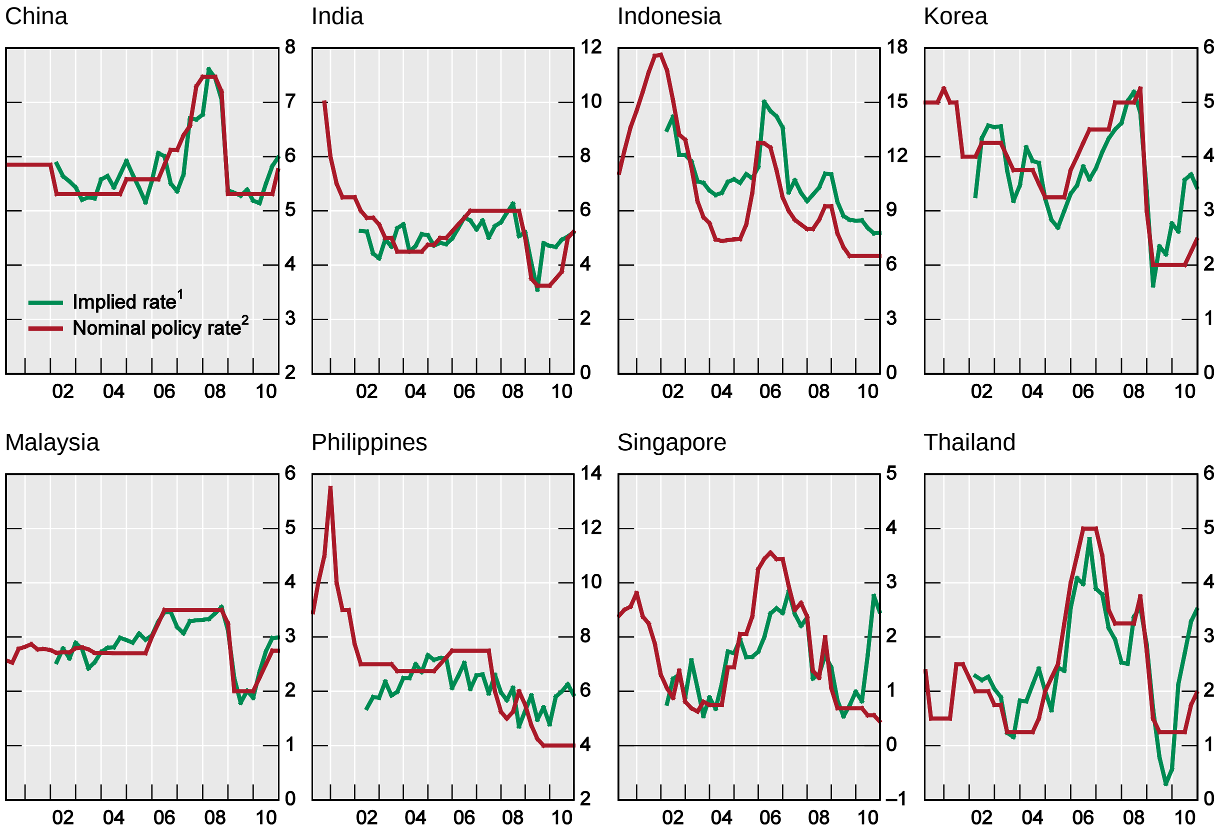
3. *The stance of monetary policy and the return of the MCI*

Some years ago, it was common practice to assess the monetary policy stance in terms of a Monetary Conditions Index (MCI) that combined both the level of interest rates and the exchange rate. The rationale was that, if the market had pushed up the exchange rate, this appreciation would restrain both domestic demand and prices, so that a lower interest rate would be consistent with the same policy stance. The use of the MCI has since become less common, as it came to be recognised that the MCI can give misleading signals on the appropriate policy stance when the terms of trade change.[19]

Graph 13

Policy rates and those implied by the Taylor Rule

In per cent



[1] Fitted values of model $R_t = a + b(\pi_{t-1} - \pi^T_{t-1}) - g(y_{t-1} - y^*_{t-1}) + m f_t + h f_{t-1} + e_t$, excluding the period Q1 2008–Q3 2009 and previous crises. *R* is the nominal policy rate; π is the headline inflation rate; π^T is the inflation target for inflation targeting countries; the five-year moving average of headline inflation is taken to be a proxy for the inflation objective in the other economies; *y* is output; *y** is the output trend estimated with a Hodrick-Prescott filter (smoothing parameter 1,600); *f* is the year-on-year nominal effective exchange rate change. [2] For China, one-year lending rate; for India, reverse repo rate; for Indonesia, one-month SBI rate; for Korea, overnight call rate; for Malaysia, overnight policy rate; for the Philippines, overnight reserve repo rate; for Singapore, three-month interbank rate; for Thailand, 14-day repo rate before 17 January 2007; overnight repo thereafter.

Sources: © Consensus Economics, Bloomberg; Datastream, national data.

In fact it may be useful to bring this MCI idea (with its prominent role for the exchange rate) back from the wilderness when assessing whether recent monetary policy has been appropriately set. Graph 13 summarises the results of a Taylor Rule regression which incorporates the exchange rate both as a policy objective (on the right-hand side of the equation) and as a policy instrument (on the left-hand side of the equation).

[19] If the exchange rate appreciation reflects stronger terms of trade (eg higher export commodity prices), it would not be appropriate to lower interest rates in order to keep the MCI stable. A higher MCI would be appropriate, and policymakers still have to make this judgment. Similarly, when the market delivers a lower exchange rate, it is not always appropriate to keep the MCI constant by raising interest rates.

Of course, such Taylor Rule estimations only show how policy at a particular point of time compares with what it would have been if the authorities had responded to the objectives in the way they have done on average over the estimation period. But it suggests that, for most of these countries, recent policy settings as measured by an MCI are quite accommodative.

4. Macrofinancial risks arising from possible misperceptions

The choice of an intermediate exchange rate regime requires greater reliance on foreign exchange intervention both on the upside and the downside of the exchange rate pressure cycle. In the past decade, the appreciation pressures in Asia were symptomatic of emerging market economies experiencing strong economic growth. If the shocks hitting these economies are largely permanent, potential output grows quickly, and this calls for considerable credit expansion to finance the increased activity. This situation is consistent with an upward trend in private credit in the 2000s (see Graph 7).

A more worrisome situation could arise if the supply shocks are thought to be permanent but prove to be transient. In this case, a pickup in productivity growth would draw in capital flows, boosting bank lending and aggregate supply. The resulting growth in supply would help to hold down goods and services prices while, at the same time, lifting equity and housing prices. All this would tend to confirm a view that the potential growth of the economy was on a higher trajectory in the short term. However, if this higher trajectory is transient and disappoints expectations, the additional credit growth and associated investment could prove to be excessive. Depending on the extent of the excess, this credit cycle gone bad could lead to a collapse of confidence, a recession and a sudden end to capital flows.

All this suggests that correlations between foreign exchange intervention and credit need not suggest imperfect sterilisation. The correlations could simply reflect a tendency for policymakers to assume that "this time it is different" and to put too much weight on the possibility that a run of good outturns is symptomatic of a permanently new trajectory for economic activity. Over the whole cycle, which admittedly can be long in the case of emerging market economies, this could lead to excessive debt accumulation by both domestic agents and foreign investors, all of which may end badly. Emerging Asian economies should remain vigilant against this possibility.[20]

III. The costs of holding foreign exchange reserves in Asia

In the previous section, it was argued that policy can both influence the exchange rate to some degree and, at the same time, maintain an independent monetary policy. Even if feasible, though, is this a good idea? One important consideration in this decision is the cost of holding these very large investments in foreign reserves. In other words, can the continued expansion be justified in terms of the costs and benefits? Arguably, these costs will play an increasingly important role in determining when to stop accumulating, or when it would be appropriate to reverse current trends.[21]

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[20] As Reinhart and Rogoff (2009) remind us, "Policymakers should not have been overly cheered by the absence of major external sovereign defaults from 2003 to 2009 after the wave of defaults in the preceding two decades. Serial default remains the norm, with international waves of defaults typically separated by many years, if not decades."

[21] While central banks in the western world have typically seen domestic assets rising over time, the Swiss National Bank is an exception. In recent years, it has intervened in its foreign exchange markets and has amassed a large quantity of foreign exchange reserves. Danthine (2011) stresses that the losses associated with holding such reserves should be evaluated over the whole risk cycle. Nonetheless, significant short-term losses can raise questions about the appropriate degree of central bank independence.

The average running cost ("quasi-fiscal costs" represented by the differential between domestic and foreign interest rates) of reserve-holding has been relatively modest over the past decade, and the benefits of substantial foreign reserves were demonstrable during the international financial crisis (especially for Korea, Malaysia and Indonesia). But the interest differential is only one component of the cost of reserve-holding: the central bank also incurs a capital loss when the domestic currency appreciates, which has been the case for almost all these economies. Allowing for this, the cost of reserve-holding is roughly twice as large as the interest differential measure of quasi-fiscal costs. A series of factors seems likely to raise the net cost of reserve-holding in the future, thereby raising questions about how much longer the current trends can be sustained.

Costs of reserve holding

The net cost of foreign exchange reserve-holding is usually measured in terms of the interest differential between the foreign exchange-denominated reserve asset and the domestic funding cost (see Graph 14). There are various ways of calculating this cost: simple interest differential; opportunity cost of funding; opportunity cost in terms of the marginal productivity of capital (Genberg et al (2005)). The cost could be calculated as an average of the various funding sources, or as the cost of the marginal (most expensive) funding source. For our purposes here it will be enough to compare a measure of the income on reserve holdings with the cost of official debt.[22] For most countries in this group during the past decade, domestic interest rates have been historically low (reflecting in part the slow recovery from the 1997–98 Asian crisis). With the exceptions of India and Indonesia, the differential to foreign rates has been less than 2%.

This, however, is an incomplete measure of the costs of holding reserves. If uncovered interest parity (UIP) held, this measure would overstate the cost where domestic interest rates were higher than the foreign interest return: the capital gains on holding the foreign assets would precisely offset the interest differential. While UIP clearly does not hold (see Engel (1996)), the capital gains/losses should be included in the calculation of the cost of reserve holding. In fact, the lesson of the failure of UIP is that the high-interest currencies routinely depreciate by substantially less than the UIP interest differential would imply, and often even appreciate.[23] The capital gains and losses should be taken together with the net interest cost in calculating the costs of maintaining foreign exchange reserves. Graph 14 (right-hand panel) shows that, in recent years, low interest rates in the developed countries have implied considerable capital gains on longer-term bonds; of course, this phenomenon will go into reverse as central banks normalise policy rates.

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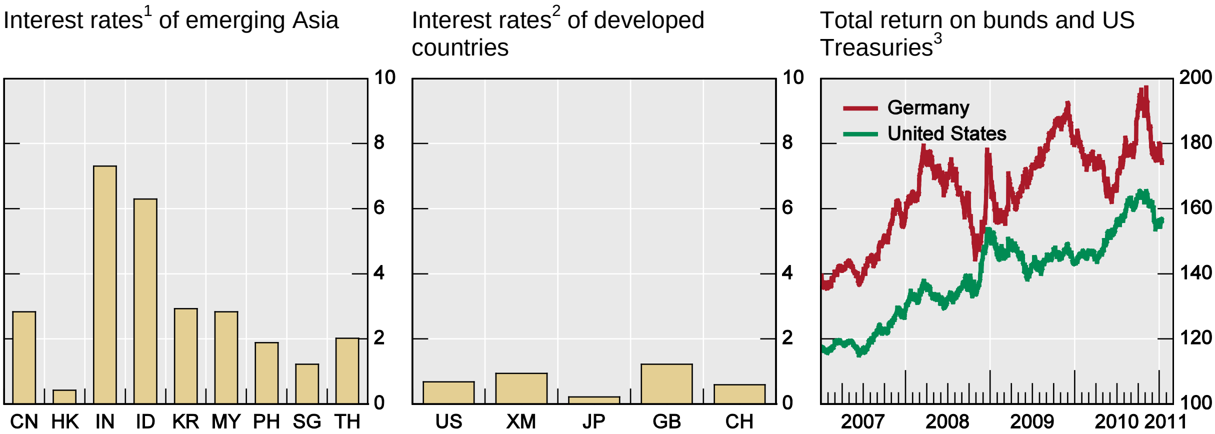
[22] As a rough measure of the financial opportunity cost of holding the foreign exchange assets: if the foreign exchange reserves had not been held, this debt could have been redeemed.

[23] The net of the interest differential and the exchange rate change has tended, for much of the time, to provide a positive return to those who held the high-interest currency. This has led to the popularity (and profitability) of the currency carry trade: borrowing in low-interest currencies and holding high-interest currencies. In effect, building up official foreign exchange reserves puts the authorities in the recipient countries on the other side of the carry trade transactions: the authorities are borrowing in the high-interest rate domestic currency, which is usually appreciating (perversely in terms of the UIP) and holding assets in the low-interest currencies that are losing value.

Graph 14

Interest rates and total bond returns

In per cent / index



CH = Switzerland; CN = China; HK = Hong Kong SAR; GB = United Kingdom; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = euro area.

[1] Latest observed yields of available three-month, six-month, one-year, five-year and 10-year government bills and bonds; weighted average based on amount issued in 2010. [2] Simple average of one-year to three-year government bonds. For Switzerland, average of one- and two-year bonds. [3] GBI global traded total return index level, seven-to-10 year, in US dollar terms; 2000–06 = 100.

Sources: Bloomberg; Datastream; JPMorgan Chase; national data; BIS calculations.

Table 4 shows the change in exchange rates over the past decade. The precise result depends on the period chosen, but the trend and broad message is clear enough: for most of the countries in this group, investing in US dollars results in a loss of around 2% per year, calculated in terms of the domestic currency of these countries.[24] For India and Indonesia, the capital appreciation cost has been smaller than the group average but the interest-differential cost has been higher. For the others (except for Hong Kong SAR with its fixed rate), the overall cost of reserve holdings roughly doubles the currency appreciation cost is taken into account.

Capital losses of this nature do not limit the central bank's ability to intervene to restrain an appreciation and to sterilise the effect of that intervention, but they do cause asset valuation losses which weaken their profit-and-loss accounts or their balance sheets. The capital losses on appreciations either diminish profits or are taken into the balance sheet in the form of reductions to reserves.

For most countries, the costs of reserve holding will impinge on the central banks' balance sheets which typically do not have large capital to absorb such losses, especially on an on-going basis. The dominant position of foreign exchange holdings on these balance sheets makes them susceptible to huge losses from currency appreciation: their balance sheets are much more vulnerable and fragile than would be permitted for a commercial bank.[25]

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[24] Behind these figures is a more fundamental story of structural change: most of these countries show trend appreciation in their real effective exchange rate (see BIS data), reflecting the Balassa-Samuelson structural effects of higher productivity. For countries that have maintained low inflation, this is reflected in appreciating nominal exchange rates as well. For some countries (eg Indonesia, Hong Kong SAR), the real appreciation took the form of a faster rate of inflation, relative to the US. The outcome, in terms of the cost of holding reserves, is reflected in a different form of cost: higher-inflation countries pay a larger interest differential on their reserve holdings but experience a smaller capital loss.

[25] Ho and McCauley (2007) discuss central bank balance sheet losses from appreciation for three countries, including Korea and Thailand.

Table 4

Bilateral exchange rates versus the US dollar

	Percentage changes, end-2001 to latest[1]
CNY	21.53
HKD	0.21
IDR	16.18
INR	2.34
KRW	10.46
MYR	21.12
PHP	13.78
SGD	36.53
THB	41.50

[1] July 2010 for Indonesia; August 2010 for others.

Source: IMF, *International Financial Statistics*.

In all the countries of this group, the foreign exchange reserves are held by the central bank. Accounting conventions differ from institution to institution, but a bank applying IFRS should bring the capital losses associated with appreciation into its profit and loss account (P&L) each year.[26] The public reporting of the weakened P&L may diminish the central bank's reputation. Even when these losses are taken into revaluation reserves rather than into the P&L, currency appreciation reduces reserves and net capital.[27] If the central bank has to go cap-in-hand to the ministry of finance and parliament to seek their approval for a capital replenishment, the reputational damage may be attended by a weakening of its independence.

The costs of reserve holdings are likely to rise in the future. First, the greater size of the foreign exchange reserves relative to GDP will increase costs. Second, the funding interest differential between domestic and foreign rates seems likely to widen. With interest rates in the reserve currency countries likely to stay low for quite some time and regional domestic rates likely to rise as economic growth resumes, the differential will widen from the abnormally small levels seen over much of the past decade. Larger inflows will be attracted by this wider interest differential, accelerating the accumulation. In addition, credit rating agencies might upgrade the country in question, belatedly adjusting to the region's stronger prospects. Lastly, to the extent that exchange rates will unwind any existing undervaluation, reserve holding will become more costly in terms of capital losses.

[26] For discussion of cross-country information on the institutional settings for monetary, exchange rate and intervention policies, see Moser-Boehm (2005).

[27] In addition, year-by-year variations in exchange rates can bring about a distribution of capital gains, with depreciations of the domestic currency giving rise to foreign exchange revaluation gains that are recorded as profits and transferred to the budget. Subsequent appreciations impose losses that will diminish capital over time.

Benefits of reserves

Weighed against these net holding costs are the benefits of *precautionary reserves* and the *macro-benefits* from resisting an unwelcome appreciation.

There is a large literature on how much reserve holding is needed for precautionary purposes.[28] The usual measures are unsatisfactory.[29] A more useful approach would be to see what degree of reserve usage was practised in countries that came under pressure in the international financial crisis, with scenario simulations replacing these arbitrary rules of thumb (Table A1). This sort of country-by-country stress testing might take into account the experience of Korea and Indonesia during the international financial crisis, when the market focused on (and was alarmed by) the *fall* in reserves rather than being reassured by the substantial level of reserves still remaining. This might suggest that large reserve holdings are not a very effective way of providing support to market confidence.[30]

The macro-motivation for persistent intervention is harder to quantify. There is certainly a perception that a significantly stronger exchange rate would restrain growth in the most dynamic part of the economy – the export sector – and some of the literature suggests that the export-led strategy has been beneficial (Rodrik (2008)). There is also the example of Japan's "lost decade", which many observers see as demonstrating (a least in part) the dangers of rapid exchange rate appreciation when other instruments to offset deflationary pressures are lacking. In an earlier era, Japan's experience during the Bretton-Woods period also supports the idea that an undervalued exchange rate is good for growth.

Against this, there is the near-inevitability of some structural appreciation over time, as encapsulated in the ideas of the Balassa/Samuelson mechanism. When these countries close the technological gap with the advanced economies over time, their equilibrium real exchange rates will appreciate. To resist this rise in the equilibrium rate is expensive in the near term (in terms of valuation losses and other reserve-holding costs) and ultimately futile.

The broad conclusion might be that these countries already have ample reserves and have no prudential reason to accumulate more. Yet the macro-motivation is like a treadmill: just to stay in the same place requires continuous (and probably increasing) accumulation. The additional reserve holdings go beyond a broad notion of the necessary precautionary requirements and, instead, they have to find their justification in terms of investment returns

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[28] Of course this intervention could be done through official foreign borrowing at the same time as the intervention (running up liabilities rather than running down assets). A number of these countries have, in fact, used the forward markets for intervention rather than draw on reserve holdings (see Graph A1). That said, most countries feel the need to have a substantial level of reserves ("in the shop window") to demonstrate their ability to intervene, and not all countries can be confident of being able to borrow under very adverse circumstances.

[29] Early criteria, relating reserves to months of imports, are much less relevant when the capital account provides much of the volatility in the balance of payments. Measures in terms of M2 seem to imply that all those holding domestic currency will seek to convert their currency holdings, whereas the experience is that this does not happen, even in severe crises such as the Asian financial crisis. The Guidotti/Greenspan ratio suggests that countries should hold reserves equal to all the foreign debt falling due over the next year. This might make sense in those countries (eg Latin America) where there are significant longer-term overseas borrowings, where this ratio is designed to enable the country to remain solvent even if borrowers cannot roll over the foreign debt for a year. This metric, however, makes little sense in response to short-term capital inflows: it suggests, in effect, that the short-term inflow should be entirely used to build up foreign reserves, against the possibility that this same inflow proves to be volatile. Rather than the official sector taking on the risks associated with private short-term capital inflows in this way, there is a compelling logic to discourage this sort of inflow.

[30] This may suggest that multilateral sources (eg liquidity facilities available through the Chiang Mai Initiative and the International Monetary Fund and central bank swap arrangements) might be more effective, especially when viewed in combination with ample domestic foreign reserve assets.

and national-level portfolio diversification. For many of the region's countries, intrinsic factors seem to make reserve holding a poor investment. A 4% cost (reflecting a 2% interest differential plus a trend appreciation of 2%) combined with reserve holdings equal to half of GDP would result in a cost of roughly 2% of GDP per year. Whether this is calculated as a financial cost (as reflected in the central bank's balance sheet) or in terms of opportunity cost (the benefits that would have accrued had this investment been in a higher-return asset), the message is the same: large reserve holdings have serious macro implications. Whatever rationales there may be for existing levels of reserve holdings, serious questions are raised, for many of the countries in this group, by current policies – which, if continued, will take reserves above levels that can be justified in terms of precautionary benefits.

IV. Towards a sustainable macroeconomic configuration

We noted above that the build-up in foreign exchange reserves has not yet resulted in serious financial pressures. The authorities have seen the growth in credit as benign, a position supported by the strong balance of payments and moderate inflation. But this situation is changing. In 2010–11, inflation pressures have been building significantly, in part because of the advanced stage of the Asian business cycle and in part because of the sharp rise in food and energy prices. And, a soft patch in global economic activity in 2011 has affected both the advanced and emerging market economies.

Looking ahead, a continuation of accommodative monetary policy seems neither desirable nor sustainable. With inflation now showing up more clearly, substantially less monetary policy accommodation is needed in various Asian jurisdictions to ensure price stability (Graph 13). But, these firmer monetary policies are likely to intensify currency appreciation pressures. Unfortunately, the current response – to resist this appreciation by accumulating foreign exchange reserves – will become increasingly costly and could threaten the integrity of central bank balance sheets. More worrisome is the possibility that the substantial volume of "lazy assets" (in the form of low-return sterilisation assets) on the balance sheets of the commercial banks will encourage these banks to lower credit standards and expand credit faster.

To the extent that foreign reserves serve a precautionary purpose, facilitating two-sided intervention that nets out over time, this is sustainable and presents no serious policy conflicts. Intervention in response to an exchange rate that is veering from equilibrium should prove profitable when the exchange rate returns to equilibrium. Variations around the equilibrium give central banks the opportunity to make profits while at the same time stabilising the currency. This profit can offset the costs of reserve-holding. Examples of this sort of exchange rate management can be seen in Korea, Indonesia and Malaysia in 2008.

These examples are, however, the exception in the past decade. Most intervention has been predominantly on one side – to resist appreciation – and hence the trend accretion in foreign reserves.

This does not necessarily imply that the best alternative is a free-floating exchange rate. Rather, it suggests that intervention should be based on an assessment of where the fundamental equilibrium exchange rate (FEER) might lie. This assessment in turn would be based on estimates of the sustainable current account position, and the capital flows that are the counterpart of this position. Of course the precise value of this FEER will be uncertain, so it might best be seen as a band or range, and perhaps quite a wide one if the uncertainties are great.[31] The band should be wide enough to accommodate the expected changes in the

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[31] See Williamson's BBC proposals (Williamson (2000)).

equilibrium over the course of the business cycle (appreciating in the strong phase of the cycle, weakening in the trough). For countries with terms-of-trade cycles, the band might similarly be wide enough to accommodate the cyclical shift in the equilibrium exchange rate implied by the commodity-price cycle. The band might also appreciate gradually over time, to accommodate the Balassa/Samuelson effect, and could be modified when evidence suggested that the equilibrium was not well centred in the middle of the band.[32]

In this framework, the role of foreign reserve accumulation is clear and rule-based. When the exchange rate approaches the edges of the band, the presumption would be that intervention would occur. If the band were centred on the FEER, over time the interventions would be two-way, roughly symmetrical and profitable. This strategy requires that foreign reserves (under the "precautionary" rationale) should be sufficient not only to fund the intervention but also to support the intervention-credibility of the authorities. Of course, the costs of carrying these reserves on the central banks' balance sheet must be factored into the calculation, over the whole risk cycle.

This approach needs to be embedded in a broader macro-strategy that identifies what a sensible sustainable current account would be for the country. Current account surpluses have been typical in the region over the past decade, perhaps reflecting the disastrous vulnerability that external deficits inflicted in the 1997–98 Asian crisis. But there is a powerful argument that capital should "flow downhill" from the advanced economies towards the emerging countries, with their greater productivity and profitability, as they move towards the technological frontier. This implies a shift in current accounts towards deficit, through an increase in investment (ie the savings/investment balance has to change). In this scenario, the exchange rate would be allowed to appreciate so that it is consistent with this new, more sustainable current account configuration.[33]

Foreign capital flows need to match these current accounts if sustainability is to be achieved. While foreign capital shortages are part of the legacy mind-set of many policymakers in the region, inflows are much more likely to be excessive.[34] The progressive shift towards the technological frontier holds out the prospect of high productivity and profitability for some decades ahead. With closer global integration, foreign investors are increasingly responding to this underlying profitability differential.

How could these excessive inflows be constrained? This might require a range of capital account management approaches. Controls on capital inflows are now more readily accepted as a legitimate part of the policy toolkit, especially when such controls are market-friendly (eg Chilean-style interest rate taxes) and focused on short-term inflows, which probably provide the least benefit and greatest volatility risk. At the same time countries receiving excessive inflows might have to be prepared to see some of their asset prices rise above equilibrium. Such overpriced assets present the foreign investor with a

[32] Detailed specification of this FEER strategy is not explored here. Within this approach, there is room for the edges of the band to be flexible, to be announced or unannounced. The key point here is that successful intervention requires some view on where the equilibrium exchange rate lies, and some ideas about the best tactics for effective intervention around this rate. When floating was seen as the best approach, there was no need to have a notion of what the equilibrium exchange rate might be. But, if a managed float is to make sense, assessments of the equilibrium are needed.

[33] The sterilisation of existing capital inflows is, in effect, a conscious avoidance of the real resource transfer that these financial flows potentially represent. An alternative policy would recognise the benefits of a higher level of investment (with both the funding and real resources coming from overseas). This alternative would also acknowledge that (China and India aside) rates of investment (and GDP growth) have been substantially lower since the Asian crisis of 1997–98. This different macro configuration would result in a greater appreciation of exchange rates, combined with current account deficits, greater investment and faster growth.

[34] This conclusion is consistent with the broad historical record for emerging market economies presented by Reinhart and Rogoff (2009).

downside risk of reverting towards their lower equilibrium level, and thus might discourage further inflows. Asset prices in this category would include the exchange rate (thus the authorities might have to accept some degree of persistent overvaluation),[35] but would also include equity prices and commercial and residential property, especially the high-end developments favoured by foreign investors.

Conclusion

Our starting point might seem to be similar for most of the region – the fast build-up of foreign exchange reserves as countries intervened to offset foreign capital inflows combined with rapid, perhaps excessive, credit growth. But closer examination suggests differences rather than uniformity. Several countries have had capital outflows rather than inflows (with their foreign exchange accumulation reflecting big current account surpluses rather than capital inflows). While the reserve build-up is large for five of the countries, it is modest for the others. Credit growth is clearly faster than nominal GDP in several of the economies. The policy response also differs: most notably, two countries have monetary approaches which give policy no influence over interest rates, with the only effect on credit growth being via prudential policies and suasion.

Yet a common message does come out of this exploration. All these countries now have foreign exchange reserve levels that are adequate or more than adequate (in some cases, much more). While these countries have, in general, been able to sterilise the impact of foreign exchange reserve build-ups, they do not seem to be able to use the interest rate setting vigorously enough to impinge on the demand for credit when it is growing strongly. They are in transition, not only in their financial sectors, but in their monetary policy. Control over reserve money growth is no longer an effective fulcrum for constraining the growth of bank balance sheets, but they have not yet put in place the full institutional backing (including one that addresses the political economy constraints) for operating monetary policy through interest rates.

Foreign exchange reserves in many emerging Asian economies are now at levels that raise important policy questions about the return on this national investment. With the possible exception of China, all these countries would seem likely to benefit if they allowed the real resource transfer corresponding to capital inflows to occur to a greater extent (ie to move the current accounts in the direction of deficit), using the extra real resources for investment. This investment is likely to be more socially beneficial than the current alternative of holding low-return foreign reserve assets.

This provides the starting point for an overall macro-response. Current accounts moving towards deficits (with higher investment and faster GDP growth) point to greater appreciation of exchange rates. This does not require the abandonment of the successful policy, over the past decade, of managing the exchange rate to achieve stability and so avoiding a disruptive pace of appreciation. If the authorities are managing the exchange rate so that it is somewhere near the equilibrium consistent with a sustainable current account position, the Impossible Trinity would not be violated. Pressures on this strategy may come from excessive capital inflows, but these can be addressed by accepting some overvaluation of assets, together with active discouragement of short-term capital inflows.

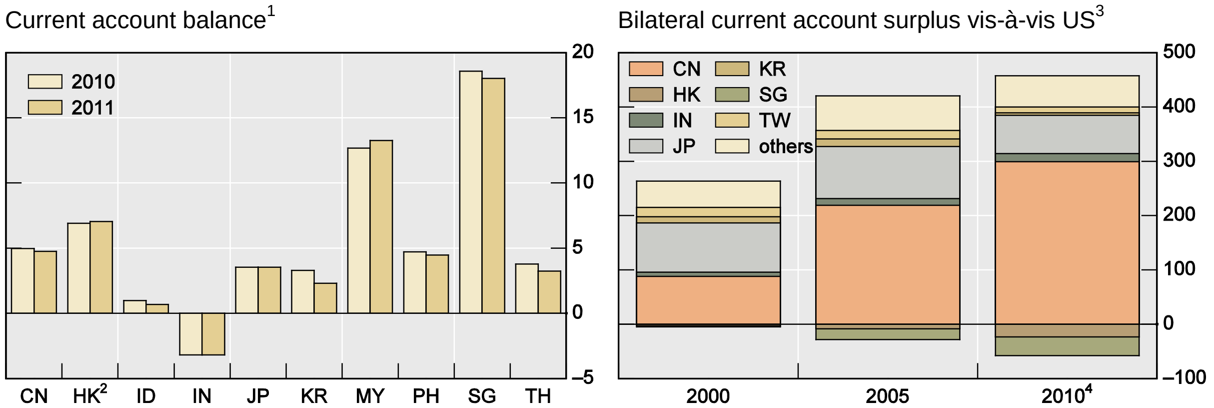
Finally, even though this paper has focused on the issues in emerging Asia, the actions taken by policymakers in the region have significant implications for the global economy.

[35] One classical motivation for a transitory exchange rate overshoot of this type is given by Dornbusch (1976). However, the transition may prove to be much longer-lived than in the conventional application of the model.

Graph 15 highlights the fact that current account surpluses in general have been large and in particular substantial and growing with the United States. One issue that we have not addressed in this paper is whether the prolonged and large-scale foreign exchange intervention strategy followed in Asia has effectively worked against the inherent features of the international adjustment mechanism to promote an orderly resolution to global imbalances. To fully understand this important issue, policy spillovers from both sides have to be evaluated. While Asia has certainly pursued exchange rate regimes based on heavy intervention, the West has pursued policies (eg quantitative easing and fiscal deficits) that arguably destabilised the global macroeconomic environment and pushed capital flows into the dynamic emerging market economies. From this perspective, the exchange rate regimes adopted in Asia may be a second-best way of addressing these global frictions.

Graph 15

Current account imbalances in Asia



CN = China; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; TW = Chinese Taipei.

[1] Surplus as a percentage of GDP; Consensus Economics and IMF estimates. [2] Goods and services balance. [3] In billions of USD. [4] Q4 2010 estimates are average of Q1–Q3 2010.

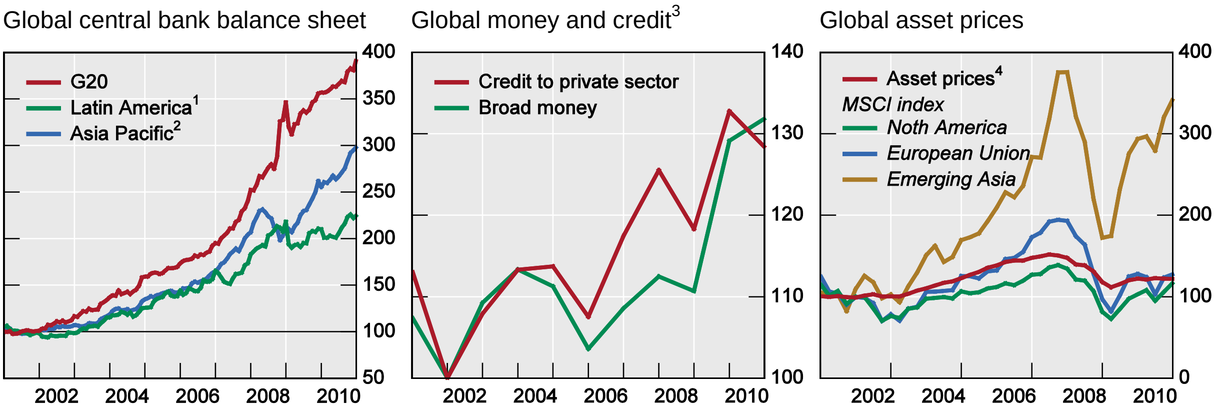
Sources: Consensus Economics©; IMF, *International Financial Statistics*; IMF, *World Economic Outlook*; national data.

In addition, we have not addressed the potentially important implications of a simultaneous surge in central bank balance sheets globally, as was highlighted in Graph 1. While it appears that Asian central banks have been able to sterilise the impact of foreign exchange interventions on domestic inflation, one has to wonder whether the accommodative monetary policy in Asia and that in the advanced economies may be contributing to a surfeit of global liquidity that is finding its way into asset prices and, in 2011, into a surge in commodity prices and into generalised inflation in some economies (Graph 16). The trends in central bank balance sheets also may play a significant role in driving the prices in international financial markets. What might be the implications of a significant shift in the future trend of foreign asset accumulation? Such issues deserve further exploration.

Graph 16

Global dimensions

2001 = 100



[1] Chile, Columbia, Peru and Venezuela. [2] Hong Kong SAR, Malaysia, New Zealand, Philippines, Singapore and Thailand. [3] As a percentage of GDP; aggregate of G20 and economies listed at footnotes 1 and 2. [4] An index represents equity price, residential property price and commercial property price; weighted average of Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, United Kingdom and United States based on 2005 GDP and PPP exchange rates.

Sources: IMF, World Economic Outlook; IMF, World Economic Outlook; national data.

Annex

Table A1

Foreign reserve adequacy[1]

Outstanding year-end reserves position

	In billions of US dollars			As a percentage of quantity indicated							
				GDP	3-month Imports	Short-term external debt[2]			Broad money		
	96	08	10[3]	10[3]	10[3]	96	08	10[3]	96	08	10[3]
Australia	14	29	42	3	89	21	15	15	4	4	3
China	105	1946	2761	49	852	376	1868	1147	11	28	26
Hong Kong SAR	63	178	261	116	283	36	189	226	19	22	28
India	20	247	269	19	351	260	338	235	11	27	20
Indonesia	18	49	86	13	310	51	174	201	15	30	33
Japan	207	1003	1042	19	665	...	264	199	4	12	11
Korea	33	200	287	29	278	45	172	171	6	19	19
Malaysia	26	91	102	47	288	226	402	457	20	35	29
New Zealand	6	11	15	12	222	61	55	93	25	26	31
Pakistan	1	7	13	8	169	19	343	617	2	12	20
Philippines	10	33	53	28	378	121	406	364	26	43	52
Singapore	77	174	218	101	293	44	150	184	73	75	69
Thailand	37	108	162	52	387	80	998	1169	18	38	42
Memo:											
Asia[4]	*617*	*4076*	*5310*	*38*	*351*	*...*	*413*	*391*	*18*	*29*	*30*
Latin America[5]	*142*	*440*	*545*	*13*	*345*	*145*	*362*	*270*	*77*	*53*	*...*
Central Europe[6]	*40*	*133*	*180*	*25*	*193*	*383*	*171*	*258*	*39*	*33*	*38*
Other[7]	*29*	*513*	*564*	*17*	*390*	*59*	*272*	*379*	*19*	*42*	*36*

[1] For the outstanding year-end position, regional aggregates are the sum of the economies listed; for percentages, simple averages. For 2009, latest available data. [2] Consolidated cross-border claims to all BIS reporting banks on countries outside the reporting area with a maturity up to one year plus international debt securities outstanding with a maturity of up to one year. [3] Latest available data. [4] Economies shown above. [5] Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela [6] The Czech Republic, Hungary and Poland. [7] Russia, South Africa and Turkey.

Sources: IMF; Datastream; national data.

Table A2

Central bank total assets

	In billions of USD		As a percentage of quantity indicated							
			GDP		Currency held by the public		M2[1]		Bank credit[2]	
	01	10[3]	01	10[3]	01	10[3]	01	10[3]	01	10[3]
Australia	32	73	8	6	217	165	12	6	10	5
China	516	3680	39	63	272	591	27	35	35	48
Hong Kong SAR	105	259	63	114	811	943	27	35	42	63
Indonesia	60	97	38	15	817	457	74	43	209	66
India	86	340	18	21	180	179	31	27	63	43
Japan	892	1510	24	27	181	174	12	12	21	25
Korea	123	326	25	34	867	1168	35	45	31	33
Malaysia	39	106	42	52	679	949	31	37	33	52
New Zealand	6	23	12	16	675	895	14	18	11	11
Philippines	20	56	28	30	524	718	45	54	79	169
Singapore	79	227	93	98	1232	1343	81	74	79	97
Thailand	46	142	39	48	477	678	34	42	41	51
Memo:										
Euro area	*718*	*2490*	*12*	*21*	*285*	*230*	*17*	*23*	*11*	*15*
United Kingdom	*71*	*388*	*5*	*17*	*190*	*562*	*4*	*9*	*4*	*8*
United States	*680*	*2377*	*7*	*17*	*111*	*263*	*9*	*21*	*13*	*30*

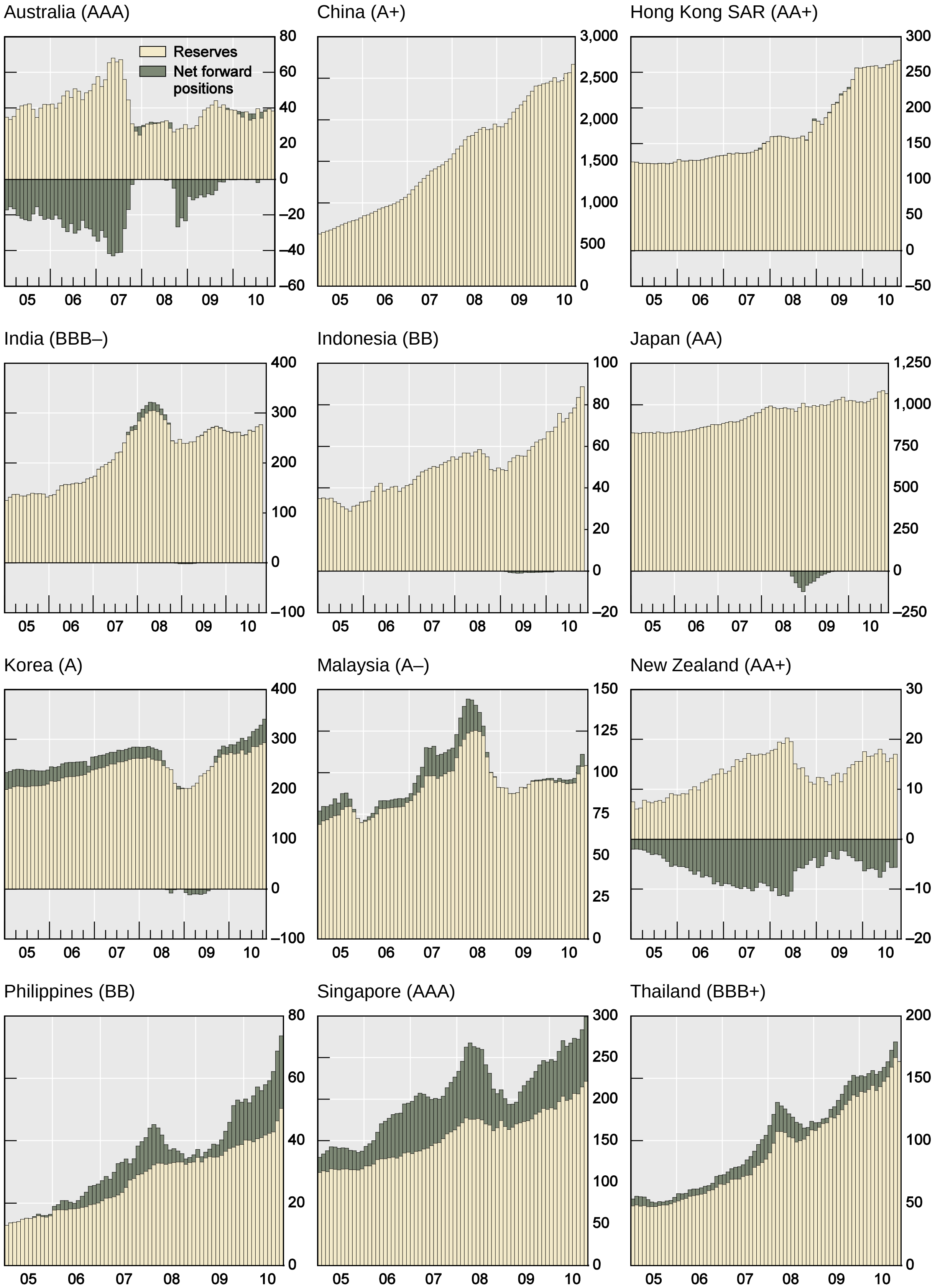
[1] Money plus quasi-money. [2] Bank credit to private sector. [3] Latest available data.

Sources: IMF; national data.

Graph A1

Foreign exchange reserves[1] and net forward positions[2]

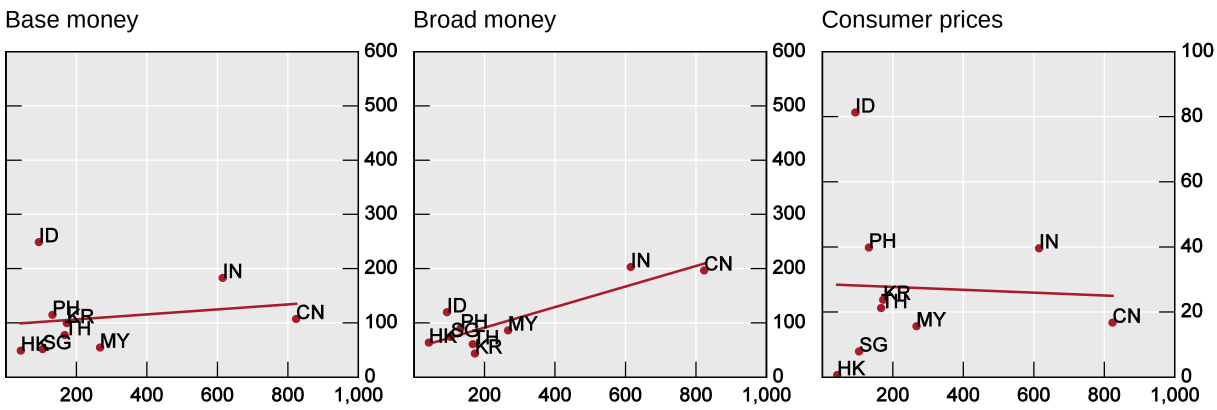
In billions of US dollars



Graph A2

Growth of foreign exchange reserves relative to the growth of money and consumer prices[1]

2001–07; in per cent



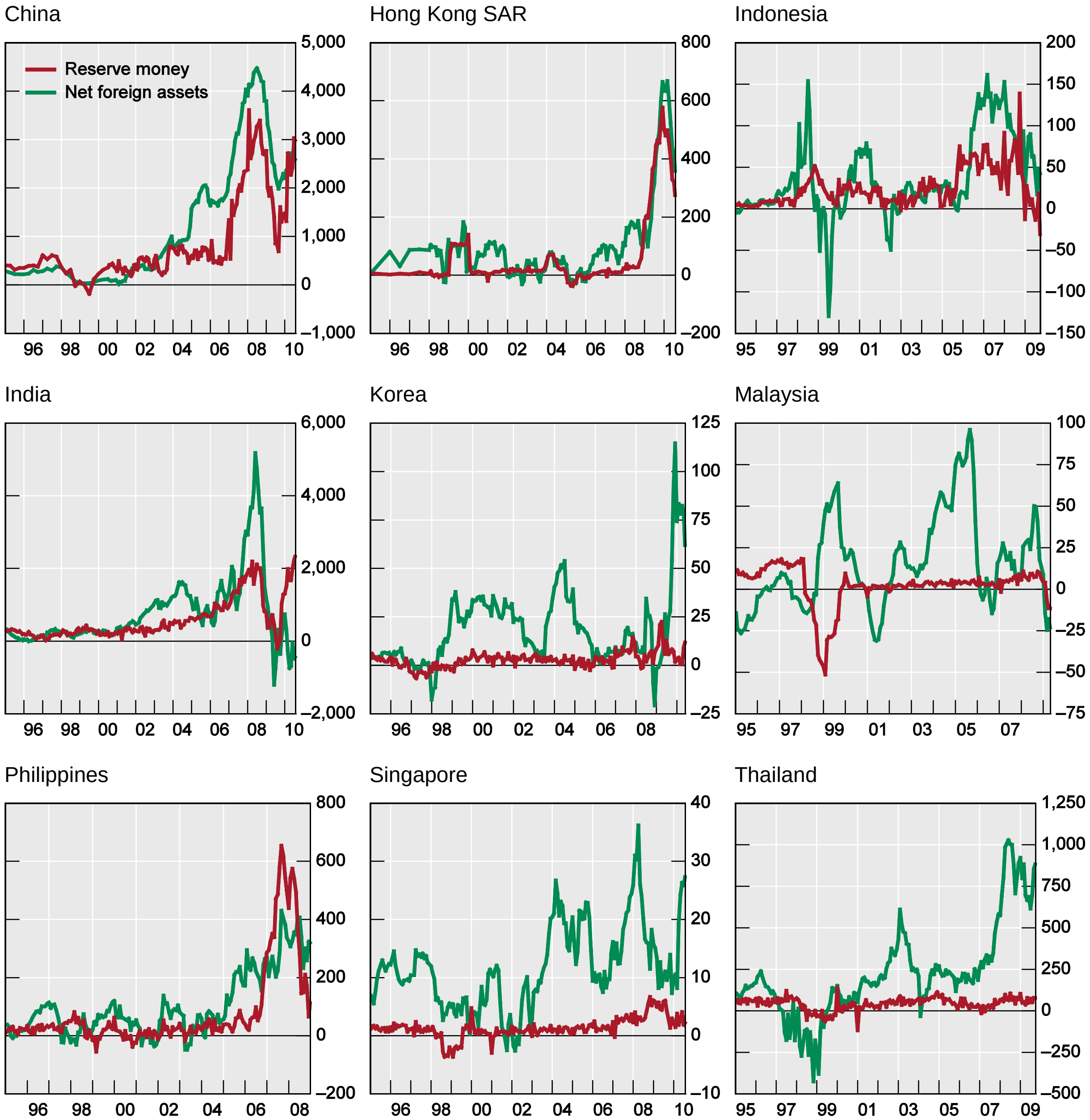
[1] The horizontal axis show change in foreign exchange reserves; the vertical axis represents the change in the variables shown at the panel title.

Sources: Datastream; IMF, *International Financial Statistics*; national data.

Graph A3

Reserve money and net foreign assets, by economy

Annual changes, in billions of local currency[1]



[1] For Indonesia and Korea, trillions of local currency.

Sources: IMF, International Financial Statistics.

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On the use of sterilisation bonds in emerging Asia[1]

Aaron Mehrotra

Abstract

We document recent developments in the use of sterilisation bonds by six central banks in emerging Asia, and discuss the implications for monetary policy and the financial sector. An important development in the sterilisation of foreign exchange interventions in past years has been the frequent use of central banks' own paper. There has been an attempt to lengthen the maturity structure of sterilisation bills, and maturities have risen, especially in 2010–11. The choice of sterilisation instrument is likely to depend partly on their relative costs. In particular, as the yield on central bank securities has fallen relative to the rate of remuneration of required reserves, some central banks in Asia have increasingly used central bank securities for sterilisation.

Keywords: Sterilisation bond; central bank bonds and bills; foreign exchange reserves; emerging Asia

JEL classification: E43, E50, E52, E58

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[1] Bank for International Settlements, Representative Office for Asia and the Pacific, 78th floor, 2 IFC, 8 Finance Street, Central, Hong Kong, Hong Kong SAR. Email: aaron.mehrotra@bis.org. All opinions are those of the author and do not necessarily represent those of the Bank for International Settlements. I am grateful to Andrew Filardo, Guonan Ma, Madhusudan Mohanty, Philip Turner and James Yetman for their insightful comments. Marjorie Santos Beslmeisl and Agne Subelyte provided excellent research assistance.

Introduction

Since the Asian crisis, central banks in emerging Asia have accumulated large reserves in order to build up precautionary balances and to provide assurance to markets about the sustainability of the exchange rate regime. The experience from the international financial crisis largely vindicated this policy, as central banks had considerable leeway to run down their assets in the face of depreciation pressures. Indeed, foreign exchange reserves in the region shrank at the end of 2008, perhaps most prominently in India, Korea and Malaysia. During the subsequent recovery, as inflation pressures rose, emerging market central banks were generally more willing to accept increased exchange rate flexibility, in particular letting their exchange rates appreciate. Among major emerging economies in Asia, the rates of appreciation against the USD in 2010 ranged from 2.5% (Korea) to 9.9% (Malaysia).[2] While more flexible, economies in the region continue to manage their exchange rates, as foreign exchange reserves have continued to accumulate in an environment of persistent current account surpluses and in most cases strong capital inflows.[3]

The ballooning reserves have led to significant increases in central bank balance sheets, with implications for overall macroeconomic and financial stability.[4] In order to maintain monetary stability, central banks in the region have largely sterilised the interventions in the foreign exchange markets through both non-market and market-based approaches. The former include the use of reserve requirements, the compulsory transfer of public institutions' deposits to the central bank and direct controls on bank lending; the latter encompass sterilisation bonds (either government or central bank paper), foreign exchange swaps, repo agreements and direct borrowing from banks through an overnight deposit facility.

In this paper, we describe the recent use of one market-based approach to sterilised intervention in emerging Asia, the issuance of sterilisation bonds. As discussed by Filardo and Grenville (2012), an important development vis-à-vis sterilisation tools in recent years has been the issuance of central banks' own paper. While some central banks in the region have a longer history in using central bank paper for sterilisation purposes (eg Indonesia and Korea), its use has increased notably in the recent past. In addition to concerns about the financial disintermediation that some non-market based measures could entail, the issuance of central bank bills could help deepen the local bond market and further develop a yield curve. There has been an attempt to lengthen the maturity structure, in order to enhance monetary control, and possibly discourage an increase of short-term positions in sterilisation paper by foreign investors in an environment of heavy capital inflows. In most jurisdictions, maturities dropped during the crisis in the face of capital outflows, and lengthened across the board in 2010–11.

While the choice of sterilisation instruments obviously depends on the available toolkit and the financial system characteristics of the different economies, the relative costs of using the different instruments are arguably of major importance. The choice of sterilisation instrument can be seen as a cost-minimisation problem for the central bank, where for a given size and structure of its assets it needs to optimally choose its liability structure, taking their prices as given. We show simple econometric evidence that cost considerations indeed seem to matter for the choice of sterilisation instrument, in particular for the choice between changes

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[2] The Hong Kong dollar is an exception to this general trend, as it is pegged to the US dollar via the currency board arrangement – the linked exchange rate system.

[3] While a mercantilist policy could in principle explain the accumulation of reserves, Aizenman and Lee (2007) find that empirical evidence supports precautionary rather than mercantilist motives after the Asian crisis.

[4] From a policy framework perspective, there has arguably been a re-emergence of the importance of quantities, whereby the central bank assets and liabilities structure plays an important role in policy, over and above the short-term policy interest rate.

in reserve requirements and the issuance of central bank securities, in the cases of China and Indonesia.

This paper is structured as follows. The next section discusses the use of sterilisation bills in the context of central bank balance sheets, and the third section describes the use of sterilisation bonds in emerging Asia. The fourth section discusses the implications of the use of this instrument for monetary policy and the financial sector as a whole. The fifth section presents both descriptive and econometric evidence linking the use of sterilisation instruments to their relative costs. The final section concludes with policy implications.

Sterilisation in the context of a central bank balance sheet

The accumulation of reserves and the sterilisation procedure can be discussed in the context of a central bank's balance sheet.[5] Table 1 provides a stylised version of the balance sheet. The central bank's assets are comprised of foreign and domestic assets, and its liabilities include monetary liabilities (currency and bank reserves), non-monetary liabilities (central bank securities and others) and equity capital. Equity capital includes government transfers to the central bank, coupled with any accumulated profits or losses. The increase in foreign exchange reserve assets is financed by liabilities within the domestic financial system. Of these liabilities, currency is usually assumed to be determined by the public's demand for cash balances. Strong growth in emerging Asia has implied an increase in the amount of currency in circulation in the region, while bank reserves have risen partly on the back of increased reserve requirements by many central banks to mop up excess liquidity.

Table 1

A central bank's balance sheet

Assets	Liabilities
Foreign assets Domestic assets	Monetary liabilities · Currency in circulation · Bank reserves Non-monetary liabilities · Central bank securities · Government deposits · Other liabilities Equity capital

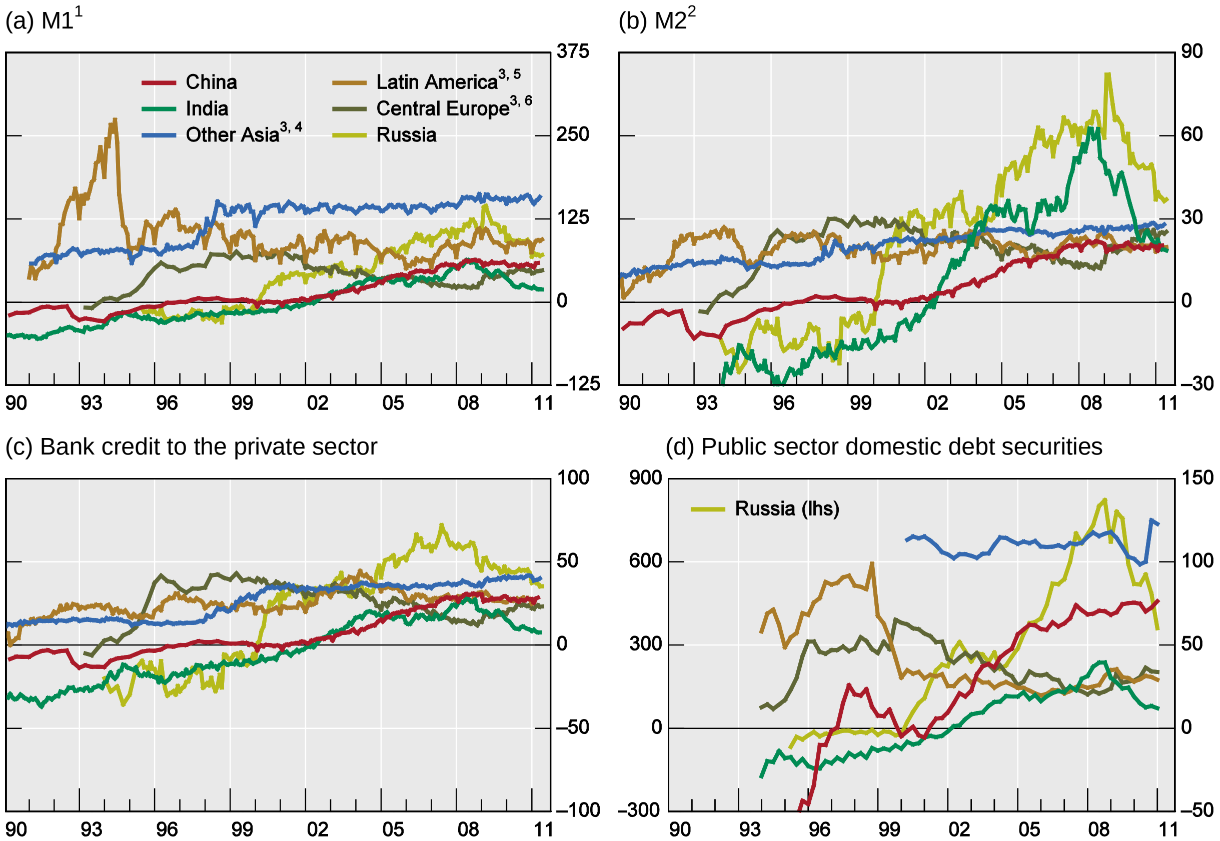
If equity capital is unchanged, and the demand for currency remains constant, reserve accumulation results in a financing need for the central bank. This financing need can be captured by the excess of foreign exchange reserves over currency in circulation. Graph 1 shows this financing need as a ratio of foreign exchange reserves less currency as a percentage of the size of the overall financial system in the major emerging regions (including China and India). Graphs A1 and A2 in the Appendix display these measures for the other economies in our sample. As the financing need becomes large, the central bank's financing operations are likely to have an important impact on the financial system.

[5] The balance sheet discussion draws on BIS (2009) and Mohanty and Turner (2006).

Graph 1

Foreign exchange reserves minus currency held by the public

As a percentage of:



[1] M1, also called narrow money, comprises transferable deposits and currency outside deposit money banks. [2] M2 is a broad measure of money which in general comprises, in addition to M1, time, savings and foreign currency deposits of resident sectors other than central government. The components can vary across economies. [3] Weighted average of the economies listed, based on 2005 GDP and PPP exchange rates. [4] Chinese Taipei, Hong Kong SAR, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. [5] Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. [6] The Czech Republic, Hungary and Poland.

Sources: IMF; Datastream; national data; BIS.

The central bank addresses the financing need by issuing domestic monetary liabilities. If the central bank has a target for the short-term interest rate, it cannot allow the increased monetary reserves to lead to increased bank credit and inflation pressures. In such a case, it typically sells domestic assets (although these may be limited relative to the size of the required amount) or issues its own securities to offset the increase in bank reserves. This sterilised intervention can take place either using market- (sterilisation securities; direct borrowing from banks; repo transactions; foreign exchange swaps) or non-market based instruments (direct controls on bank lending; reserve requirements; shifting deposits to central bank). There is substantial evidence in the literature to suggest that a large part of intervention has been sterilised in most economies where intervention has taken place (see eg Mohanty and Turner, 2006; Aizenman and Glick, 2009).[6]

[6] For China, Ouyang et al (2010) find that roughly 90% of reserve accumulation was sterilised during 2000–08; He et al (2005) also suggest that sterilisation has been effective.

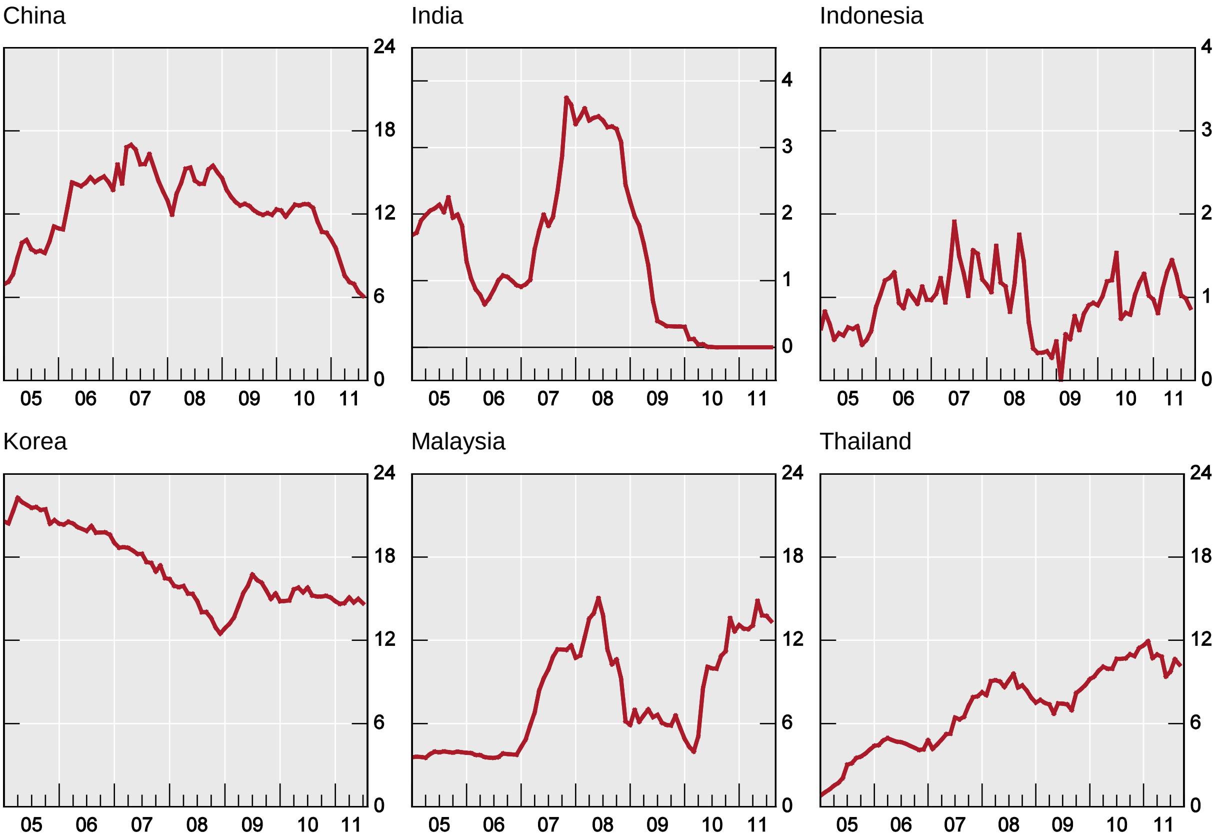
Descriptive evidence on issuance of sterilisation bonds in emerging Asia

Central banks in emerging Asia have been increasingly using their own securities for sterilisation purposes. In this section, we provide a descriptive analysis of the use of sterilisation bonds in six emerging Asian economies. Five of them (China, Indonesia, Korea, Malaysia and Thailand) issue central bank bills, while one (India) issues government and other securities under a separate account held at the central bank solely for sterilisation purposes. Graph 2 shows the amounts outstanding of central bank securities for the six economies in our sample, as shares of GDP. Amounts outstanding in national currency are displayed in Graph A3 in the Appendix.

Graph 2

Central bank securities[1]

As a percentage of GDP[2]



[1] For India, proceeds from auctions of treasury bonds and securities under the market stabilisation scheme, deposited at the Reserve Bank of India. [2] The scaling variable used is annual GDP data converted to monthly using linear interpolation.

Sources: IMF; CEIC.

Korea

In Korea, sterilisation bonds (monetary stabilisation bills, MSBs) were issued for the first time in 1961, and their importance as a tool to remove excess liquidity has since increased, especially after the Asian crisis. As a share of GDP, outstanding central bank securities amounted to 20% of GDP still in 2005 (the highest in our sample). The share has since declined, but still amounted to roughly 15% of GDP in 2011. In national currency terms, the outstanding volume in 2005 was similar to that in 2011. In contrast to many other Asian economies, non-market based approaches, such as changes in the reserve requirement ratio, have not played an important role in Korea (see Table A4 in Mohanty and Turner, 2006).

Indonesia

The issuance of central bank bills for sterilisation had also begun in Indonesia prior to the Asian crisis. The central bank securities in question are Bank Indonesia Certificates (SBIs). As a share of GDP, the outstanding amount of SBIs has hovered around 1% in recent years, falling close to zero at the time of the international financial crisis. Indonesia has also used statutory reserve requirements to absorb liquidity, among its other instruments for liquidity management.

China

In China, the issuance of central bank bills started somewhat later, and their use has coincided with that of several other instruments for sterilisation, including reserve requirements, open market operations of special government bonds and currency swaps with commercial banks.[7] The People's Bank of China started to issue three-month, six-month and one-year central bank bills in 2003. Longer-term (three-year) bills were issued from December 2004 onwards. In the case of China, market-based issuance of sterilisation bonds has been combined with targeted issuance – bills targeted at those commercial banks that experienced a rapid growth in credit and fairly abundant liquidity. In 2010–11, the outstanding amount of central bank securities fell in both nominal terms and as a share of GDP, standing at roughly 6% of GDP in mid-2011. In 2006–08, their share was close to 15% of GDP.

Malaysia

Malaysia uses a variety of instruments for liquidity management. Interventions are sterilised using direct borrowing, repos and the issuance of Bank Negara Malaysia Monetary Notes (BNMNs). Over time, policy has shifted towards the use of repo operations and BNMNs (Ooi, 2008). The Bank Negara Malaysia introduced the BNMNs in December 2006 in order to gradually replace Bank Negara Bills (BNBs) and Bank Negara Negotiable Notes for managing liquidity.[8] We consider the Bank Negara Malaysia Monetary Notes/Bank Negara Bills (BNMNs/BNBs) as the relevant sterilisation bonds. As a share of GDP, the volume of outstanding central bank securities more than doubled during 2011 and now stands at above 13% of GDP.

Thailand

For Thailand, the sterilisation bond of interest here is the Bank of Thailand (BOT) bond, which is the principal absorption instrument (Bank of Thailand, 2010, p 73). Thaicharoen and Ananchotikul (2008) note that BOT bonds are efficient in absorbing liquidity on a large scale with longer maturities. For this economy as well, central bank bonds are accompanied by repo transactions and foreign exchange swaps in the management of liquidity. Central bank securities have been slowly increasing as a share of GDP and now stand at close to 10%.

India

The Reserve Bank of India is not allowed to issue its own securities. Large capital inflows were traditionally managed through the day-to-day Liquidity Adjustment Facility (LAF), in particular its repo and reverse repo auctions, and supplemented by outright sales of government securities by open market operations (Mohan, 2008). Liquidity was also absorbed by increasing the surplus balances of the government with the Reserve Bank. However, given the limited stock of government securities, India adopted a new instrument in

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[7] A non-market based tool that has been very prominent during the recovery is the required reserve ratio (see Ma et al, 2011, and the discussion in the fifth section of this paper).

[8] See http://www.bnm.gov.my/index.php?ch=8&pg=14&ac=1349.

2004. This new instrument, the Market Stabilisation Scheme (MSS), is solely used for sterilisation purposes. Under the scheme, the Reserve Bank may issue government treasury bills and medium-term dated securities. The proceeds from the auctions are placed on a separate MSS cash account that is maintained and operated by the Reserve Bank. MSS has become the instrument for medium-term liquidity management, while the LAF is used for the management of liquidity on a daily basis.

Table 2

Management of liquidity in India by market stabilisation scheme (MSS) and cash reserve ratio (CRR)

	2007–08	2008–09	2009–10	2010–11
Liquidity impact of MSS	1054.2	803.1	853.4	27.4
First-round impact of CRR change	–470.0	1022.5	–360.0	–125.0

A positive sign indicates an injection of liquidity into the banking system.

Source: Reserve Bank of India, *Macroeconomic and Monetary Developments*.

In contrast to other economies where the stock of issued central bank securities has been growing over time, in India the amount of MSS outstanding was drawn down quickly during 2009 and 2010, as surplus liquidity was low (Graph 2). Table 2 shows that liquidity management operations through the MSS resulted in an injection of liquidity from the financial year 2007–08 through 2010–11. In contrast, adjustments of the cash reserve ratio (CRR), in line with a tightened policy stance in an inflationary environment, resulted in absorptions of liquidity for all other years except 2008–09.[9]

Trends in maturities and yields

Some central banks have aimed at lengthening the maturity of the issued sterilisation bills. For instance, the Bank Negara Malaysia (2011) claims that this could in principle enhance monetary control and improve the cost-effectiveness of sterilisation in an environment of rising interest rates, as surplus liquidity is being absorbed at a lower rate for a longer period. Where capital inflows are strong and foreign investors are taking short-term positions in domestic currency, longer maturities could help avert some of the speculative inflows. Nevertheless, central banks might prefer to issue paper at different maturities than the central government, in order to avoid possible crowding out effects. Figure 3 shows the average maturity of outstanding sterilisation bonds for the different economies. For all economies, the average maturity of outstanding sterilisation bonds (central bank paper) is indeed lower than that for the general government.[10]

In most countries, the financial crisis brought about a decline in maturities in the face of FX depreciation pressures, but maturities have again increased lately. For Korea, there has been relatively little movement in the average maturity over time. In 2009, the share of

[9] Mohan (2008) suggests that the MSS is better than the LAF for dealing with longer-term flows, and the CRR is appropriate for dealing with fairly long-term flows.

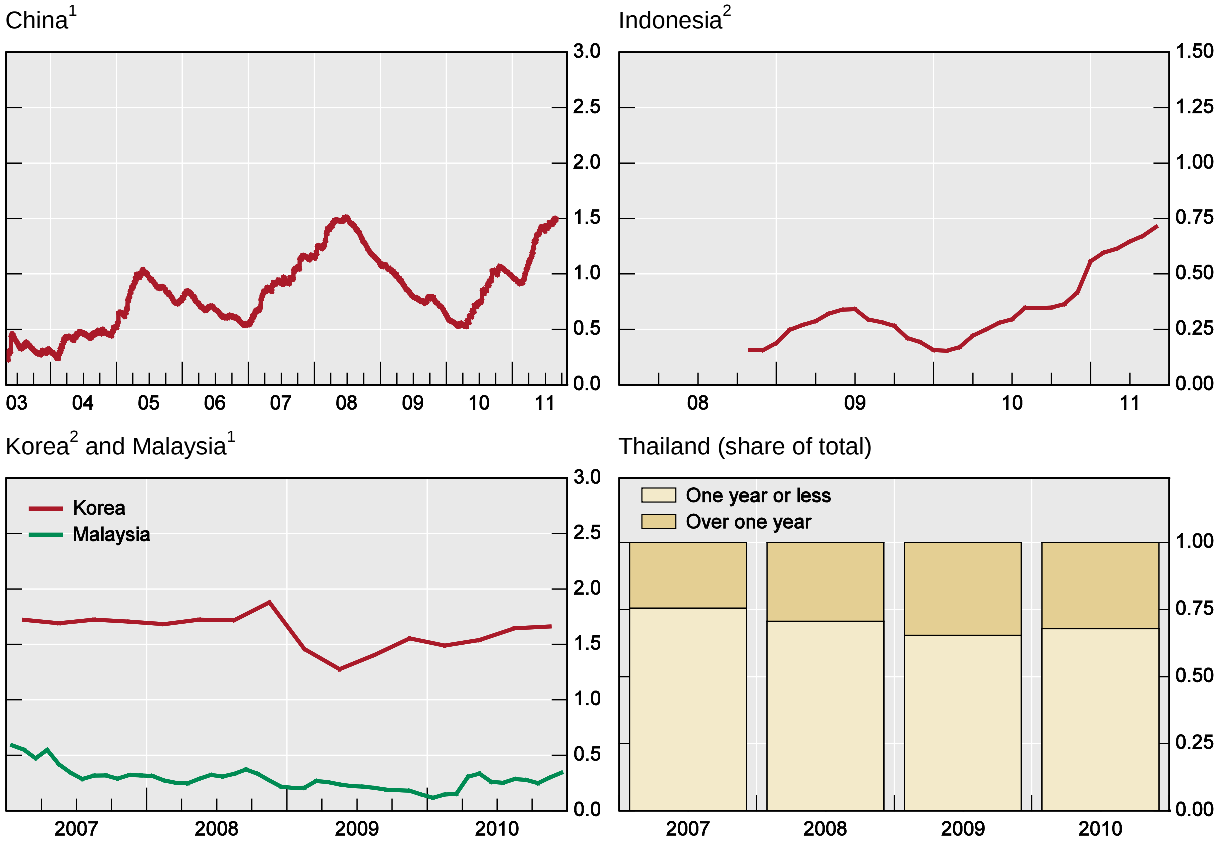
[10] According to BIS securities statistics, the remaining maturity of domestic central government debt in 2010 was 6.0 years in Thailand, 5.0 years in Korea, 4.5 years in Malaysia and 0.9 years in Indonesia. Data are not available for China.

MSBs with maturities of less than one year rose, with the increase in the 91-day maturity being especially stark. In 2010, the maturity of outstanding bonds increased, with the share of MSBs with maturities of at least one year growing.

Graph 3

Average maturities of central bank bonds and bills

In years



[1] Weighted average of remaining maturity by notional amount. For Malaysia, the series is computed by assuming that issuance takes place on the last day of each month. [2] Average maturity of outstanding bills.

Sources: CEIC; national data; BIS calculations.

The maturity dynamics in Malaysia have been similar to the ones in Korea, although the average maturity has been shorter. The average maturity on new issues fell from close to half a year in 2007 to below four months in 2009, only to pick up again to over five months in 2010.[11] In early 2008, BNMNs were used aggressively to mop up excess liquidity during periods of strong portfolio and trade flows (Bank Negara Malaysia, 2009). As concerns in the international financial system intensified, monetary operations were focused on shortening the average maturity of sterilisation operations. This was instrumental in an environment of strong portfolio outflows. The fall in the maturity for the central bank bills is in line with the fact that the average maturity for all monetary instruments declined from 39 days in April 2008 to 19 days by end-December 2008. The increase in the maturity period of sterilisation bonds coincided with the economic recovery of 2009–10, and again went in hand with the

[11] Prior to 2007, the average duration of outstanding Bank Negara Bills, Negotiable Notes and Monetary Notes was gradually increasing (Table 2 in Ooi, 2008). The average duration increased from 75 days in 2003 to 104 days in 2006.

increasing maturity profile of all monetary instruments (from 27 days in 2009 to 40 days in 2010).

In China, the average maturity of outstanding bills has fluctuated notably. Three-year bills were issued between December 2004 and May 2005 and again in 2007, leading to a significant increase in the average maturity of both new issuance and outstanding bills. As the financial crisis hit, the PBoC halted the issuance of three-year bills in July 2008, resuming it again in April 2010.

Bank Indonesia has also aimed at issuing longer-term paper (SBIs) to deepen the money market and to encourage liquidity management from a longer-term perspective (Bank Indonesia, 2011). By July 2010, the amount of outstanding one-month SBIs had dropped to zero. From September 2010 onwards, three-, six- and nine-month SBIs were issued, with a gradual reduction in outstanding three-month SBIs. By January 2011, the amount outstanding of three-month SBIs had fallen to zero as well. The average maturity of outstanding SBIs had increased from less than three months to over six months by early 2011 (Graph 3).

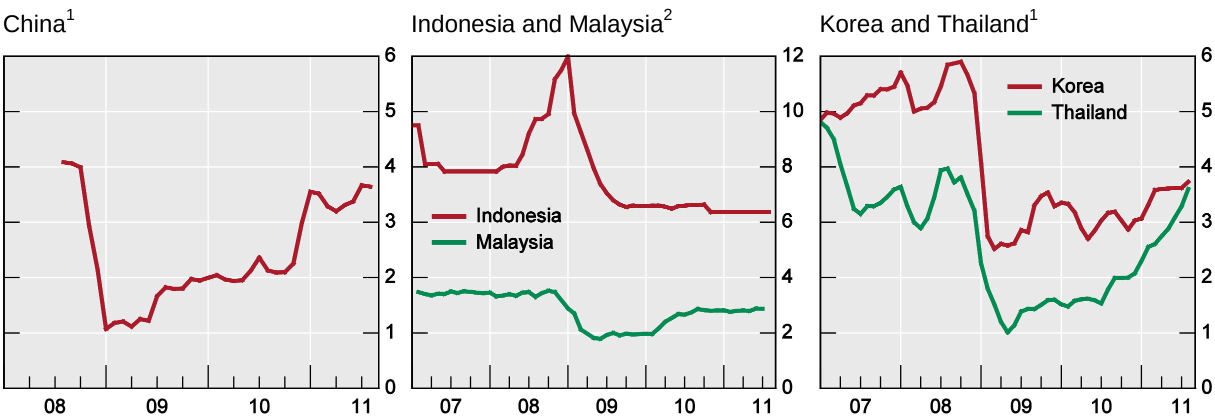
Similarly, in 2010, the Bank of Thailand aimed to lengthen the maturity profile of BOT bonds to "establish a more appropriate structure of the absorption tools" (Bank of Thailand, 2011, p 90). Bonds with remaining maturities of one year or less still dominated the outstanding stock of central bank bonds (Graph 3), but their share fell from 75% in 2007 to 68% in 2010.

The yields on sterilisation bonds have moved rather uniformly across countries (Graph 4). They fell as the financial crisis intensified in late 2008–early 2009. The yields have climbed notably in China from the levels witnessed during the crisis (from roughly 1% to over 3%), but remain relatively low. The yields paid on central bank bills in Korea and Thailand were at similar levels in mid-2011. Thailand has seen climbing yields since mid-2010, but the differences between maturities have narrowed notably since 2009 (not shown). In Indonesia, the yields are higher across the maturity spectrum, but have remained very stable since 2009.

Graph 4

Yields on central bank bonds and bills

In per cent



[1] One-year yield. The series for Thailand includes T-bills, Bank of Thailand bonds and government bonds. [2] Three- and six-month yields, respectively.

Sources: CEIC; national data.

Trends in holding sector

Is there evidence of a proportionally higher share of sterilisation bonds being held by households and non-bank firms over time, in which case sterilisation would have become more complete? Data for Thailand suggest that the share of "other non-financial corporations", "public non-financial corporations" and "households and non-profit institutions serving households" as holders of Bank of Thailand bonds increased from some 7% of the total amount outstanding in 2007 to 15% in 2010. In the case of Indonesia, non-banks now hold a substantial share of SBIs (Table 3). The share increased from 19.8% of outstanding SBIs at end-2009 to 31.2% at end-2010. However, a very large part of non-bank holdings are in the hands of non-residents (88.1% at end-2010). This stands in contrast to Thailand, where non-resident holdings of BOT bonds increased from 0.2% in 2007 to 0.7% in 2010.

Table 3

Bank Indonesia Certificates, IDR trillions

	Non-bank holdings		**Total outstanding**
	Resident	Non-resident	
End-2009	6.51	44.18	255.52
End-2010	7.43	54.93	200.11

Source: Bank Indonesia.

In the case of Korea, foreigners held slightly below 16% of outstanding MSBs at the end of 2010. And for Malaysia, with the exception of 2008, between 32% and 52% of total outstanding Bank Negara Bills and Monetary Notes have been held by non-residents in recent years (Table 4).

Table 4

Central bank securities

	Non-resident holdings	**Total outstanding**
	MYR millions	
2007	36,065.8	69,010.0
2008	4,165.4	43,710.2
2009	11,923.9	33,357.4
2010	31,623.7	100,376.8

Source: Bank Negara Malaysia Monthly Statistical Bulletin.

Implications for monetary policy and the financial system

An obvious benefit of using market-based instruments such as sterilisation bonds over non-market based measures is that central banks are able to withdraw liquidity without creating market distortions or disintermediation in parts of the financial system associated with increases in reserve requirements. Reserve requirements may cause lending to be directed away from banks or the domestic financial system more generally. If borrowing by domestic firms is redirected to banks abroad, sterilisation becomes ineffective, and the riskiness of the domestic financial system may increase.[12] Indeed, to the extent that the central bank does not pay a market interest rate to remunerate reserves, reserve requirements act as a tax on the domestic banking system.[13]

From the viewpoint of monetary policy, sterilisation may be more effective if households and non-bank firms are the ultimate holders of the sterilisation paper. The impact of foreign exchange interventions on base money can be fully sterilised simply as commercial banks buy sterilisation paper from the central bank. However, as discussed later in this section, central bank paper is a relatively liquid asset, and its ownership by commercial banks might do little to restrain lending in the economy. Moreover, if the origin of the currency appreciation and the foreign exchange intervention is a current account surplus, foreign exchange earnings by exporters initially lead to an increase in bank deposits. In the case where a commercial bank sells the foreign exchange proceedings to the central bank and receives a sterilisation bond in return, it maintains the deposit and holds the sterilisation bill. Only if non-banks subsequently purchase the sterilisation bond by drawing down their deposits would broad money be reduced.

Non-bank ownership of sterilisation paper is more likely if the sterilisation paper markets are liquid and long-term paper is available. As sterilisation bond markets have deepened and central banks have aimed at replacing short-term paper with longer maturities, these conditions have arguably strengthened in recent years in the Asian region. Filardo and Grenville (2012) show that the correlation between the growth in central bank assets and reserve money has been basically zero in emerging Asia in the 2000s, with virtually no impact on the inflation rate. Therefore, the monetary effect of reserve accumulation was effectively sterilised.

Mohanty and Turner (2006) suggest that if longer-term bills replace central bank bills with shorter maturity, this could have a longer-term impact on excess liquidity and enhance monetary control. The case of China provides an example. When the issuance of three-year bills was resumed in 2007, the issuance of one-year bills dropped from CNY 2.5 trillion in 2006 to CNY 1.6 trillion in 2007 (six-month bills fell from CNY 95 billion in 2006 to zero in 2007). This coincided with increased monetary control to the extent that the PBoC was able to achieve its targets for broad money growth more closely. In particular, in 2007, the actual growth in broad money was 16.7%, very close to the 16% target set by the PBoC. In contrast, in 2006, actual growth in M2 was almost 3 percentage points higher than the target (16.9% versus 14%), with relatively large deviations experienced also in 2003–05.[14]

Evidence about the link between the level of monetary control and the lengthening maturity structure can be also found for Indonesia. While Indonesia does not specify intermediate money growth targets, headline inflation rates have been falling throughout 2011 to levels consistent with the inflation target as the average maturities of outstanding central bank bills have increased.

The use of market-based paper for sterilisation purposes could prove to be counterproductive for monetary policy in some cases. If the central bank sterilises strong

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[12] Government deposits with the central bank as a sterilisation instrument do not have the same drawback as reserve requirements of pushing lending abroad. However, as pointed out by Filardo et al (2012), government deposits tend to be volatile, reflecting the timing of tax payments, public expenditures and debt managers' portfolio allocation decisions.

[13] Reinhart and Reinhart (1999) show that changes in reserve requirements may have an impact on the real exchange rate. If the central bank increases reserve requirements to sterilise its intervention, and depositors pay the tax, domestic deposits become less attractive. If borrowers pay the tax instead, loans become more expensive – in both cases depreciation pressure on the real exchange rate may ensue. Moreover, depending on the incidence of the tax, there may be effects on domestic spending and production.

[14] See Table 6 in Geiger (2008) and the statistical update at http://mgeiger.wordpress.com/statistics/.

capital inflows by issuing short-term securities, foreign investors may be encouraged to take short-term positions in the currency using sterilisation paper – the relatively large foreign holdings of central bank securities in the cases of Indonesia and Malaysia were highlighted in the previous section. Thus, the issuance of short-term sterilisation paper could in fact encourage capital inflows and threaten the success of sterilisation. The issuance of short-term paper may also create interest rate risks for the central bank. As the need for future liquidity absorbing operations increases, there could be a heavy interest cost burden if domestic interest rates rise. Large sterilised intervention by means of issuing securities may also damage the credibility of domestic monetary policy. The central bank may be unwilling to tighten policy sufficiently when faced with inflationary pressures, as the costs of sterilisation increase when the difference between local and foreign interest rates increases. This could lead to an inflationary bias in policy over time.

For the financial system, the increased use of sterilisation bonds could be seen as helpful in developing and deepening the local debt markets. In an emerging economy, bond issuance could help develop a yield curve. But such a process is endogenous, as the tendency to resort to market-based measures of sterilisation increases as local bond markets deepen. With thin markets, market-based measures may cause big fluctuations in domestic interest rates. As noted by Mohanty and Turner (2006), the low interest rate environment has probably played a role in the increased use of market-based sterilisation measures. Given the improved monetary control in emerging Asia, especially over the past decade, low interest rates are likely to continue contributing to the use of market-based tools for sterilisation in the region.

Bank lending behaviour could be affected if banks hold large volumes of sterilisation bonds, as discussed by Ooi (2008). The perception of sterilisation bonds as a source of risk-free profits could curtail bank lending to the private sector, reducing productive investment. Indeed, Cook and Yetman (2012) find that there is a negative relationship between increases in foreign reserve holdings and the growth rate of bank lending for banks in some economies in emerging Asia.

The liquidity characteristics of sterilisation bonds may play an important role in determining the impact on the bank lending channel. If banks perceive sterilisation bonds as very liquid assets, and the ownership of liquid assets has a positive impact on lending, banks may be inclined to extend loans to the non-bank private sector even when holding substantial amounts of sterilisation bills, running counter to the ultimate aim of sterilisation. Tobin (1963) argues that banks consider short-term government bonds as close substitutes to excess reserves, as they can easily be sold to finance new lending.[15] Similarly, if there is easy access to wholesale funding, credit growth may be rapid despite sterilisation. In contrast, if no profitable lending opportunities are available for commercial banks, the monetary authority may lower the interest rate on the sterilisation bonds that the commercial banks hold and therefore lower the costs of sterilisation (Filardo and Grenville, 2012). Over time such a process encourages the commercial banks to seek new lending opportunities, possibly with higher risk. Risk taking may be particularly relevant in a low interest rate environment (Borio and Zhu, 2012). Alternatively, if the commercial banks are state-owned, the monetary authority may be able to conduct sterilisation operations at a lower cost than when dealing with privately owned banks. This could be a relevant issue when considering sterilisation costs in China, for example.

[15] Kumhof (2004) presents a theoretical model featuring the possibility that sales of sterilisation bonds at high interest rates actually raise consumption demand.

Choice of sterilisation instrument

The choice of sterilisation instrument depends on the available toolkit and the financial system characteristics of the different economies. Another important consideration is the relative cost of using the different instruments. In this section, we focus on the latter aspect. In particular, we investigate whether the relative cost has been of importance for three emerging Asian central banks, as they have mopped up liquidity from the financial system by central bank paper issuance and increases in reserve requirements. The use of the non-market based instrument of reserve requirements has been prominent during the recovery, especially in the case of China, but changes in the reserve requirement ratio have been applied also, eg in Indonesia and Malaysia. While both methods could be used to freeze liquidity simultaneously, their relative importance could vary across time as the relative costs change.

The problem facing central banks can be summarised as follows. An increase in foreign exchange reserve assets needs to be financed by liabilities within the domestic financial system. A central bank addresses this financing need by issuing domestic monetary liabilities, but may choose to sterilise the resulting liquidity by the instrument of its choice. The choice of sterilisation instrument can be seen as a cost-minimisation problem for the central bank, where for a given size and structure of assets, it needs to optimally choose its liability structure, taking their prices as given.

We simplify the decision problem of the central bank here by considering only two sterilisation instruments, central bank paper and reserve requirements, and their relative cost. The difference between the amount of liquidity withdrawn by the two instruments is specified to be a function of the difference of the yield on central bank paper i^{bond} and the rate of remuneration on required reserves, i^{RR}:

$$(B_t - RRR_t) = f(i_t^{bond} - i_t^{RR}). \tag{1}$$

Here, *B* and *RRR* denote the amounts of liquidity absorbed by central bank securities and reserve requirements, respectively. The relationship described in (1) is admittedly a simplification, but other motivations for choosing a particular instrument can also be addressed in a cost-minimisation framework. Consider a central government that needs to issue debt in order to finance budget deficits. At times of large government paper issuance, the central bank may be more reluctant to issue its own paper in order to not directly compete with the government – central government debt issuance could then be regarded as increasing the cost of issuing central bank securities. The level of outstanding stock of central bank securities could matter as well. As the cost of sterilisation is likely to increase as the volume of issuance increases, the central bank may be increasingly reluctant to issue central bank paper and possibly choose to increase the reserve requirement ratio instead – again implying that the relative costs of the instruments matter.

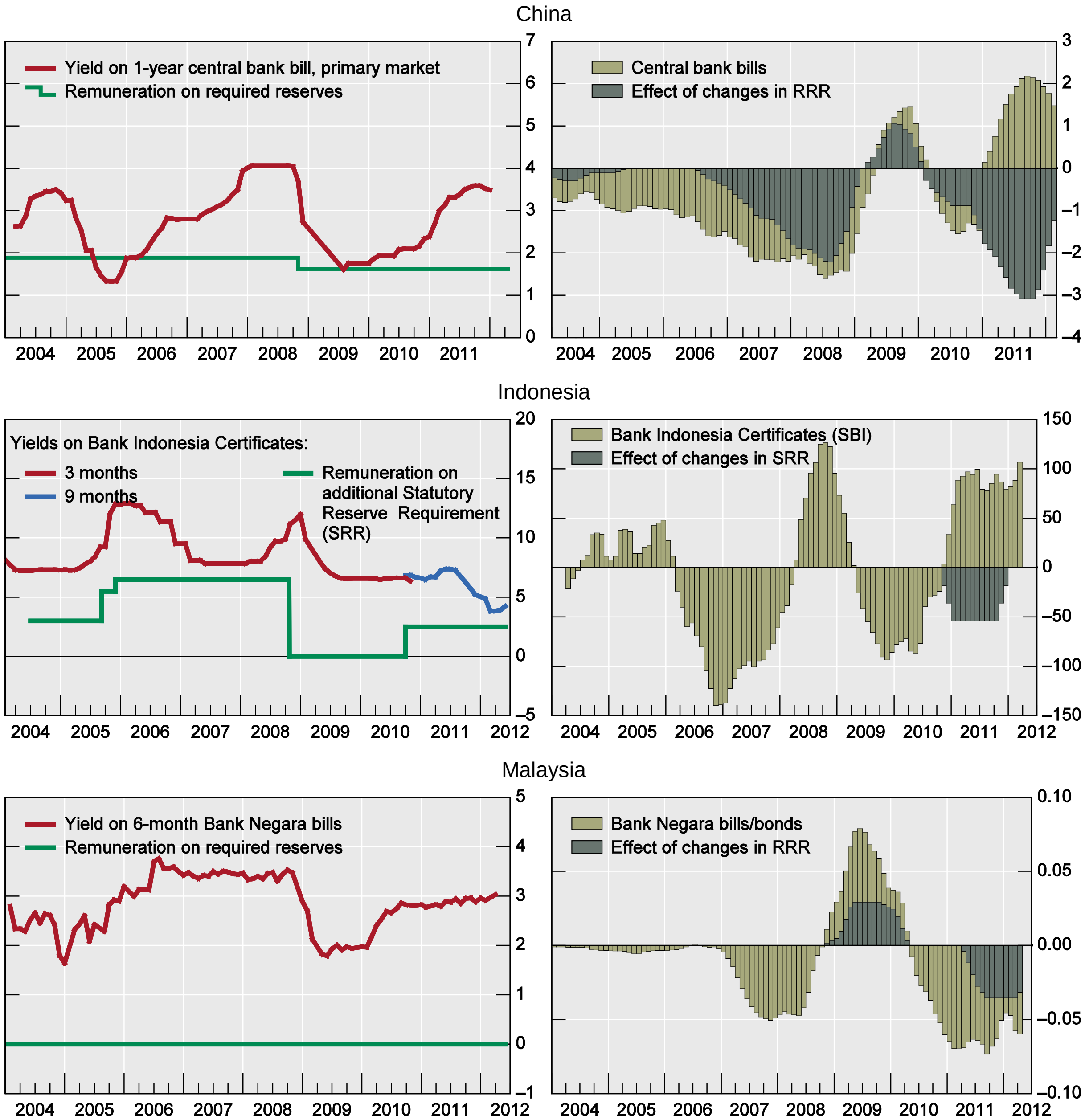
What does descriptive analysis suggest about the choice of sterilisation instrument and the relative costs? Starting with China, we follow Ma et al (2011) and display the one-year PBoC bill auction yield relative to the remuneration rate on required reserves (Graph 5, top left-hand panel), and the liquidity withdrawal/injection by the different sterilisation tools (Graph 5, top right-hand panel). For most of the time since 2004, the rate of remuneration on required reserves has been below the yield on one-year central bank bills. Therefore, reserve requirements have been a lower-cost instrument for the People's Bank of China for withdrawing liquidity than central bank paper. And changes in relative costs over time seem to matter. When the yield on central bank paper increased in 2007 and 2011, reserve requirements were increasingly used to absorb liquidity, while the importance of central bank securities fell. During January–June 2011, China increased reserve requirements for large banks six times (a total of eleven times since the start of 2010). Further, in the fall of 2011, reserve requirements were extended to cover banks' margin deposits, further draining liquidity. In contrast, when the yields on central bank securities climbed in 2011, their impact on liquidity was one of injection rather than withdrawal.

Graph 5

Sterilisation tools and costs

Central bank bills yield and remuneration on required reserves, in per cent

Reserves withdrawal (–) or injection (+) by sterilisation tool, in trillions of local currency[1]



[1] Components of net domestic assets; year-on-year change of three-month moving average; positive (negative) indicates injection (withdrawal) of liquidity.

Sources: CEIC; national data; estimates of Ma et al (2011).

A similar picture emerges for Indonesia (Graph 5, centre panels). In 2006, as the cost of issuing SBIs relative to the remuneration on additional statutory reserves fell, there was significant issuance of central bank paper. A similar dynamic occurred between end-2008 and end-2009. In both cases, the adjustment occurred via the issuance of central bank securities rather than by changing the reserve requirement ratios. Indeed, reserve requirements in Indonesia were not adjusted during the sample prior to the increase from 5% to 8% per annum in November 2010.

For Malaysia, the picture is somewhat different from China and Indonesia (Graph 5, bottom panels). There, increases in central bank bill yields sometimes coincide with increased securities issuance, as in 2010, or increased issuance overlaps with relatively flat yields, as in 2007. Required reserves are not remunerated in Malaysia, so any change in relative costs stems solely from fluctuations in central bank securities' yields.

Table 5

Choice of sterilisation instrument

	China (1)	**China (2)**	**Indonesia (3)**	**Indonesia (4)**	**Malaysia (5)**	**Malaysia (6)**
$i^{bond} - i^{RR}$	–1.414*** (0.333)	–1.397*** (0.332)	–10.061** (4.460)	–6.548 (4.788)	0.015*** (0.006)	0.014** (0.006)
Obs	95	95	78	77	99	99
Adj R-squared	0.403	0.379	0.126	0.046	0.128	0.108

Ordinary least squares estimates. Dependent variable: Liquidity absorbed by central bank securities less liquidity absorbed by reserve requirements. Variables transformed as described in the footnote to Graph 5. Columns (1), (3) and (5) report estimations with the interest rate differential at current lag; columns (2), (4) and (6) report results with the interest rate differential at first-period lag. HAC Newey-West consistent standard errors in parentheses. Samples: China: February 2004–March 2012; Indonesia: July 2004–December 2010; Malaysia: January 2004–March 2012.

Does econometric evidence support the graphical observation about the importance of the relative costs of instruments? We estimate simple least square regressions, where the difference between the liquidity withdrawal by the two instruments is regressed on the difference between their remuneration, for China, Indonesia and Malaysia.[16] The results are shown in Table 5 (columns 1, 3 and 5). For China and Indonesia, the interest rate variable, at the contemporaneous lag, obtains a negative and statistically significant coefficient. This suggests that when the cost of issuing central bank securities increases relative to the rate of remuneration on reserve requirements, the relative use of central bank paper to absorb liquidity falls.[17] However, for Malaysia, higher yields on central bank paper coincide with

[16] Liquidity withdrawal/injection is specified as in Graph 5, as the year-on-year change of three-month moving average of net domestic assets.

[17] For Indonesia, the sample ends in December 2010, in order to maintain a consistent time series (three-month SBIs were not issued after December 2010). If we extend the sample until March 2012 by considering nine-month SBIs from January 2011 onwards, the estimated coefficient is still negative but falls below conventional levels of significance. We obtain similar result using the remuneration rate of zero on required

increased paper issuance, with a positive and statistically significant coefficient, suggesting that the relative costs of the instruments matter less in this economy.

What could explain the finding of the interest rate differential being of importance for China and Indonesia, but not for Malaysia? The mere size of the interest rate differential is unlikely to provide the explanation, as it does not differ notably between the three economies (see Graph 5). But differences in the *amounts* of cost saving could still be important. Indeed, simple back-of-the-envelope calculations suggest that using the reserve requirement instead of the central bank bill provided a cost saving for the People's Bank of China of roughly 0.1% of GDP in 2010 (as reported by Ma et al, 2011), and, similarly, 0.1% of GDP for Bank Indonesia in 2009. However, cost saving was less important for Malaysia, amounting to 0.01% of GDP in 2010.[18]

The above approach does not deal with potential endogeneity. In particular, when the issuance of central bank paper increases, the relative costs of using this instrument may rise, if commercial banks are increasingly reluctant to hold additional central bank securities. But note that such endogeneity would imply a *positive* relationship between the two variables – we actually obtain a *negative* coefficient for China and Indonesia. When lagged values of the interest rate variable are used instead, we still obtain a negative and statistically significant coefficient on the interest rate variable for China, and a negative but no longer statistically significant coefficient for Indonesia (Table 5, columns 2 and 4). In sum, we obtain evidence that the relative costs of instruments indeed matter, at least in the cases of China and Indonesia.

Conclusion and policy implications

In this paper, we have investigated the issuance of sterilisation bonds in emerging Asia. An important development in recent years in the conduct of sterilisation has been the issuance of central banks' own paper. While some central banks in the region, such as Indonesia and Korea, have a longer history in issuing their own paper, the stock of outstanding central bank bills has increased rapidly in recent years. This partly reflects the increase in net foreign assets in central bank balance sheets, ie the sterilisation need has increased, and partly the deepening of the local financial markets that has supported the move to market-based methods for sterilisation.

We document that while the average maturities of outstanding bonds fell during the international financial crisis, maturities lengthened across the board in 2010–11. This is consistent with the aims of monetary authorities in many jurisdictions, and is argued by some central banks to enhance monetary control. The average maturities in our sample at end-2010 were longest in China and Korea, and the sharpest increases in maturities have recently been experienced in China and Indonesia.

The choice of the sterilisation instrument can be seen as a cost-minimisation problem for the central bank, where for a given size and structure of its assets, it needs to optimally choose its liability structure, taking their costs as given. We show both descriptive and simple

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reserves for computing the interest rate differential (based on remuneration on non-additional statutory reserves). We also note that the rather low R-squared values in the cases of Indonesia and Malaysia suggest that only a part of the dynamics of the explanatory variable can be explained by the behaviour of interest rates alone.

18 These calculations use the yield on the one-year PBoC bill for China, the three-month SBI for Indonesia and the six-month Bank Negara Bill for Malaysia, together with the rate of remuneration on reserve requirements for all three economies. The amount of cost saving for Indonesia is likely to be underestimated, as it is based on the remuneration for additional statutory reserves – the other part of statutory reserves is not remunerated.

econometric evidence that cost considerations indeed seem to matter for the choice of sterilisation instrument, in particular for the choice between changes in reserve requirements and the issuance of central bank securities, in the cases of China and Indonesia. This is line with the casual observation that in China, as yields on central bank paper climbed in 2007 and 2011, the central bank actively hiked reserve requirements to withdraw liquidity.

What implications do our findings have for policymakers? The increase in maturities is encouraging, as it may help to withdraw excess liquidity for a longer period, especially in an environment of persistent capital inflows. Evidence from China suggests that increased issuance of longer-term bills has coincided with increased monetary control in terms of meeting the intermediate money growth targets. Inflation approached the central bank's inflation target in Indonesia as maturities increased during 2010–11. In principle, the increase in maturities should also facilitate effective sterilisation through the increased attractiveness of sterilisation paper.

As sterilisation bonds are market-based instruments, their use in sterilised intervention is likely to lead to fewer distortions in the economy in the long run, relative to reserve requirements. Moreover, the increased stock of central bank paper has added to the depth of the bond markets and has probably helped to further develop a yield curve. However, large volumes of relatively liquid central bank bills on the balance sheets of commercial banks may have impacts on the bank lending channel in ways not intended by the monetary authority. This, and the possibility that higher yields on central bank bills lead to increasing sterilisation costs, may lead the monetary authority to increasingly return to non-market based sterilisation instruments. We find some evidence for this, as the use of the different sterilisation instruments appears to be related to their relative cost.

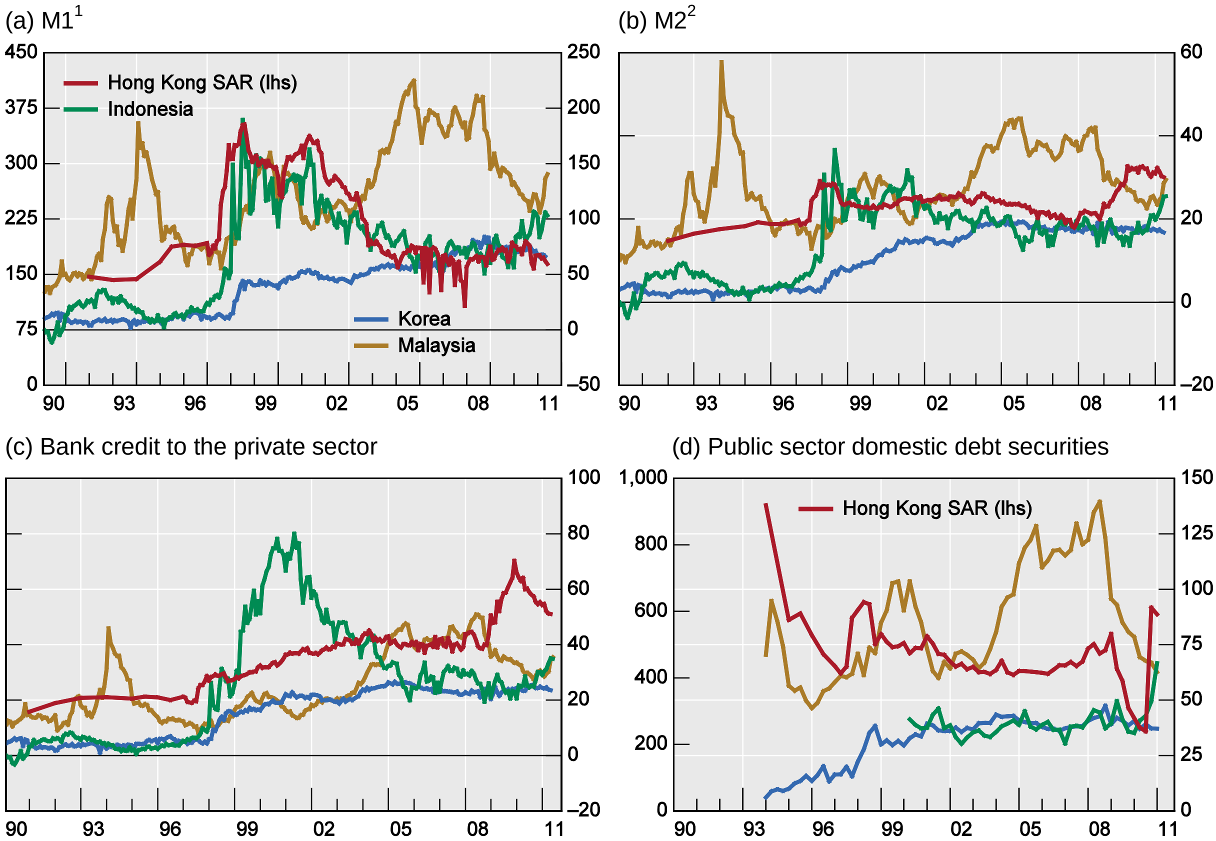
Finally, given the very uneven global growth prospects and the associated capital inflows into emerging Asia, there is little evidence to suggest that sterilisation through the issuance of central bank securities would assume a smaller role in the years to come.

Appendix

Graph A1

Foreign exchange reserves minus currency held by the public

As a percentage of:



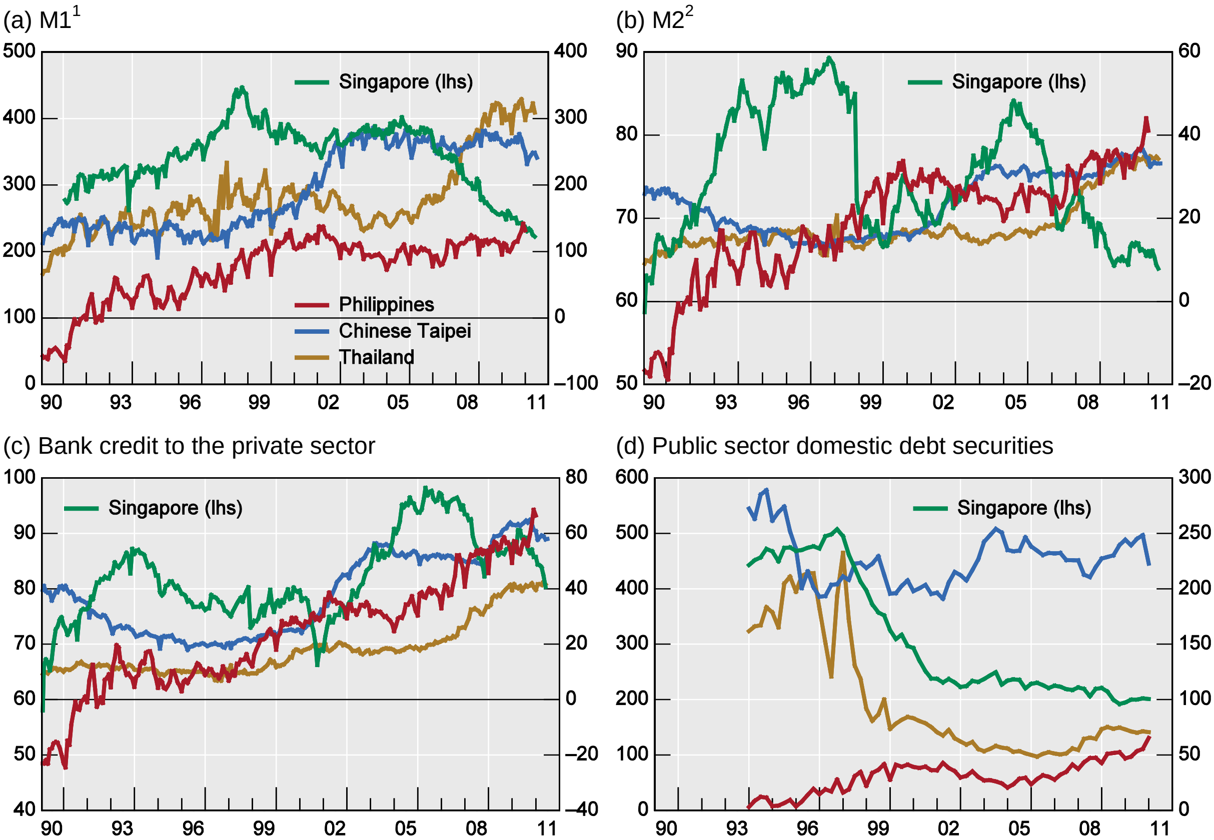
[1] M1, also called narrow money, comprises transferable deposits and currency outside deposit money banks. [2] M2 is a broad measure of money which in general comprises, in addition to M1, time, savings and foreign currency deposits of resident sectors other than central government. The components can vary across economies.

Sources: IMF; Datastream; national data; BIS.

Graph A2

Foreign exchange reserves minus currency held by the public

As a percentage of:



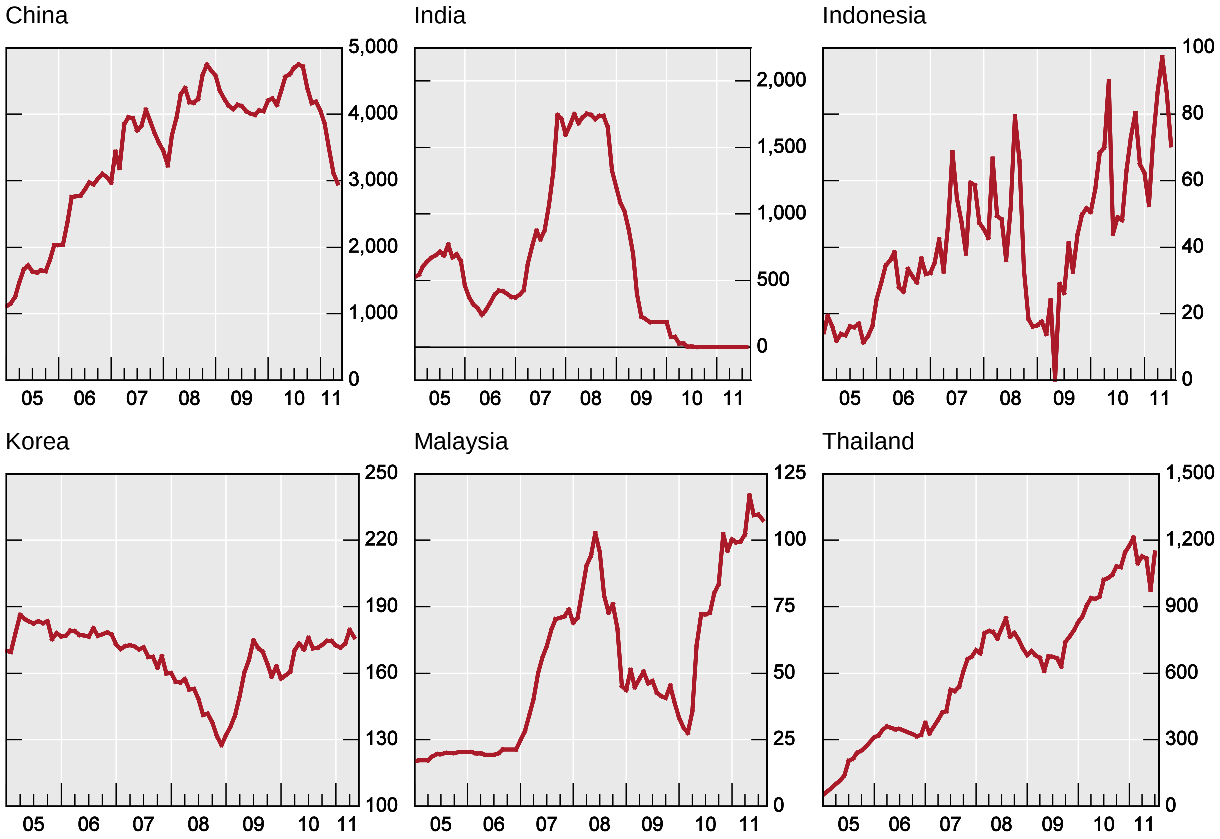
[1] M1, also called narrow money, comprises transferable deposits and currency outside deposit money banks. [2] M2 is a broad measure of money which in general comprises, in addition to M1, time, savings and foreign currency deposits of resident sectors other than central government. The components can vary across economies.

Sources: IMF; Datastream; national data; BIS.

Graph A3

Central bank securities[1]

In billions of national currency[2]



[1] For India, proceeds from auctions of treasury bonds and securities under the market stabilisation scheme deposited at the Reserve Bank of India. [2] For Indonesia and Korea, in trillions.

Sources: IMF; CEIC.

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Central bank balance sheet expansion: Japan's experience

Kazumasa Iwata and Shinji Takenaka[1]

Abstract

The expansion of central bank balance sheets and the changes in their composition during financial crises have been effective in rectifying market malfunction and stabilising financial markets in Japan and elsewhere. However, the unconventional policy measures are accompanied by costs, as they are likely to lead to misallocation of resources and to the risk of looser fiscal discipline. An additional possibility is the adverse international transmission of monetary expansion through changes in exchange rates and terms of trade, depending on the price setting behaviour of exporting firms. Even more harmful is the effect on emerging economies when there is financial market disruption in the financial centres.

Keywords: Central bank balance sheets; international transmission; financial stability

JEL classification: E58, F42

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I. Introduction

With the onset of the Lehman shock, central banks of advanced economies faced the zero bound of nominal interest rates and embarked on unconventional monetary policy measures. The Bank of England was in the forefront, initiating its large-scale asset purchase program in March 2009. That move was followed by the Federal Reserve, and the Bank of Japan instituted a new fund to purchase a variety of risky assets in the framework of "comprehensive easing policy" in October 2010.

The Bank of Japan had experience with unconventional policy measures prior to the Lehman shock, however. It should be noted that the expansion of central bank balance sheets is only one aspect of unconventional policy measures. In its second round of unconventional policy measures, extending from December 2008 to the present, the BOJ put emphasis on easing credit and bolstering growth, rather than on quantitative easing as in the first round of policy measures.

The recent expansion of central bank balance sheets was accompanied by a depreciation of major currencies, including the US dollar, the euro and the pound sterling, but not the Japanese yen or Swiss franc. The expansion of central bank balance sheets in advanced economies provoked criticism from the governments of emerging economies. Mr. Mantega, the Brazilian Minister of Finance, accused the aggressive expansion of the US Federal Reserve's balance sheet of causing "currency wars", because the dollar depreciation that it entailed a "beggar-thy-neighbor" effect in emerging economies.

Yet Eichengreen and Sachs (1985) had already pointed out that devaluations via monetary base expansion increase global aggregate demand by lowering the global real interest rate. They argued that the beneficial effect was at least as important as the expenditure-switching effect of competitive devaluation.

In the context of "new open-economy macroeconomics" (NOEM), Obstfeld and Rogoff (1995) insisted that not only the home economy, but also foreign economies, benefit from monetary expansion. They pointed out that the impact of terms-of-trade and current-account changes on national welfare is of secondary importance.

However, terms-of-trade improvements cause a welfare-enhancing shift of national budget constraints. Corsetti and Pesenti (2008) graphically showed that terms-of-trade changes can play a critical role in the international transmission of monetary policy. Depending on exporters' price-setting behavior, the international transmission mechanism may be either positive or negative.

This paper attempts to examine how monetary expansion in the form of large-scale purchase programs has affected welfare, both nationally and internationally. We investigate the international transmission of monetary expansion through changes in exchange rate and terms of trade, in light of the Japanese experience.

The emerging economies may benefit from lower global real interest rates and improved terms of trade. However, aside from the added complication of macroeconomic policy management with respect to inflation and asset price bubbles in the domestic economy, adverse effects on manufacturing production due to the erosion of competitiveness cannot be ruled out.

Section II provides an international comparison of quantitative and credit-easing policies, examining those of the advanced economies in comparison with the Japanese experience specifically. Section III reviews the long-term movement of real exchange rates and terms of trade in advanced economies. In Section IV, we turn to the relationship between real exchange rate and terms of trade. Section V focuses on the role of price-setting behavior by exporting firms, which is linked to their choice of invoice currency. Section VI discusses the difference in international transmission of monetary policy arising from the different price-setting behaviors of exporting firms. We offer an evaluation of the recent episodes of international transmission of monetary policy, on the basis of observations regarding developments in exchange rates and terms of trade.

II. Scope of Quantitative Easing / Credit Easing Policies

Bank of Japan

Japan's unconventional monetary policy began in March 2001, one week after the announcement in the Japanese government's monthly economic report that the nation's economy was in "mild deflation". Before the announcement, neither the government nor the Bank of Japan had recognized mild deflation of about 1% as deflation.

The first unconventional policy period, from March 2001 to March 2006, comprised several measures, including (1) the zero interest rate policy (ZIRP), (2) quantitative easing (balance sheet expansion), (3) policy duration announcements and (4) credit-easing policy (changes in the composition of the balance sheet).

On the quantitative easing (QE) front, the bank reserve target increased from 5 trillion yen to 32–35 trillion yen, with purchase of government bonds amounting to 18 trillion. Thus, the ceiling on government bond holdings was set not to exceed the amount of the BOJ note outstanding at the time when the first round of QE was initiated. The BOJ note rule was introduced under the premise that it would prevent facile monetization of budget deficits (Shiratsuka, 2009). As a result, the unconventional policy measure was executed in conventional fashion, since the BOJ took into account that currency issuance on the liability side is normally backed by long-term assets on the asset side.

The BOJ was evidently more cautious about the consequence of long-term government bond purchasing than were other central banks, as the Ministry of Finance did not indemnify it for the cost of purchasing long-term bonds and other risky assets – a practice that contrasts sharply with TARP in the US or APF in the UK. The BOJ's total assets increased by about 42 trillion yen, and the ratio of the assets to nominal GDP rose from 20% in 2001 to 30% in 2006 (Figure 1). However, it should be noted that prior to the introduction of QE, the BOJ balance sheet had already started to grow – since mid-1997, when the risk of financial crisis intensified both in Japan and in the Asian economies in general.

A commitment regarding the duration of the policy was made as part of the framework of the quantitative easing. The conditions for exit from QE were clarified in October 2003, when it was decided that the policy would be maintained until the core consumer price index showed a stable rate of positive change.[2]

The credit-easing policy included the purchase of ABS (Asset-Backed Securities), ABCP (Asset-Backed Commercial Paper) and equities from financial institutions. It should be noted

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[2] Facing tremendous market stress and disruption, the Bank of Japan embarked on the zero interest rate policy (ZIRP) in February 1999, announcing the duration of the policy in order to affect longer interest rates through the channel of market expectations.

With hindsight we may argue that the termination of the ZIRP in August 2001 was premature, since the Japanese economy entered recession in October 2001. The recession in Japan was caused in part by the bursting of the IT bubble in the United States in April 2001.

Moreover, the conditions for termination of the ZIRP were not transparent enough. Then Governor Hayami noted that the ZIRP would be sustained until fears about deflation subsided. When the ZIRP was terminated, the consumer price index continued to register negative rates of change. Presumably, the deflation of about 1% was not identified as deflation. It seems to us that the "deflationary spiral" that occurred during the Great Depression, which was accompanied by unemployment of 20%–30%, was defined as deflation (Iwata, 2010).

that the purchase of equities was implemented as an instrument of macro-prudential policy, for Japan's major private banks held large amount of equities of customer firms, and the collapse of equity prices endangered the maintenance of their capital base.

What was remarkable was the massive intervention policy implemented by the MOF (Ministry of Finance). From the spring of 2003 to the spring of 2004, the MOF conducted a massive intervention on the foreign exchange market, amounting to about 35 trillion yen, with the implicit target rate ranging from 110 to 120 yen to the dollar.[3] Meanwhile, the bank reserve target was raised by 15 trillion. This may imply that the Ministry of Finance virtually implemented an unsterilized intervention policy to the tune of 15 trillion yen under the zero interest rate policy. The intervention policy, supported by monetary policy easing, seemed to support the downward trend in the value of the yen during the period of quantitative easing.

Moreover, in 2006 and 2007, the yen carry trade maintained the downward trend. Foreign banks could borrow yen-denominated funds at negative interest rates on the short-term money market, due to the advantageous position they enjoyed over Japanese banks on the international financial market. Given the BOJ's sustained zero interest rate policy, foreign banks borrowed yens at comfortably low interest rates, conducting carry trades through interoffice accounts. This helped fund the general increase in the balance sheets of hedge funds and financial intermediaries at financial centers (Hattori and Shin, 2007).

After the bankruptcy of Lehman Brothers, a second round of unconventional monetary policy was implemented, consisting of three pillars: (1) market stabilization, (2) reinforcement of growth and (3) comprehensive monetary easing. For market stabilization, the BOJ instituted a policy measure to support enterprise financing in December 2008, focusing on providing credit to enterprises. It also implemented a measure to enhance the growth base by providing fixed interest-rate funds in June 2010.

In October 2010, the Bank of Japan initiated a "comprehensive easing policy". There was more emphasis on credit easing than there had been in the previous quantitative easing policy. The scope of the assets menu was widened to include private bonds with lower ratings, ETFs and J-REITs. The J-REIT dividend yield in particular reacted sharply, and the J-REIT index bottomed out immediately after the announcement of the BOJ J-REIT purchase (Figure 2).

Within a framework of comprehensive easing, the BOJ established a BOJ asset-purchase fund, thereby abolishing the ceiling on long-term government bond purchasing. The size of fund was expanded three times, rising from 35 trillion to 55 trillion yen by October 2011, and the total purchase of long-term government bonds will increase to 30.6 trillion yen. Yet the losses involved in the asset purchase were not covered by the MOF. It seems desirable to establish an entity separate from the BOJ balance sheet, and to widen the scope to expand the purchase of various assets, including foreign bonds, with collaboration from the MOF. One of the authors proposed establishing a crisis prevention fund of 50 trillion yen for purchasing foreign bonds. The MOF should indemnify this fund from loss at an initial meeting of the state strategy conference in late October 2011.

Furthermore, it is reasonable to conduct the purchase of government bonds in a manner consistent with debt management policy. Lengthening the maturity structure from the debt management policy side should be avoided, because it will prevent long-term interest rates from dropping. In QE 1, debt management policy lengthened the maturity structure by issuing new bonds, while the maturity of the government bonds held by the BOJ was shortened (Iwata, 2010).

3 See Taylor (2008) for details regarding the implicit exchange-rate target range proposed by Mr. Zenbei Mizoguchi, then MOF Vice-Minister.

The comprehensive easing policy also extended the time horizon for the policy. The easing policy will be maintained until an inflation rate of about 1% appears on the forecast horizon. We can interpret this as a sort of "forecast inflation targeting". One of the authors found it appropriate to introduce that practice in October 2003, when the concept of policy duration was clarified.

In the second round of unconventional policy measures, the expansion of the BOJ balance sheet was initially modest. However, the size of the balance sheet as a proportion of nominal GDP increased more rapidly after October 2010. Yet the level of BOJ's total assets remained lower than during the first quantitative easing policy (Figure 1).

As to intervention policy, there were four market interventions – in August 2010 (2.1 trillion yen), in March 2011 (700 billion yen in a "concerted intervention with the G7 countries"), in August 2011 (4.5 trillion yen) and in October/November 2011 (approximately 10 trillion yen). The total amount was modest in comparison with the major intervention policy of 2003–4.

Where the yen differs from the US dollar, euro and UK sterling is that the nominal/real effective value of the yen showed a sustained upward trend from a bottom in 2007, despite the adoption of BOJ's expansionary monetary policy. This may be due to the fact that Japanese financial institutions sustained less damage than their US counterparts during the global financial crisis, and that Japan's monetary expansion was modest in comparison with the US.

The IMF's annual consultation report provided an assessment of QE 2, pointing to a 25–50bp decline in 10-year bond rates, a stock price rise of 5–7% and an increase of 14.3% in the J-REIT index. However, the effect on the yen was found to be ambiguous.

In spite of the implementation of the two unconventional policies, the deflationary trend persists. The CPI, excluding energy and food, registers approximately a 1% decline, while the rate of change of the comprehensive CPI remains close to zero following the change of base year in August 2011.

Based on various empirical studies, the effects of the two rounds of unconventional policy measures in Japan can be summarized as follows:

1. Liquidity and credit premiums narrowed significantly.
2. The private bond spread was reduced, reflecting smaller risk premiums. In the second round of unconventional policy measures, the impact on the J-REIT dividend yield was conspicuous.
3. Longer-maturity interest rates declined, mainly due to the policy duration effect. This was supplemented by quantitative easing policy in the first round of unconventional policy measures. In the second round, the lower long rates were primarily achieved by direct asset purchasing, for the policy duration effect was not employed until the comprehensive easing policy was announced.
4. Equity prices responded positively to the unconventional policy measures, while the impact on bank credit was limited, due to balance sheet adjustments both by banks and non-financial firms in the process of deleveraging during QE 1, and as a result of weak demand for bank loans in a stagnant economy during QE 2.
5. The impact on the exchange rate seems to have been significant in the first QE, as massive intervention was employed in the process of increasing the bank reserve target under the ZIRP (Watanabe and Yabu, 2007). The joint efforts succeeded in bringing down the nominal/real yen exchange rate, which in turn helped to bring about a gradual increase in the rate of change of core consumer prices to slightly above zero in early 2006. In the second round of unconventional policy measures, however, the effect on the exchange rate was muted, because the Federal Reserve

and other central banks implemented asset purchase programs on a far greater scale than the BOJ.

6. The impact on aggregate demand was limited, primarily due to the fact that the expansion of BOJ's asset holdings and the monetary base expansion cannot be permanent, given the commitment to exit from QE. QE was conceived as a temporary measure to employ while the financial intermediary function of financial institutions was restored. This problem is common to other central banks' balance sheet expansion as well. The BOJ has not yet succeeded in reversing the persistent deflationary expectations.[4]

The Federal Reserve

After the policy rate was reduced to its essentially zero lower bound in December 2008, the Federal Reserve introduced the first large-scale asset purchase program (QE 1) amounting to $1.75 trillion in March 2009. This included the massive purchase of MBS ($0.6 trillion), agency bonds and government bonds ($0.3 trillion). The spreads between MBS and Treasuries were significantly reduced.

Before launching QE 1, the Fed introduced the dollar swap line program with the ECB and the SNB, in the face of disruption in the dollar funding market, including the euro/dollar FX swap market**,** in December 2007. At the peak of the program, swaps outstanding totaled more than $580 billon, accounting for over 25% of the Fed's total assets in December 2008 (Flemming and Klagge, 2010).[5] The swap arrangements proved to be effective in stabilizing financial markets. At the same time, they pointed to a need for international coordination to provide sufficient global liquidity when financial shocks originate at centers of international reserve currencies. At the end of November 2011, in the face of global fear regarding the euro's existential crisis, the Federal Reserve slashed the penalty rate on dollar liquidity from 1% to 0.5% in swap arrangements with the ECB, BOE, BOJ, BOC and SNB.

The second large-scale purchase program was initiated in November 2010 and ended in July 2011. The second policy program focused on purchases of government bonds totaling $0.6 trillion, as the Federal Reserve adopted quantitative easing rather than a credit-easing policy.

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[4] Dr. Ryuzo Miyao argued at the conference that the deflationary expectation has been removed since the mid-2000 decade, citing the survey report on inflation expectations in Japan. Yet the break-even rate for index bonds has revealed persistent deflationary expectations, although the index bond market is not well-developed in Japan.

[5] The Fed introduced a system of reciprocal currency arrangements, a dollar swap line program, with the ECB and the SNB in December 2007; its function was similar to the Term Auction Facility, constituting an instrument to stabilize the financial market as a "lender of last resort".

The first phase, from December 2007 to September 2008, aimed to extend the TALF to overseas financial institutions, and the second phase, from September to October 2008, involved the BOE, BOJ, BOC, RBA, SR, NB, DN, RBZW, BCB, BM, BOK and MAS. The Fed expanded the size and scope of the program, and the available amounts rose from $67 billion to $620 billion.

The BOJ joined the arrangement in the third phase, from October 2008 to February 2010. In the case of Korea, the Bank of Korea loans funded by the swap arrangement with the Fed were more effective in stabilizing the financial market than were swaps in which the BOK used its own foreign reserves. This is because of market confidence and the effective additional amount of foreign reserves (Baba and Shim, 2010). The total available amount peaked at $580 billion, representing 25% of the FRB's total asset holdings. In September 2009, the Fed opened foreign currency swap lines with the ECB, the SNB, the BOE and the BOJ, which enabled it to provide liquidity in foreign currencies to US financial institutions. In the face of deepening fiscal crisis in Europe, the dollar swap arrangement entered the fourth phase in May 2011.

One of the differences between the Fed's policy and Japan's quantitative easing policy was its focus on the asset side of the central bank balance sheet, whereas the BOJ set its target on the liability side of the balance sheet, ie the amount of sight deposits outstanding by financial institutions at the BOJ. The policy centering on the asset side aimed to support the financial intermediary function through asset purchases by the central bank, while the liability-side policy provided a buffer against funding liquidity by increasing private banks' excess reserve. The difference between the unconventional policy measures of the Fed and the BOJ reflects in part the difference in financial structure (market-based system versus banking-based system). The emergency liquidity was provided not only to commercial and investment banks but also to the shadow banking system.

A second difference is the inclusion of large-scale purchasing of MBS, putting emphasis on the credit-easing side of unconventional policy measures. A third difference is the speed of expansion of the central bank balance sheet. The Fed took about one year to increase the size of its balance sheet from 20% to 30% (Figure 3), while the BOJ took five years to reach a 10% increase in the ratio.

In August 2011, the Federal Reserve announced the extension of the low interest rate through mid-2013, aiming to produce lower long rates through the channel of market expectations regarding policy duration. Mr. Evans, President of the Chicago Federal Reserve Bank, urges further clarification of the exit conditions. Monetary easing should remain in place as long as the unemployment rate remains above 7.5%, given the dual mandate of the Federal Reserve.

In September 2011, the Fed implemented "Operation Twist" (the asset composition change policy) to the tune of $400 billion. The Maturity Extension Program was designed to change the composition of the balance sheet and lengthen the maturity of the Fed's holdings of government bonds from 75 months to 100 months. Operation Twist is expected to lower the long-term interest rate by 15bp, an effect is similar to that of QE 2 (Alon and Swanson, 2011).

After the announcement of the two policy measures – one to lower interest rates on maturities of one month to two and half years, and the other to reduce rates on maturities longer than three years – the decline of nominal long rates was accompanied by lower real bond yields, which fell below 0%. The sharp reduction in long-term interest rates was in part due to the flow of money from money market funds into the Treasury market that occurred because the money market funds proved to be engaged in lending to European borrowers.

According to the IMF's assessment of the cumulative effects of QE 1 and 2, the long-term interest rate fell 105bp. Gagnon et al (2010) estimated that the 10-year term premium was reduced by 30–100bp. If the effect of agency bonds and MBS are included, the impact was much larger. The announcement of QE 1 provided the real turning point for the market in CDS and equities in the US and emerging countries, thereby narrowing the spread between MBS interest rates and government bond interest rates.

The IMF study found that QE 1 and 2 pushed the dollar down by 5%. It is interesting to note that, according to IMF estimates, the two programs served to raise the yen 12%. The estimates suggest that US LSAP 1 and 2 dominated the movement of the yen. The yen/dollar ratio rose sharply after 2008, thereby dampening the effect of the BOJ's expansionary policy measures on the yen.

As to effect on aggregate demand and unemployment, the San Francisco Federal Reserve Bank, citing the FRB/US model, argued that LSAP 2 would raise real GDP by 3% and increase the inflation rate by 1%, thereby reducing unemployment 1.5% (Chung, Laforte, Reifschneider and Williams, 2011). The actual outcome was rather disappointing. The limited effect may be in part attributable to the issuance of new government bonds at a faster rate than the Fed's purchase of bonds.

So far, the US seems to have escaped falling into deflation. Although the expected inflation rate rose with QE 2, it fell steeply as commodity prices started to decline. In September 2011, it stood at the same level as it had in the summer of 2010 when QE 2 was announced.

Moreover, US expansionary monetary policy was accompanied by a rise in commodity prices that fed back into the US economy, dampening consumer spending. The US expansion slowed down starting in early 2011, in part due to the oil price hike.[6] Adverse international repercussions from monetary expansion can undermine improvement in the welfare of the domestic economy – an issue that we shall return to in Section VI.

ECB

The liquidity shock of early August 2007 prompted the ECB to provide massive liquidity (a total of Є95billon) to the financial market through main refinancing operations, in response to the first signs of the subprime seizure. The majority of the liquidity was sterilized, as the widening of the Euribor-OIS spread slowed down.

In the wake of the Lehman shock, the euro system's balance sheet expanded from €1.5 trillion to €2 trillion by mid-2008. In comparison with other central banks, the expansion of its total assets remained relatively modest until mid-2009.

In October 2008, the ECB decided to change its weekly main refinancing operations to a tender procedure with full allotment at a fixed rate. Mr. Trichet called this "enhanced credit support". The enhanced credit policy worked to lower funding costs for banks of peripheral countries such as Greece, Ireland and Portugal; average cost was estimated to have fallen almost 500bp, according to the IMF spillover study (2011).

However, the balance sheet expansion began again in June 2009. The ECB began to purchase the covered bonds and continued the operation for one year. This asset purchase can be described as an "ambiguous quantitative easing policy" or as "non-standard monetary policy".

Facing the deepening fiscal crisis, the ECB began to purchase bonds issued by the governments of Greece, Ireland and Portugal in May 2010, in an attempt to remedy the malfunctioning of the government bond market (the Securities Markets Program). In July 2011, it purchased Italian and Spanish government bonds. As of end-October, total purchases of government bonds had reached about Є183 billion.

The Treaty on European Union (Article 21.1) prohibits the ECB from directly buying bonds from EU governments, based on the premise that the ECB is not allowed to engage in deficit financing of euro member governments. The purchase of government bonds from secondary markets is not prohibited. But the potential loss will erode the ECB's capital base.

It is not the General Council of the ECB, but the European Council, that has the power to make decisions on increasing the ECB's capital. The issue of indemnification will arise immediately if euro member governments want to employ the ECB's securities markets program for the purpose of leveraging the European Financial Stability Facility. As early as late 2010 the ECB attempted to persuade finance ministers to at least double the EFSF rescue fund and indemnify it against possible losses from its purchase of weaker euro member countries' securities.

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6 Empirical evidence based on event study does not support the notion that the announcement of LSAP 1 and 2 pushed up energy prices (Glick and Ludec, 2011). However, it may be that energy demand rose due to the expansion in emerging economies produced by the US stimulus measures.

While it is uncertain to what extent the ECB will purchase government bonds in the future, the ECB decided to reinstitute the purchase of covered bonds in October 2011. The ratio of its total assets to nominal GDP increased comparably to other central banks' ratios: from 15% in 2007 to 25% in 2011 (Figure 4).

Non-standard monetary policy seems to have exerted a significant effect on bank lending rates, but not on the amount of bank lending. The euro rate was affected by the interest rate differential between the US and the euro area, while the effect of non-standard monetary policy on the euro rate seems to be ambiguous (Takaya, 2011).

Bank of England

In January 2009, the Bank of England created a new fund, the "Asset Purchase Facility", which initially purchased commercial paper funded by the proceeds of sales of short-term Treasury bills by the Debt Management Office. This policy measure can be classified as credit easing akin to fiscal operations. In March 2009 the BOE embarked on its quantitative easing policy, announcing that it would purchase ₤200 billion of long-term government bonds, or 14% of nominal GDP, exceeding the expected size of the newly issued 2009 bond. In October 2011, the BOE expanded the asset purchase by ₤75 billion in view of weak domestic demand and an expected inflation rate lower than the medium-term target, despite the current high inflation rate of 4.5% in August.

The BOE asset purchase was conducted by a separate entity, the BOE Asset Purchase Facility Fund, a limited liability company. Both the BOE and the Fund are fully indemnified by the Treasury for any losses arising out of the asset purchase program. Furthermore, an agreement was concluded between the Chancellor of the Exchequer and Governor King to the effect that the debt management policy would not alter the plan for gilt purchases as a result of the temptation to minimize cost (Iwata, 2009).

Another difference from the BOJ's quantitative easing policy is that the BOE focused its asset purchases on the non-bank private sector, such as pension funds; it did not aim to expand bank lending directly. The banking sector was in a process of deleveraging, and faced a risk of capital shortage.

The BOE's total assets had already expanded prior to the launch of the quantitative easing policy. The ratio of the balance sheet to nominal GDP increased from less than 5% at end-2008 to over 15% in mid-2010 (Figure 5).

According to the BOE's empirical evidence based on event studies regarding the effect of QE 1, the long-term interest rate in the 5- to 25-year segment was lowered by 50–120bp, mainly through a portfolio rebalancing effect (Loice et al, 2010). The size of the effect was similar to the effect of US QE I and II. Yet the impact on equity prices was muted, although the negative tail risk diminished considerably with the implied volatility, falling about 40%.The medium-term inflation expectation seems to have remained stable, despite the fact that the inflation rate considerably exceeded the target. Moreover, the effect of QE 2 is expected to be larger than that of the 0.75% interest rate cut.

The impact on the exchange rate was small; the event study suggests that the scale of the immediate response of sterling to the QE announcements would bring about an estimated depreciation of 4%.

During the period of February 2009 to March 2010, sterling actually appreciated 1%. The uncovered interest rate parity suggests an 8% depreciation, if we consider the reduction of ten-year spot yields around the QE announcement events.

The smaller impact on sterling may be attributed to two facts. First, prior to the introduction of the large-scale asset purchase program, the nominal/real sterling rate began to drop sharply in mid-2007. The large-scale asset purchase program was instituted after the depreciation bottomed out.

Secondly, other advanced economies also implemented expansionary monetary policies.

Thirdly, Mr. Broadbent, a member of the BOE Monetary Policy Committee, pointed out that the sustained expected depreciation of the real 5-year forward sterling rate could be attributable to the changes in terms of trade and the relative price of non-traded output to traded output (Broadbent, 2011).

In his view, the market judged that the credit crunch would hit the demand for non-tradables hard, as shown by weak residential investment and the anticipated reduction of public spending due to the vulnerability of public finances. Moreover, the low supply elasticity arising from a low degree of factor mobility added to the expected decline in non-tradable prices.

In other words, a sharp expected decline of expenditure in the non-tradable sector brought about a sizable depreciation in the real sterling rate, judging from the developments of real 5-year forward rates against the dollar and the euro. This insight is illuminating indeed, and we shall return in Section IV to this issue of the relationship between the real exchange rate, the terms of trade and the relative price of non-traded to traded output.

The Swiss National Bank

The ratio of the SNB's balance sheet to nominal GDP increased sharply immediately after the collapse of Lehman Brothers, at the same time as the second phase of international agreement on the US dollar swap arrangement came into play. Furthermore, the SNB engaged in intervention policy starting in the spring of 2009, with the aim of moving out of deflation and avoiding an excessive appreciation of the Swiss franc.

The size of the SNB's balance sheet as a proportion of nominal GDP expanded rapidly, from 25% in September 2008 to over 50% in 2010 (Figure 6). When the ECB introduced its 12-month long-term repo operations in 2009, the SNB was obliged to intervene on the foreign exchange market. Then euro-area banks unable to access Swiss franc funding on the interbank markets to finance loans denominated in Swiss francs used the ECB's liquidity tenders and immediately sold euros on the spot market. The Swiss franc is now a shadow currency such as the German mark prior to the introduction of the euro.

The Swiss economy fell into deflation in early-2009. But thanks to a massive intervention policy, deflation ended in October 2010. The achievement was accompanied by a large capital loss, which invited criticism. Yet in Japan we have accumulated even greater capital losses in the Foreign Exchange Account due to the sharp appreciation in the yen rate after 2008.

In August 2011, Switzerland's central bank announced an upper limit on the euro/franc rate, virtually pegging the Swiss franc to the euro. No appreciation would be tolerated beyond 1.2 francs to the euro, though a lower limit was not set. This implied a policy of unlimited intervention on the foreign exchange market. The ECB reintroduced its 12-month repo operations. This would imply upward pressure on the Swiss franc vis-à-vis the euro, leading the SNB to intervene in the spot market, with a consequent further expansion of the SNB's balance sheet. Critics expressed the view that the unlimited intervention policy would invite danger from a beggar-thy-neighbor effect and provoke protectionist pressures in trading-partner countries. We will return this issue in Section VI.

III. Long-term Developments in Exchange Rates and Terms of Trade

Long-term developments in nominal/real effective exchange rates

In our discussion of the effect of unconventional monetary expansion, we now turn to the long-term evolution of the Japanese nominal/real exchange rate and terms of trade in comparison with other major economies.

The first remarkable fact is a sustained upward trend in the nominal and real effective yen rate since 1970. As to nominal rates, the Japanese yen and the Swiss franc show a strong upward trend (Figures 7.1 and 8). The degree of appreciation in the two cases is quite comparable, the nominal rates rising by a factor of four, the real rates nearly doubling. The difference between the two country's rates reflects two factors: the difference in their inflation rates, and the identities of their other trading-partner countries.

The nominal effective rate of the German mark (or, after 1999, the euro), as in the case of the Japanese and Swiss currencies, followed an upward, though much less pronounced, trend. In contrast, the real effective rate remained remarkably stable, with no appreciation since 1970 (Figure 9). The nominal/effective euro rate moved in parallel with the German rate, but appreciating more steeply than the German currency (Figure 10).

Germany benefited greatly from the introduction of the euro. After the introduction, the mark's real effective rate (employing unit labor cost as a denominator) depreciated by about 18%, while the real rates of the peripheral countries' currencies appreciated on the order of 7%–10% (Table 1). The competitiveness of German firms was substantially strengthened.

On the other hand, the US dollar has depreciated both in nominal and real terms, hitting a new low in 2011. The divergence between the nominal and real effective dollar rates was small in comparison with the sterling spread (Figure 11).

The nominal sterling rate depreciated drastically, by about 100%. But real effective rate depreciation was limited to about 25%, due to the fact that inflation was higher in the UK than in the economies of its trading partners (Figure 12).

As to the Asian economies, the depreciation of the nominal rate for the Korean won, at about 400%, was much greater than the depreciation of sterling, though the real rate depreciation was limited to about 70% (Figure 13). Similar trends can be observed with respect to the Chinese yuan (Figure 14).

The second marked feature is a sharp appreciation in nominal/real effective yen rates after the burst of the bubble, which reached its apotheosis in 1995. As Obstfeld (2011) noted, "In Japan's economic history after the bubble burst, the yen's strong nominal/real appreciation in 1990–95 stands out as a pivotal episode".

It is rare indeed, following the burst of a huge bubble, that a nation's currency should experience such an uninterrupted rise in both nominal and real terms (the "yen appreciation syndrome").The nominal effective yen rate appreciated by 45%, while the real effective rate underwent a revaluation of 38% between the second quarter of 1990 and the second quarter of 1995. In spite of the sharp appreciation of the real effective yen rate, the terms of trade deteriorated 1.9%. If we exclude energy prices from import prices, however, the terms of trade improved by a slight 0.1% (Table 3).

After the Lehman collapse, for instance, the US dollar continued to slide from its 2002 peak, reaching a trough in 2011. The nominal effective dollar rate depreciated 55%, while the real effective rate lost 33% (Table 3). This large depreciation is comparable only to what occurred after the Plaza Accord, when the nominal effective dollar rate fell 53% while the real effective rate dropped 45%. The difference between these two episodes of major dollar depreciation is the magnitude of the deterioration in the United States' terms of trade. This time around, the terms of trade worsened by 12%, whereas the deterioration was only 2.2% in the earlier event. This has implications for the international repercussions of US expansionary monetary policy, an issue dealt with in Section VI.

It is interesting to note that Reinhardt and Rogoff (2008) identified dollar crashes in 1969, 1971 and 1975 – a currency crash being defined as a sharp exchange-rate decline of more than 15% in a year's time. With the dollar's delinking from the gold standard in August 1971, the depreciation in the nominal effective rate was only 20% between the first quarter of 1970 and the third quarter of 1973 (Table 3).

Finally, even the nominal effective euro rate declined 7.1% from its peak in the third quarter of 2009, though this was a much smaller drop than experienced by other major currencies.

The third salient feature is related to quantitative easing. The trend of both the nominal and real effective yen rates was downward during the period of the first quantitative easing policy from March 2001 to March 2006. Empirical research by Watanabe and Yabu (2009) indicated that the increased bank reserve target combined with the massive intervention policy from the spring of 2003 to the spring of 2004 exerted a significant impact on the nominal/real yen rate, contrasting with conventional sterilized intervention policy.

The fourth way in which the yen rate differed markedly from other major currencies consisted of an extraordinary surge, from a bottom in 2007, despite the ample provision of liquidity and the subsequent implementation of comprehensive easing policy by the BOJ.

In the wake of the Lehman collapse, the yen and Swiss franc have been chosen as safe haven currencies. The nominal effective yen rate appreciated by 34%, while the real effective rate rose 27% between the second quarter of 2007 and the third quarter of 2011. It is important to note that Japan's terms of trade deteriorated a very significant 27.5%. Excluding energy prices from import prices, the deterioration was 6% (Table 2). The Japanese yen appreciated more than the Swiss franc in this period.

Long-term trends in the terms of trade

As to trends in the terms of trade, several features can be identified, as follows:

First, Japan's terms of trade showed a long-term decline from 1970 to 2011, in contrast to movements in the nominal/real effective yen rates (Figure 7.1). One of the primary factors worsening the terms of trade was the rising trend in energy prices. Japan's terms of trade deteriorated markedly in the course of the two oil price hikes of 1973–74 and 1979–80, in addition to the effects of the sharp upward trend from the middle of the 2000 decade to 2008.

Second, both the real effective yen rate and Japan's terms of trade are affected by shocks to the nominal yen rate, moving in the same direction as the latter.

On the other hand, the US terms of trade moved in tandem with the real effective dollar rate, except for the first half of the 1980s, when the real effective dollar rate deviated markedly from the terms of trade. At that time, protectionist pressures mounted, and led to the Plaza Accord in 1985 to avoid excessive overshooting of the dollar rate. However, the overshooting and upward deviation of the real dollar rate were much smaller than occurred with the Japanese currency after 1985 (Figure 11).

It is remarkable that both the UK and German terms of trade remained stable over the long term despite the fluctuation of real effective exchange rates.

Third, Japan's terms of trade continued to worsen during the QE 1 and 2 periods, although they improved slightly with the sharp decline of oil prices in July 2008. The real effective yen rate was on a downward trend during the QE 1 period, while QE 2 was accompanied by a sharp rise in the real effective yen rate and a worsening in the terms of trade. This worked to reduce the profit margin of Japanese firms, as discussed in the next section.

In the case of the UK, nominal sterling depreciation was about 40% between mid-2007 and 2009 (Figure 12). QE 1 was adopted after the sharp decline in the nominal effective rate. The decline in the effective exchange rate was accompanied by higher import prices, which significantly raised consumer prices. The depreciation may enhance international competitiveness by lowering UK export prices on the international market. However, it is notable that the terms of trade have remained virtually stable since 1980. The rise in import prices has been almost completely offset by higher export prices.

MacCoille et al (2010) explained the stability of the UK terms of trade as a result of the pricing strategies adopted by UK exporters and trading partners who export to the UK. According to their research, the equal proportions of UK exporting companies pricing in local currency (LCP) and foreign exporting companies pricing in their own domestic currency (PCP) led to the increase of both export and import sterling prices, broadly corresponding to the exchange-rate depreciation. The asymmetrical pricing behavior of UK and euro-area exporters left terms of trade unchanged in the face of exchange rate changes.

We elaborate in Section V on the question of exchange rate pass-through and choice of invoice currency in relation to changes in the terms of trade. Before discussing the question of invoice currency selection, we turn to Section IV, which examines the relationship between exchange rates and terms of trade.

IV. Relationship between Exchange Rates and Terms of Trade

The nominal exchange rate is responsive to asset market shocks, including changes in monetary policy. On the other hand, terms of trade are affected by exogenous productivity shocks and by changes in international commodity prices, which are determined exogenously to individual countries.

Changes in terms of trade in response to exchange-rate changes depend on a number of factors.

First, changes in the terms of trade in response to exchange-rate changes will initially depend on the currency in which domestic and foreign companies set their prices under the assumption of nominal price rigidity. Firms may also have agreed fixed-price contracts. The menu costs could be non-negligible.

Second, over time firms will be able to change their prices, depending on the timing of the renegotiation of fixed-price contracts. Prices will reflect changes in marginal costs and in price markups over marginal costs in response to exchange-rate changes. The relative responsiveness of demand and supply elasticity and the market structure affect outcome as far as prices are concerned.

Third, it is conventional wisdom that depreciation in the nominal/real exchange rate is accompanied by worsening terms of trade as import prices rise. However, this may not always be the case. Under conditions of flexible prices with non-tradable goods, absence of home bias with respect to tradable goods in trading nations will make the movement of terms of trade entirely independent of changes in real exchange rates.

Okada and Hamada (2010) have pointed out that the real exchange rate can diverge from the terms of trade as a result of two factors, namely:

1. the degree of home bias with respect to tradable goods produced by the home country; and
2. the international "difference in differences" of non-tradable/tradable price relationships from one country to another.

To demonstrate these two points, we follow the procedure employed by Okada and Hamada (2010) and by Obstfeld (2011).

The overall price index is defined as the weighted sum of tradable goods (P_T) – composed of goods 1 (export goods) and goods 2 (import goods) – and non-tradable goods (P_N). The price index of tradables is the weighted average of the two tradable goods (P_1, P_2), as follows:

$$P = P_T^{\theta_T} \cdot P_N^{\theta_N}, \quad P^* = P_T^{*\theta_T^*} \cdot P_N^{*\theta_N^*};$$

$$P_T = P_1^{\delta_1} \cdot P_2^{\delta_2}, \quad P_T^* = P_1^{*\delta_1^*} \cdot P_2^{*\delta_2^*}.$$

Then the real exchange rate = E P^*/P

$$= E \cdot \left[\left(P_1^{*\delta_1^*} \cdot P_2^{*\delta_2^*} \right)^{\theta_T^*} \left(P_N^* \right)^{\theta_N^*} \right] \Big/ \left[\left(P_1^{\delta_1} \cdot P_2^{\delta_2} \right)^{\theta_T} \left(P_N \right)^{\theta_N} \right]$$

$$= E \cdot \left[P_1^* / P_1 \right] \cdot \left[\left(P_1 / P_2 \right)^{\delta_2 \theta_T} \Big/ \left(P_1^* / P_2^* \right)^{\delta_2^* \theta_T^*} \right] \cdot \left[\left(P_N^* / P_1^* \right)^{\theta_N^*} \Big/ \left(P_N / P_1 \right)^{\theta_N} \right]$$

$$= E \cdot \left[P_1^* / P_1 \right] \cdot \left[\left(P_1 / P_2 \right)^{\delta_2} \Big/ \left(P_1^* / P_2^* \right)^{\delta_2^*} \right] \cdot \left[\left(P_N^* / P_1^* \right)^{\theta_N^*} \Big/ \left(P_N / P_1 \right)^{\theta_N} \right]$$

If we express the real exchange rate logarithmically (in small letters), then:

Real exchange rate = $(e + p_1^* - p_1) + [\delta_2\theta_T (p_1 - p_2) - \delta_2^*\theta_T^* (p_1^* - p_2^*)] + [\theta_N^* (p_N^* - p_1^*) - \theta_N (p_N - p_1)]$

As already pointed out by Mr. Broadbent, the real exchange rate is affected by terms of trade changes and by the relative price of non-traded output to tradables. The first term describes the "head-to-head competition" effect among exporting firms; the second term represents the "overall terms of trade" effect; and the third indicates the modified "Harrod-Balassa-Samuelson" effect (we employ the word "modified" because the third term includes the price of non-tradables relative to the price of tradable goods 1 only, rather than the price of both categories of tradables.

Based on the above equation, Obstfeld argues that "a rise of import price pushes up Japan's tradables price level and causes the real appreciation of the yen" (smaller value). This may not necessarily be true. The assumed opposite movements of the terms of trade and the real effective exchange rate are contrary to Japan's experience, except for 2007 and 2008. Our conjecture is somewhat different from his, as explained below.

Let us assume that prices are flexible, ie the "law of one price" holds with respect to the two tradable goods categories, so that

$P_1 = E \bullet P_1^*$, $P_2 = E \bullet P_2^*$.

Then the real exchange rate can be greatly simplified, as follows:

$$EP^* / P = \left(P_1 / P_2 \right)^{(\delta_2 - \delta_2^*)} \left[\left(P_N^* / P_T^* \right)^{\theta_N^*} \Big/ \left(P_N / P_T \right)^{\theta_N} \right].$$

In logarithmic form:

Real exchange rate = $(\delta_2 - \delta_2^*)(p_1 - p_2) - [\theta_N (p_N - p_T) - \theta_N^* (p_N^* - p_T^*)]$.

This result was obtained by Okada and Hamada (2010). The first term represents the terms of trade multiplied by the difference in weights attached to tradable goods 2 in home and foreign country. If there is a home bias with respect to the tradable goods produced by the foreign country, then it implies that $\delta_2 < \delta_2^*$.

As a result, real exchange-rate appreciation will be positively correlated with change in the terms of trade. However, the change in the terms of trade will be much larger than the real exchange-rate changes, as the home bias is less than one by definition. In reality, the terms of trade are more stable than the real exchange rate in the countries under observation (the US and UK; see Figure 7.3).

In addition, the positive association may be mitigated by the difference between the non-tradable/tradable price relation in one country and the non-tradable/tradable price relation in the other. If the non-tradable/tradable price differential is higher in the home country than in the foreign country, the positive association will diminish.

Furthermore, if purchasing power parity holds, with the home bias remaining in tradable goods, then the real exchange rate remains constant at one, for the purchasing power parity can be defined as:

$PPP=P/P^*$

and the terms of trade are determined entirely by the difference between one country's non-tradable/tradable price relationship and the other's.

Terms of trade = $(p_1 - p_2) = [\theta_N (p_N - p_T) - \theta_N^* (p_N^* - p_T^*)] / (\delta_2 - \delta_2^*)$.

Domestic productivity in tradable goods higher than non-tradable productivity pushes up the ratio of non-tradable to tradable goods prices. In addition, it tends to worsen the terms of trade. In reality, the trend of worsening terms of trade in Japan is often attributed to the differential between tradable-sector productivity and productivity in the non-tradable sector. On the other hand, a positive productivity shock to the tradable sector abroad works to improve the terms of trade in the domestic economy.

Harrod-Balassa-Samuelson effect

If there is no home bias, ie the consumers in the two country have identical preferences, $\delta_2 = \delta_2^*$, then the real exchange rate is completely independent from movement in the terms of trade. In this case, the real exchange rate is determined solely by the difference between the non-tradable/tradable price ratios of the two countries.

Given that the price differential between tradable goods and non-tradable goods may reflect a difference in labor productivity between the two sectors, a larger labor productivity differential in the home country implies the appreciation of its real exchange rate.[7]

Japan's labor productivity in the tradable sector is much more rapid than it is in the non-tradable sector. As a result, the productivity differential between the tradable and non-tradable sectors is larger in Japan than in the US. Thus, there is a tendency for Japan's real exchange rate with the dollar to appreciate (Harrod-Balassa-Samuelson effect). The terms of trade tend to worsen if the purchasing power parity holds.

To his surprise, Obstfeld (2011) could not detect any empirical evidence of short-run correlation between relative productivity changes and the yen real rate vis-à-vis the US dollar. In reality, real exchange rates show much more volatility than do relative productivity changes in the two economies. Obstfeld pointed out that only in the 1995–2004

[7] On a more rigorous derivation based on production function, see Obstfeld (2011), pp.72–77.

period, when Japan's relative productivity growth rate became smaller than that of the US, did the Harrod-Balassa-Samuelson model point in the right direction.[8]

The role of oil price changes

In Japan, the divergence between the real exchange rate and the terms of trade is conspicuously larger than it is in other countries like the UK and Germany.

In addition, the secular decline in terms of trade is notable. This may be due to heavy dependence on oil imports for the energy supply. Rising oil import prices may lower the relative price of non-tradable goods, and thus induce real depreciation, as the energy input share may be larger in the tradable sector. The secular deterioration of terms of trade during the period from 1970 to 2010 can be attributed at least partially to the rise in oil and food prices. Dollar-denominated oil and commodity prices are determined on the international market.

Moreover, the real price of oil and the real effective yen rate display a high negative correlation. Rising oil prices affect not only the terms of trade, but also, simultaneously, the real effective exchange rate. Japanese import prices have been strongly correlated with movement in oil prices.

Obstfeld (2011) found that Japan's terms of trade declined by more than 54% between 1988 and 2007, while the decline in the ex-energy terms of trade was much more moderate, at only about 18%. The ex-energy terms of trade have shown more stability than the overall terms of trade (Figures 7.2, 7.3).

It is true that the energy price rise contributed significantly to the deterioration in Japan's terms of trade. But given the existence of home bias with respect to tradable goods, it remains a puzzle why the terms of trade have worsened despite the strong rising trend of Japan's real effective exchange rate over the long run.

It is characteristic that Japan's export price did not respond to the rise in the oil price. Moreover, the export prices show a great deal of stability, despite the strong rising trend of nominal and real effective exchange rates. This suggests that Japanese firms resisted the appreciation by squeezing profits and cutting the ratio of markup to marginal costs. This suggests that Japanese exporters adopted the strategy of "pricing-to-market" or "non-pass-through" of exchange-rate changes to export prices.

Mark-ups and deflation

If the real effective exchange rate appreciates sharply and deviates from the fundamental rate, it will compress markups under conditions of monopolistic competition, and erode the international competitiveness of exporting firms.

If we can represent production costs by average costs, then international competitiveness can be described as:

$\phi = (P/Wc)/(P^*/Wc^*) = (P/P^*)/\ (Wc^*/Wc)$.

Fukao and Dekle (2011) focused on estimating average costs for high-productivity manufacturing, low-productivity manufacturing and the service sector in the US and Japan

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8 Yet he also added that the real yen rate against Germany is more consistent with the HBS theory. Moreover, Lane (2011) confirmed the possibility that the real exchange rate might appear to be co-integrated with the relative productivity variables. Dekle and Fukao (2011) find more evidence than does Obstfeld (2011), by adding the low productivity manufacturing sector to the model in Japan and the US.

during the period from 1980 to 2005. After the Plaza Accord, the ratio of average US costs to average Japanese costs declined sharply.

The above-mentioned authors derived the long-run equilibrium dollar-yen rate (benchmark PPP) from estimated average costs. The actual exchange rate widely overshot their putative equilibrium values in the 1985 to1995 period.

An attempt to arrest the erosion of the international competitiveness of Japanese firms by cutting wages and increasing the proportion of non-regular workers was one of the major factors which brought the Japanese economy into persisting deflation and depressed the level of investment, including software investment. It is symbolic that the trend of nominal wages began to register a negative rate of change in 1997.

We conjecture that Japan entered the era of deflationary equilibrium after 1995; the GDP deflator showed a negative rate of change in late 1994. CPI deflation started after the reappreciation in mid-1998, when the Asian crisis required appreciation of the yen through joint US-Japan intervention.

According to the estimates of the Dekle-Fukao model, the real exchange rate returned to the equilibrium level in 2003 when the nominal yen-dollar exchange rate was around 120 yen/dollar. This was exactly the rate at which the Ministry of Finance initiated the “Great Intervention Policy” in the spring of 2003. Thanks to the intervention policy, with implicit agreement between the Japanese and US authorities, the nominal yen/dollar rate remained around the 110–120 range. However, the findings of Dekle and Fukao diverge significantly from those of Jorgenson and Nomura (2007), who have provided empirical evidence, based on the PPP in terms of GDP, that the overvaluation reached levels of 78%, 41% and 24% in 1995, 2000 and 2004, respectively.

International competitiveness

If consumer prices can be taken to represent the movements of wage costs, and the law of one price holds, then international competitiveness can be measured by the difference between the terms of trade and the real exchange rate.

$\phi = (P_1/P)/(P_2^*/P^*) = (P_1/P_2)(EP^*/P)$

Hence, we can see that international competitiveness will be eroded if the appreciation of the real exchange rate exceeds the improvement in the terms of trade. In other words, if the real effective appreciation is not accompanied by improved terms of trade, it will lead to more difficult competitive conditions for Japanese industries. On the other hand, if the real effective exchange rate remains at one, then international competitiveness can be measured by changes in the terms of trade.

In fact, the US real effective exchange-rate appreciation exceeded the terms of trade improvement in the first half of the 1980s (Figure 11). The excessive dollar appreciation led to the Plaza Accord in 1985, although the appreciation of the real effective dollar rate was comparatively small (about 20%) in comparison with the appreciation of real effective yen rate in the mid-1990s (about 100%).

The international competitiveness of Japanese firms has been eroded by the steady rise of the yen, with a peak in 1995. Japan’s share of the world export market declined from 10% in 1993 to 5% in 2010, although its GDP continued to represent about 9% of the global economy (Figure 15).

It is debatable whether the current appreciation of the nominal/real effective exchange rate since 2007 is excessive or not. The current real effective exchange rate is close to its 2003 level, which is lower than the 1995 level. However, Jorgenson and Nomura (2007) estimate the equilibrium yen rate at 134 in 2004. It should be noted in addition that the terms of trade have continued worsening in recent years, diverging significantly from the real effective exchange rate.

Figure 16 shows the current real yen/dollar rate, with the Japan-US wage cost differential by industry as a denominator. Real appreciation has been greater in the case of major industries such as electrical equipment and transportation machinery than it was in 1995. Figure 17 presents Balassa's findings on comparative advantage by industry. The comparative advantage of general machinery and electrical machinery tends to decline after 1995. The comparative advantage of transportation equipment followed an upward trend up to 2008, but finally turned downward in 2009.

In addition, import penetration rose sharply in 2009, showing a pattern similar to the increase in 1995–1996 (Figure 18). Furthermore, the ratio of output price to input price in manufacturing, ie the terms of trade at the enterprise level, showed a declining trend starting in the mid-1990s, with the exception of precision machinery. A sharp drop in the terms of trade implied a heavy reduction in markups, notably in iron and steel, and in electrical machinery – industries that are exposed to fierce competition from Korean and Chinese exporters. Real effective exchange rates in Korea and China continued on a substantial downward trend that had begun in the 1970s or 1980s (Figure 13, 14).

In contrast, Germany maintained its share of the world export market at its early-1990s level by maintaining a stable real exchange rate thanks to the lower nominal euro rate, reflecting the international competitiveness of German exporters within the euro area.[9] German export industries have been well protected by the introduction of the euro.

V. Choice of invoice currency

Three options

There are three options for monopolistic exporters facing exchange-rate uncertainty in invoicing their transactions. The currency used for trade contracts is referred to as the invoice currency.

Given wide and rapid exchange-rate fluctuations under a floating exchange-rate system, it can be very costly for exporting firms to re-optimize offer prices at the time when the exchange rate changes. It seems reasonable to assume that exporters have to set prices before the exchange rate is known. Demand is then a function of the price that importers face after the exchange-rate uncertainty is removed. The choice of invoice currency would not have a different effect on the profit functions if exporters were to set prices after the exchange rate is known.[10]

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9 The productivity differential between traded and non-traded sectors is larger in accession economies than in euro-member economies. The price of non-traded goods in relation to traded goods is higher in the accession countries. Thus, overall inflation will be higher at a given exchange rate. This leads to appreciation of the real effective exchange once a country joins the euro system.

10 Friberg (1998) noted that under the pre-set pricing framework, the invoice currency functions as a store of value, after the price is set in some currency which functions as the accounting unit. The medium-of-exchange function of money is fulfilled by the currency used for payment – which is normally the same as the one used for the invoice.

Baccheta and Wincoop (2002) argued that within the partial equilibrium framework, the choice between PCP and LCP depends on the shape of the profit function, ie whether it is convex or concave in price (exchange-rate) changes. A monopolistic firm chooses PCP when the profit function is convex and the product differentiation is high. It chooses LCP when the profit function is concave and the product differentiation is low.

Producer currency pricing

The first option for exporters is to set their export prices in their home currency. The export price is P_1, irrespective of exchange-rate changes. In the literature this is termed "producer's currency pricing" (PCP).

In the case of PCP, the pass-through is 100%. This means wide fluctuations in import prices. In reality, import prices change much less than the exchange rate.

Under PCP, both the law of one price and purchasing power parity hold. Furthermore, the terms of trade immediately worsen as the exchange rate depreciates, for the terms of trade under PCP can be expressed as follows:

Terms of trade = $(P_1/P_2) = (P_1/EP_2^*)$.

Depreciation of the home country currency implies a greater E, thus worsening the terms of trade of the home country.

Assuming that exporters do not hedge their demand risk by buying forward contracts in their own currency, their offer price is higher due to risk aversion.[11] The optimal price is set independently from the shape of the utility function or the stochastic properties of the exchange rate ("separation theorem"), except for the specific demand function.

Local currency pricing

The second choice is to set the price in the currency of the destination country (local currency pricing, or LCP). By definition, the exchange rate pass-through is zero. The implicit assumption made here is perfect price discrimination by exporting firms, or market segmentation across the border. As a result, neither the law of one price nor purchasing power parity holds in the presence of nominal price rigidities.

In addition, by using the forward market and setting their prices in the importing country currency, exporters can fully avoids risk and achieve the same profit as under conditions of certainty. If the forward markets are efficient, exporters will hedge fully. In the case of LCP with hedging in the forward market, exporters' offer price does not depend on the shape of utility function or the stochastic properties of the exchange rates ("separation theorem").

Under LCP, exchange-rate depreciation is immediately accompanied by improved terms of trade for the home economy, because the export price is set in local currency, as denoted by P_1^F.

Under LCP, the terms of trade can be expressed as follows:

Terms of trade = $(P_1/P_2) = (EP_1^F/P_2^*)$.

Depreciation of the domestic currency (ie greater E) leads to an improvement in the terms of trade for the home country, while worsening the terms of trade for the foreign country. This is exactly opposite to that of the PCP case. It must be noted that the law of one price does not hold, because P_1 is different from EP_1^F. The terms of trade changes to depreciation/appreciation can be summarized as shown in Table 6. It may be noted that asymmetric use of PCP and LCP results in no change in the terms of trade, as pointed out by MacCoille et al (2010).

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11 Friberg (1998) noted that exporters usually do not hedge against demand risk by buying forward contracts in their own country. Yet it is not to be assumed that multi-national firms such as trading companies do not hedge against demand risk in the forward market.

On the other hand, uncovered interest rate parity can still hold, if we assume the international bond trading. The differentiated response of terms of trade to exchange-rate changes has important implications for the international transmission of monetary policy and its impact on national welfare, as discussed in Section VI.

Pricing to market and LCP

The choice of invoice currency is often discussed in relation to the practice of exchange rate pass-through or “pricing-to-market” (PTM) employed by exporting firms.

From the perspective of maximizing profits under exchange-rate uncertainty, exporters can stabilize demands in the foreign market by choosing LCP and engaging in less than full exchange rate pass-through. In fact, the choice of invoice currency is a function of the same factors (related to demand and cost functions) that determine the exchange rate pass-through[12].

Knetter (1993) provided empirical evidence that, for Japanese exports, destination-specific export price adjustment offsets 48% of the impact that exchange-rate changes have on price in the buyer’s currency. For Germany and the UK, the number is 36%, while for the US, it is zero.

It is understandable that the US terms of trade have moved in tandem with the exchange rate. Both exports and imports are invoiced in dollars (this is true for 90% of exports and close to 100% of imports).

Conversely, Japanese exporters’ exchange rate pass-through to export prices is 52%, which is much lower than the numbers for US, UK and German exporters. The difference may reflect the degree of product differentiation and shape of profit functions of the exporters of different countries.

It may also be due to the increasing share of intra-firm transactions and to market share considerations among Japanese exporters, the role of yen as an international currency aside.

Empirical evidence shows “mark-to-market” practices or low exchange rate pass-through to be positively associated with the choice of local currency (LCP) as the invoice currency. In other words, under LPC, exporting firms tends to choose the local currency as their invoice currency.

On the other hand, a study by the Cabinet Office estimated the exchange-rate change pass-through to be about 30%–40% between 1983 and 1990. But the share of the pass-through dropped to about 20% in the 1990s, before recovering to about 40%–60% in the latter half of the 2000 decade. The proportion to which the yen was used as an invoice currency for Japanese exports gradually increased during the period under observation. Thus, the magnitude of the pass-through was apparently affected not only by the choice of invoice currency but also by other prevalent economic conditions in the world economy.

The third-currency pricing option

The third option is for exporters is to use a third country’s currency for invoicing. Many Asian countries use the US dollar. Goldberg and Tille (2005) found the use of dollar as an invoice

[12] Friberg (1998) demonstrated that the sufficient conditions for choosing the local currency as an invoice currency are the same as the conditions requiring the exchange rate pass-through of export prices to be less than one.

currency in trade with non-US counterparts to be closely correlated with the extent to which a country's exports or imports featured organized-exchange transactions in items like commodities, precious metals and reference-priced goods such as chemical products.

An organized-exchange good is one that has an overt market, while a reference good is a uniform good without an official market but with reference prices that are published in trade magazines. In these markets, the firm is a price taker, and exchange-rate uncertainty easily translates into commodity price uncertainty.

We also observe that exports of differentiated goods tend to be invoiced in the exporting country currency, whereas organized-exchange goods and reference-priced goods are predominantly invoiced in the US dollar.

The role of the vehicle currency

The choice of a vehicle currency as a medium of exchange in order to facilitate international transactions in the foreign exchange market is influenced by network externality and low transaction costs coupled with the presence of inertia (Krugman, 1980). Low transaction costs are closely associated with a high degree of liquidity in the foreign exchange markets and domestic financial markets.

When a vehicle currency is used, stochastic changes in the third country's exchange rate affect demand. Exporters will prefer LCP, as they can fully insulate themselves from risks by using the forward currency market. But if the vehicle currency has less variance than the domestic currency, an exporter will prefer pricing in the vehicle currency to pricing in the home currency.

Actual use of invoice currency

It is interesting to note that the proportion of Japan's dollar-invoiced exports was 47.4% in 2009, while the dollar-invoiced proportion of US exports was 95% in 2003. In the case of Germany the 2002 figure was 32.3% (Table 5).

On the other hand, the yen-invoiced share of Japan's exports increased gradually from 36.1% in 2000 to 42.2% in 2009.[13] For Japanese imports, the dollar is the dominant invoice currency, reflecting in part the fact that commodity prices are denominated in dollars. Dollar-invoiced imports represent 72.1% of total imports, while yen-invoiced imports hover around 20–24% of the total (Table 4).

It is important to note that price setting behavior affects the terms of trade and the international transmission of monetary policy. Both the exchange rate pass-through and the choice of invoice currency suggest that not only PCP, but also LCP, plays an important role in firms' price setting throughout the global economy, except for the US. Even the mixed use of PCP and LCP may be one source of deviation from the law of one price and purchasing power parity.

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[13] Grassman (1973) found that the producer's currency tends to be the chosen currency in trade of Sweden and Denmark ("Grassman's Law").

VI. Difference in international transmission of monetary policy

New open-economy macroeconomics has provided new insight into the international transmission of monetary policy. Under conditions of nominal price rigidities, the transmission mechanism is influenced by differences in price setting behavior, which is linked to the choice of invoice currency.

It is also important to discern the effect of production and employment on a nation's welfare. Although the effects of monetary expansion on employment and production are the main focus in the political debate, it is crucial to watch the effects of monetary expansion on terms of trade for different countries, as well as the world real interest rate, in assessing impact on economic welfare.

As regards the effect of international transmission of monetary expansion on welfare, the main findings in the literature on the new open-economy macroeconomic model can be summarized as follows (Obstfeld and Rogoff, 1995; Corsetti and Pesenti, 2008; Betts and Devereux, 2000).

1. If all domestic and foreign exporting firms adopt PCP, then exchange rate changes affect export price in the foreign economy via a 100-percent pass-through effect. The 100% pass-through raises the home-currency price of imports, while it leaves export prices unchanged; thus it worsens the terms of trade for the home economy. Higher import prices expand domestic production, thereby reducing foreign production. At the same time, the domestic economy's current balance improves, while the foreign country's worsens.

   The deterioration of the home country's terms of trade will not necessarily affect the domestic labor supply, for the income and substitution effects tend to offset each other, and the domestic labor supply is completely shielded from changes in the terms of trade in the case of the Cobb-Douglas utility function.

   Foreign consumers can enjoy a higher level of consumption for an unchanged level of labor effort; the terms of trade improvements more than offset the reduction in production (Obstfeld and Rogoff, 1995; Corsetti et al, 2000). Thus, it is unlikely that domestic monetary expansion will cause a "beggar-thy-neighbor" effect. The expenditure-switching effect (which shifts world demand from foreign goods to home goods) works to dampen the volatility of the exchange rate by reinforcing the reallocation of resources. Monetary policy that is optimal for world welfare can be conducted without international policy coordination.

2. If all domestic and foreign exporting firms adopt LCP as their price setting behavior, then changes in the exchange rate do not affect export prices as denominated in foreign country currency. The terms of trade change with exchange-rate changes; depreciation raises the home currency price of exports, but leaves import prices unchanged. This results in terms of trade improvements for the home economy, contradicting the observation that depreciation is usually accompanied by a worsening of terms of trade.

   Changes in exchange rate involve no expenditure-switching effect. The trade balance is left unchanged in the absence of an expenditure-switching effect. Depreciation of the home currency, however, raises the markup over marginal costs in terms of the domestic currency, and reduces the markup of foreign firms; it shifts world income distribution toward the home economy. Home consumption increases relative to foreign consumption. As a result, domestic monetary expansion always improves domestic welfare by improving the terms of trade and increasing domestic income and production, while the welfare of the foreign country is eroded by the poorer terms of trade, although foreign production increases due to the lower real world interest rate and the expansion of world consumption. The terms of trade deterioration offsets the increase in foreign production, leaving the foreign income unchanged. Instead of an expenditure-switching effect, the switch of the labor burden produces a "beggar-thy-neighbor" effect. Workers in the foreign country need to work more to sustain the same level of consumption. The adoption of LCP increases the cross-country correlations for production, but reduces the consumption correlations.

Moreover, given the absence of expenditure-switching effects, the adoption of LCP will result in an exchange rate that is more volatile in response to unanticipated monetary and fiscal shocks; each central bank attempts to stabilize changes in marginal costs in the home economy. Facing high volatility of exchange rates, foreign producers raise the markup rate on export prices. Stabilizing the exchange rate is helpful to stabilize marginal costs in the two countries. This points to advantages associated with choosing a fixed exchange-rate regime under LCP, rather than a flexible exchange-rate regime (Devereux and Engel, 2003).

The optimal monetary policy for maximizing welfare in the domestic economy depends on the foreign monetary policy's being optimal. Assuming a symmetric objective function for the two central banks, there is no need for international policy coordination. International policy coordination is, however, needed in the case of asymmetric and mixed use of PCP and LCP in the two countries (Corsetti and Pesenti, 2008).

3. The story becomes more complicated if, in addition to the mixed use of PCP and LCP, one country adopts PCP while another adopts LCP.

By incorporating the asymmetry and mixture cases into the Obstfeld-Rogoff model, Otani (2002) argues that whether the beggar-thy-neighbor effect is generated or not depends on the share of LCP, the value of elasticity of substitution and the size of the country.[14]

Table 7 summarizes the above results. Caution is in order, in that the spillover effect of domestic monetary expansion can actually be accompanied by worsening welfare in foreign countries. It should be noted that the IMF spillover study focuses on the effect of monetary policy on production in foreign countries, rather than on welfare. Moreover, if LCP dominates the world economy, it is sensible to have a more stable exchange-rate regime. Let us turn now from the results of the model to evaluating the spillover effect of monetary expansion in Japan in comparison with other countries.

Japan's unconventional policy measures

In the period of the BOJ's first round of unconventional policy measures, the nominal/real yen rate depreciated as a trend. But the nominal/real depreciation was accompanied by worsening terms of trade, which implies better terms of trade for trading-partner countries.

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[14] If all Japanese exporters adopt LCP and all US foreign firms employ PCP, the US monetary expansion exerts a greater influence on US domestic consumption. But Japanese monetary easing will have little influence on US consumption.

Under the assumption that 100 percent of US exporters adopt PCP, while less than half of Japanese exporters do, Japan's monetary expansion can exert a welfare-reducing effect on the US economy if the value of elasticity of substitution exceeds 8.37. But the international transmission effect of Japanese monetary policy on US welfare is negligible, as compared with the effect of US monetary policy. On the other hand, both Japanese and US monetary expansion have beggar-thy-neighbor effects in the case of 50% adoption of LCP by Japanese exporters (Otani, 2003).

In the second round of unconventional policy, the nominal/real yen rate appreciated sizably, reflecting a relatively small adverse effect from financial market disruptions, relatively modest monetary expansion, and the yen's role as a safe haven currency. Despite the nominal/real appreciation of the yen, Japan's terms of trade again deteriorated. It is unlikely that Japan's monetary expansion caused a beggar-thy-neighbor effect, but it could be that Japanese industries are suffering as the result of another excessive spurt in the yen rate due to the combination of real yen-rate appreciation and worsening terms of trade.

The recent US monetary expansion

US monetary authorities seem to regard US monetary expansion as beneficial to all trading-partner countries, implicitly assuming that PCP is employed not only by US firms but also by all the firms of its trading-partner countries.

However, commodity prices reacted to the extraordinary monetary expansion of the US. The commodities market – notably the oil market – was financialized through the participation of various funds, including hedge funds, commodity index funds and pension funds (Iwata, forthcoming). Fund managers aimed to enhance investment in commodities as an alternative investment to traditional equities and bonds starting in the middle of the first 2000 decade. The commodities turned out to be liquid assets whose prices are determined on the forward market.

A rise in oil prices accelerates the worsening of terms of trade triggered by domestic monetary expansion. In April 2011, US gasoline prices rose to nearly four dollars a gallon, the threshold price for dampening consumer spending.

In May, the Chicago Mercantile Market twice raised the margins on forward market transactions, to prevent a speculative, forward-market-led acceleration of oil prices. Moreover, the emergency release of oil stock by the IEA member countries in June and July slowed down the pace of the oil price increase. These two measures suggest the usefulness of additional policy weapons to ward off adverse international repercussions.

These measures mitigated the adverse effects of the worsening US terms of trade. Certainly, the commodity-producing countries enjoyed an improvement in their terms of trade. If the US terms of trade turned down more sharply due to the sharp oil price increase, which dampens consumer spending, a strong monetary expansion could bring about a "beggar-thyself" effect through international repercussions.[15] However, moderate dollar depreciation brings great comfort to the US, since it strengthens the international competitiveness of US firms and has the effect of revaluing US residents' holdings of foreign-currency-denominated assets.

International repercussions for oil prices from US monetary expansion appeared as early as 2007–2008. The US economy entered recession in December 2007, before the Lehman bankruptcy. Hamilton (2009) argued that the recession from the fourth quarter of 2007 to the third quarter of 2008 was triggered by higher oil prices. In other words, more modest monetary expansion could have prevented the recession. In fact, the Federal Reserve temporarily stopped cutting the policy rate in the period from June 2008 to September 2008. On the other hand, the ECB raised its policy rate in July when the oil price peaked. However, the ECB faced the immediate risk of an autumn recession, and cut the policy rate in October.

[15] Corsetti and Pesenti (2001) has already pointed out the possibility that domestic monetary expansion can reduce the domestic welfare if the openness is high and the elasticity of input substitution is not so small under the PCP.

The depreciation of the real sterling rate and the appreciation of the real yen rate

As already pointed out by Broadbent (2011), it is possible that the sharp depreciation of the sterling in 2007–8 was not caused by monetary expansion. But we should note that there was a sharp cut in the policy rate by the BOE, from 5% in late 2008 to 0.5% in early 2009. Therefore, expansionary monetary policy in the form of a lower policy interest rate contributed in part to the depreciation of the nominal exchange rate.

Broadbent pointed to a sharp expected decline of expenditure on non-tradable output, which supposedly brought about a sharp depreciation in the real five-year forward sterling rate.

In the framework of the new open-economy macroeconomic model, exchange-rate changes are determined by uncovered interest rate parity. As a result, the real exchange rate is determined by the difference between the two countries' money-to-consumption ratios. A sharp reduction in domestic consumption (an erosion of the domestic currency's purchasing power) leads to the depreciation of real sterling.[16]

In sharp contrast, Japan experienced an "ever-rising real yen rate" after the bubble burst. In 1990, in a dialogue on US-Japan structural impediments, the Japanese government made a commitment to expand its cumulative public investment to 430 trillion yen over the next ten years, in response to the US request regarding domestic demand expansion to reduce the bilateral current account balance. The ratio of public investment to nominal GDP increased sharply from 1990, reaching a peak in 1995.

After the asset price bubble burst in 1990, Japan's real GDP never fell below the peak of the asset price bubble period, in contrast to the recent experience of other major economies. Presumably, the market expected the boost in demand for non-tradable output due to the increase in public investment. Coupled with this was a stable increase in consumer spending. Both could contribute to an ever-rising real yen rate.

Yen depreciation in the latter half of the 1990s

Based on a three-country, 100% pass-through (PCP) model, taking an approach similar to that of Corsetti et al (2000), Shioji (2001) examined the impact of yen depreciation during the latter half of the 1990s on the welfare of Asian countries.

The insight provided by the model makes it easy to see that yen depreciation via Japanese monetary expansion improves the welfare of Asian countries, although the expansion may exert adverse effects on production in Asian economies. However, the outcome would differ if the assumption regarding the price setting behavior of Asian exporting firms were changed; these firms are likely to adopt LCP rather than PCP.

In addition, it is doubtful whether the yen depreciation in 1995–98 was really caused by monetary expansion in Japan. The BOJ maintained the policy rate at a low level close to zero after December 1995. The ratio of the size of the BOJ balance sheet to nominal GDP evolved stably, while the terms of trade worsened slightly during that period.

We conjecture that the yen rate depreciation was triggered by a notable turnaround of US exchange rate policy, with motion from a weak dollar to a strong dollar in the midst of the Mexican crisis in 1994–5. The joint US-Japanese intervention to strengthen the US dollar caused a marked shift to expected depreciation of the yen/dollar rate. The yen depreciation trend can best be described as a movement toward the equilibrium point of the yen rate, following its overshooting in the preceding post-Plaza Accord period.

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[16] In the conversation with Ippei Fujiwara, he made this point more explicit.

On the other hand, if the yen depreciation were caused by a negative productivity shock to the tradables sector, or by financial market shock in Japan, it is obvious that the Asian economies would be more seriously affected.[17]

VII. Conclusion

The expansion of central bank balance sheets and the changes in their composition were designed to mitigate the effects of adverse financial shocks. The unconventional policy measures were effective in rectifying market malfunction and stabilizing the financial market. Central banks acted as a lender of last resort as well as last market-maker. However, the unconventional policy measures adopted by the BOJ have not succeeded in reversing the persistent deflationary tendency, and there has been limited effect on aggregate demand.

The benefit of unconventional policy measures is accompanied by costs: the market distortions created by central banks' massive purchasing of assets are likely to lead to misallocation of resources, not to mention the risk of looser fiscal discipline with the easy monetization of the budget deficit.

This paper explores the possibility of adverse international transmission of monetary expansion through changes in exchange rate and terms of trade; terms of trade changes are one of the most important channels by which domestic monetary expansion is transmitted to foreign countries.

Under the assumption of pre-set pricing, the price setting behavior of exporting firms plays a critical role in determining terms-of-trade changes in response to exchange-rate changes. The terms-of-trade deterioration in the US, with no change in UK or the euro area, may imply that monetary expansion in the advanced economies will have a limited effect on the welfare of emerging economies. In the case of Japan, sharp real yen appreciation has been accompanied by worsening terms of trade, creating benefits for the welfare of trading-partner countries.

More recently, capital flows to advanced economies from emerging economies reversed, reflecting risk-off behavior by global investors in response to the fiscal crisis in the euro area. Now some emerging economies face the risk of sudden capital outflow and downward pressure on the exchange rate of their domestic currencies. More harmful is the effect on emerging economies when there is disruption of financial markets in financial centers. It seems desirable to strengthen international coordination of dollar liquidity provision, with the IMF preventing excessive volatility of exchange rates among major economies[18].

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[17] The simulation outcome may be changed if Japanese and Asian firms adopt LCM in their exports and pass-through is less than one. But it seems problematic to assume that Japanese firms prefer LCP to PCP, given the limited room for hedging on the Asian forward market, with the exception of Korea.

[18] In preparations for the G20 Summit Meeting, the Korean government insisted on the idea of creating a global financial safety network to prevent global financial crisis. As pointed out by Ms. Lagarde, the IMF's "one year forward commitment capacity" amounts to only 246 billion SDRs ($38 billion or €280 billion). This is equivalent to 15% of Italian government debt outstanding.

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Comments on Kazumasa Iwata and Shinji Takenaka's paper "Central bank balance sheets expansion: Japan's experience"

Shinji Takagi[1]

The paper considers the impact of aggressive monetary easing by one country upon the welfare (as opposed to production or employment) of its trading partners. Its central message is that in order to assess the international transmission of monetary policy one must consider the impact on terms of trade, which together with the impact on production and employment determines the overall impact on welfare. The working assumption, based on casual empiricism, is that monetary easing causes the exchange rate to depreciate (no distinction needs to be made between nominal and real rates in the short run, when prices are not fully flexible). But how currency depreciation alters the terms of trade depends on the price setting behavior of exporting firms, which in turn is related to the choice of invoice currency. The paper notes that the predominant use of local currency pricing by Japanese exporters has led to a negative relationship between exchange rate and terms of trade (eg depreciation accompanied by worsening) and concludes by implying that, in view of the worsening of the country's terms of trade (and given the favorable impact on the level of global interest rates), recent aggressive monetary easing by the Bank of Japan did not have a beggar-thy-neighbor effect on the welfare of foreign countries.

The theme of the paper is by no means specific to Japan. But given the first author's background (as former Deputy Governor of the Bank of Japan), it is natural that the paper should focus on the experience of Japan while also touching on the experiences of other countries in the recent past. Following the Lehman shock of September 2008, the central banks of several advanced economies, including the Bank of Japan (BOJ), resorted to what is now commonly called "unconventional" monetary policy measures. Two broad types of unconventional policies are identified: quantitative easing, which consists of policies that aim to increase free reserves in the banking system, and credit easing (or qualitative easing), which consists of policies aimed at affecting the composition of central bank balance sheets (though instruments used for this purpose, such as direct lending to market participants, typically involve an increase in the size of the balance sheet). Both types of unconventional measures were adopted during the current crisis.

Before the onset of the global financial crisis, however, the BOJ was almost alone in having accumulated significant experience with unconventional monetary policy. From this standpoint as well, the authors' focus on the Japanese experience is appropriate. After a prolonged period of economic stagnation, in February 1999 the BOJ reduced the overnight call rate to virtually zero. In March 2001, it went beyond the zero interest rate policy to adopt a policy of quantitative easing consisting of: (i) supplying ample liquidity by using the deposits of commercial banks held at the central bank (current account balances, or CAB) as the main operating target; (ii) publicly committing itself to maintaining ample liquidity until core CPI inflation became zero or higher on a sustained basis; and (iii) increasing the purchases of Japanese government bonds (JGBs).

Over the period of quantitative easing (which was to last until March 2006), there was a rapid growth in base money. The BOJ steadily increased the CAB target, from about 5 trillion yen to

[1] Graduate School of Economics, Osaka University.

30–35 trillion yen. The CAB was increased through the purchases of both private sector assets and JGBs. The BOJ began to announce the amount of monthly JGB purchases, which it raised in several steps, from 400 billion yen initially to 1.2 trillion yen in October 2002. In the meantime, the Japanese Ministry of Finance made a massive foreign exchange market intervention to purchase dollars, amounting to 35 trillion yen from January 2003 to March 2004, during which period base money increased by 15 trillion yen. This amounted to a non-sterilized intervention of 15 trillion yen. Iwata and Takenaka observe that a steady depreciation of the yen accompanied this "first round" of unconventional monetary policy.

The "second round" of unconventional monetary policy began after the Lehman shock. In December 2008, the BOJ established a scheme to provide credit to enterprises; in June 2010, it began to supply fixed-interest funds to support commercial bank lending to productivity-enhancing and demand-creating activities; and in October 2010 (in what was called "comprehensive easing policy") it widened the scope of eligible assets in the asset purchase program, increased the amount of JGB purchases by abolishing the ceiling (previously set equal to the amount of BOJ notes outstanding), and strengthened the policy duration commitment (until about 1% inflation was achieved). Despite the acceleration of monetary easing, however, the BOJ balance sheet did not expand as much as it had during the first round, as the focus of the second round has been more on the credit easing aspect. This explains why the yen has appreciated against major currencies despite monetary easing, given the much more aggressive easing policies pursued by the central banks of other advanced countries.

Iwata and Takenaka, summarizing the broad conclusions of the empirical literature on the two rounds of unconventional monetary policy in Japan, state that the impact on aggregate demand or deflationary expectations was limited, possibly because the policies are perceived by the markets to be temporary. Instead, the effectiveness of unconventional monetary policy in Japan appears to be indirect, reducing liquidity and credit premiums, spreads on private sector instruments, and long-term interest rates, while pushing up equity prices. BOJ balance sheet expansion, however, appears to have caused the yen to depreciate, as attested to by the experience of Japan in the first round of monetary easing (a similar exchange rate impact of central bank balance sheet expansion is indicated by the more recent experience of the United States, the euro zone, and the United Kingdom). But whether or not central bank balance sheet expansion has a beggar-thy-neighbor effect depends on how currency depreciation affects the terms of trade and the responsiveness of aggregate demand and output to the lower global interest rates in the rest of the world.

In illuminating the terms of trade channel of international monetary policy transmission, the paper gives considerable space to reviewing the historical relationship between the (nominal/real) exchange rate and the terms of trade (Section 3), to a theoretical exposition of how a change in the exchange rate is related to a change in the terms of trade (Section 4) and to the critical role the choice of invoice currency plays in the determination of the short-term impact of exchange rate changes on the terms of trade (Section 4). The upshot of this rather long and involved discussion is that the relationship depends on the choice of invoice currency, the degree of home bias with respect to domestically produced tradable goods, and cross-country differences in the relative price of tradable and non-tradable goods. Of these, Iwata and Takenaka argue that the invoice-currency-linked price setting behavior of Japanese exporting firms is the most critical element in explaining the worsening terms of trade as the exchange rate appreciated over time.[2] This largely reflects the fact that

[2] Iwata and Takenaka show, under the assumption that consumer prices move with wage costs and that the law of one price holds for tradable goods, that a real effective appreciation not accompanied by a corresponding improvement in the terms of trade represents a loss of international competitiveness.

Japanese exporters tend to use local currency pricing (which causes appreciation to worsen the terms of trade).[3]

Monetary easing in one country is transmitted differently depending on whether local currency pricing or producer's currency pricing is used by domestic and foreign exporters. Iwata and Takenaka's review of the literature on new open economy macroeconomics suggests the following transmission mechanisms under the assumption of nominal rigidity:

1. Under producer's currency pricing (PCP), depreciation worsens the home country's terms of trade, expands domestic production, reduces foreign production and causes the current account balance to improve in the home country and to deteriorate in the foreign country. Foreign welfare is likely to improve as the improvement in the terms of trade tends to more than offset the reduction in production. Thus, the beggar-thy-neighbor effect of monetary easing is unlikely to be present.

2. Under local currency pricing (LCP), depreciation improves the domestic terms of trade, but involves no expenditure switching effect; depreciation, however, reduces (increases) the markup over marginal costs of foreign (domestic) exporters, thereby transferring income from the foreign to the home country. Welfare unambiguously improves in the home country, while welfare falls in the foreign country (a lower global interest rate and an increase in world consumption would cause production to rise, requiring workers to work more to maintain the same income level). There is a beggar-thy-neighbor effect in this case.

In practice, the real world involves a mixture of PCP and LCP, and in this case the scenario depends, among other things, on the relative shares of PCP and LCP, as well as on the relative size of each country. Unfortunately, this is where the paper stops. Iwata and Takenaka do not go further to explore the implications for the international transmission of Japanese monetary easing, except to note that during both rounds of unconventional policy Japan experienced a worsening of its terms of trade. The implication is that recent aggressive monetary easing by the BOJ did not involve a beggar-thy-neighbor effect (during the second round the yen appreciated, as the easing was less aggressive than in other advanced countries, so the beggar-thy-neighbor effect was absent in the first place).

As stated at the outset, the central message of the paper is to highlight the need to consider terms of trade changes when one assesses the international transmission of monetary policy. In articulating this transmission mechanism the authors stress the critical role played by the choice of invoice currency, along with the associated price setting behavior of exporters. This may well be valid in the short run when prices are less than fully flexible. But the authors make too much of this. We must believe that, in the medium to longer term, the terms of trade are determined largely by real forces, and not by monetary policy. Ultimately, the key to understanding the secular deterioration of Japan's terms of trade must be sought, not only in rising energy prices, but also in the fact that Japan exports higher-end manufactured products whose prices are under constant downward pressure due to innovation and global competition. The question of what the global impact of aggressive monetary easing by the Bank of Japan was remains unanswered.

The paper is full of insightful remarks, such as the authors' suggestion that the BOJ's JGB purchases should be made consistent with the government's debt management policy; their characterization of an element of the recent "comprehensive easing policy" as a type of "forecast inflation targeting"; and their suggestion that an entity separate from the BOJ

[3] In contrast, producer's currency pricing would cause appreciation to improve the terms of trade. In the case of Japanese exports, the authors cite the existing literature to conjecture that the incidence of local currency pricing is relatively high (about 50%).

should be created to purchase various assets, including foreign bonds, in view of the fact that the Japanese government does not provide indemnification for central bank assets. I have also noted with interest their argument that the erosion of international competitiveness should be blamed for the persistent deflationary pressure and low level of investment the Japanese economy experienced from the late 1990s, as exporting firms cut wages and increased the share of non-regular workers in their workforce (Japan's export share in the world declined from 10% in 1993 to 5% in 2010, even as the GDP share remained relatively constant at 9%).

For what it delivers, however, the paper covers too much ground, often in excessive detail, much of which is little related to the central theme. A more focused presentation, stressing the importance of export pricing behavior in determining the impact effect of aggressive monetary easing, would have been friendlier to the reader. I would have wanted the paper to present a deeper analysis of the exchange-rate impact of monetary easing. The authors simply assume that monetary easing leads to exchange-rate depreciation. In this context, they do briefly discuss how the yen carry trade enforced the trend depreciation of the yen from 2006 to 2007; they also mention how recent Federal Reserve actions caused a "currency war". Because exchange rate impact is the critical element in the international transmission of monetary policy, it would have been useful to go further in exploring exactly how the mechanism has worked in practice, with central bank balance sheet expansion in one country leading to an adjustment of exchange rates through the actions of market participants.

Comments on Kazumasa Iwata and Shinji Takenaka's paper "Central bank balance sheets expansion: Japan's experience"

Mark M Spiegel[1]

I would like to thank the organizers for inviting me to this interesting conference at such a wonderful site, and to discuss this interesting paper. Given the sharp downturns experienced during the global financial crisis, leading global central banks found themselves at the "zero bound", or close to it, ie close to minimal feasible nominal policy rates. Unfortunately, the long-term stagnation suffered by Japan implies that this country has experiences in unconventional monetary policies at the zero bound that potentially provide lessons for other countries currently pursuing such policies.

The paper examines the impact of unconventional monetary policies adopted by the Bank of Japan during Japan's experience with low output growth and low inflation, as well as the policies of other central banks. It pays particular attention to Japan's experiences with large-scale asset purchases of the type also recently pursued by both the Federal Reserve and a number of other central banks. The paper also reviews the Bank of Japan's experiences in giving forward guidance concerning future monetary policy. Finally, it investigates the scope for international transmission of these policies to other economies through its impacts on international terms of trade and exchange rate effects.

Interestingly, the paper argues that unconventional monetary expansions at the zero bound may inadvertently result in "beggar thyself", rather than "beggar thy neighbor", effects. The example given in the paper is one of potential adverse terms-of-trade changes for large commodity-importing countries. For example, as an oil importer, the United States, by driving down the value of the dollar, may actually be pushing up the prices of its imported commodities.

Figure 1 below is taken from Kobayashi, et al (2006). It can be seen that there were substantial movements into unconventional policies by the Bank of Japan (BOJ) during the period now commonly referred to as "QE1". Subsequent to policy meetings, the BOJ made a series of announcements of expansion both of its current-account targets for commercial banks and of targets for monthly purchases of longer-term Japanese Government Bonds (JGBs). In addition, the BOJ committed to maintaining its 0% policy until inflation registered an increase year on year. This provided an early example of "forward guidance", the policy of easing through manipulation of public expectations regarding future short-term policy rates. The BOJ achieved substantial expansion of its balance sheet during this period of unconventional monetary policy, with its top range between 30 and 35 trillion yen.

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[1] Vice President, International Research, Director, Center for Pacific Basin Studies, Federal Reserve Bank of San Francisco; comments are author's own and not necessarily those of Federal Reserve Bank of San Francisco or the Federal Reserve Board of Governors.

Figure 1

Bank of Japan announcements during QE1 period

Date	Current Account Balances	Long-term JGB monthly purchase target	Other Changes
3/19/01	Increased Y 1 trillion to Y 5 trillion	Allowed to exceed Y 400 billion limit	
8/14/01	Increased Y 1 trillion to Y 6 trillion	Increased Y 200 billion to Y 600 billion	
9/18/01	Allowed to exceed Y 6 trillion limit		Discount rate reduced from 0.15 to 0.10, and maximum discount loan term extended to 10 business days
12/19/01	Increased Y 4-9 trillion to Y 10-15 trillion	Increased Y 200 billion to Y 800 billion	Broadened set of acceptable commercial paper and asset-backed securities
2/28/02	Allowed to exceed Y 10-15 trillion target	Increased Y 200 billion to Y 1 trillion	Suspended limit on number of business days for discount borrowing
10/30/02	Increased Y 5 trillion to Y 15-20 trillion	Increased Y 200 billion to Y 1.2 trillion; maturity limit for bills purchased increased to 1 year	
3/25/03	Increased Y 2 trillion to Y 17-22 trillion (After 4/1/03)		
4/30/03	Increased Y 5 trillion to Y 22-27 trillion		
5/20/03	Increased Y 3-5 trillion to Y 27-30 trillion		
10/10/03	Increased Y 2 trillion to Y 27-32 trillion	Renewed extension of maturity limit for bills purchased	Commited to maintaining quantitative easing until CPI registers a 0% or increase year on year
1/20/04	Increased Y 3 trillion to Y 30-35 trillion		

Source: Kobayashi et al (2006).

In their review of Japanese unconventional monetary policy, Iwata and Takenaka find that the policy did achieve a "substantial" narrowing of liquidity and credit premia, and a reduction in long-term rates, primarily from forward guidance. However, they find that the asset purchases in the recent round of quantitative easing had little impact on credit or aggregate demand. While there was an observable downward move in the value of the yen during this period, they ascribe this move primarily to the foreign exchange "great intervention" conducted by the Ministry of Finance.

I enjoyed the paper, and agree that important lessons from the Japanese experience are likely to be of use not only to other central banks contemplating similar policies, but also to the Japanese themselves in the current version of unconventional monetary policies. However, I do have a few comments that one might consider.

First and foremost, I think that the authors need to acknowledge the inherent difficulty of assessing the impact of policies undertaken during the crisis. Reasonable policies are by necessity endogenous, as they should respond to current conditions. Moreover, they are typically counter-cyclical, with policymakers intervening most when times are worst. In practice, this implies that, at best, the acts of policymakers sometimes leave things merely "less bad", not good.

Moreover, typically monetary policy is not conducted in isolation. A good example of this can be seen in the current paper, where the authors acknowledge difficulty in isolating the impacts of monetary policy by the Bank of Japan from the foreign exchange intervention conducted by the Ministry of Finance. This leaves it difficult to assess impact of QE on exchange rates. Ideally, one would like to have a model, as in the Chung et al (2011) paper cited by the authors.

Without such a structural model, the papers' characterization of the impacts of unconventional monetary policies such as the "QE2" policy pursued by the Federal Reserve as "disappointing" seems unwarranted. What should we have expected in terms of reductions in long-term interest rates or spurred economic growth? There were a number of other adverse shocks that hit the United States during the QE2 period, including the Japan earthquake, which caused severe supply disruptions in US manufacturing, and the uncertainty that arose during the debt ceiling debate, which acted against lowering US long-term debt.

A similar case can be made for commodity prices. The paper argues that commodity price increases, particularly increased oil prices, were primarily fueled by the Federal Reserve's quantitative easing activities. However, higher-frequency data calls this into question. In a recent paper, Glick and Leduc (2011) find that commodity prices, including oil, fell on the dates of important quantitative easing announcements. While endogeneity makes it difficult to know what to make of these results as well, at a minimum they argue against a quick association between quantitative easing and the commodity price increases that followed the policy.

The paper also seems to give less than adequate consideration to the rise and fall of the yen carry trade over the QE period. There is little discussion of this phenomenon in the paper, but it seems to explain a lot. In particular, the surge in the yen that was observed during the quantitative easing period was more likely due to closing of carry trade positions than to US monetary policy. Recall that QE, an exceptional policy, was undertaken because of the exceptional turbulence in financial markets. These are precisely the periods where carry trade positions tend to do badly and be closed. I am also surprised by the claim in the paper that the use of the yen in invoicing was on increase during this period. Carry trade funding currencies would seem to make poor invoicing currencies in turbulent times due to their volatility.

I should turn briefly to the discussion of forward guidance in the paper. It is important to remember that the forward guidance issued by the BOJ differed from that issued by the Federal Reserve. The BOJ's forward guidance contained an explicitly verifiable commitment to maintaining the zero interest rate until certain conditions were met. In contrast, the forward guidance pursued by the Federal Reserve was explicitly "conditional", giving guidance on expected conditions and policy responses. In particular, the Fed statement said that conditions were likely to warrant exceptionally low levels for the Federal Funds rate at least through mid-2013. This statement gave no explicit conditions for moving away from exceptionally low rates, apparently leaving more discretion. Still, 10-year Treasuries fell about 20 basis points on the news, suggesting that the policy had real effects.

Forward guidance in the form of policy commitments (rather than guidance about expected policies) is controversial. Most standard theories would advocate such policies at the zero bound, since credible commitment to future policy can affect long-term rates through expectations. However, this comes at a price: The optimal policy would be to commit to something one would not choose to do ex post, and is therefore time-inconsistent. It should be noted that the forward guidance issued by the Federal Reserve concerned guidance about expected future policies, rather than commitments to policies that might not be desirable ex post.

It should also be acknowledged that the large-scale asset purchases by the Federal Reserve were also controversial. Most standard optimal portfolio theories say they won't work well in the absence of financial frictions or "preferred habitats". As mentioned in the paper, most studies find about a 15–20 basis point decline in 10-year treasury yields. However, as San Francisco Fed President John Williams noted in a recent speech (Williams, 2011), such a reduction in 10-year yields was roughly equivalent to what one would expect to get from a 75 basis point cut in the Federal Funds rate, which as monetary policy actions go is clearly "not small potatoes"!

Finally, the paper, and indeed most QE studies, concentrate on the average impact of the policy, as measured by movements in long-term Treasuries or similar assets. However, there is some evidence that these policies may disproportionately benefit the most distressed financial institutions and economies. In the Kobayashi et al (2006) paper mentioned earlier, we also found that QE announcements by the BOJ had only a modest impact on long-term rates, but we also found that the announcements had disproportionately high impacts on the most distressed Japanese commercial banks. Thus, these policies may have had exactly their intended impact. In assessing the impacts of these policies, it is important to allow for such heterogeneous effects, rather than solely looking at movements in yields of widely-traded government assets.

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Global imbalances and foreign asset expansion by developing-economy central banks

Joseph Gagnon[1]

Abstract

In the aftermath of the Asian financial crisis of 1997–99, central banks and governments throughout the developing world have accumulated foreign exchange reserves and other official assets at an unprecedented rate. This paper shows that this official asset accumulation has driven a substantial portion of the recent large global current account imbalances. These net official capital flows have become large relative to the size of the industrial economies, and they are a significant factor contributing to the weakness of the economic recovery in the major industrial economies.

Keywords: Current account, foreign exchange reserves

JEL classification: F31, F32

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[1] Peterson Institute for International Economics.

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I. Introduction

Over the past 10 years, central banks and governments throughout the developing world have accumulated foreign exchange reserves and other official assets at an unprecedented rate. This paper shows that this official asset accumulation has driven a substantial portion of the recent large global current account imbalances. Somewhat surprisingly, most recent studies of the determinants of current accounts have ignored these official policies that seem expressly designed to engender or sustain current account imbalances.

Net official capital flows from developing economies have become large relative to the size of the industrial economies, and they are a significant factor contributing to the weakness of the economic recovery in the major industrial economies.

II. The evolution of imbalances: time series evidence

Figure 1 displays the evolution of net official flows and current account balances around the globe, divided into five developing regions and the industrial economies.[2] Official flows include purchases and sales of foreign exchange reserves, foreign-currency borrowing and repayment by the government and central bank, and purchases and sales of foreign assets by sovereign wealth funds.[3] The net flow is positive when purchases of foreign assets exceed sales; this is also known as net outflow.

The coherence of net official flows and current account balances is very strong in Asia-Pacific, Sub-Saharan Africa, and Middle East and North Africa (MENA). The coherence of net official flows and current account balances is moderate in Eastern Europe and former Soviet Union and in Latin America. In all of the developing regions, there were pronounced spikes in net official flows and current account balances just before the global financial crisis of 2008–09. In each region, the spike in net official flows exceeded the run-up in the current account. The difference between the two lines indicates that net private financial flows were negative on balance in 2006–07. As shown in equation 1, the current account is the sum of net official flows, net private flows, and errors and omissions. (The latter are relatively small for most economies.) Overall, it appears that the sharp rise in net official flows is associated with an increase in the current account and a decrease in (more negative) net private flows.

1. Current Account = Net Official Flow + Net Private Flow + Errors and Omissions

In principle, the sum of all countries' current accounts is zero, so that surpluses in some countries must be matched by deficits in other countries. However, no such adding up constraint is applied to net official flows and net private flows. The definition of official flows for each country includes only the assets held or liabilities owed by its own government in foreign markets, and not those of foreign governments in its own market. For the industrial economies as a group, net official flows are very small, as these economies generally do not hold reserve assets in the developing economies, do not engage in much foreign-currency

[2] This paper employs the older IMF classification of industrial and developing economies, rather than advanced, emerging, and developing economies. See Appendix 2 for a definition of the regions. With respect to official flows and current account balances, the newly advanced economies of Asia and Europe (plus Israel) are more similar to their emerging and developing neighbours than they are to most of the industrial economies.

[3] Official flows in Figure 1 differ from those reported by the IMF because they include an estimate of sovereign wealth fund flows for countries that do not include such assets in their foreign exchange reserves. For a detailed description of the data and sources, see Appendix 2.

public borrowing or lending, and have few large sovereign wealth funds.[4] Of greater interest, however, are the imputed net official flows from developing economies to the industrial economies. These data are displayed here under the assumption that all official flows in developing economies are directed toward the industrial economies. Some of these official assets may be held in financial institutions in developing-economy financial centres such as the Cayman Islands, Hong Kong, and Singapore, but data suggest that financial institutions in these centres funnel the bulk of this investment to the industrial economies.[5]

As shown in the bottom right panel of Figure 1, the imputed net official flows of the developing economies into the industrial economies reached $1.5 trillion in 2007. The dashed line is the current account surplus recorded in the industrial economies. The dotted line is -1 times the current account surplus of the developing economies. The difference between the dashed and dotted lines is the sum of all economies' current accounts, which equals zero in principle, and is also known as the global current account discrepancy. Although the current account discrepancy is not actually zero, the movements in the dashed and dotted lines are broadly similar. After several decades with a current account close to zero, the industrial economies moved into a large deficit in the middle of the last decade.

The correlation of net official flows and the current account in each region strongly suggests a causal mechanism. However, the direction of causality is not clear. Other things equal, an official decision to purchase foreign assets is likely to depreciate the exchange rate and boost the trade and current account surpluses. On the other hand, an increase in foreign demand for exports causes the current account to increase and tends to appreciate the exchange rate. Governments may decide to resist this currency appreciation by purchasing foreign exchange reserves, thereby increasing net official flows. So net official flows may be driving the current account or the current account may be driving net official flows.

However, the current account cannot drive net official flows without an official policy decision to resist exchange rate adjustment. And, to the extent that this policy is successful in delaying exchange rate adjustment, it will also enable the current account imbalance to persist. Thus, in a deeper sense, the correlation is ultimately caused by an official policy choice. It is in this sense that we can say that official flows are important drivers of current account imbalances.

III. The causes of imbalances: cross-country evidence

A number of studies have examined the medium-term structural factors that are exogenous drivers of current account imbalances.[6] The papers use four-year or five-year averages of the data to minimize the influence of business cycles, transitory factors, and adjustment lags. The studies use a panel approach to combine data from dozens of industrial and developing economies over the past three or four decades. The studies agree on three important factors behind current account imbalances: fiscal balances, net foreign assets, and net oil (or net energy) exports. Importantly, the studies do not include measures of the real exchange rate

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4 Norway is an exception. Government pension funds as defined in Truman (2011, Table 1) are not included in net official flows in this paper because they are presumed to behave in a manner similar to private pension funds.

5 See, for example, the BIS's *Locational Banking Statistics* and the IMF's *Coordinated Portfolio Investment Survey*.

6 See Chinn and Prasad (2003), Gruber and Kamin (2007, 2009), Chinn and Ito (2008), Lee et al (2008), Cheung, Furceri, and Rusticelli (2010), Abiad et al (2011), Chinn, Eichengreen, and Ito (2011), and Gagnon (2011).

or terms of trade because these are viewed as endogenous to the underlying factors driving current accounts.

The role of the fiscal balance is motivated by the following accounting identity, which is based on the broadest definition of the fiscal balance, general government net lending:

2. Current Account = Gov't Net Lending + Private Net Lending + Statistical Discrepancy

In principle, the current account equals an economy's overall net lending to the rest of the world. Causality can flow in both directions in equation 2. The fiscal balance can affect domestic demand and the exchange rate, both of which influence the current account. But the current account can affect economic activity, which in turn has both direct and indirect (through macroeconomic policy) effects on the fiscal balance. The effect of economic activity on the fiscal balance should average out over the business cycle, whereas the effect of the fiscal balance on the current account is longer lasting. Taking multi-year averages of the data thus helps to identify the effect of the fiscal balance on the current account while minimizing the bias associated with causality in the opposite direction.[7] The coefficient on the fiscal balance should be positive; a value of 1 would indicate that private net lending is not influenced by government net lending. However, if government borrowing crowds out private borrowing, the coefficient should be less than 1.

The roles of net energy exports and net foreign assets are motivated by the following identity:

3. Current Account = Trade Balance + Net Factor Income + Unilateral Transfers

Energy prices and energy exports are widely seen as exogenous with respect to the current account.[8] The net energy exports coefficient will be less than 1 when fluctuations in energy exports have a positive effect on consumption and thus on imports. Factor income is income earned on capital and labour abroad, of which capital income is by far the most important. Because capital income responds to the current account and to other factors that influence the current account, previous studies have used the lagged value of net foreign assets, which are the base for net capital income. In steady state, the coefficient on net foreign assets will equal the rate of return on assets.

Previous studies also examined a range of other candidate factors, some of which will be used here, but none of these is robustly significant. In particular, the correlations between current account imbalances and institutional factors (such as financial market depth or quality of governance) are highly sensitive to the countries and time periods included in the analysis. These institutional factors are not explored in this paper.

An important factor that was not considered by previous empirical studies, except by Gagnon (2011), is the official policy of the government toward its exchange rate and foreign assets, sometimes referred to as external financial policy. Indeed, it is remarkable that so many studies have ignored this obviously important factor.[9] For many – perhaps most – countries,

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7 Abiad et al (2011) identify the fiscal effect by using a subjective analysis of fiscal policy intentions. They obtain a fiscal coefficient near 0.5, but they do not allow for any effect of official financial flows. The 10-year-averaged data in this paper substantially reduce the bias in the fiscal effect compared to the four-year and five-year averages used in previous work. As shown in Table 2, when official flows are not included in the regression, the coefficient on the fiscal balance is near 0.5, much higher than in previous work, except for Abiad et al.

8 Indeed, it might be preferable to use a measure of net natural resource exports, if one were available.

9 Some studies have pointed to the possible connection between reserve accumulation and current account surpluses in Asia, but they generally have not conducted statistical analysis of this connection. See, for example, Dooley, Folkerts-Landau, and Garber (2004), Cova, Pisani, and Rebucci (2009), Adams and Park (2009), and Cook and Yetman (2012)

the real exchange rate is not a useful measure of external financial policy. Rather, it is endogenous to factors influencing the current account, including trade barriers and local tastes and technologies. The central insight of Gagnon (2011) is that net official purchases of foreign assets *are* a useful measure of official policy for analysis of current accounts. Figure 1 shows that net official flows appear to be an important driving factor behind current account imbalances over time. This section focuses on the cross-country determinants of current account imbalances.

If the government's holdings of foreign assets are exogenous, regressing the current account on net official flows provides an unbiased estimate of the effect on the current account of a given movement in net official flows. If the government's holdings of foreign assets react endogenously to pressures on the exchange rate, the coefficient may be a biased estimate of the effect of a hypothetical exogenous purchase. As shown in Appendix 1, the direction of the bias depends on which shocks are most important. If the shocks are primarily to the official exchange rate target, there is no bias. If the shocks are primarily to the trade balance, the bias is upward. If the shocks are primarily to domestic demand, the bias is ambiguous. If the shocks are primarily to monetary policy or private capital flows, the bias is downward. Regardless of which shocks dominate, the bias is downward when private financial flows do not respond much to the real interest rate.[10]

The evidence suggests that the bias is likely to be small. Gagnon (2011) showed that the coefficient on net official flows is not sensitive to the exchange rate regime. Indeed, the coefficient on net official flows is more stable and robust than any other coefficient explored in the literature.

There is a significant amount of collinearity between net official flows and fiscal balances. Governments that are accumulating foreign assets often have fiscal surpluses, and external borrowing is one way to finance a fiscal deficit. But as will be discussed below, net official flows are more strongly correlated with current account imbalances than fiscal balances are. This result suggests that private agents do not view assets in different economies as close substitutes, perhaps because of legal restrictions, tax treatment, exchange rate volatility, or differences in financial market soundness or sophistication. In an environment of perfect capital mobility (asset substitutability), the fiscal balance would affect the current account and official flows would not. In an environment of zero private capital mobility, only official flows can affect the current account and nothing else matters (see equation 1). In between these extremes, the following interpretation of the coefficients applies: the coefficient on official flows captures the effect of government borrowing in local currency to purchase foreign assets, whereas the coefficient on the fiscal balance captures the effect of a budget surplus invested in local-currency assets (or repayment of local-currency debt).[11] The effect of a budget surplus that is invested entirely in foreign assets would be the sum of the two coefficients.

Table 1 displays regressions on the two main policy variables and on other variables commonly used in the literature. To minimize temporary and cyclical influences on the current account, the data are expressed as non-overlapping 10-year averages except for net foreign assets, which are levels in the year before each 10-year period. To minimize the

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[10] For the developing economies, Ostry et al (2010) document widespread use of capital controls, particularly for the short-term debt flows that are most sensitive to interest differentials. Much of the capital flowing to developing economies is in the form of equity and foreign direct investment, which are mainly motivated by long-term development opportunities rather than the real interest rate.

[11] Official flows are defined according to the location of the assets, not the currency in which they are denominated. However, essentially all official assets and liabilities are denominated in foreign currency and it is the currency denomination that likely plays the key role in differentiating the effect of net official flows from that of the fiscal balance.

importance of small (often poor) economies with noisy data, the regressions are weighted by each economy's share of world nominal GDP. This is equivalent to running the regression on all variables as a share of world GDP instead of as a share of national GDP.[12]

Note that most variables are missing at least some observations. Thus, adding more variables comes at the cost of losing observations—in some cases many observations. The most statistically significant and robust alternative variables are the initial stock of net foreign assets and the change in the old-age dependency ratio. These two variables also contribute a lot to the explanatory power of the regression, and their coefficients are economically large. The coefficient on net foreign assets in column 2 implies that an increase in net foreign assets of $100 is associated with an increase in a country's current account of more than $7. This is a plausible estimate, considering that the coefficient is motivated as a rate of return on net foreign assets. The coefficient on the change in the elderly dependency ratio in column 4 implies that a rate of increase in the ratio of elderly to working-age people of one percentage point per year would increase the current account by nearly 5 percent of GDP. This effect presumably works through an increase in desired saving for retirement. Other demographic variables, including the change in youth dependency and the levels of both elderly dependency and youth dependency are not statistically significant.

The other variables contribute relatively less to the explanatory power. The coefficients on energy exports, GDP growth, and relative PPP GDP per capita are economically small. The coefficient on population growth is fairly large, but it is not significant when GDP growth is not included in the regression. Note that the coefficient on relative PPP GDP per capita changes sign when other variables are included. It is expected to have a positive coefficient because private capital should flow from richer to poorer economies, and thus richer economies should have current account surpluses.

Overall, column 8 seems the preferred specification, with nearly as high an R^2 as column 7 though it has only half the variables, with plausible coefficient values, and with fewer lost observations. However, it is apparent in Table 1 that the coefficient estimates are sensitive to the sample and to the inclusion of other independent variables.

Table 2 examines the sensitivity of the results for the main variables to econometric specification and sample selection. Column 2 displays an unweighted regression, which leads to roughly equal coefficients on official flows and fiscal balance, though official flows contribute significantly more than the fiscal balance to the overall fit of the regression.[13] Columns 3–5 run each decade separately as a pure cross-section. Column 6 uses a version of official flows that does not allocate developing-economy reserve accumulation as a negative official flow for industrial economies, and does not include estimated sovereign wealth fund flows into developing-economy flows.[14] Columns 7–8 present univariate regressions, which show that official flows explain much more of current account imbalances than fiscal balances. The overall conclusion is that the official flows coefficient is strongly robust and the fiscal balance coefficient is moderately robust.

The second set of results in Table 2 conducts further exploration on the sensitivity of results to different groups of economies. Columns 9–11 show that the change in elderly ratio and the initial level of net foreign assets are very important for industrial economies, with essentially

[12] Independent variables that are not expressed as a share of national GDP would need to be multiplied by national GDP as a share of world GDP.

[13] An unweighted regression of the current account on official flows yields an R^2 of .23 versus .18 for an unweighted regression of the current account on the fiscal balance.

[14] Note that sovereign wealth fund flows and non-reserve official flows are not allocated to specific industrial economies in any of the regression data because there is no information on the proportions going to each destination. In Figure 1, however, they are allocated to the aggregate for industrial economies.

no lost observations, but much less important for developing economies, with many lost observations. Columns 12–16 show that the two main policy variables are fairly robustly related to current account balances across different regions, but the official flows variable is more consistently important. Differences in the coefficient estimates across regions are often economically, and sometimes statistically, significant. Sensitivity of the coefficient estimates to the countries and time periods included is a hallmark of this literature and it is even more pronounced for other regressors than official flows and the fiscal balance. This sensitivity may reflect differences across countries, and over time, in policy regimes, stages of development, and mobility of goods and capital.

Figure 2 displays an example of the correlation that drives these results. Across major Asian economies, accumulation of substantial quantities of foreign official assets is strongly associated with current account surpluses. This is true for the decade on average and does not merely reflect temporary fluctuations in official flows related to exchange-rate smoothing.

IV. Macroeconomic implications of the imbalances

According to the IMF's Fall 2011 *World Economic Outlook* (p. 9),

> "The continued expansion of the global economy has come with increasing cyclical diversity. The picture is one of excess capacity in advanced economies and signs of overheating in emerging and developing economies."

Could the current account imbalances of the developing economies and the official flows that drive them be an important factor behind this two-speed recovery?

The IMF projects that net official financial flows from developing economies will be around $1.2 trillion in both 2011 and 2012.[15] The vast majority of these flows likely were destined for Europe and the United States. $1.2 trillion represents roughly 4 percent of combined EU and US GDP. This is a large flow of capital in net terms. Average net national saving over the past 20 years was about 3 percent of GDP in the United States and 6 percent of GDP in the euro area.[16] The official flow from developing economies means that financial markets in Europe and the United States need to find a productive use for almost double the amount of net new capital that they would otherwise need to allocate.

Based on the regression results of Tables 1 and 2, roughly one third of these net official flows may be funnelled back to developing economies in the form of increased private financial inflows. About two thirds of these flows is the amount that is likely to be associated with a higher current account surplus for developing economies, representing a significant net drag on aggregate demand in the industrial economies. This assessment is consistent with the IMF's forecast of developing-economy current account surpluses of about $550 billion in 2011 and 2012. Based on previous trends, the developing economies likely would have had a current account deficit of $200–300 billion in the absence of their massive net official financial outflows. So the net effect of the official flows may have been to increase the current account balance of the developing economies by around $800 billion, which is two thirds of projected net official flows from developing economies in 2011 and 2012.

[15] Projections are from the fall 2011 IMF *World Economic Outlook* database. These projections do not include flows from most sovereign wealth funds in developing economies or from the new advanced economies of Hong Kong, Israel, Korea, Singapore, and Taiwan, which also have large current account surpluses and positive net official flows. On the other hand, net official flows appear to have eased in the final months of 2011 after the forecast was released.

[16] Data are from the US Bureau of Economic Analysis and Eurostat.

A reduction of $800 billion in the current account balance of the industrial economies represents a loss of aggregate demand of roughly 2 percent of GDP. According to the IMF, the output gap in the industrial economies in 2011 was around 4 percent of GDP, so the policy-driven imbalances of the developing economies are an important factor behind slow growth in the industrial economies, but not the only factor.

Federal Reserve Chairman Bernanke (2011) apparently concurs with the conclusion that developing-economy currency policies are an important factor behind slow industrial-economy recoveries. In response to a question on Chinese currency policy, he recently said the following, but his remarks apply more broadly to developing-economy policies in the aggregate.

> "I think right now a concern is that the Chinese currency policy is blocking what might be a more normal recovery process in the global economy. In particular, we have now a two-speed recovery, where advanced industrial countries like the United States and Europe are growing very, very slowly; where emerging-market economies are growing quite quickly. In a more normal recovery, a more balanced recovery would have some more demand being shifted away from the emerging markets toward the industrial economies. The Chinese currency policy is blocking that process. And so it is to some extent hurting the recovery process."

V. Conclusions

Studies of the causes of current account imbalances in developing economies that do not include official financial flows or some other measure of external financial policy or exchange rate policy are like Hamlet without the prince. By far the most important factor behind current accounts in developing economies is the official policy of the government toward the exchange rate, the current account, and/or official holdings of foreign assets. Governments in many economies appear to have sought current account surpluses through massive purchases of foreign assets.

Official financial flows explain less of the pattern of current accounts across industrial economies, probably reflecting the much greater mobility of private capital between industrial economies as compared to developing economies.

Aggregate net official financial flows from the developing economies to the industrial economies are conservatively projected at $1.2 trillion in 2011 and 2012. These flows cause a serious net drag on aggregate demand in the industrial economies and they are a major contributing factor to weak recovery in Europe and the United States.

Table 1

Alternative factors behind current account balances, 1981–2010

(Pooled cross-country regression on decade averages with decade dummies)

(weighted by country share of world nominal GDP)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Official Flows	0.65**	0.62**	0.64**	0.59**	0.72**	0.72**	0.42**	0.59**
	(.11)	(.10)	(.11)	(.08)	(.11)	(.12)	(.10)	(.07)
Fiscal Balance	0.23*	0.24*	0.22	0.35**	0.27**	0.20	0.35**	0.33**
	(.11)	(.10)	(.12)	(.09)	(.09)	(.11)	(.09)	(.09)
Net For. Assets		7.23**					5.92**	5.25**
(× 100)		(1.40)					(1.38)	(1.29)
Energy Exports			0.03				0.09**	
			(.04)				(.03)	
Change in Elderly Ratio				4.86**			3.08**	3.64**
				(.79)			(1.01)	(.90)
GDP Growth					–0.23		–0.12	
					(.13)		(.16)	
Population Growth					–1.34**		–1.05*	
					(.40)		(.47)	
PPP GDP per capita (rel. to US)						0.51*	–0.97**	
						(.27)	(.36)	
R^2	.41	.51	.41	.54	.49	.41	.63	.59
No. Obs.	397	300	296	387	391	387	256	300

Note: This table presents panel regressions using non-overlapping 10-year periods. There are 158 countries and 3 time periods. Some data are missing for some countries, especially in the earlier time periods. A full set of time effects is included. No country effects are included. Current accounts, official flows, fiscal balance, net foreign assets, and energy exports are in percent of GDP. Net foreign assets are measured in the year before the start of each period. Change in elderly ratio is the average annual change in the ratio of persons aged 65 and older to those aged 16 to 64, in percentage points. GDP growth and population growth are in percent average annual rates. PPP GDP per capita is measured as the logarithm of the ratio to US GDP per capita. (The raw ratio was consistently less statistically significant.) Robust standard errors are shown in parentheses. * and ** denote significance at 5 and 1 percent levels.

Table 2

Factors behind current account balances, 1981–2010

(Pooled cross-country regression on decade averages with decade dummies)

(weighted by country share of world nominal GDP)

	(1)	Un-weighted (2)	1981–1990 (3)	1991–2000 (4)	2001–2010 (5)	Unadj. Official[1] (6)	Official Only (7)	Fiscal Only (8)
Official Flows	0.65**	0.39**	0.34	0.56**	0.71**	0.67**	0.75**	
	(.11)	(.11)	(.21)	(.21)	(.18)	(.13)	(.10)	
Fiscal Balance	0.23*	0.44**	0.26	–0.11	0.33	0.41**		0.56**
	(.11)	(.13)	(.14)	(.19)	(.26)	(.13)		(.14)
R^2	.41	.28	.20	.20	.55	.34	.38	.19
No. Obs.	397	397	108	131	158	399	430	441
	Ind. Econ. (9)	**Devel. Econ. (10)**	**Devel. Econ. (11)**	**Devel. Asia (12)**	**Africa (13)**	**MENA (14)**	**Latin America (15)**	**Eastern Europe & FSU (16)**
Official Flows	0.69**	0.54**	0.59**	0.60**	0.51**	0.44	0.38**	0.99*
	(.21)	(.08)	(.10)	(.10)	(.17)	(.29)	(.10)	(.38)
Fiscal Balance	0.40**	0.27**	0.30**	0.22**	0.49*	0.55**	–0.13	0.76*
	(.15)	(.09)	(.08)	(.09)	(.23)	(.20)	(.11)	(.30)
Change in Elderly Ratio	3.59**	–2.15						
	(1.27)	(2.04)						
Net Foreign Assets (x100)	6.93**	3.85**						
	(1.92)	(1.20)						
R^2	.62	.59	.58	.68	.27	.78	.25	.75
No. Obs.	65	235	331	67	103	40	90	31

Note: This table presents panel regressions using non-overlapping 10-year averages of all data. There are 158 countries and 3 time periods. For a complete country list with regional breakdowns, see Appendix 2. Some data are missing for some countries, especially in the earlier time periods. A full set of time effects is included. No country effects are included. Variables are in percent of GDP, except for elderly dependency ratio. Net foreign assets are measured in the year before the start of each decade. Change in elderly ratio is the average annual change in the ratio of persons aged 65 and older to those aged 16 to 64, in percentage points. Robust standard errors are shown in parentheses. * and ** denote significance at 5 and 1 percent levels.

[1] In this regression, global reserve accumulation is not allocated to recipient countries as negative official flows, and no adjustment is made for estimated flows from sovereign wealth funds.

Figure 1

Net official flows and current account balances by global region

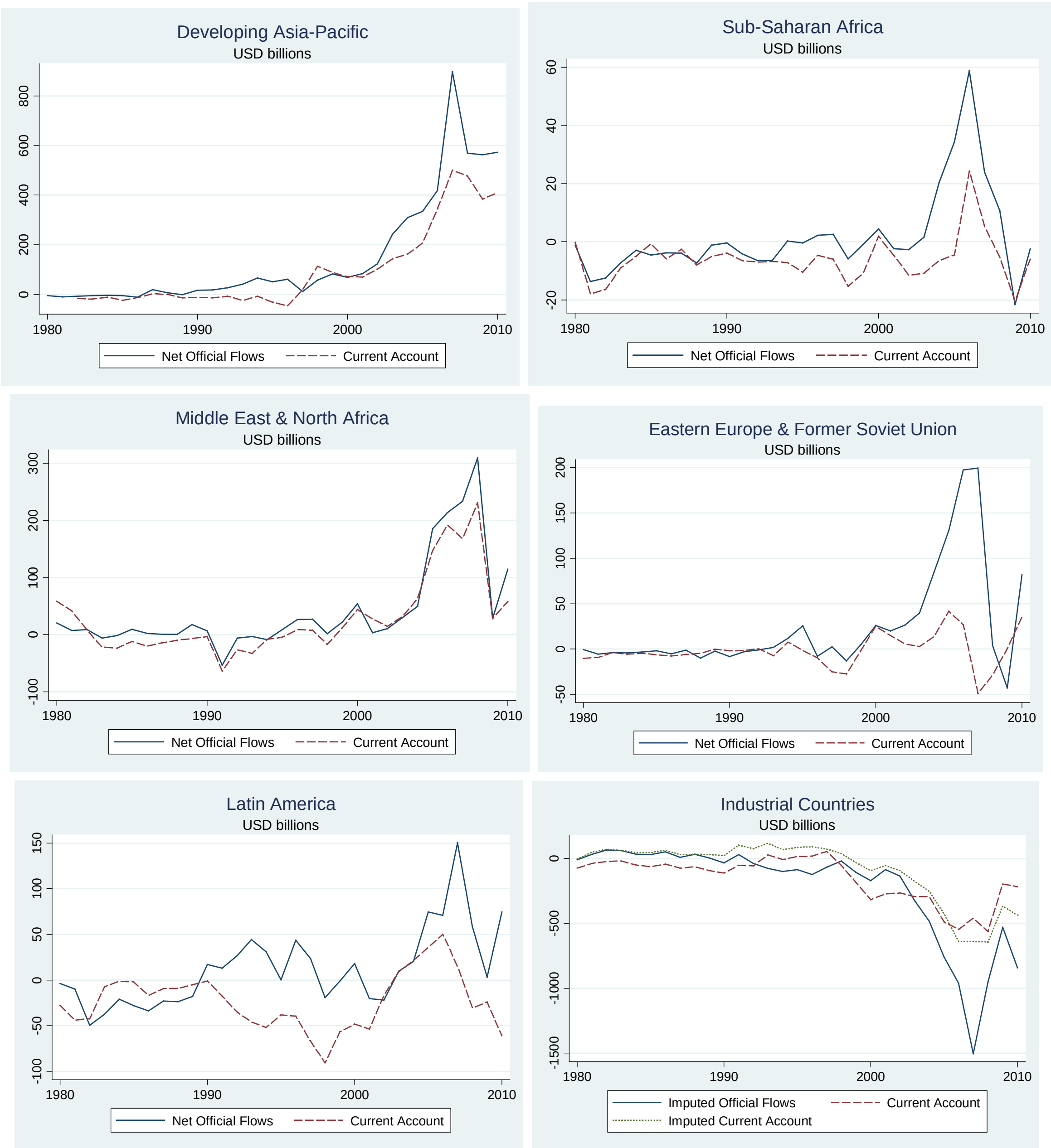
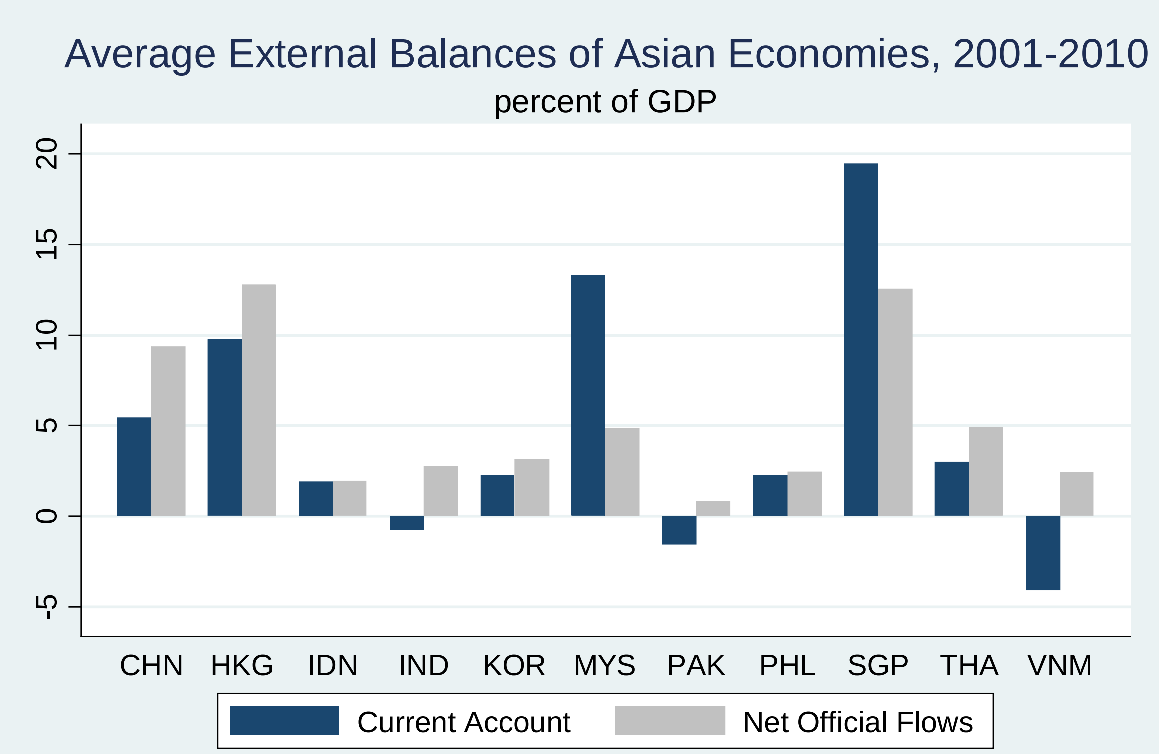


Figure 2



Sources: IMF International Financial Statistics and Truman (2011, Table 1).
Note: Net official flows include an estimate of sovereign wealth fund flows.

Appendix 1: Coefficient bias in a simple model of the current account

The following model abstracts from cyclical factors and dynamics, consistent with the 10-year averaged data used in Tables 1 and 2. Economic variables are denoted in capital letters; unobserved shocks are denoted by lower case letters; parameters are denoted by Greek letters.

1. $CAB = \alpha\ RER + t - d, \ \ \alpha > 0$

2. $RR = \beta\ CAB + m + \delta\ d, \ \ \beta > 0, \delta > 0$

3. $PFF = \gamma\ (RR^* - RR - \rho\ RER) + w, \ \ \gamma \geq 0, \ \ \rho \geq 0$

4. $CAB = OFF + PFF$

5a. Floating Exchange Rate: $OFF = z$

5b. Fixed Exchange Rate: $RER = z$

The current account balance (CAB) responds positively to the real exchange rate (RER), which is defined so that an increase is a real depreciation. Trade shocks (t) increase the CAB, whereas domestic demand shocks (d) decrease the CAB through higher imports.[17] The real rate of interest (RR) responds positively to the CAB because monetary policy tightens to stabilize output when the CAB increases. RR also responds positively to domestic demand shocks (d) and to monetary shocks (m).

Private financial flows (PFF) respond positively to the difference between foreign and domestic real rates of interest (RR*–RR). An increase in PFF is an outflow of capital. PFF may respond negatively to the RER to the extent that a depreciated exchange rate is expected to appreciate in the future, as in the standard overshooting model of exchange rates. The case in which $\rho = 0$ corresponds to random-walk expectations in which the future RER is expected to remain at its present value.

The CAB equals PFF plus official financial flows (OFF) by identity. Equations 5a and 5b represent external financial policy. In a pure floating exchange rate regime, OFF is an exogenous policy choice. In a pure fixed exchange rate regime, the RER is an exogenous policy choice. In the real world, it is possible to have an intermediate regime, such as a managed float, but analysing the two extreme cases will provide natural benchmarks that should encompass intermediate behaviour.

Shocks to PFF (w) reflect poorly understood risk premiums in financial markets (including currency markets) and perceived excess returns on direct investment flows. Shocks to external financial policy (z) include building war chests of foreign exchange reserves, official development lending, and changes in the target exchange rate.

This model assumes that prices are sticky, which allows the central bank to affect the real interest rate and the real exchange rate. For simplicity, prices are not modelled explicitly. It is assumed that the central bank's response to output fluctuations (β) is sufficiently strong to be consistent with well-behaved inflation. The central bank has independent control of interest rates and the exchange rate because of its control over official financial flows, as long as private capital is not perfectly mobile ($\gamma < \infty$).

[17] The shock, d, reflects the effect of a domestic demand shock on the CAB and is not equal to domestic demand. The model cannot be solved analytically in MATLAB with a separate equation for domestic demand.

In general, it can be shown that all variables respond to all shocks in the model.[18] The standard approach has been to regress the CAB on observable variables that are elements of the shocks and that are plausibly viewed as exogenous to the CAB. Thus, the fiscal balance, demographic ratios, per capita income, and growth are elements of the shock d. Net exports of oil and per capita income (through the Balassa-Samuelson effect) are elements of the shock t. In the pure floating exchange rate regime, OFF is exogenous and equal to the shock z. In this case, regressing the CAB on OFF is appropriate for identifying the effect of a shock to external financial policy.

Table A.1 displays the asymptotic values of the coefficient of a regression of the CAB on OFF under both floating and fixed exchange rate regimes under the assumption that the shocks are not correlated with each other. These asymptotic values are bounded strictly between 0 and 1. The term σ_d^2 denotes the variance of d; the variances of the other shocks are denoted similarly. Under a floating exchange rate, the asymptotic coefficient does not depend on the relative variances of the shocks. Under a fixed exchange rate, the asymptotic coefficient does depend on the relative variances of the shocks. When the trade shocks (t) are large (technically, as the ratios of σ_t^2 to the variances of all the other shocks approach infinity), the asymptotic coefficient under a fixed exchange is in general greater than under a floating rate (row 2).[19] However, this difference shrinks to zero in the case of random-walk exchange rate expectations (ρ=0) which are an implication of a credible fixed exchange rate regime. When domestic demand shocks (d) are large (row 3) the coefficient may be biased up or down under a fixed exchange rate, depending on the parameters and the variances of the shocks. When the policy shocks (z) are large (row 4), the asymptotic coefficients are identical under both fixed and floating exchange rates. When any of the other shocks dominate (row 5), the asymptotic coefficient under a fixed rate is zero, and thus is smaller than under a floating rate.

The sixth row of the table presents the asymptotic coefficients when PFF does not respond to the interest rate differential (γ=0). In this case, the asymptotic coefficient under fixed exchange rates is always less than or equal to the coefficient under floating rates. The combination of very low values of γ and σ_w^2 describes circumstances of very low capital mobility. As shown in the seventh row of the table, when these parameters equal zero the asymptotic coefficient equals 1 under either floating or fixed exchange rates. Finally, in the case of perfect capital mobility ($\gamma=\infty$), the asymptotic coefficient equals 0 under either floating or fixed exchange rates.

[18] Regressing the CAB on the RER yields a biased estimate of α because RER responds endogenously to u except under a pure fixed exchange rate regime. Cross-country studies typically do not use RER as a regressor because of the difficulty of finding valid instruments.

[19] This result is calculated by setting all variances equal to zero except for s_t^2.

Table A.1

Asymptotic regression coefficients for CAB on OFF

	Floating: Equation 5a	**Fixed: Equation 5b**
1. general case	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$	$\frac{(1+\beta\gamma)(\sigma_t^2+\sigma_d^2)+\alpha(\alpha+\gamma\rho+\alpha\beta\gamma)\sigma_z^2}{(1+\beta\gamma)^2(\sigma_t^2+\sigma_d^2)-(\gamma+\beta\gamma^2-\gamma^2\delta)\delta\sigma_d^2+(\alpha+\gamma\rho+\alpha\beta\gamma)^2\sigma_z^2+\gamma^2\sigma_m^2+\sigma_w^2+\gamma^2\sigma_{RR}^2}$
2. σ_t^2 large	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$	$\frac{1}{1+\beta\gamma}$
3. σ_d^2 large	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$	$\frac{(1+\beta\gamma)\sigma_d^2}{(1+2\beta\gamma+\beta^2\gamma^2-\gamma\delta-\beta\delta\gamma^2+\gamma^2\delta^2)\sigma_d^2}$
4. σ_z^2 large	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$
5. $\sigma_m^2, \sigma_w^2, \sigma_{RR}^2$ large	$\frac{1}{1+\frac{\gamma\rho}{\alpha}+\beta\gamma}$	0
6. PFF unresponsive to RR*–RR: $(\gamma=0)$	1	$\frac{\sigma_t^2+\sigma_d^2+\alpha^2\sigma_z^2}{\sigma_t^2+\sigma_d^2+\alpha^2\sigma_z^2+\sigma_w^2}$
7. No capital mobility: $(\gamma=0 \text{ and } \sigma_w^2=0)$	1	1
8. Perfect capital mobility: $(\gamma=\infty)$	0	0

Under a pure floating exchange rate regime, the coefficient in a regression of the CAB on OFF is an unbiased estimate of the effect of an exogenous policy change in OFF on the CAB. Under a managed float or fixed exchange rate, this coefficient may be biased, but under many plausible circumstances the bias will be downward.

Appendix 2:
Data definitions and sources

Where available, data are from the IMF's *World Economic Outlook* (WEO) database (September 2011 version). Missing observations are filled in by the IMF's *International Financial Statistics* (IFS) database and the World Bank's *World Development Indicators* (WDI) database in that order. Data are expressed in percent of GDP except as follows: Change in elderly ratio is the annual change in the ratio of persons aged 65 and older to those aged 16 to 64, in percentage points. GDP growth and population growth are in percent annual rates. PPP GDP per capita is expressed as the logarithm of the ratio to US GDP per capita.

Official flows are the sum of balance-of-payments flow data for reserves and related items, other assets of monetary authorities, other assets of government, other liabilities of monetary authorities, and other liabilities of government, from *IFS*. The total of world reserve flows (but not the flows of other assets) is subtracted from the industrial economies in the following percentages, roughly consistent with the IMF's *Composition of Official Foreign Exchange Reserves* data on average over the past decade: 65 percent for the United States; 10 percent for Germany; 5 percent each for France, Japan, and United Kingdom; 2 percent each for Italy and Netherlands; 1 percent each for Australia, Belgium, Sweden, and Switzerland. Estimated sovereign wealth fund flows were added to those economies with sovereign wealth funds as listed in Table 1 of Truman (2011). The Truman estimates for the stock of sovereign wealth assets in 2010 were allocated into flows in proportion to each economy's current account surpluses since the establishment of the fund. For China, the total amount was allocated to the year of establishment, as reports suggest that China has not been adding to its sovereign wealth fund since then. For Mexico, which had current account deficits, the total amount was allocated in proportion to energy exports. The Truman estimate of holdings of the Government of Singapore Investment Corporation includes some but not all of the foreign exchange reserves reported to the IMF. For Singapore, net official flows are assumed to equal general government net acquisition of cash assets (which equals net lending plus net debt issuance) from IFS. These flows cumulate to the government of Singapore's published gross financial assets as of 2010, almost all of which are believed to be held in foreign countries.

No attempt was made to allocate developing-economy sovereign wealth fund flows to specific industrial economies. However, in Figure 1, sovereign wealth fund and all official flows from developing economies are labelled as imputed official flows to the industrial economies in aggregate. Foreign assets of government pension funds as defined in Truman (2011, Table 1) are not treated as official assets because it is assumed that they operate similarly to private pension funds.

The fiscal balance is general government net lending. Net foreign assets are the difference between international investment position assets and liabilities from IFS. Missing historical data for the fiscal balance are filled in with older-vintage WEO data graciously provided by Menzie Chinn and Hiro Ito. Missing historical data for net foreign assets are filled in with data from Lane and Milesi-Ferretti (2007), provided that the Lane and Milesi-Ferretti data do not deviate from the *IFS* data by more than 20 percentage points of GDP in the first year of overlap.

Energy data were reported in terms of tons of oil equivalents. They were converted to US dollars using the price of Brent oil. Energy exports are the difference between energy production and energy use.

The data in Figure 1 are annual. The data used in Tables 1 and 2 and Figure 2 are 10-year non-overlapping averages (except for net foreign assets, which are values from the year before each 10-year period.) For a few observations, the 10-year average data are based on only 9 years when either the first or last year of the decade was missing.

The industrial economies are *IFS* codes 101 through 196, except for 186 (Turkey). Middle East and North Africa (MENA) is defined to include *IFS* codes 401–499 plus 186 (Turkey), 612 (Algeria), 672 (Libya), 686 (Morocco), and 744 (Tunisia). Sub-Saharan Africa is defined as *IFS* codes 199 (South Africa) and 601–799, except for those countries included in MENA. Asia-Pacific is defined as *IFS* codes 501–599 and 801–899 plus 924 (China) and 948 (Mongolia). Latin America is defined as IFS codes 201–399. Eastern Europe and the former Soviet Untion is defined as *IFS* codes 901–999, except 924 (China) and 948 (Mongolia).

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Comments on Joseph Gagnon's paper "Global imbalances and foreign asset expansion by developing-economy central banks"

Chris Aylmer[1]

Let me start by thanking the Bank of Thailand and the BIS for organising this conference, and for giving me the opportunity to participate. I would also like to thank Dr Gagnon for his paper and discussion on some of the global implications of foreign asset expansion by emerging-market central banks.

What I like about Dr Gagnon's work is its emphasis on underlying distortions. Current accounts, as we know, are fundamentally endogenous, reflecting the net outcome of a raft of savings and investment decisions taken by households, businesses and government across the whole economy. Similarly, behind the capital (or financial) account is a large array of gross capital flows reflecting decisions taken by both domestic and foreign investors. The current account position reflects the aggregate outcome of all these decisions. If one is concerned about an imbalance, the focus should be on the distortion that creates it. Importantly, however, a balanced current account does not imply an absence of distortions.

Take Australia for example. Prior to the float of the Australian dollar in 1983, the current account deficit generally moved in range of 0 to 3 per cent of GDP. Following deregulation of the financial system, dismantling of protection and floating of the exchange rate, however, the current account deficit has increased and now tends to move in a range of 3 to 6 per cent of GDP. Similarly, Europe's balanced current account position does not necessarily imply an absence of distortions.

For Australia, deregulation and floating the currency have been beneficial. Notwithstanding some significant transitional difficulties, the move away from using direct controls to implement monetary policy to a system based on market operations has given Australia greater scope to manage its economy. The exchange rate bears the brunt of the adjustment to external shocks, freeing up domestic monetary policy to meet domestic objectives.

Looking back over the past thirty years, it has done this. The system has been reasonably tested by the financial crisis of the late 1990s, and the more recent North Atlantic crisis. Australia has also experienced a doubling in its terms of trade over the past decade. But growth has been steady, and inflation generally well behaved.

At the same time, deregulation has resulted in improvements in the operation of the financial system. Once regulations were removed, the financial sector eventually became not only more efficient but also more responsive to the financial needs of the economy. New financing techniques and markets developed, resulting in a more diversified and resilient financial sector.

The ability to hedge foreign-currency liabilities has been very significant in terms of minimising the risks of floating the Australian dollar and helping businesses manage a sometimes volatile exchange rate. Fledgling currency-futures markets (including an active non-deliverable forward market) existed prior to the float, but floating the exchange rate was

[1] Reserve Bank of Australia.

always going to be a precondition for these markets to develop in any meaningful way. Importantly, these things came *after* the event rather than before.

I relay this story because while we are discussing the global implications of foreign asset expansion, the solutions are essentially national. The case for a change in exchange rate arrangements has to be made domestically. So how might that case be made?

It rests on a number of propositions:

1. The first proposition is that the allocative efficiency of the economy (as opposed to productive efficiency) can be improved by bringing prices closer to marginal costs, allowing the products that consumers want to buy to be sold, and improving the allocation of investment. An undervalued exchange rate results in countries being overly reliant on goods and services produced in the trade-exposed sector, relative to those produced in the non-traded sector. It is essentially a wealth transfer from consumers and businesses that use imported inputs to exporters and the import-competing industries.

   It leaves countries particularly vulnerable to external developments and promotes a banking sector which is overly focused on the export sector. This results in a short-term focus, to the detriment of the maturity transformation of the household sector's financial assets. Credit rationing may also occur outside the trade-exposed sector.

   The allocative efficiency benefits can be measured, though inevitably this has to be over long periods. In Australia, for example, while average growth in GDP has been remarkably constant over a number of decades, the standard deviation of that growth is now one third what it was in the decade prior to the float of the currency. While this trend is evident elsewhere, the movement is sizable, and it has occurred at a time when the industry make-up of the economy has changed markedly.

2. The second proposition is that private capital flows can be viewed as a positive. It's not surprising that the experience of extremely volatile capital flows in the late 1990s plays in the mind of policy makers in the region. As a result, decision makers need to feel comfortable that there will not be a repeat of that episode (possibly with the direction reversed).

   The argument is that greater exchange rate flexibility offers an important buffer against the risks posed by large capital inflows, as it can reduce the contribution to domestic demand overheating from large capital inflows, can curb expectations of a large step appreciation, and can lessen the need for foreign exchange intervention.

   The considerable development of local currency yield curves in the region over the past decade has given countries a greater capacity to manage the risks around these flows by providing a basic building block for development of the forward foreign exchange market, which in turn can facilitate borrowing from non-residents in local currency. The yield curve also promotes the appropriate pricing of risk by providing a long-term risk-free interest rate, and it enables governments to borrow long term to fund infrastructure.

   In Australia's experience, this cannot be done overnight. It usually means a gradual re-weighting of the three main means of managing capital flows – capital controls, reserve accumulation and movements in the exchange rate.

3. The third proposition is that the implementation of monetary policy may well be compromised should the accumulation of foreign assets continue. That is, there may well be limits to how much sterilization can be undertaken. Given the very large accumulation of foreign exchange reserves in the region over the past decade, the sterilization effort has been reasonably successful, to the extent that the standard transmission from foreign exchange asset accumulation to reserve money growth to inflation does not seem to have operated. Thus the emerging Asian economies have

been able to adopt intermediate exchange rate regimes while retaining some degree of monetary autonomy, even as greater financial openness was achieved. Sterilisation has been aided in no small part by the ability of central banks to issue their own securities, and by overfunding budgets and placing government deposits at the central bank.

But is it sustainable? At the extreme, banks will only hold central bank liabilities (a number of central bank balance sheets in the region are already in excess of 50 per cent of GDP). Even leaving this aside, the build-up in high-quality, relatively low-yielding liquid assets comes at a cost to banks, which they in turn pass on to customers. This leads to growth in financial intermediation outside of the regulated sector. It also means that banks are cashed up, ready to lend once the demand for credit increases. This could quickly lead to unstable financial conditions that promote excess credit expansion, rapid asset price growth, and eventually financial instability.

A more ominous development is the financial narrowing that occurs within the financial sector as the central bank *becomes* the short-term money market and creates a dependency that is hard to wean institutions off. This stifles the development of a true risk-based market that responds to price signals, and increasingly influences the term structure of interest rates. The risk of re-regulation going too far is also a risk.

4. Finally, there is a fiscal cost associated with the build-up of foreign exchange assets which is potentially very large given the size and un-hedged currency exposures of the relevant central banks. This cost, which can be quantified, has the potential to produce large swings in the public sector's net worth.

Underpinning all of this, of course, there needs to be a plan.

Even though the intellectual climate within the Reserve Bank and other economic policy agencies was already moving in favour of deregulation in the early 1970s, wider community acceptance of the case for change did not come until after the Government set up a broad-ranging inquiry, conducted by a group of independent experts. This was important in harnessing public and community support for change. Its guiding philosophy (and that of the subsequent Martin and Wallis reports) was a stable, better-informed and fairer financial system, yet one that is adequately flexible and responsive to changing needs and conditions.

It gave everyone an idea of where the reforms were headed, as the process can take a long time to implement, since controls are typically removed sequentially. While it is possible to take a 'big bang' approach and remove many regulations simultaneously, such a process can be difficult to manage. In Australia's case, it was not regarded as feasible to remove regulations simultaneously, mainly because of uncertainty about the consequences, and in fact the process of deregulation started in the early 1970s.

While public inquiries had mapped out a range of reforms that needed to be introduced, the sequencing of these reforms was determined in a pragmatic way, in response to unfolding events and the consequences of previous reforms. The plan guided policy responses as the consequences of reforms are not always entirely predictable. Australia's experience was that the removal of one set of controls often put pressure on other controls. This meant that the reform process, once it had begun, developed its own momentum.

As Keith Campbell, the author of the original plan, said: you never make the right decision, you just take a decision and make it the right one!

Thank you.

Comments on Joseph Gagnon's paper "Global imbalances and foreign asset expansion by developing-economy central banks"

Ooi Sang Kuang[1]

Thank you very much, Khun Paiboon. I would like to thank the Bank of Thailand and the BIS for inviting me to speak at this very important and interesting conference. I would, however, start off with a disclaimer: the views that I'm about to express do not reflect the views of the Central Bank of Malaysia. Second, I would like to congratulate Joseph for a very interesting and excellent paper. In particular, the paper has contributed to increasing the depth and breadth of knowledge on the issue of rapid balance sheet expansion of Central Banks, and also provided a greater understanding of the various factors driving current account imbalances, in particular with the observation that external financial policy is a very important determinant driving current account imbalances in emerging economies.

I think the challenge for practitioners in managing a managed float exchange-rate regime and reserves accumulation is to what extent do we allow the exchange rate to move reflecting changes in the structural terms of trade and fundamental improvements in the competitiveness of the economy, and as a cushion to absorb the influx of very large short-term capital flows into the country. Estimates of appropriate exchange-rate levels to reflect changes in economic and financial factors are very difficult to derive indeed, and are wide ranging. A few years ago the IMF showed us various estimates of what should be the appropriate exchange rate of the Ringgit. That was before the global financial crisis. And it ranged from an undervaluation of 5% to 15%. Some models showed even a broader range. So it's indeed really not an easy task to determine where you pitch the level of exchange the rate – to what degree do you say that it is reflecting terms-of-trade adjustments, or to what extent is it short-term capital flows, and how much do you allow the exchange rate to reflect this? We are aware that short-term capital can flow out at very short notice and such movements can cause disruptive misalignments of the exchange rate.

So the issue facing policymakers is one of regularly fine-tuning the policy mix of reserves accumulation and changes in the magnitude of exchange rate movements, and the use of macro-prudential policies, as an addition to the toolkit to manage the impact of balance sheet expansion and the implications for the macroeconomy.

In this regard, the policy risks that we faced in Asia have to a large degree been successful managed, but that does not mean that we are going to be successful in the future. The issue pointed out this morning by the BIS is that one needs to constantly and regularly analyze risk in the medium to longer term – I think it's an important reminder to all of us. I think one needs to constantly review and reassess the policy mix and the risks that might emerge.

So on this issue of managing the impact of capital flows and the expansion of balance sheets of central banks, Andrew asked me to share some of Malaysia's experiences. And if you will forgive me, I will run through some of these charts fairly quickly, because I have quite a number to cover.

As shown in the charts, three important episodes of very large movements of capital flows in Malaysia took place over the period. As you are probably all aware, Malaysia adopted a fixed

[1] Special advisor to Bank Negara Malaysia.

exchange rate regime in September 1998 at the height of the Asian financial crisis. In July 2005, we moved to a managed float regime. The interesting part is that you see episodes of huge opportunistic financial flows. Before we moved to a managed float, there was widespread speculation about possible change in the exchange rate in regime. Our reserves went up by almost 50% over six months following large capital inflows. After we moved to a managed float regime, the exchange rate did not strengthen as much as the market had expected. Initially, there were more inflows, but the capital flows reversed shortly, and we lost 25% of our reserves in a matter of six months.

Intervention therefore had to go two ways, or else we would have experienced very large fluctuations and misalignments in the exchange rate. That was the first episode of large and volatile capital flows after the Asian financial crisis. The second episode was during the global financial crisis of 2008/09. During the early part of the crisis, reserves rose as inflows were large. Then, in the latter part of 2008 and early 2009, huge outflows took place. And the third episode of very large volatile capital flows was the recent European sovereign debt crisis.

The challenge for small countries like Malaysia is that the forex market is small and does not have the breadth and depth of more developed markets. So capital flows can have large and significant impact on exchange rate movements over very short periods of time – over 6 months, reserves can rise by 50%, and then over the next 6 months decline 25%. Such volatile and large flows can have a significant impact on the exchange rate and create sharp domestic price distortions in many sectors of the economy.

I think the challenge here is how do we manage the balance of exchange rate change and reserves accumulation to avoid significant changes in relative prices of goods and assets that could in turn be very disruptive and cause macroeconomic imbalances in the real and financial sectors. As you know, exports of manufactured goods account for 75% of Malaysia's exports. The impact on exchange rates will have to be managed in such a way that there are not large changes in relative prices, so that economic agents are able to manage their trade, investment, and exchange rate exposures.

If we break down capital flows, in the case of Malaysia we find that, over the years, initially the trade balance was the key determinant. Now it is capital flows that are the key determinant of changes in reserve accumulation. The current account surplus was driven by strong commodity exports in the early period, while in the later period the surplus in the capital account has been driven by sharp movements in short-term capital flows.

What is interesting in our experience is that if we strip out the commodities and look at the underlying terms of trade, we see that the trade and current accounts are broadly in balance. This shows that very large volatile portfolio flows, both into bonds and into the equities market, have become predominant in determining reserves accumulation and exchange rate movements.

What is significant is that in managing the exchange rate over time we initially started the managed float with a limited degree of volatility, and movements were relatively narrow. But as the market adapted to a floating exchange rate regime, and as the foreign exchange market gained in terms of breadth and liquidity, we allowed the exchange rate to move in a broader range. You can thus see in the chart the broader range of ringgit flexibility over time.

Similarly, the volume of forex transactions has risen very significantly. What is important is that, when we examine the bid/offer spread, we see that with the greater liquidity and larger volume of forex transactions, the bid/offer spread for the ringgit against the US dollar has narrowed very significantly over the period. The useful lesson we have experienced in managing exchange rate and developing the foreign exchange market is the need to promote a greater volume of forex transactions in a single market and to encourage a greater number of participants.

I would like to jump to another policy response which has been widely promoted and recommended by the IMF – that emerging countries should develop domestic demand policies to balance growth and help reduce the current account surplus. In Malaysia's case, consumption as a share of GNP rose from 61% to 66% by 2010. So domestic demand, especially consumption, has become a very important driver of growth, as well as helping to rebalance the current account. In the case of Malaysia, the picture is that private investment has not recovered to its pre-Asian-crisis levels. The lower level of investment to some extent explains the current account surplus. In this, sense savings could not be utilized in full to fund domestic investment. So is this a case of too much saving or too little investment? Interesting in Malaysia's case is that Malaysian corporates have invested significantly across Asia in the past few years. So the rebalancing of the current account surplus takes the form of long-term capital outflows. We have seen a sharp increase in overseas investments by Malaysian corporates around the region – from the banks to the telcos to the plantation companies. These investments in the Asian region have been very sizable indeed. Part of the reason Malaysian corporates have expanded to other countries in the region is that we have a very small domestic market compared with the larger markets of Indonesia, Thailand, Vietnam and China. So outward investment is one way we see the rebalancing taking place.

We are aware that managing the cost of sterilization and generating sufficient returns on assets has been a great challenge during this period of very low interest rates for major reserve currencies. And of course we used various instruments to try and manage down the costs of sterilization and also try to balance the returns on reserves with a wider spread of investments, while ensuring that there is sufficient liquidity and safety in instruments we hold. We have thus diversified among different asset classes and across different currencies, and moved down the credit curve. We have also diversified geographically.

The chart shows the various instruments we used to sterilize inflows. The risks we all face managing the balance sheet are similar – currency risk, interest rate risk, credit risk, market risk and liquidity risk. The problem today is that market movements tend to be highly correlated, even among different asset classes and across regional and global markets. Markets are more highly correlated today than before. The traditional wisdom in asset management is that if you diversify your asset classes you'll have a more balanced and stable portfolio. Today, financial markets are highly correlated.

Thus, the challenge is managing the impact of the financial gains and losses in the balance sheets and financial statements of central banks. What we try to do is: in periods of positive returns and financial gains we transfer as much of the gains as possible to the Exchange Rate Fluctuation Reserves, Revaluation Reserve and Contingency Reserve, so that in times of losses there is a buffer to offset negative changes.

I would like to conclude that a completely free-floating exchange rate regime can result in very large and volatile movements in the exchange rate – and can cause great misalignments. So intervention to smooth out large volatilities due to large volatile short-term capital inflows and outflows is helpful in terms of building confidence among businesses and investments in the real sector.

Furthermore, domestic markets need to be developed – in particular financial markets, as well as the foreign exchange markets, to improve intermediation between capital outflows and inflows, and also to enhance liquidity.

Our experience reflects that when we moved from a fixed exchange rate to a managed float, the adoption of a gradual and paced approach allowing greater flexibility in the managed float over time proved useful. The challenge however remains: how much do we balance allowing the exchange rate to move in a manner that appropriately reflects changes in economic fundamentals, with allowing it to change according to short-term capital flows influences? Important, as well, is that macro-prudential measures can and should be used to manage distortions arising in the market – in particular, asset inflation in certain sectors, such as the property sector. These measures have been used in Singapore and Hong Kong. We have used them very selectively in Malaysia.

When we look at the trend appreciation of the Ringgit and the positive current account surplus, we see that both have largely been driven by improving terms of trade for commodities in the earlier years of the float, and in recent years by capital flows as well. In assessing whether there have been significant misalignments of exchange rate and macro-imbalances in the economy, we find comfort in the fact that domestic inflation has remained low and output has been pretty close to potential, rather than there being a case of excess demand. Looking at the monetary aggregates and the financial sector, we see limited evidence of excessive credit growth. Nor have monetary aggregates expanded at levels inconsistent with the level of economic activity. Similarly, we see limited signs of over-valuation in the equity market, although there have been some price movements in the property market.

With that, I conclude my presentation. Thank you very much for your patience.

Central Bank balance sheets as policy tools

A Durré and H Pill[1]

Abstract

In the face of the recent financial crisis, central banks have varied the size and structure of their balance sheets. Such actions attempt to exploit additional instruments of central bank policy that go beyond the traditional monetary policy instrument (ie control over the short-term interest rate). The objectives of these measures have varied across countries: offering additional stimulus to the economy in the face of a lower bound on the level of short-term interest rates; supporting market functioning by expanding central bank intermediation; and managing cross-border capital flows in an environment where the domestic financial system lacks the ability to intermediate such large and/or foreign-currency-denominated financial flows. This paper reviews experience with such measures, in particular drawing lessons from the European experience that have potential relevance for Asian central banks.

Keywords: Money, credit, money markets, central bank balance sheets

JEL classification: E5, E4

[1] European Central Bank, Kaiserstrasse 29, 60311 Frankfurt, Germany. E-mail: alain.durre@ecb.europa.eu. Tel: +49 69 1344 5972. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the ECB or the Eurosystem.

1. Introduction[2]

In meeting the challenges of the financial crisis since 2007, the world's leading central banks have resorted to a variety of exceptional measures, largely revolving around changing the size and composition of their own balance sheets: 'credit easing' in the United States, 'quantitative easing' in the United Kingdom, and 'enhanced credit support' in the euro area. Such measures are credited by some with having saved the world from another Great Depression. They certainly appear to have played an important role in halting the disorderly collapse that threatened to engulf the global financial system after the failure of Lehman in September 2008.

With this narrative in mind, the present paper has two ambitions: first, to better understand the channels through which non-standard central bank measures may have worked, and second, on the basis of this analysis, to draw some conclusions about the appropriate structure of central bank balance sheets in the future. The academic literature offers few guidelines in this respect. We therefore hope that the paper can stimulate further thinking on what promises to be an important topic going forward.

Drawing on experience during previous crisis episodes (notably in Europe during the early 1990s and in Asia during that latter half of that decade), we place recent central bank policies in a broader context. We conclude that the non-standard measures introduced by the Federal Reserve, Bank of England and European Central Bank (ECB) since 2007 may be less exceptional than current conventional wisdom holds. Taking a wider cross-sectional and historical view offers an insight into how non-standard measures may have worked in recent years. And on the basis of this broader analysis, we consider the pros and cons of different central bank balance sheet structures.

2. Transmission channels for non-standard central bank measures

Much of the existing analysis of non-standard central bank policy measures focuses on the importance of *portfolio balance* channels in transmission. This analysis takes as its starting point the view that, owing to the existence of financial frictions in credit markets, assets held in private sector portfolios are not perfect substitutes for one another, even once credit risk and other inherent attributes are allowed for. Where financial markets are not 'efficient' (in Fama's sense), changes in the central bank's portfolio of asset holdings and/or the structure of its liabilities – which, as a mirror image, imply changes in the private sector's balance sheet – can induce changes in the structure of yields and returns in financial markets. In turn, these asset price changes may influence private spending, saving and investment decisions, and thus macroeconomic outcomes.

This analytical framework can be illustrated with reference to quantitative easing: through the portfolio balance mechanism described above, a central bank that purchases long-dated government securities by creating bank reserves (i.e. credits in the accounts of the banking system at the central bank) can hope to flatten the treasury yield curve to a greater extent than implied by the pure expectations theory of the term structure (a corollary of the efficient-market paradigm). Empirical analyses of such policy actions conclude that a sizable impact

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[2] This paper was prepared for the BIS-Bank of Thailand Research Conference on 'Central bank balance sheets in Asia and the Pacific: The policy challenges ahead' held in Chiang Mai, Thailand on 11–13 December 2011. We thank H. Vargas Herrera and B. Soenaryo Mukasan for their very generous discussions of the paper at the conference. Thanks are also due to N. Cassola, A. Filardo, D. Giannone, C. Holthausen, M. Lenza, L. Reichlin and J. Yetman for their comments on the paper and/or contributions to earlier collaborations. Assistance from K. Chung, C. Garcia de Andoain Hidalgo, L. Lam and B. Morley is gratefully acknowledged.

on long-term interest rates can be achieved, as reflected in the growing number of papers that evaluate the impact of central bank balance sheet expansion on the slope and level of the yield curve.[3] The emphasis on portfolio balance effects is in tune with a thread of the literature on (unsterilized) central bank foreign exchange interventions that suggests that these balance sheet effects explain the efficacy of such policy actions (eg Dominguez and Frankel, 1993). In this context, purchases of domestic currency assets by a central bank trigger an attempt by the private sector to replace such assets in its portfolio, thereby driving up their price and causing the currency to appreciate.

In previous work on the euro area (Lenza et al, 2010; Giannone et al, 2011a/b; Cassola et al, 2011), we have argued that another channel of transmission for non-standard monetary policy measures may be equally, if not more, important. This alternative view starts from the premise that financial markets can periodically become dysfunctional on account of information problems. The simplest example – but nonetheless arguably the one most relevant to the immediate post-Lehman episode – concerns a situation where an external shock raises questions about the solvency of some potential counterparties in a financial market. Owing to the asymmetric structure of information on the strength of balance sheets, adverse selection can occur in that market, leading to some institutions' being 'red-lined' (ie excluded from the market at any price) in the manner proposed by the credit rationing literature.[4] Applied to the interbank money market, such considerations have been central to analysis of the financial crisis that followed the failure of Lehman Brothers in September 2008.

On the basis of a structural model of the money market where the existence of information asymmetries between market participants gives rise to adverse selection among banks, Heider et al (2009) offer a compelling explanation of these developments. While their model is inevitably highly stylised, it demonstrates how concerns about the solvency of specific banks can lead to the breakdown of interbank trading. The model distinguishes three regimes: first, a situation of low interest rate spreads and active interbank trading; second, a market exhibiting elevated spreads and adverse selection, with continued but lower trading volumes; and third, a regime where market trading breaks down. What determines the transition from one regime to another in this model is the extent of concerns about counterparty solvency. But when such concerns emerge, the outcome is growing liquidity risk for all banks, not just for those perceived as facing a heightened threat of insolvency as credit risks mount.

When the private market seizes up in this way, the potential spillover to other markets is high because of the central role that the interbank money market plays in refinancing short-term positions in the economy. Central banks therefore have a case for intervention: in doing so, they aim to insulate the rest of the economy and financial system from the impact of the breakdown of liquidity and activity in a specific segment of the financial markets. The simplest way for the central bank to intervene is to expand intermediation across its own balance sheets in that particular dysfunctional segment.

To further use the example of the interbank money market, consider the situation where two banks are unable to complete a Pareto-improving trade with each other owing to mutual – and possibly unjustified – concerns about counterparty solvency. In this case, the central bank can act as an intermediary between the two banks, allowing the underlying transaction to take place, and thereby avoiding the negative externalities that the dysfunctionality in the money market might imply for other market segments. In practice, this means that the central bank will lend to the cash-short bank, and the resulting liquidity injected into the system will

[3] See, for example, Kozicki et al (2011), Gagnon et al (2010) and Joyce et al (2010).

[4] See Stiglitz and Weiss (1981).

ultimately return to the central bank from the cash-rich bank that accumulates a long position in its reserve account at the central bank as a result of interbank payments. Note that this intermediation function of the central bank is not without cost: the central bank absorbs the perceived counterparty risk that prevented the original underlying bank-to-bank transaction. Absorbing such potential counterparty risk can be justified on two grounds: (1) that the central bank has a better assessment of the underlying balance sheet strength of the banks excluded from interbank trading than do their immediate private counterparties; and/or (2) that the central bank internalizes the externalities that do not enter the private banks' calculus about whether to conduct the transaction or not. The latter consideration in particular demonstrates how well-intentioned central banks run the risk of assuming (quasi-) fiscal tasks when they engage in non-standard monetary policy measures of this sort, something we warn against in a subsequent section.[5]

This analysis also has parallels with the literature on central bank exchange rate interventions and policies, in this case where the literature discusses 'sudden stops' in capital flows to emerging markets.[6] The literature points to the need for central banks to accumulate foreign exchange reserves so as to insure themselves against an unexpected halt in the inflow of capital from abroad. In the remainder of the present paper, we explore this analogy between the non-standard measures introduced in the face of the global financial crisis since 2007, and earlier foreign exchange interventions.

3. Context: Financial crises in developed and emerging markets

In a variety of papers written in the mid-1990s, McKinnon and Pill (1997, 1998) explored the "overborrowing syndrome" – a situation where apparently successful structural reforms in emerging market economies triggered an excessive capital inflow that led first to a boom (in both economic activity and asset prices) followed by a bust (as the unsustainable nature of such financial flows became apparent).

At the heart of their explanation of these phenomena was the "original sin" notion introduced by Hausman and Panizza (2003): emerging market economies lack the institutional infrastructure and associated credibility to deal with such capital flows.

At the macro policy level, the 'fear of floating' (Calvo and Reinhart, 2002) associated with this situation led to the adoption of de facto (and often de jure) exchange rate pegs, given the difficulty faced in running an independent monetary policy and accepting the exchange rate consequences thereof. At the micro level, the inability of domestic financial systems to successfully and efficiently direct the flow of capital from abroad led to a build-up of ultimately unsustainable financial imbalances. In particular, the existence of often implicit retail deposit insurance encouraged excessive risk-taking, and bid asset prices up to their 'Panglossian' levels (since downside risks were socialised) (Krugman, 2000).

This type of analysis was seen to be consistent with a number of the financial crises of the last decade of the previous century, such as the "Tequila Crisis" in Mexico and the Asian financial crisis of 1997–98. Moreover, it led to a number of policy proposals, modest in scope though they were. First, as regards the broader regulatory environment, the analysis emphasized the need for institutional development prior to liberalising the balance of payments capital account, and the need for gradual removal of capital controls so as to permit this development before the economy is exposed to the full force of the global capital

5 See Durré and Pill (2010).

6 See Calvo and Reinhart (2000).

market. Central to this institutional development were improved regulation and supervision of the banking system (eg preventing currency mismatches on bank balance sheets). Collectively, such measures – which at the time were seen as potentially illiberal and contrary to the prevailing Washington consensus in favour of liberalisation – would now be labelled macroprudential policies.

Second (and partially fulfilling the agenda sketched out in the introduction), the analysis pointed to more specific proposals for central bank balance sheet policies. Notable among these were: (a) preventing reserve requirements from leading to an implicit subsidisation of foreign capital inflows, eg by excluding foreign currency deposits from the definition of the reserve base on which reserve requirements were calculated; (b) the potential use of Chilean-style holding requirements to lengthen the maturity of foreign liabilities in the banking system; and (c) using sterilised intervention to support exchange rate pegs. All three of these initiatives should be viewed as attempts to build a central bank balance sheet structure that is resistant to 'sudden stops' or reversals in capital inflows from abroad. This discussion therefore coincides with the goal of the present paper: to explore how central bank balance sheets can help contain financial crises, although, given recent experience, the focus is on domestically generated and propagated crises.

As has been recognized by several authors, the financial crisis of 2007–11 exhibits a number of simple features shared by the emerging-market crises of the 1990s. In particular, institutional weaknesses (including inadequate prudential supervision) led to poor incentives and ultimately to excess credit creation and asset-price boom/bust cycles. Just as in the sudden stops characteristic of emerging-market currency crises, we have seen how certain key financial markets – notably the interbank money market – can seize up, undermining credit creation and threatening broader macroeconomic stability. And just as in the case of responses to past exchange rate crises, this has led in turn to the introduction of central bank balance sheet policies, and poses questions of how the central bank balance sheet should be structured to make for a more robust and resilient situation in the future.

Annex I briefly reviews recent financial crises in order to provide an empirical context for this comparison between recent non-standard measures and previous foreign exchange interventions – two versions of central bank balance sheet policy. In the remainder of the paper, we aim to develop the argument that understanding balance sheet policies and their effects requires a more functional approach – identifying which markets the central bank is forced to support, and how it can do so – rather than simply looking mechanically at indicators such as balance sheet size or composition.

4. Analytical framework

Before turning to the data, it is useful to sketch out elements of an analytical framework. Figure 1 offers a stylised view of a financial market. For illustrative purposes, it takes as its starting point the interbank money market – an object of intense study in the 2007–09 financial crisis.

A traditional analysis of financial intermediation focuses on the flow of resources from private sector savers to private sector borrowers. To simplify, we assume that the flow of savings takes the form of deposits by the domestic private sector in the domestic banking system (A in Figure 1), while borrowing consists of a flow of bank loans to the domestic private sector (B).

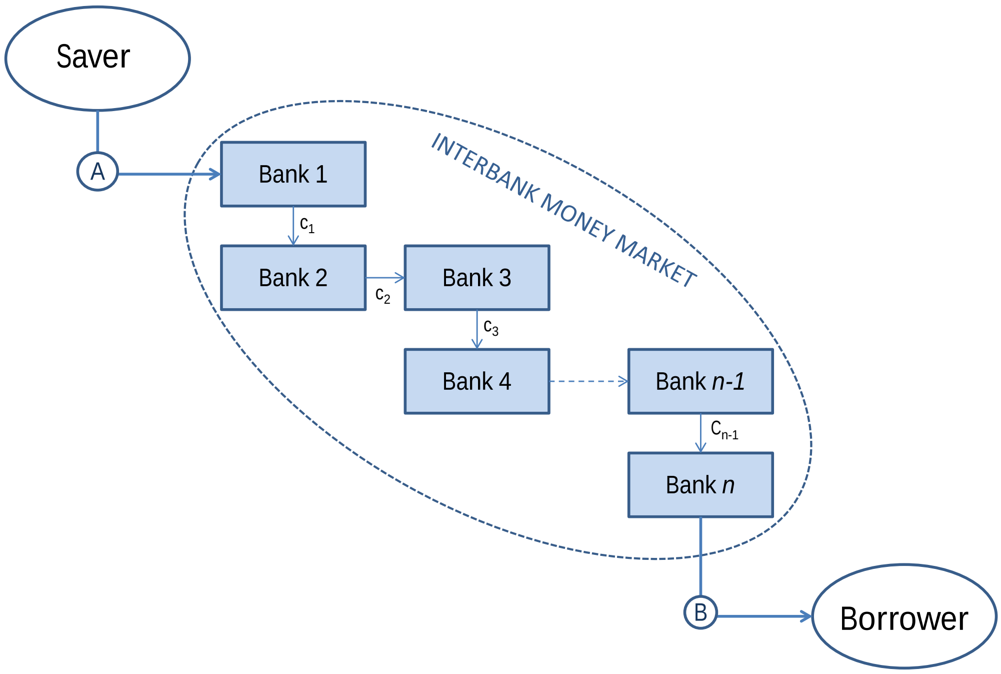
Such an approach excludes all the intervening transactions among banks (c1 … cn).[7] This is a serious shortcoming in two respects.

First, such transactions are becoming more numerous and important. Using data on US flow of funds, Adrian and Shin (2010a/b) have demonstrated how the build-up of intra-financial-sector leverage prior to the onset of the 2007–08 financial crisis was associated with the emergence of longer 'intermediation chains'. In other words, the flow of resources from non-bank saver to non-bank borrower passed through an increasing number of banks in the course of being intermediated between private sector saver and borrower. Shin and Shin (2011) make a similar point about the role played by offshore markets in the financing of overborrowing episodes in emerging markets.

Second (and more importantly in the present context), since, as the starting point for our account of the transmission of non-standard policy measures posits, central banks act so as to overcome disruption to these interbank markets, we need to ensure that they are treated and monitored appropriately.

Figure 1

The growing role of wholesale financial markets in financial intermediation



Brunnermeier and Pedersen (2009) and Gorton and Metrick (2011) offer theoretical and empirical accounts, respectively, of how disruptions to wholesale financial markets can induce a wider freezing up of the financial system, with serious adverse consequences for the wider macroeconomy. Our characterisation of the transmission of non-standard policy measures is based on the central bank's offering its own balance sheet as a vehicle for intermediating those intra-financial sector flows that are disrupted as the financial market seizes up.

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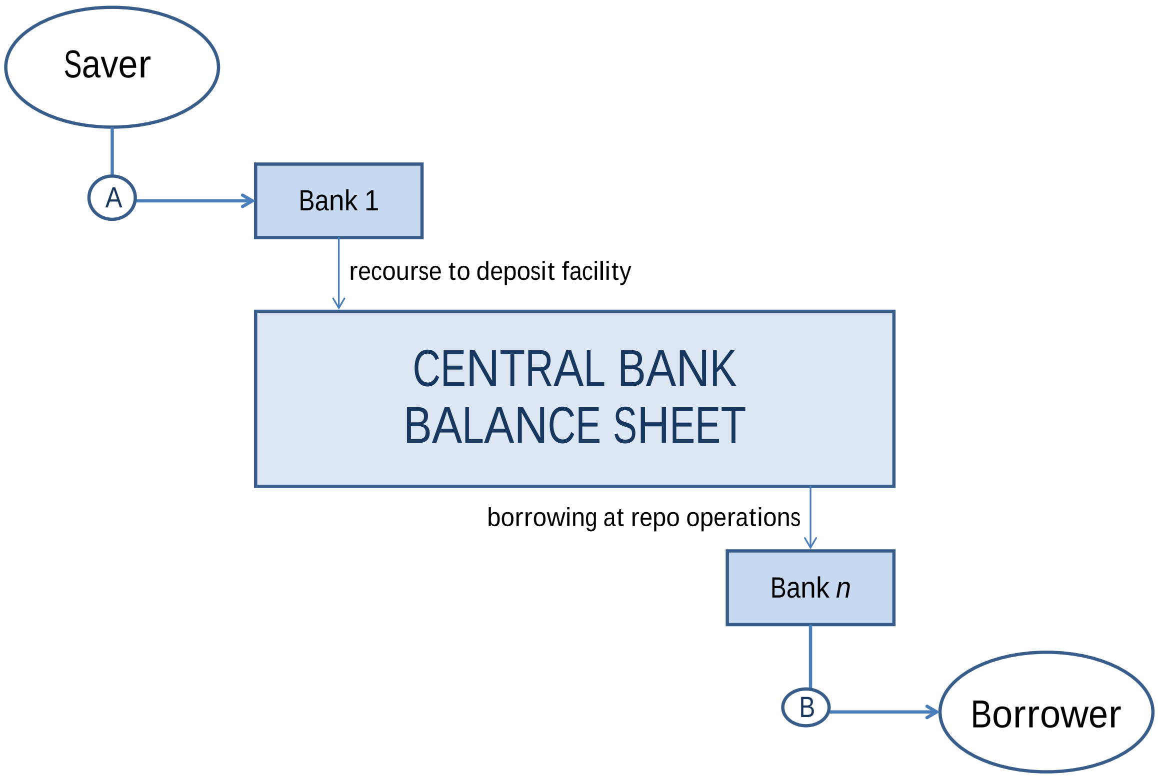
[7] By construction, interbank positions should consolidate to zero: a short-term loan from bank X to bank Y is equivalent to a deposit placed by bank Y at bank X.

In essence, non-standard policy measures represent an attempt to use a central bank's balance sheet, and the tools it has available under its operational framework, for the implementation of monetary policy to act as a de facto central counterparty for wholesale financial transactions. In the case illustrated in Figure 1, the central bank, by so doing, replaces the frozen private interbank market, ensures that the flow of resources from private sector savers to borrowers is maintained, and thereby sustains the necessary flow of credit to the real economy (see Figure 2). By these means, the central bank is able to ensure that disruptions to real economic activity caused by a 'sudden stop' in financial flows are minimised. In the course of intermediating these flows, the central bank's balance sheet will expand, as recourse to its refinancing facilities by those banks making the loans is matched by build-up of reserve holdings by other banks receiving savings deposits.

Figure 2

Central bank intermediation as a de facto central counterparty



To anticipate our subsequent empirical analysis, a number of points can be made even on the basis of this very simple framework. First, success of non-standard measures in this context should be understood as ensuring that the pre-existing flow of resources from and to the real economy is maintained. Rather than stimulating the real economy anew, the purpose of non-standard measures in our framework is to contain disruption. Selecting the relevant counterfactual scenario for the purposes of comparison is therefore key. Second, the stylised representation in Figures 1 and 2 demonstrates that the central bank does not need to substitute for all transactions in wholesale markets. What is crucial is that it maintain the flow of deposits **A** into loans **B**. It does not need to substitute for the (growing number of) intermediate transactions ($\mathbf{c}_1$ … $\mathbf{c}_n$). Hence while effective interventions in wholesale markets will substitute for private transactions, they need not do so one-for-one.

5. Stylised facts in the various crises

a. Methodology and data

In this section, we discuss the evolution of central bank balance sheets (both their size and composition) during the crisis periods described in Annex I. In the case of a currency crisis (as in Europe in 1992–93 and Asia in 1997–98), we distinguish those countries which devalued from those which did not. As regards the recent financial crisis, countries which experienced very significant market tensions and disruption are compared with others that have faced limited, if any, tensions.

For each of the crises described below, the evolution of the following variables is explored: (i) the size of the central bank balance sheet (% of GDP); (ii) the total amount of loans to government and the domestic private sector by deposit money banks (% of GDP); and (iii) the main components of both the asset and liability sides of the central bank balance sheet (% of total balance sheet size). Deepening the analysis of balance sheet composition under (iii), we look (on the asset side) at (a) foreign assets, (b) claims on the public sector and (c) claims on banks, and (on the liability side) at (d) reserve money, (e) foreign liabilities, (f) government deposits and (g) capital accounts. All the data are quarterly, based on the IMF's International Financial Statistics database. To ensure the robustness of the ratios, we have checked their consistency with national data published by the respective central banks.[8] For the sake of clarity and parsimony, average and standard deviation are displayed for each category of countries, although some specific information on specific countries is provided when necessary. The full set of charts is provided in Annex III.

b. Main developments in the data

While the market segment affected by crisis varies in the different episodes considered (notably according to whether the focus lay in foreign/offshore markets or in the domestic market), the three crises discussed in detail below share a common feature – the emergence of a liquidity shortage owing to market disruption, which has the potential to affect economic prospects significantly and adversely. As a result, in each episode, the central bank in question has had to substitute for the market by increasing its intermediation role, which in turn affects its balance sheet (both size and composition).

When the crisis episode is rooted in the foreign exchange market, banks have to face huge capital outflows against the backdrop of increased demand for foreign currencies. Banks can thus rapidly become short of (foreign) liquidity, which eventually may endanger their solvency in the medium term.[9] The central bank has thus provided foreign currency via interventions to stabilize the exchange rate, while simultaneously increasing the provision of liquidity to banks to offset the impact that the withdrawal of foreign capital has on their funding situation. As a result, foreign assets at the central bank fall and its claims on the domestic banking sector increase. The flight to quality triggers capital movements, which reduces reserve money, while the peg defence increases foreign liabilities, and the need for a larger buffer tends to increase the capital accounts. All in all, the size of the central bank balance sheet is expected to decrease slightly or to remain unchanged over time, since the main impact of the intervention is a change in the composition of the asset side of the central bank's balance

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8 Cross-checking with data provided by national authorities was necessary in some cases in order to disentangle the possible content of important other items for some central banks. Details are provided in Annex II.

9 See Shin and Shin (2011) and McKinnon and Pill (1997).

sheet – a substitution of domestic assets in the form of loans to domestic banks for foreign assets.

In the case of a crisis centred on the domestic market, the central bank's increased intermediation role for the purpose of overcoming market distortions materialises through an increase of central bank claims on the banking system (and/or on the public sector), while the foreign components of its balance sheet tend to exhibit opposing effects (the foreign assets experiencing a short-lived increase while the liabilities tend to decrease). Furthermore, the capital accounts remain broadly unchanged or decrease slightly. All in all, the size of the central bank balance sheet tends to increase.

Thus (beyond some country-related specificities), changes in the size and composition of central bank balance sheets reflect the market affected by the crisis, even when the underlying rationale of the measures – namely, increased central bank intermediation to offset disruptions created by a sudden stop in private markets – is the same. At the same time, over a longer horizon (say five to ten years), the evolution of central bank balance sheets may also reflect lessons drawn by policy makers from the crisis itself. For example, the continued accumulation of reserves and/or the expansion of the central bank balance sheet in some Asian countries in the 2000s could be seen as a precautionary building up of financial buffer by the central bank to face a future crisis. These expected developments are in fact confirmed by the developments displayed in the charts of Annex III, which are also summarised in Table 1.

Table 1

Overview of main developments across countries around the crisis year

Crisis period	1993 (ERM) Financial Crisis	1997 (Asian) Financial Crisis	2008 Financial Crisis	
			Advanced economies	Asian economies
Central bank balance sheet size	↓	↓	↑	↔
Banking system size	↔	↓	↔	↔
Foreign assets	↓	↓	↑	↔
Claims on governments	↔	↔	↓ ↑	↔
Claims on banks	↑	↑	↑	↓
Reserve money	↑	↓	↑	↑
Foreign liabilities	↓	↑	↓	↓
Government deposits	↓	↓	↓	↓
Capital accounts	↑	↑	↓	↓

Note: The arrows reflect the tendency observed on average for the corresponding variable directly in the aftermath of the crisis quarter in the sample of countries experiencing tensions in financial markets (ie those that devalued in FOREX crisis episodes or experienced a breakdown of the domestic money market).

In the sections below, we focus on more region-based specificities by systematically two categories of country: (a) countries that devalued during a currency crisis and/or were significantly adversely affected by financial crisis (Category I); and (b) countries that were somewhat more immune than other countries to the crisis in terms of duration, depth and impact (Category II). To facilitate cross-crisis comparison, we centre the charts in Annex III on the quarter of the crisis year labelled by 'Y', using a 6-year horizon, ie extending 3 years (24 quarters) before and after the crisis.

c. The European ERM Crisis (1992–1993)

During this crisis, the intensification of exchange rate tensions within the ERM peaked in the third quarter of 1992 (=Y on the charts), during which the first devaluations were seen. Central banks in 'more adversely affected' Category I are the Bank of England (UK), Banca d'Italia, Banco de España, Central Bank of Ireland and Banco de Portugal. 'Less adversely affected' Category II includes the Deutsche Bundesbank (Germany), the Banque de France and the National Bank of Belgium. Although both the French and Belgian francs also faced exchange rate tensions within the ERM, they were able to maintain their pegs, albeit with significant assistance from the German authorities and a widening of the exchange rate fluctuation bands in August 1993.

The most striking country-specific developments during this period can be summed up as follows.

With regard to size, central banks with larger balance sheets are not necessarily those that proved immune to the tensions and avoided devaluation. In the third quarter of 1992, balance sheet size amongst the Category I central banks varied between 6% of GDP for the Bank of England and 31% for Banco de Portugal, with the average for the Category II central banks falling in between (at around 11%). As might be expected in a currency crisis, the magnitude of foreign assets was a more relevant determinant of the severity of the crisis. That said, for countries in both categories over the medium term (6-year horizon) the size of the balance sheet was not significantly changed by the crisis: the impact was a transient one.

By contrast, a clear difference appears as regards the evolution of the composition of the balance sheet. On the asset side, central bank foreign assets decreased ahead of the crisis quarter in the devaluing countries (Category I – most importantly in the UK, Italy and Spain), whereas the decrease occurred *with* the crisis in Category II countries (with the noticeable exception of Germany, where foreign assets jumped from 30% of the total balance sheet in 1992-Q2 to almost 50% in 1992-Q3). In both categories, claims on banks increased, with a certain delay for Category II, mostly explained by the fact that tensions vis-à-vis the French franc and Belgian franc occurred in the first half of 1993 (ie shortly before 'Y+1' on the corresponding charts in Annex III).

On the liabilities side, the defence of the peg led to a significant increase of the foreign component in both categories. However, this proved to be a one-time development for central banks in Category I, as they devalued in 1992-Q3 ('Y' in the charts), and a double dip for those in Category II, since the parity of the French and Belgian franc against the German Mark was gradually tested. It is also interesting to note that the enlargement of the confidence interval in the chart, associated with the evolution of foreign liabilities for Category II, is entirely due to the figures for the Banque de France (which jumped from 10% in 1992-Q2 to 26% in 1992-Q3). Finally, in contrast to central banks in Category II, for which they remained broadly unchanged, the size of the capital accounts of central banks in Category I increased gradually in the aftermath of the crisis.

d. The Asian Financial Crisis (1997–1998)

The start of the Asian financial crisis is associated with the devaluation of the Thai baht on July 2, 1997 (thus, Y=1997-Q3 on the relevant charts). According to the definition of country categories, the central banks in Category I are those of Thailand, Korea, Malaysia, Indonesia and the Philippines. Category II includes Hong Kong, Singapore, China and India. Although these latter countries were also affected by the tensions prevailing in the region at that time, their currencies proved more resilient than those of the Category I countries.

As shown by the charts on the Asian financial crisis, the features characteristic of a currency crisis revealed by our analysis of the ERM episode are broadly replicated here. Some Asian specificities are nonetheless interesting. First, countries that proved more resilient to the crisis included both those with hard currency arrangements (such as a currency board, as in the cases of Hong Kong and Singapore) and those with more flexible currency regimes or where currency convertibility was limited.

Developments in the more adversely affected Category I countries were more volatile and display a number of contrasts with what occurred in the ERM crisis. First, as a share of the overall central bank balance sheet, reserve money significantly decreased for central banks in Category I, whereas foreign liabilities significantly increased with the onset of the crisis. Second, the crisis appears to have had a more persistent effect on the structure of central bank balance sheets: the decrease of foreign assets at the time of the crisis was reversed relatively quickly, but it was followed by a gradual accumulation of foreign assets over time as countries sought ‘self-insurance’ for a repeat of the ‘sudden stop’ episode. Furthermore, claims on banks increased significantly during the crisis period, but subsequently decreased to a level below that seen pre-crisis.

e. The 2007–2011 financial crisis

Although the current financial crisis formally started on 9 August 2007, its intensification came with the collapse of Lehman Brothers Ltd on 15 September 2008, which led very quickly to a seizing up of the money market in the euro area (in both the unsecured and secured segments). As a result, the crisis quarter (‘Y’ on the relevant charts in Annex III) is the third quarter of 2008. Although observers tend to present the ongoing crisis as a ‘global financial crisis’, it is worth recalling that most of the ongoing tensions are (still) mostly located in the Western advanced economies.

We therefore distinguish three categories of countries for this particular crisis: the central banks of the US, the euro area, the United Kingdom and Japan constitute Category I; those of Australia, New Zealand and Canada form Category II; and those of all the Asian emerging economies covered in the 1997–1998 financial crisis (ie Thailand, Korea, Malaysia, Indonesia, the Philippines, Hong Kong, Singapore, China and India) form a third category. Indeed, as reported by Filardo (2011), despite strong economic and financial fundamentals, countries in the Asia-Pacific region were not immune to the financial crisis in September 2008. However, the tensions were relatively short-lived in this case.

Not surprisingly, changes in central bank balance sheets (of both size and composition) were significantly greater for the countries in Category I than for the Category II countries or, to some extent, for the Asian emerging economies. This cross-country variation reflects differences both in the duration of the crisis (since tensions in the Asia-Pacific region and Canada were relatively limited in time) and in the nature (and magnitude) of the non-standard measures implemented by the relevant central banks. As with foreign exchange intervention in previous crisis episodes, the non-standard measures affected various domestic balance sheet items in the case of Western advanced economies, while foreign asset and liability position were less affected. These observations are broadly in line with the analysis reported in Filardo and Grenville (2012).[10]

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[10] It is, however, worth noting that the apparent stability of the category averages hides some marked cross-country differences. For example, the evolution of foreign components (assets and liabilities) is more volatile in Korea, Malaysia, the Philippines and, to a certain extent, Thailand around 2008-Q3. Similarly, we observe significant increases in the reserve money component for Hong Kong at this time (jumping from around 4.9%

More specifically, the following observations can be made regarding the central banks in Category I.

First, the evolution of foreign assets as a proportion of the balance sheet total (a decrease at the outset of the crisis, followed by an increase and then a gradual decrease) is mostly due to the figures for the US Federal Reserve and the Bank of England. This item remains broadly stable for the ECB and the Bank of Japan.

Second, the U-shape observed for the claims on the public sector between times 'Y' and 'Y+1' mainly reflects two different types of non-standard measures which affected the amount of public bonds held by the respective central banks: (a) the securities swap programmes initiated by both the US Federal Reserve and the Bank of England around 2008-Q3 following the Lehman failure, and (b) the purchase of government securities from mid-2009 on (through quantitative easing by both the US Federal Reserve and the Bank of England, and through the ECB's securities market programme – SMP – as of May 2010).

Third, the increase of claims on banks reflects the increased provision of liquidity by central banks through their non-standard measures (more pronounced for the US Federal Reserve and the ECB – through credit easing and enhanced credit support respectively – than the average figures).

Finally, the average evolution of foreign liabilities obscures a considerable divergence among the advanced economies in Category I. Indeed, the average decrease in this item mostly reflects the United Kingdom (where, after reaching 60% of the total balance sheet in 2008-Q3, this component dropped to 11% one year later) and Japan (where it decreased from 5% to 3% over the same period). By contrast, foreign liabilities for the US Federal Reserve jumped to around 6% in 2008-Q3[11] and remained stable at a level around 5% afterwards. Similarly, this component for the ECB gradually increased during the crisis period to a peak at around 14% of the total balance sheet in 2008-Q4, from a very low pre-crisis level, and it remains at around 6% to date. These developments clearly contrast with those of central banks in Australia, New Zealand and Canada (Category II countries), where foreign liabilities increased significantly as of 2008.[12]

6. Discussion of the empirical analysis

Prima facie, a diverse set of experiences is evident in the use of central bank balance sheet policies in the various episodes discussed in the foregoing section. On one hand, in the face of the Asian crisis of the late 1990s central banks largely responded by changing the composition of the asset side of their balance sheets, substituting domestic assets for foreign assets (via the mechanisms traditionally labelled sterilised foreign exchange intervention). On the other hand, in the period following the failure of Lehman central banks have expanded their balance sheets by accumulating a variety of assets and funding these purchases and/or operations through the creation of central bank reserves. In the latter case, base money creation increases whereas in the former it is kept unchanged. From a traditional monetary policy perspective, this would suggest that the policies involved are quite distinct.

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of the total balance sheet in 2007-Q3 to 40.2% in 2009 Q3), which was partly mirrored by a capital account decrease (from 58% to 33.2% over the same period). See Cook and Yetman (2012).

[11] This level was already reached in 2007-Q4, when the swap agreement with the ECB was first launched.

[12] The enlargement of the confidence interval on the corresponding chart is essentially explained by the rise of this component for Australia which rocketed from a level of 1.3% to 20.0% between Q3 and Q4 of 2008.

However, in the course of the recent crisis (indeed, before it in the case of the ECB and the Bank of England), central banks have paid interest on reserves through the adoption of a corridor system (Woodford, 2003; Manna et al, 2001). They have argued that this allows them to set the level of interest rates independently of the supply of base money, ie what the ECB has labelled the separation principle. This is consistent with the view that monetary policy – understood as the setting of short-term interest rates – can be pursued in concert with a variety of balance sheet policies. But that leaves open the possibility that these balance sheet policies may be quite different.

We argue that these balance sheet policies are in fact more similar than such an analysis would imply. In particular, we believe that the traditional monetarist focus on a specific component of central bank liabilities – namely the stock of base money – can give a misleading view of how these policies work.

One way of interpreting central bank balance sheet policies is through the lens of the portfolio balance approach. If there are sufficient imperfections in capital markets that changing the composition and/or size of the central bank balance sheet implies sufficiently significant changes in the yield structure to influence macroeconomic behaviour, then both sets of balance sheet policies can be interpreted within a common framework. But notwithstanding the event study evidence offered by some central banks, we find it implausible that this channel is sizable enough to have a large impact, even in the case of the relatively heavy interventions conducted by leading central banks.

More important in our view is the support central bank interventions have offered to market functioning. In particular, when financial markets seize up during the course of generalized loss of confidence and exploding concerns about counterparty risk, expanding central bank intermediation in order to keep markets working plays a crucial role in avoiding financial and macroeconomic collapse.

In the Asian crisis of the 1990s, as capital inflows that were crucial to domestic bank funding dried up (McKinnon and Pill, 1997), central banks stepped in to replace the funding of domestic banks by expanding their domestic monetary policy operations, while simultaneously addressing the capital outflow by running down their foreign currency reserves. In other words, the 'sudden stop' in foreign capital inflows – symptomatic of dysfunctionality in cross-border money markets – was met by central bank intermediation of that market, replacing foreign capital flows with reserves and expanding domestic operations. In doing this, the central banks absorbed the foreign currency risk that had previously been held by the domestic banking system, and the credit risk that was previously held by the foreign suppliers of capital. In the face of the macroeconomic and financial crisis at the time, neither party was willing or able to continue to hold such risks and therefore these markets had ceased to work – which is what caused the sudden stop in the first place.

By the same token, after the failure of Lehman in September 2008, banks became unwilling to lend to one another owing to the perceived level of counterparty risk. The interbank money market seized up, especially at term maturities. In essence, there was a 'sudden stop' in the money market of a similar nature to that which had previously been seen in emerging FX markets. Similarly, markets for asset-backed securities also dried up as doubts emerged about the quality of the underlying assets, and the threat of risk cascades became better understood. In both cases, central banks expanded their own intermediation in these markets to ensure that the financial sector as a whole did not collapse. For example, the ECB gave banks that were no longer able to access the interbank money market the possibility of funding their assets (including a very broad set of ABS) in potentially unlimited amounts at a fixed low rate, via its monetary policy repo operations. In doing so, the ECB assumed some (indeed, much) of the counterparty credit risk that prevented the direct bank-to-bank transaction from taking place in the first place.

In the Asian case, the main impact of the balance sheet operation was a change in the composition of central bank assets. In the more recent case, the main impact was an expansion of the central bank balance sheet (including the monetary base). As mentioned earlier, while a traditional monetarist approach would view these two operations as quite different, the above perspective suggests they had many similarities. In short, central bank intermediation substituted for direct private transactions as the market came to a sudden stop. By intermediating in this way, the central banks became ‘market makers of last resort’. Crucially, they also played an important novation function by absorbing onto their own balance sheets much of the credit risk that was impeding the underlying private transactions.

Viewed in this light, successful central bank balance sheet policies rely on a number of features. First, they point to a need for long balance sheets. In this respect, a large and diverse balance sheet makes it easier for a central bank to intermediate quickly in a variety of market segments. For example, the ECB’s relatively high level of remunerated required reserves implied that it had a large buffer upon which to operate as the euro money market seized up in late 2008, while its very long list of eligible collateral allowed it to intermediate and thus maintain a variety of markets, notably in ABS. Similarly, after the experience of the Asian crisis of the 1990s, many central banks in that region had accumulated large holdings of FX reserves as ‘self-insurance’ against a repeat of the experience. This has obviously served them well in the 2008 crisis, where a weakening of capital inflows was met by drawing down FX reserves, intermediating between foreign lenders and domestic borrowers, and absorbing the FX and credit risk. Second, by maintaining confidence, such policies appear to have maintained market confidence. This has certainly insulated Asian emerging markets from the immediate impact of the crisis in the advanced economies. But it has also allowed lending to the real economy to continue in advanced economies.

7. Further considerations in using central bank balance sheets as a policy tool

We have argued that the main channel through which balance sheet policies have influenced macroeconomic outcomes is by supporting market functioning and, albeit to a much lesser extent, via portfolio balance effects. Yet to reach a comprehensive view of their impact, a number of other considerations need to be kept in mind.

Certain balance sheet policies can be used to impose an implicit tax on activities that the central bank deems undesirable owing to the possible negative externalities that they imply for other market segments and/or for real activity. For example, tools such as (unremunerated) reserve requirements can be used to place an implicit tax on financial intermediation (of at least some types). This can be used in the Pigouvian mode to internalise externalities and other spillovers (Gallego et al, 2002). However, the danger exists that these taxes will be evaded by offshore and/or shadow banking activity, simply serving to divert transactions to less well-regulated (and thus potentially more dangerous) venues. Moreover, central banks may adopt balance sheet policies to offer signals to other market participants on the appropriate level of asset prices, setting a focal point for private decision-making. There is a longstanding tradition of this approach in FX interventions, but it can also be applied to asset markets (eg HKMA purchases of equity in 1998 and ECB purchases of covered bonds in 2009–10).

However, it is also extremely important to recognize that actively using the central bank balance sheet as a policy tool comes with potential negative side effects.

First, there is the risk of giving the market confusing signals regarding policy intentions. To the extent that central bank balance sheet management represents a novel policy instrument, communication on the monetary policy stance can become multidimensional and therefore more complex. For example, in mid-2011 the ECB faced scepticism among market participants about the internal consistency of its policies, when it simultaneously raised interest rates while expanding or reintroducing its non-standard measures.

Second (and potentially more important), there is a danger that well-intentioned balance sheet policies to support market functioning (essentially liquidity operations) will end up as quasi-fiscal operations (ie effectively provide solvency support to the banking sector in the form of subsidies to banks financed from central bank capital), as sections of the financial system become dependent on central bank support. In turn, this can hinder the necessary structural reforms and restructuring needed to place the financial system on a sounder footing (Durré and Pill, 2010), as the incentive to do so is blunted by the provision of the support. Thus, ultimately, a risk of introducing rigidities in the conduct of monetary policy is present.

Third, by preparing to respond to financial crises by having longer balance sheets, central banks may make such crises more likely, to the extent that moral hazard infects private financial decisions, as discussed by Giannone et al (2011b).

Finally – and as a result of the preceding arguments – the introduction of balance sheet policies threatens to erode credibility. When a central bank actively manages its balance sheet in parallel with pursuing traditional interest-rate-based monetary policy, it may suggest that other (implicit) objectives are being pursued in parallel with the pursuit of price stability, hence eroding over time the central bank's credibility as regards delivering on the explicit monetary policy objective.

8. Concluding remarks

Reviewing the features of three major financial crises, we conclude that despite the different natures of the market segments facing the crisis, these crises present more similarities than may at first appear, both in terms of market distortions and central bank reactions. In all cases, the central bank has to increase its intermediation role in order to provide a substitute for market mechanisms that provide liquidity.

Our review of the general evolution of balance sheet items across twenty-three central banks suggests that the varying impact on balance sheets among central banks may be related to financial buffers of the balance sheet prevailing or absent before the crisis. Indeed, it might be observed that the central banks that more successfully resist financial tensions (ie those that do not devalue during a foreign exchange crisis or that expand their balance sheets less in domestic market crises) are those with large financial buffers (ie large FX assets and/or relatively large balance sheets). In a foreign exchange crisis, the central bank substitutes for the market by providing foreign currency against the domestic currency, and thus assumes the FX risks that market participants would have tolerated in normal times. Similarly, during a crisis in the domestic money market, by expanding its refinancing operations to ensure continued access to liquidity for market participants who are off the market, the central bank takes on the counterparty risk that other market participants would have borne in normal times. In both cases, the central bank increases its intermediation role, which ultimately increases its balance sheet's risk exposure.

Since the initial consequence of financial crises is a shortage of liquidity, nobody questions the need for central banks to step in and provide a substitute for the market. However, the more prolonged this role, the higher the exposure to risk. Furthermore, one cannot rule out that too long an extraordinary central bank would eventually also entail a risk of quasi-fiscal activity, with prolonged liquidity problems on the part of market participants in fact hiding features of insolvency. This would inevitably introduce rigidities in the conduct of monetary policy, as the reactivation of money markets would not necessarily solve the problems of troubled banking institutions. If this appears to be the case, the real intention behind balance sheet measures could gradually be questioned by economic agents, possibly eroding the credibility of the central bank over time as the economic agents conclude that a hidden policy goal supersedes the official monetary policy objective.

Annex I:
Overview of Previous Financial Crises

a. The European exchange rate mechanism (ERM) crisis (1992–1993)

After the collapse of the Bretton Woods system of global fixed exchange rates in 1971–73, the European authorities demonstrated a strong desire to stabilise bilateral exchange rates between their countries so as to support a deepening of economic integration. From 1979, these ambitions took institutional form in the exchange rate mechanism (ERM) of the European Monetary System (EMS). From initial policies aimed at maintaining price competitiveness through periodic devaluations, European countries moved naturally towards disinflation policy by anchoring their own currency to the German Mark from the late 1980s. By renouncing autonomous monetary policy, these countries aimed to import the anti-inflationary credibility of Germany and the Bundesbank.

Tensions in Europe emerged in the early 1990s following a substantial asymmetric shock – German reunification. In this context, anchoring monetary policy by pegging to the German Mark became costly for other European countries, as German monetary policy decisions targeted domestic economic developments and were thus inappropriate for other participants in the ERM.

These tensions initially became manifest in Italy and the UK. After the Danish population rejected the Maastricht Treaty proposals for Economic and Monetary Union (EMU) in the referendum of 2 June 1992, the prospect of a delay in progress towards the introduction of a single currency created exchange rate tensions. Governments' ability to act to contain the tensions was hindered by the already weak state of their economies, which precluded a tightening of monetary policy.[13] Tensions mounted, leading to a succession of devaluations within and/or exits from the ERM and other exchange-rate pegs. On 16 September 1992 ('Black Wednesday'), sterling and the Italian lira fell out of the ERM, while the Spanish peseta was devalued by 5%. Unsurprisingly, the exit of both the British and Italian currencies from the ERM magnified pressures elsewhere.[14]

The crisis peaked on 29 July 1993, when the Banque de France was forced to intervene in favour of the French franc against the Deutsche Mark in massive amounts (the Bundesbank's reserves increased by DM 40 billion). Given their concerns regarding inflation prospects, neither central bank was ready to adjust its own policy interest rates in order to narrow the spread between French and German interest rates. Consequently, European leaders eventually decided at a special meeting on 1 August 1993 to enlarge the fluctuation bands within the ERM with a view to curbing further speculative attacks.

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[13] For instance, when pressures on the Italian lira first appeared (the lira reached its lower limit with respect to the European Currency Unit (ECU) in June 1992), the Bank of Italy hiked interest rates, which in turn increased concerns because of the implied rise in debt service. In early September, the Bank of Italy raised its policy interest rate to 30%, but its international reserves became almost exhausted. Similarly, the Swedish central bank temporarily set its policy rate at 500% on 14 September in order to defend its parity, while selling large amounts of short-term government securities. On 16 September 1992, the Bank of England increased its base lending rate from 10% to 12%, while announcing its intention of raising it by another 300 basis points the following day.

[14] The Bank of France increased its policy interest rates while reaching a low in its international reserves, in the week ending 23 September 1992. The tensions on other currencies persisted, forcing Sweden to abandon the peg to the ECU on 19 November, having lost international reserves equivalent to 10% of Sweden's GDP in the six preceding days. In the same period, Denmark, Spain and Portugal, too, were forced to increase their policy interest rates to defend their currencies. Irrespective of these defence measures, further devaluations were inevitable (about 3% each for the Spanish peseta and the Portuguese escudo on 10 December, and 10% for Irish pound on 30 January 1993).

b. The Asian financial crisis (1997–1998)

Given the interest rate differential with the United States, which was in their favour, Asian emerging countries faced capital inflows which, in presence of the peg, led to appreciation of their currency in real terms. At the same time, buoyant domestic activity and rising inflation prevented them from lowering interest rates to contain the currency appreciation. In contrast, current account deficits that had begun in 1995 actually increased with the anti-inflation policy implemented by most economies in this region, while the sterilisation undertaken by central banks to contain the currency movement proved ineffective due to the substitutability of domestic and US assets reinforced by the peg. The ongoing appreciation of local currencies further increased the current account deficits over time. Kaminsky and Schmukler (1999) associated the initial pressures on the Thai baht with the collapse of the Bangkok Bank of Commerce in July 1996 – an event that forced the Bank of Thailand to inject large amounts of liquidity to support the financial system. Tensions were noticeable from that point on, and were further fed by developments in other Asian emerging economies, as the crisis was stamped as global and successive devaluations became inevitable. With the default of the leading South Korean steel maker, Hanbo Steel Corp, on its loans on 23 January 1997, the region's various currencies experienced increasing pressures, intensified by the prospects of economic slowdown and political instability.

These tensions peaked with the decision by the central bank of Thailand to move to a managed floating for the baht on 2 July while calling on the International Monetary Fund for technical assistance. This decision effectively devalued the baht by about 15%–20%, and it reached a record low of 28.80 to the US dollar. Pressures on Indonesian, Philippine and Malaysian currencies consequently intensified, eventually leading the respective authorities to widen the Indonesian rupiah trading band from 8% to 12% on 8 July, to move to a freer float of the Philippines peso on 11 July, and to abandon defence of the Malaysian ringitt on 14 July. In October,[15] the currency crisis spread to Taiwan, with the devaluation of the Taiwanese dollar creating doubts about the sustainability of the Hong Kong dollar peg. Tension escalated in the region, and in a matter of days the Hang Seng index lost about 30 per cent of its value. Then the failure of Yamaichi Securities Co. Ltd., the fourth largest securities house (November), and the failure of the food trading firm Toshoku Ltd. (December) captured the attention of investors in Japan. Tensions in the region continued to develop in early 1998 (especially with the temporary freeze on debt servicing in Indonesia), before diminishing with better economic news in various countries.

c. The global financial crisis (2007–2011)

Although growing concerns were already perceived in early 2007, notably with the increase in subprime mortgage defaults in the US in February 2007, the "liquidity crisis" in the money market started on 9 August 2007 following the decision of one big euro-area money market player, BNP Paribas, to freeze redemptions for three of its investment funds. Towards the

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[15] For that month, the following detailed information also reported on the Executive MBA webpage: "Understanding the World Macroeconomy" of Prof. Paul Wachtel's at the New York Stern University. On 6 October rupiah reached a low of 3,845. On the same day, Russia and London Club signed agreement rescheduling roughly $33 billion of debts over 25 years with seven years grace, dated from December 1995. On 8 October Indonesia announced it will ask the IMF for financial assistance while on the 17th Taiwan decided to allow its currency to depreciate. Between 20 and 23 October the Hong Kong stock market suffered its heaviest drubbing ever, shedding nearly a quarter of its value in four days on uncertainty over the Hong Kong dollar. The Hang Seng index plunged 23.34% to 10,426.30 by Thursdays close, after 16,601.01 the previous Friday. At that time, the South Korean won also began to slump rapidly in value. On 27 October Asian jitters spilled over onto world stock markets with the Dow plunging 554 points, its largest single-day point loss ever (in a session halted twice after the drops tripped circuit breakers on the New York Stock Exchange).

end of 2007 and early 2008, tensions continued in financial markets on account of further write-downs by financial institutions, downgrading of monoliners and bank rescues in both the US and Europe. Although renewed tensions were already noticeable in the market with the release of the (de facto) nationalisation of GSE Freddie Mac and Fannie Mae on 7 September 2008, the intensification of the 2007–2010 financial crisis around the world really took off with the bankruptcy of the US company Lehman Brothers Ltd on 15 September 2008, after a failed rescue weekend during which major US banks refused to take over the hedge funds without a state guarantee. Since Lehman had counterparties across the globe and often intervened as a third party in credit derivatives contracts, the impact of its collapse on market confidence was incredibly huge. Furthermore, by letting Lehman Brothers Ltd go bust, the US authorities destroyed the ‘too big to fail’ paradigm implicitly assumed by market participants. The immediate tensions that followed this bankruptcy first materialised in the financial difficulties of the international insurance company AIG, which announced a liquidity shortage of USD 40 billion, requiring an emergency intervention of USD 20 billion by the State of New York on the afternoon of 15 September 2008. Thereafter, especially in Europe and the US, money market participants stopped trading and hoarded liquidity to protect their balance sheets and avoid a situation of liquidity shortage. The consequence of these reactions was a breakdown of both the secured and unsecured money market segments on 30 September 2008. Major central banks in the West therefore massively increased their intermediation role by introducing non-standard measures (in the form of unlimited provision of short- to long-term operations/programmes of public and private securities purchases). As discussed in Filardo (2011), this also impacted developments in Asia and the Pacific at that time.

Despite significant improvements in the money market between March and October 2009 thanks to the central bank intervention, the situation remained highly uncertain and fragile. First, credit institutions still appeared uncertain about their access to liquidity in the money market at longer horizons, especially beyond the six-month maturity. Second, the difficulties experienced by some credit institutions in Europe that played an important role in the banks' debt instruments market tended to increase tensions in the euro-area covered bank bond market. For instance, the tensions took the form of increased covered bond spreads against the swap rate, which reached a peak in April/May 2009. Further tensions regarding the public debt instruments of some euro-area countries gradually emerged from November 2009, eventually peaking on 7 May 2010. The roots of the (still ongoing) euro-area sovereign debt crisis began in Greece, where a newly elected government announced a huge revision of the public deficit figure left by the former coalition in late October 2009, calling the sustainability of the country’s public finances into question. Consequently, the CDS premium for Greece started to rise in late 2009, along with the spreads between its 10-year public bonds and German bonds. In early 2010, these concerns rapidly affected the bond pricing of other euro-area countries, increasing sovereign CDS premiums and widening spreads against the German Bund. On 7 May 2010, government bond prices registered a record low, and the CDS premium a peak. Several public bond secondary markets dried up thereafter, in turn affecting activity in both the money market and the covered bond market.

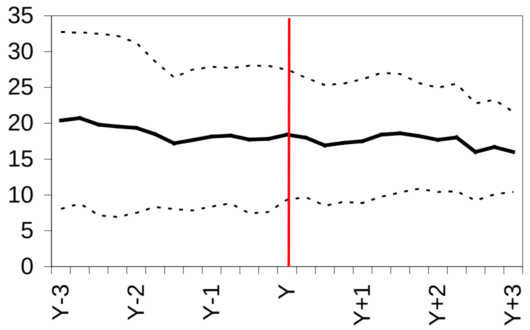
Annex II:
Data Sources

In order to ensure homogeneity across central banks, data from the International Financial Statistics (IFS) of the International Monetary Fund are used. Data on central bank balance sheets from the IFS are from the 'Monetary Authorities' section (IFS section 10), which generally consolidates central bank with the accounts of other institutions that undertake monetary functions (including issuing currency, holding international reserves and conducting IMF account transactions). Major aggregates of the central bank account on the asset side contain items from line 11 to 12g (IFS terminology). For the sake of simplicity in our analysis, we have aggregated some key asset items as follows: (i) claims on public sector are obtained by summing up items 12a, 12b and 12c; (ii) claims on other financial institutions (excluding deposit money banks) are obtained by summing up items 12f and 12g. The liabilities side corresponds to items from line 14 to 17a. In order to balance the asset and liabilities sides of the balance sheet, IFS data usually contain a variable entitled 'Other items', the importance of which varies considerably between central banks. In all cases, further investigation by cross checking information from the IFS data with national data and other sources (eg CEIC and BIS databases) was conducted to disentangle the content of 'Other items'. In this regard, note that the variable 'capital account' of the monetary authorities of Singapore also contains 'provisions and other liabilities' in addition to 'capital and general reserves'. Similar cross-checking applies to the data related to the UK central bank accounts, for which helpful cooperation was provided by the Bank of England.

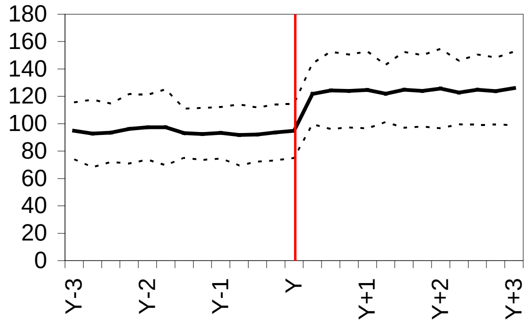
In the analysis, the loans to (central) government and to the private sector by deposit money banks are also reported (as a percentage of GDP), corresponding respectively to lines 32a and 32d in the IFS database. Finally, the figures used for the gross domestic product (GDP) correspond to data in line 99b and reflect the level of nominal GDP, equal to the sum of final expenditures in national currency.

Annex III – Figures
A. The European Exchange Rate Mechanism Crisis (1992–1993)

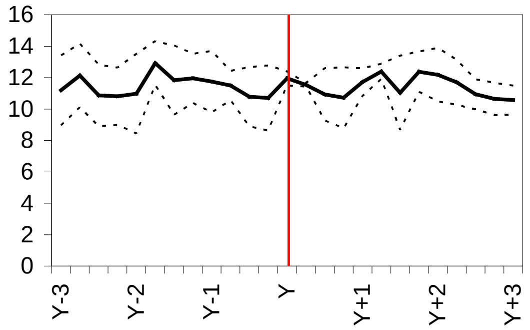
ERM Crisis: Average Size of BS in Category I
(% of GDP)



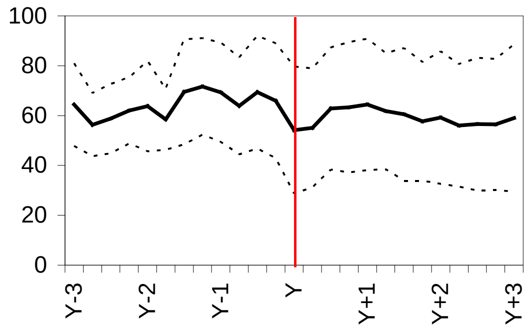
ERM Crisis: Average Size of banking
system in Category II (% of GDP)



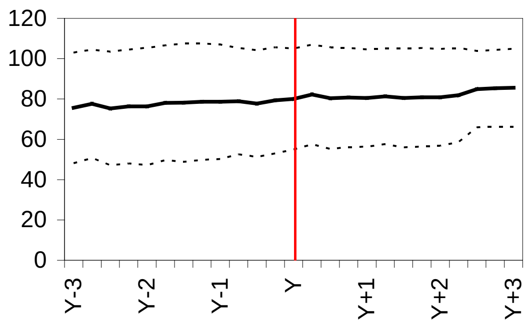
ERM Crisis: Average Size of BS in Category II
(% of GDP)



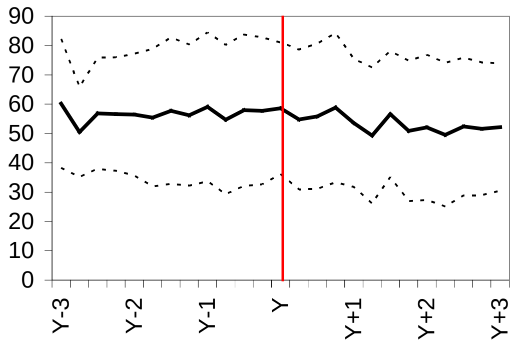
ERM Crisis: Average Size of foreign assets in
Category I (% of BS)



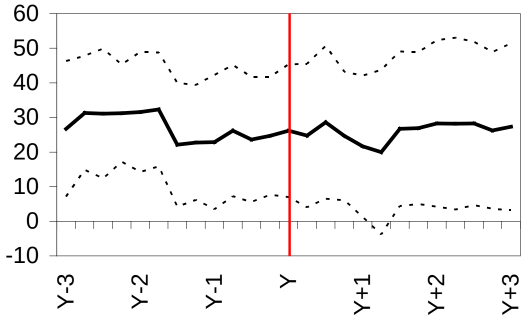
ERM Crisis: Average Size of banking
system in Category I (% of GDP)



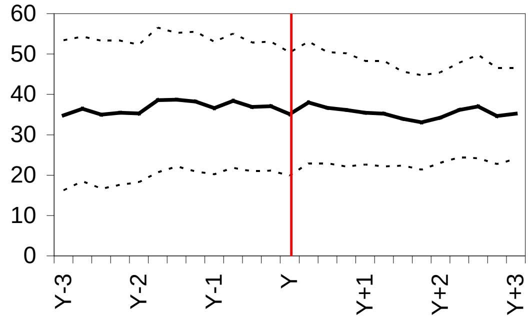
ERM Crisis: Average Size of foreign assets in
Category II (% of BS)



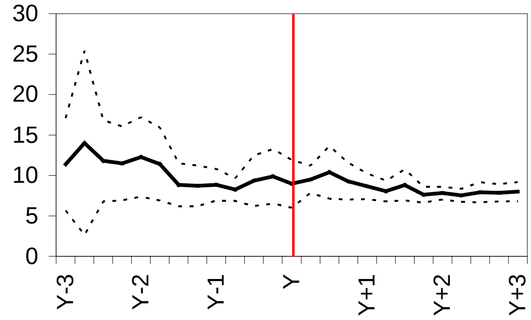
ERM Crisis: Average Size of claims on public sector in Category I (% of BS)



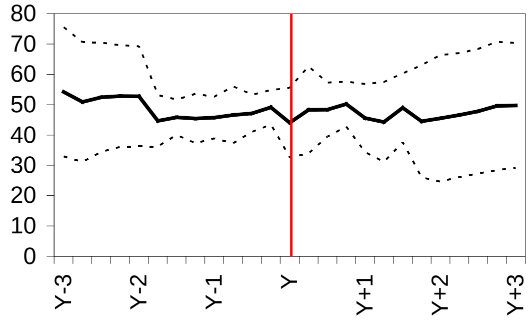
ERM Crisis: Average Size of reserve money in Category I (% of BS)



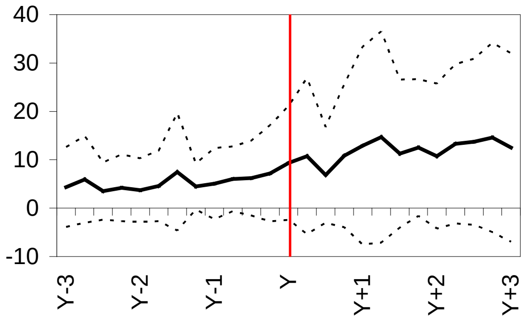
ERM Crisis: Average Size of claims on public sector in Category II (% of BS)



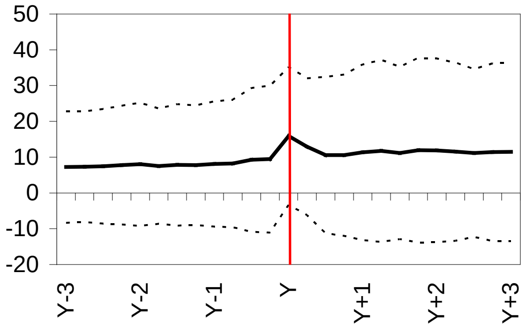
ERM Crisis: Average Size of reserve money in Category II (% of BS)



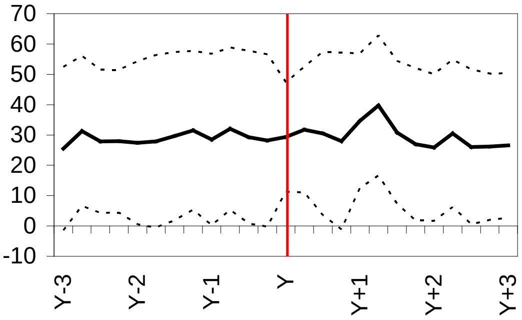
ERM Crisis: Average Size of claims on banks in Category I (% of BS)



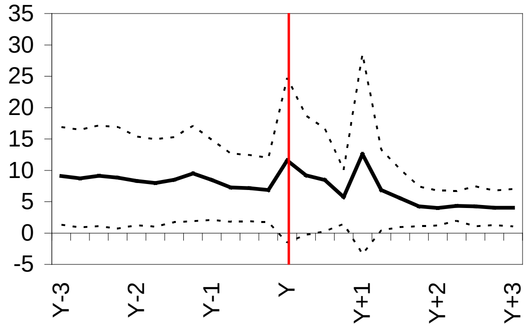
ERM Crisis: Average Size of foreign liabilities in Category I (% of BS)



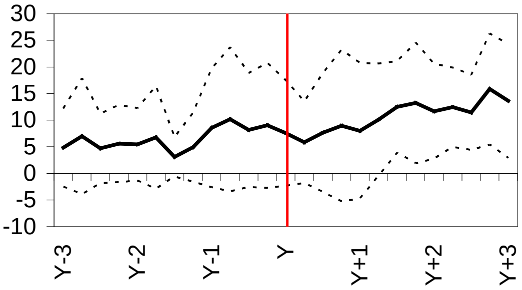
ERM Crisis: Average Size of claims on banks in Category II (% of BS)



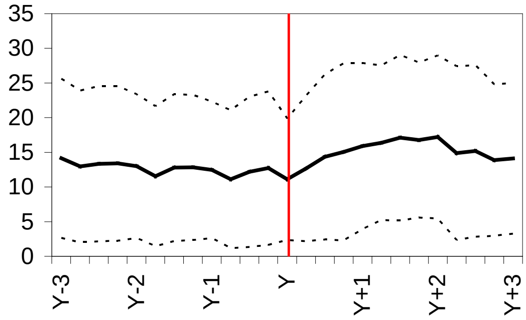
ERM Crisis: Average Size of foreign liabilities in Category II (% of BS)



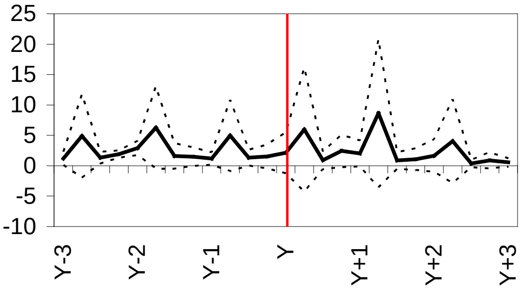
ERM Crisis: Average Size of government deposits in Category I (% of BS)



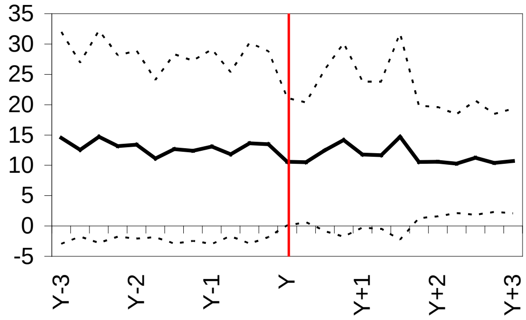
ERM Crisis: Average Size of capital accounts in Category I (% of BS)



ERM Crisis: Average Size of government deposits in Category II (% of BS)

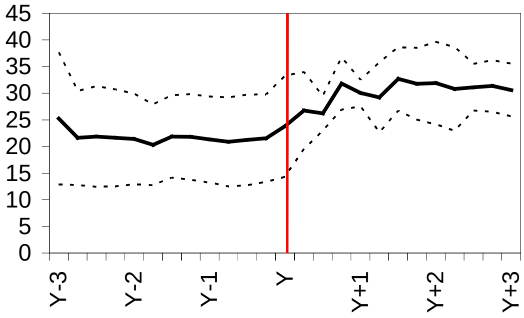


ERM Crisis: Average Size of capital accounts in Category II (% of BS)

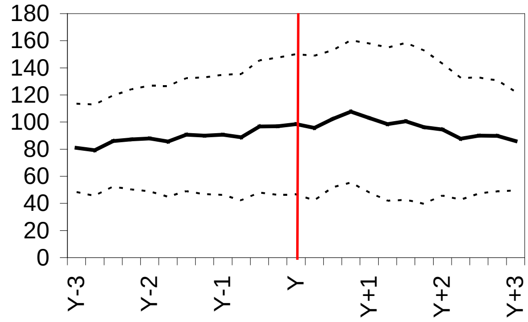


B. The Asian Financial Crisis (1997–1998)

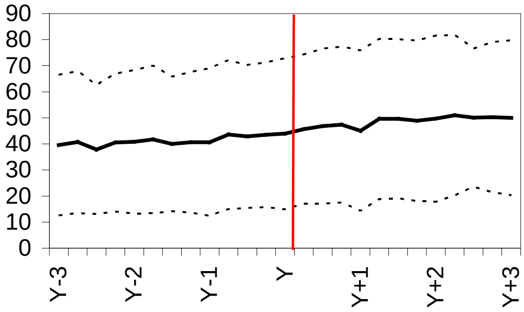
Asian EMEs around 1997: Average Size of BS in Category I (% of GDP)



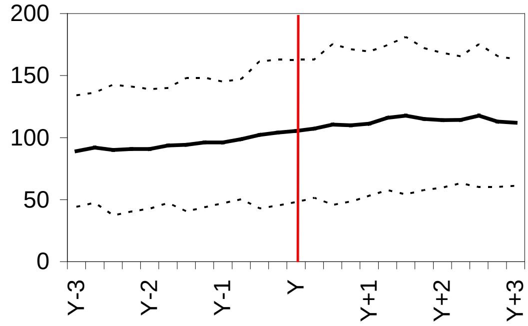
Asian emerging countries around 1997: Average Size of banking system in Category I (% of GDP)



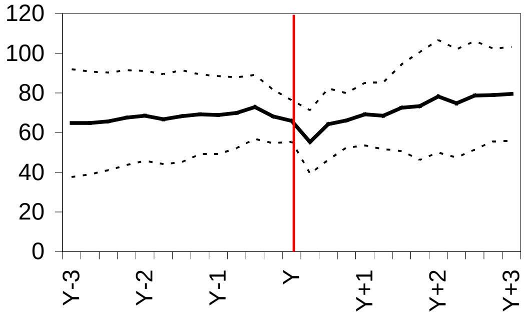
Asian EMEs around 1997: Average Size of BS in Category II (% of GDP)



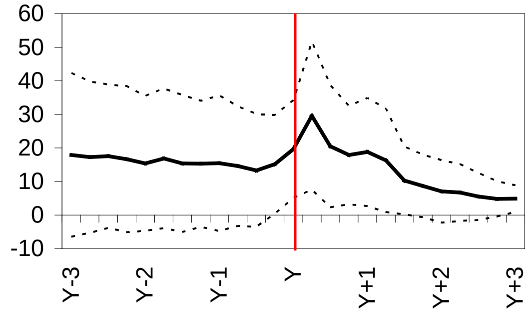
Asian emerging countries around 1997: Average Size of banking system in Category II (% of GDP)



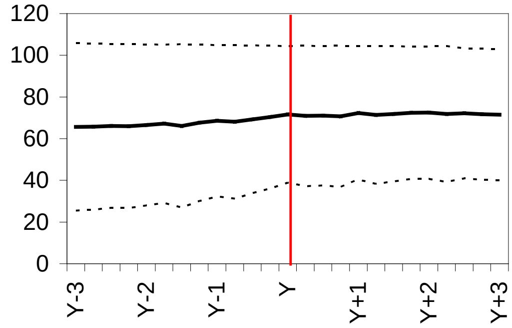
Asian EMEs around 1997: Average Size of foreign assets in Category I (% of BS)



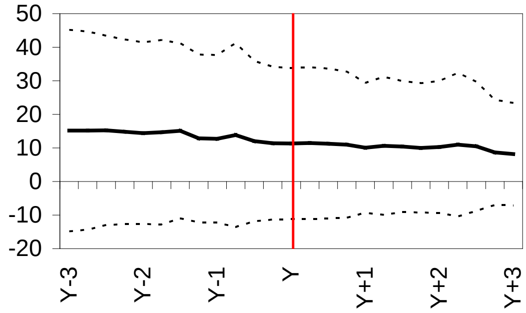
Asian emerging countries around 1997: Average Size of claims on banks in Category I (% of BS)



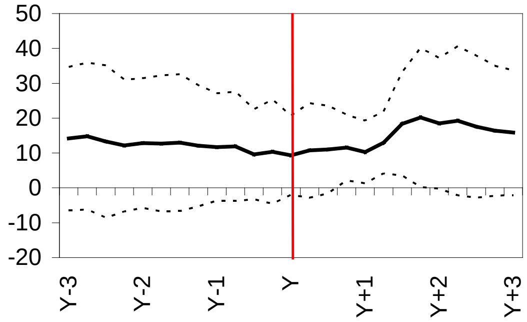
Asian EMEs around 1997: Average Size of foreign assets in Category II (% of BS)



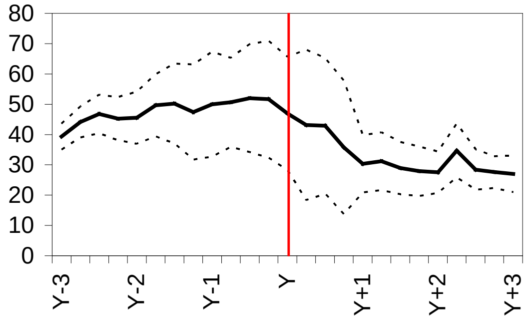
Asian emerging countries around 1997: Average Size of claims on banks in Category II (% of BS)



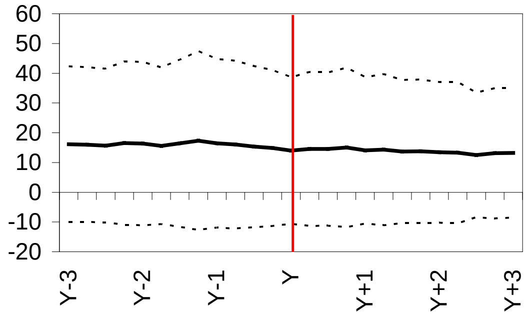
Asian emerging countries around 1997: Average Size of claims on public sector in Category I (% of BS)



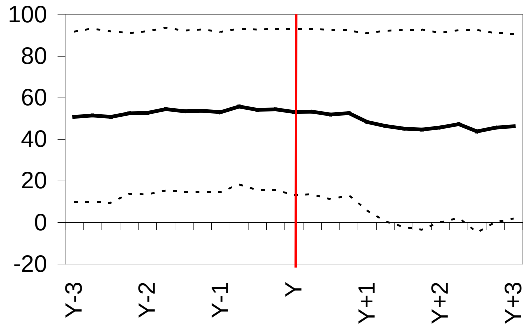
Asian emerging countries around 1997: Average Size of reserve money in Category I (% of BS)



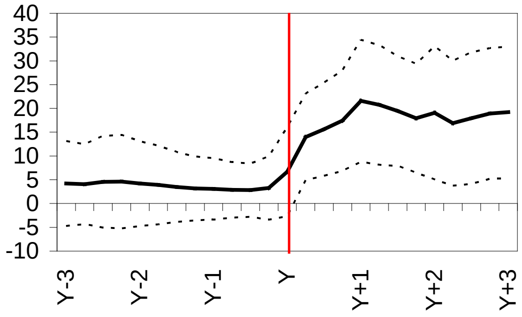
Asian emerging countries around 1997: Average Size of claims on public sector in Category II (% of BS)



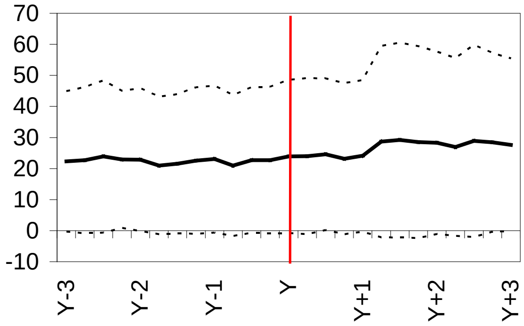
Asian emerging countries around 1997: Average Size of reserve money in Category II (% of BS)



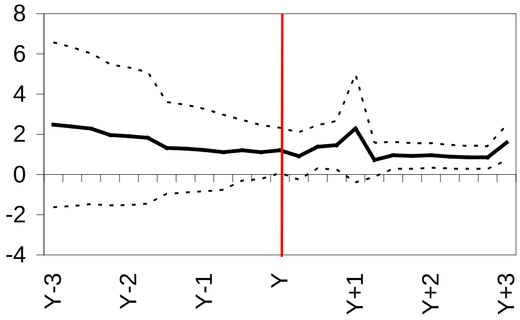
Asian EMEs around 1997: Average Size of foreign liabilities in Category I (% of BS)



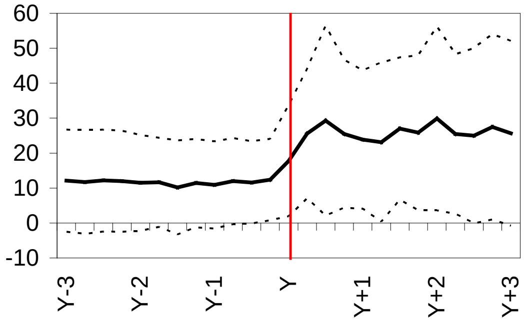
Asian emerging countries around 1997: Average Size of government deposits in Category II (% of BS)



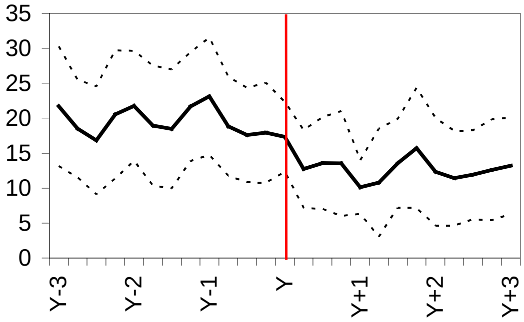
Asian EMEs around 1997: Average Size of foreign liabilities in Category II (% of BS)



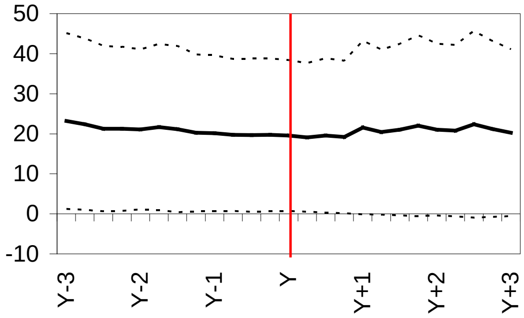
Asian emerging countries around 1997: Average Size of capital accounts in Category I (% of BS)



Asian emerging countries around 1997: Average Size of government deposits in Category I (% of BS)

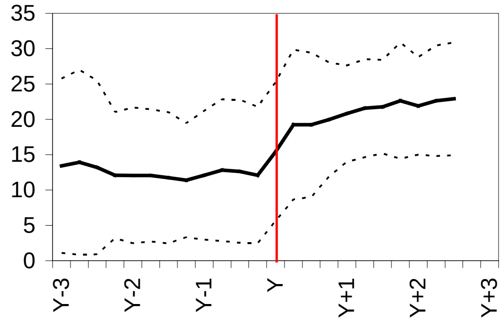


Asian emerging countries around 1997: Average Size of capital accounts in Category II (% of BS)

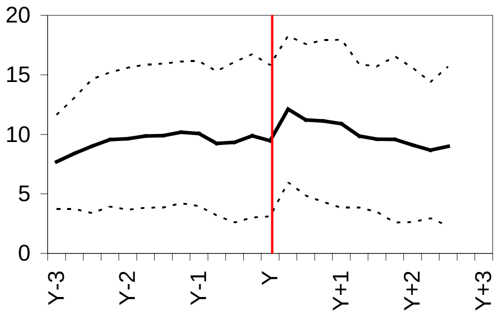


C. The Global Financial Crisis (2007–date)

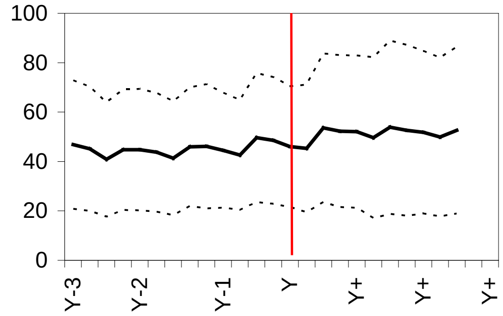
ID economies around 2008: Average Size of BS in Category I (% of GDP)



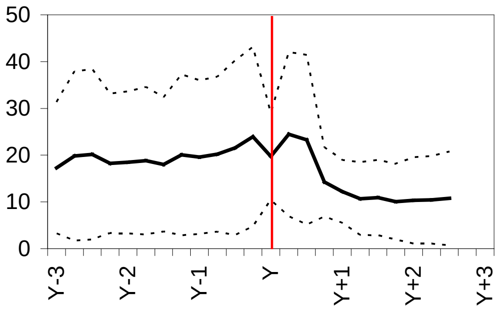
ID economies around 2008: Average Size of BS in Category II (% of GDP)



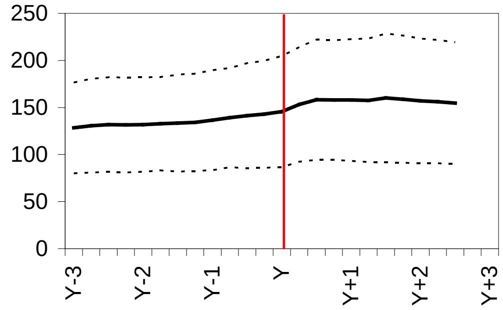
Asian emerging countries around 2008: Average Size of BS (% of GDP)



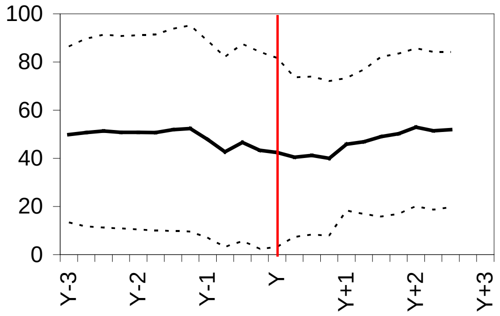
ID economies around 2008: Average Size of foreign assets in Category I (% of BS)



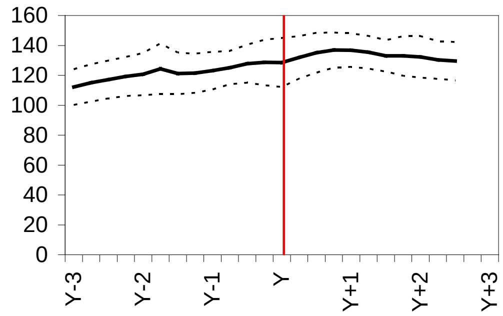
Advanced economies around 2008: Average Size of banking system in Category I (% of GDP)



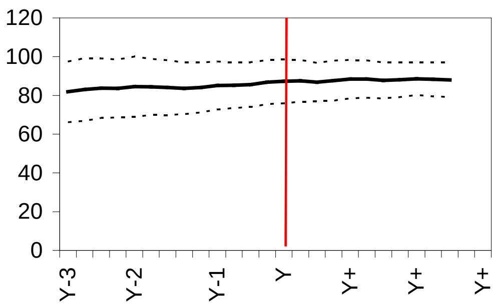
ID around 2008: Average Size of foreign assets in Category II (% of BS)



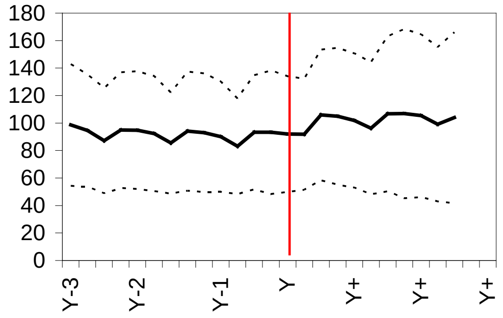
Advanced economies around 2008: Average Size of banking system in Category II (% of GDP)



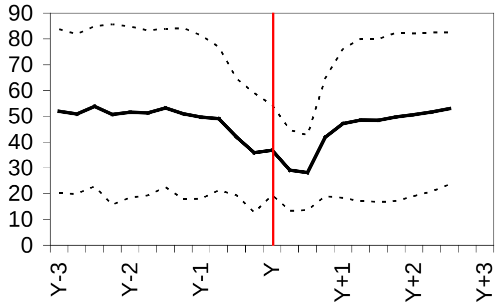
Asian EMEs around 2008: Average Size of foreign assets (% of BS)



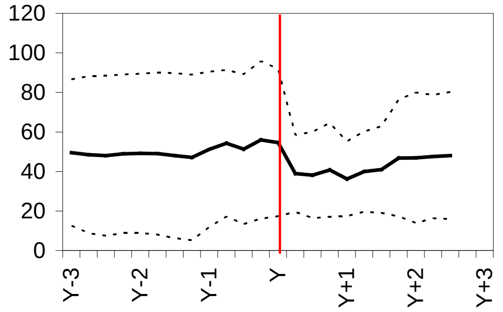
Asian emerging countries around 2008: Average Size of banking system (% of GDP)



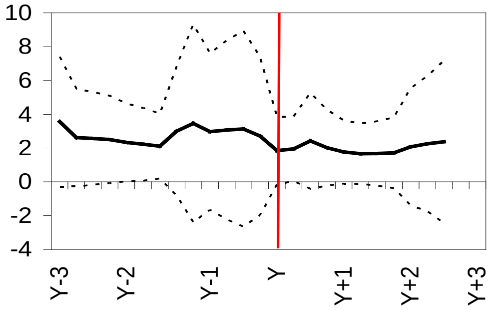
ID economies around 2008: Average Size of claims on public sector in Category I (% of BS)



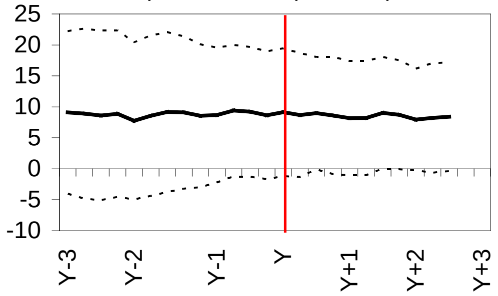
ID economies around 2008: Average Size of claims on public sector in Category II (% of BS)



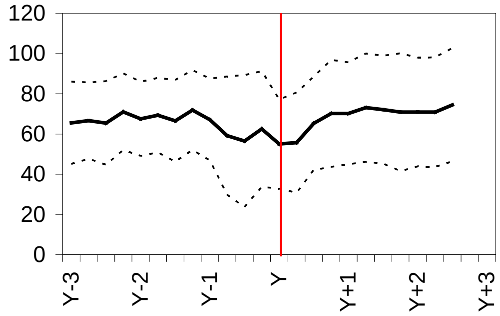
Asian emerging countries around 2008: Average Size of claims on banks (% of BS)



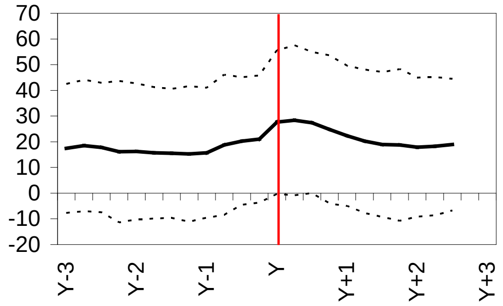
Asian emerging countries around 2008: Average Size of claims on public sector (% of BS)



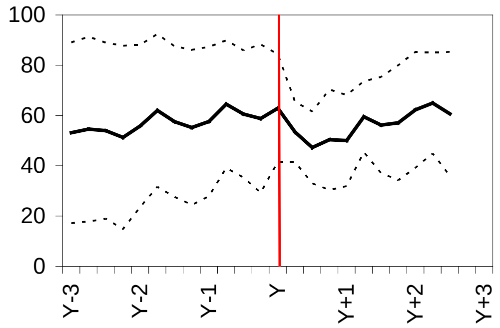
Advanced economies around 2008: Average Size of reserve money in Category I (% of BS)



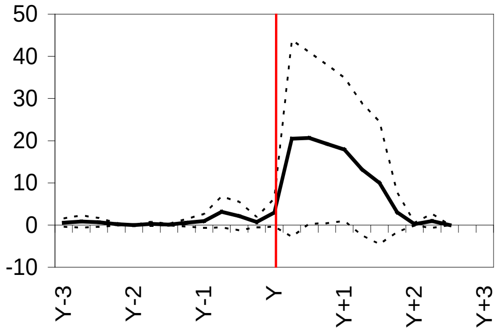
ID economies around 2008: Average Size of claims on banks in Category I (% of BS)



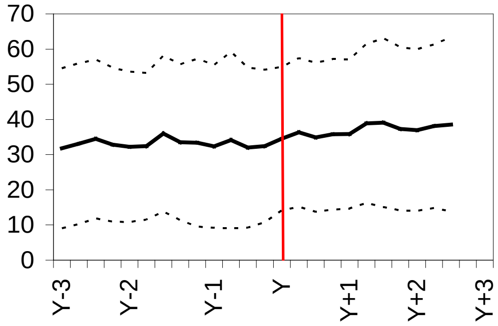
Advanced economies around 2008: Average Size of reserve money in Category II (% of BS)



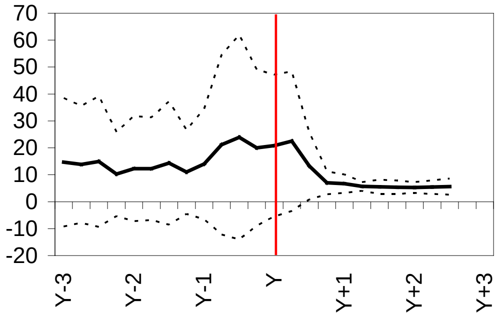
ID economies around 2008: Average Size of claims on banks in Category II (% of BS)



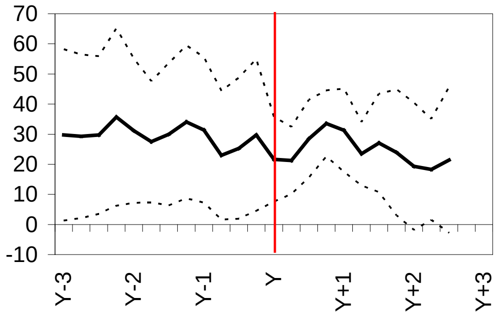
Asian emerging countries around 2008: Average Size of reserve money (% of BS)



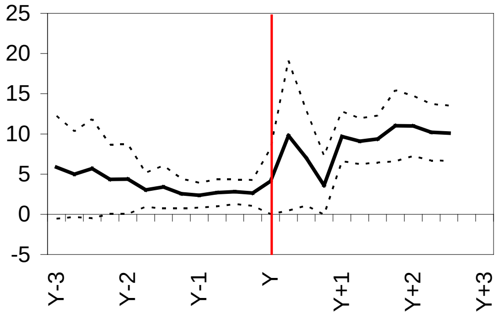
ID economies around 2008: Average Size of foreign liabilities in Category I (% of BS)



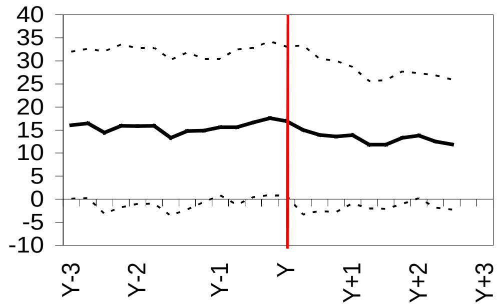
Advanced economies around 2008: Average Size of government deposits in Category II (% of BS)



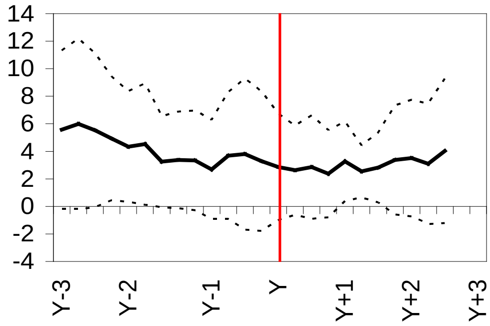
ID economies around 2008: Average Size of foreign liabilities in Category II (% of BS)



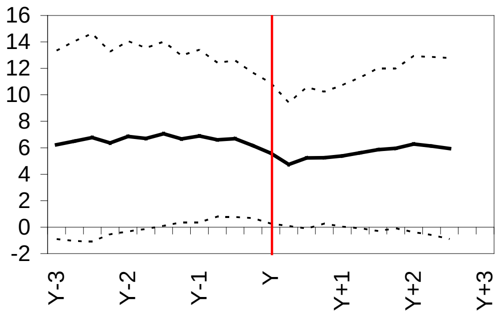
Asian emerging countries around 2008: Average Size of government deposits (% of BS)



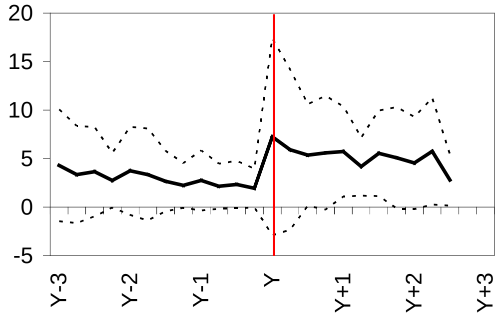
Asian EMEs around 2008: Average Size of foreign liabilities (% of BS)



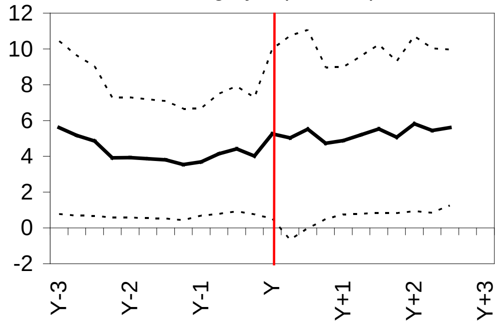
Advanced economies around 2008: Average Size of capital accounts in Category I (% of BS)



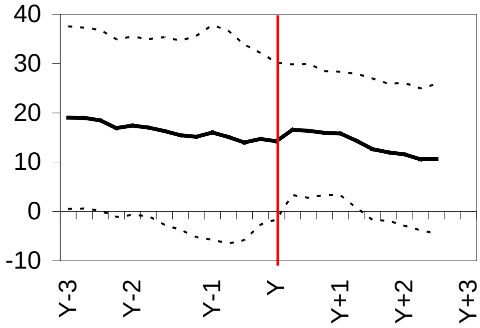
Advanced economies around 2008: Average Size of government deposits in Category I (% of BS)



Advanced economies around 2008: Average Size of capital accounts in Category II (% of BS)



Asian emerging countries around 2008: Average Size of capital accounts (% of BS)



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Comments on A Durré and H Pill's paper "Central bank balance sheets as policy tools"

Hernando Vargas[1]

The paper identifies two features of financial markets that justify the use of CB balance sheet (BS) size or composition (in addition to the short term interest rate) to affect the macroeconomy:

- Imperfect substitution between different financial assets (eg "portfolio balance approach").
- Asymmetric information (adverse selection) that may cripple financial markets in a crisis (eg the interbank market).

The paper rightly acknowledges the limited scope of the first mechanism (portfolio balance approach) …

… So the net benefits of CB balance sheet policy tools are greatest as EX-POST measures aimed at dealing with the effects of a crisis in some key financial markets ("market maker of last resort").

- ***Comment # 1***: The availability and use of CB balance sheet tools in case of crisis is helpful (even crucial), but it may create moral hazard and therefore require regulation of the relevant markets …

  … in the same way that LOLR facilities are complemented by liquidity or reserve requirements in the banking system.

  And it may be better to minimize the probability of crisis through the use of sound countercyclical policies…

- ***Comment # 2 (Question)***: Is there a role for CB balance sheet tools as EX-ANTE policy measures aimed at preventing or dealing with a crisis in EMEs?

  The paper suggests that the preemptive accumulation of reserves in EMEs could fall in this category …

  … Even the imposition of URR and supporting exchange rate pegs through sterilized intervention are discussed as possible measures to "build a balance sheet structure that is resistant to sudden stops".

  These are key issues for CBs in EMEs and most of them have used such measures at some point …

  … but a general framework is necessary to determine when and how to use these additional policy tools.

  Some sketchy ideas follow in this regard …

A starting point is that any admissible measure must not compromise the CB long term policy objectives.

[1] Deputy Governor, Banco de la República (Central Bank), Colombia.

- These typically include:
  - Ö Price Stability
  - Ö Maximum sustainable output
  - Ö Financial Stability
- Policy actions are deemed too costly if they seriously put these objectives at risk.
- For example, URRs on capital inflows are undesirable if they severely hamper credit supply and competition in the financial system for long periods of time (when effective) …
- … or if they redirect flows toward riskier, non-monitored modes (when ineffective).

A second criterion is that any admissible measure must not severely limit exchange rate flexibility.

- The ***alternative*** (peg) is simply ***worse*** for many countries (the lessons from history):
  - Ö Implies pro-cyclical monetary policy and credit supply → risks on inflation or financial stability …
  - Ö … or entails large quasi-fiscal costs.
  - Ö Encourages "one-side bets" and excessive currency and term mismatches risks on financial stability.
  - Ö Amplifies the effects of external real shocks.
- For example, prolonged and large sterilized FX intervention may involve costs in the last three dimensions.

A third criterion is that the CB Balance Sheet measures not go against real long term trends.

- Using these tools to contain a trend may be ***ineffective*** …
- … Markets will find ways to circumvent long-lasting CB BS measures that go against long term incentives of agents (eg URRs or excessive domestic reserve requirements) …
- … or sterilized FX intervention could lack credibility and attract more capital inflows if undertaken against a long-term trend in the RER.
- But even if effective in the long run, these measures may be ***inefficient*** substitutes for appropriate macro policy responses...
- For example, it may not be wise to permanently repress the financial system to compensate for the insufficient fiscal savings required to offset a real appreciation resulting from an enlarged commodity-exporting capacity.
- Hence, the additional CB policy tools should be used to deal with risky or costly ***deviations*** of macroeconomic or financial aggregates from trend.

Some Examples from Colombia

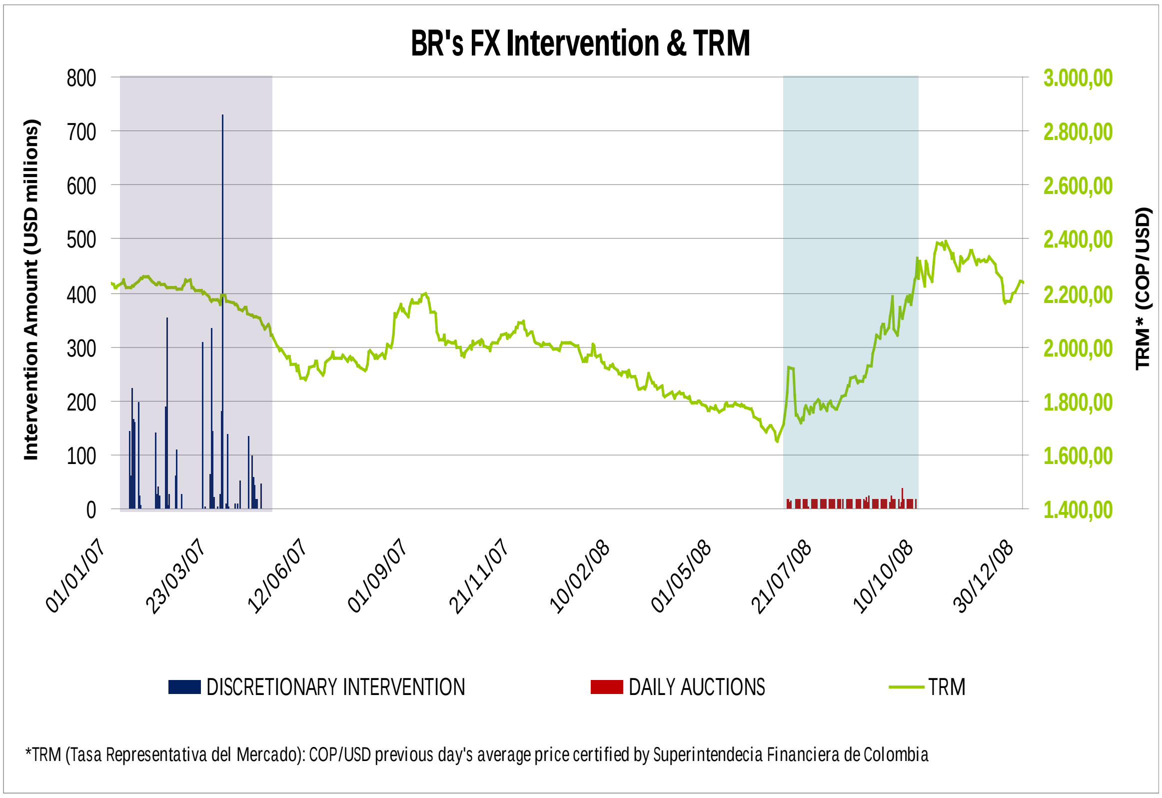
Effectiveness of Sterilized Intervention:

- In early 2007 and mid-2008 the CB made sterilized FX purchases.
- In both cases the currency was appreciating and the CB was raising or about to raise the policy interest rate (to curb inflation and/or overheating of the economy).

- Yet in 2007 intervention failed (the currency appreciated and more capital inflows were attracted), while in 2008 the appreciation was stopped (before the Lehman crisis).
- The difference was the level of the (real) exchange rate at which the intervention was undertaken and the modality of the intervention.
- ***Lesson***: Sterilized FX intervention is likely to be ineffective in the absence of large ***deviations*** from RER trend and with strong credibility of the inflation target (the modality of the intervention may also matter).

Some Examples from Colombia

Effectiveness of Sterilized Intervention



Some Examples from Colombia

The effectiveness of CB BS measures to face a sudden stop:

- The CB established a URR on foreign indebtedness in the early nineties, long before the Russian crisis.
- The CB established a URR on foreign indebtedness and marginal reserve requirements on domestic deposits in May 2007, 1½ years before the Lehman crisis.
- Between 1998-Q1 and 1999-Q3 (Russian crisis) the growth rate of the Colombian economy fell by 8.8 percentage points, a decline second only to Argentina's decline (-11 percentage points) and close to Chile's (-7.9 percentage points).

- Between 2008-Q3 and 2009-Q3 (Lehman crisis) the growth rate of the Colombian economy fell by 2.5 percentage points, the smallest decline among the largest Latin American economies.
- Beyond the differences in the shocks' source, impact and size, the contrast between the response of the economy after the two shocks is striking.
- Some local factors may be important in explaining the contrast:
  - In the 1990s the strong end of an exchange rate target zone was defended, implying a strong expansion of credit …

    … In the 2000s there was a substantial degree of exchange rate flexibility and monetary policy was countercyclical
  - In the 1990s there was a sharp expansion of public expenditure and public debt (as % of GDP) …

    … In the 2000s there was fiscal consolidation and a reduction of public debt (as % of GDP).
- ***Lesson***: Ex-ante CB balance sheet policies do not replace sound macro policies, and depending on the nature of the crisis may have only second-order effects.

A final minor comment

- A simple model of the aggregate financial system balance sheet is used to illustrate the effect of a disruption in the interbank market on the supply of loans.
- The result of the model is that "the aggregate impact of declines in the interbank deposits is greater than what would be suggested by simply summing the individual bank impacts, as there is a feedback effect through the contraction of the interbank market".
- It is easy to agree with the result, but it is not clear how the model captures the channel the authors intend to show.
- In their model, the greater aggregate effect is the result of the assumption of a fixed leverage ratio. This implies that a decline in interbank deposits must be matched by a reduction in equity, which in turn explains the contraction in aggregate loan supply.
- In the face of an interbank disruption, one would expect equity to remain stable and leverage to fall.

Comments on A Durré and H Pill's paper "Central bank balance sheets as policy tools"

Budianto Soenaryo Mukasan[1]

Overview

This insightful paper explored "how central bank balance sheets can help contain financial crises [lessons learned from The European Exchange Rate Mechanism (ERM) crisis of 1992–1993, the Asian financial crisis of 1997–1998 and the global financial crisis of 2007–2011], although, given recent experience, the focus is on domestically generated and propagated crises."

In line with much of the existing analysis of non-standard central bank policy measures, focusing on the importance of portfolio balance channels in transmission, this empirical study argues that the main channel through which balance sheet policies have influenced macroeconomic outcomes is by supporting market functioning and, albeit to a much lesser extent, via portfolio balance effects.

Varying the size and structure of balance sheets serves to provide additional stimulus to the economy, support market function (particularly interbank trading) and manage cross-border capital flows.

Key findings and conclusions

Despite the different natures of the market segments facing these different crises, the crises have more similarities than differences, in terms of both market distortions and central bank reactions (in which central banks take on the market-based intermediation role and assume exposure to FX risks). In all these cases, central banks had to increase their intermediation role in order to furnish a substitute for market mechanisms that provide liquidity.

This study also reminds us to give further consideration to the pros and cons of using central bank balance sheet as policy tools. As the authors say on the side of the ***pros***:

- We have argued that the main channel through which balance sheet policies have influenced macroeconomic outcomes is by supporting market functioning and… via a portfolio balance effect.

And as they state regarding the ***cons***:

- There is the risk of offering the market confusing signals regarding policy intentions, [so that] communication on that monetary policy stance can become multidimensional and therefore more complex.
- [T]here is a danger that well-intentioned balance sheet policies to support market functioning (essentially liquidity operations) will end up as quasi-fiscal operations [and] sections of the financial systems become dependent on central bank support.

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[1] Head of Monetary Operation Bureau, Department of Monetary Management, Bank Indonesia.

- [The introduction of balance sheet policies may find itself] eroding over time the central bank's credibility as regards delivering on the explicit monetary policy objectives.

Relevance to Indonesia's case

This study is relevant for Indonesia's recent application of central bank balance sheet policy. Bank Indonesia has been varying the size and structure of its balance sheets over the last decade: since 1997 in response to the 1997–1998 Asian crisis, and subsequently in response to the 2005 and most recent global financial crises. The implementation of balance sheet policy tools in Indonesia has helped to contain the effects of crises characterized by the following fundamental challenges (and corresponding responses):

Challenges

- The main challenges facing Indonesia are a structural and permanent excess of Rupiah liquidity, and also volatile and increasing capital flows in underdeveloped financial markets and instruments.
- The measures used to control excess liquidity have expanded the liabilities side of the balance sheet. BI's liabilities are dominated by short-term monetary policy instruments, which increases monetary operation costs.

Policy responses

- To address the problems, the strategy of the monetary operations is designed to lengthen the maturity profile of the monetary instruments by exchanging Bank Indonesia Certificates (SBI) with term deposit (TD) facilities and conducting reverse repo of government bonds.
- Higher statutory levels for the rupiah reserve requirement target (LDR-based) and foreign currency deposits, a longer minimum holding period (more months) for Bank Indonesia Certificates (MHP-SBI), and a wider corridor of rates for the interbank call money market are macro-prudential policies designed to support the monetary operation strategy. On the other hand, Bank Indonesia also uses conventional operations, purchasing government bonds and conducting sterilised foreign exchange intervention to stabilise the movement of the rupiah exchange rate.

Closing observations

This paper is insightful, and inspires further and deeper observation related to solving the optimum-equilibrium "trilemma". Addressing the recent financial market developments implies dealing with capital flows and the accumulation of foreign exchange reserves, with exchange rate levels, with interest rates and inflation, and with surplus/deficit issues on the central bank balance sheet.

We are urged to further investigate the impact for financial institutions and the banking intermediation function, the effect on market efficiency, and the implications of deepening financial needs via a portfolio balance effect.

International spillovers of central bank balance sheet policies

Qianying Chen, Andrew Filardo, Dong He and Feng Zhu[1]

Abstract

We study the cross-border impact of quantitative easing (QE) in the major advanced economies, especially on emerging market economies. We first examine the cross-border financial market impact of central bank announcements of asset purchase programmes. We find marked QE announcement effects on global financial markets. Quantitative easing influenced prices of a broad range of emerging market assets, raising equity prices, lowering government and corporate bond yields and compressing CDS spreads. The evidence supports the view that QE programmes in advanced economies influenced market expectations about the strength of cross-border financial flows to emerging market economies and about accommodative monetary policy responses of emerging market central banks to concerns about these capital flows. In other words, the announcement of QE measures in one economy contributed to easier global liquidity conditions through the immediate re-pricing of assets in global financial markets.

We then turn to the macroeconomic impact of US quantitative easing on emerging market and advanced economies using a global vector error-correcting model (VECM). In additional to the standard trade channels, this model takes account of financial linkages using the BIS locational bank lending statistics. The size of the estimated international spillover effects differed across regions. First, lower US treasury bond yields raised equity prices significantly in the advanced economies, but the expansionary impact on growth and inflation was only about half of that on the US economy. Second, there was little evidence that lower yields in the United States led to rapid credit growth in other advanced economies, at least in the immediate aftermath of the crisis. Third, the impact on emerging economies was in general stronger than that on the other advanced economies. In some economies such as Hong Kong and Brazil, the expansionary impact of US quantitative easing was significant and associated with rapid credit growth and strong capital inflow, currency appreciation and inflationary pressures.

Keywords: Unconventional monetary policy; quantitative easing; central bank balance sheets; global spillovers; emerging market financial markets; announcement effects; global VECM

JEL classification: E43, E44, E52, E65, F42, F47

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[1] We would like to express our thank for the comments of Shinobu Nakagawa, Patrizio Pagano, Eswar Prasad and the participants at the 9th Annual HKMA Hong Kong Institute for Monetary Research Summer Workshop and the 2011 Joint Workshop on Emerging Markets of the European Central Bank and the Deutsche Bundesbank. We would like to thank Lillie Lam for expert research assistance. Contact information: Qianying Chen, Hong Kong Institute for Monetary Research, email: qchen@hkma.gov.hk; Andrew Filardo, Bank for International Settlements, email: Andrew.Filardo@bis.org; Dong He, Hong Kong Monetary Authority and Hong Kong Institute for Monetary Research, email: dhe@hkma.gov.hk; Feng Zhu, Bank for International Settlements, email: Feng.Zhu@bis.org. The views expressed are those of the authors and do not necessarily represent the views of the Bank for International Settlements or the Hong Kong Monetary Authority.

I. Introduction

The recent global financial crisis and recession have had a major impact on the design and implementation of monetary policy. Following the crisis, central banks in the major advanced economies lowered policy rates rapidly to near zero, and the scope for further monetary easing through policy rate cuts became very limited. Bernanke and Reinhart (2004) suggested three policy alternatives when central banks face the zero lower bound on nominal interest rates: first, shape public expectations about the future path of the policy rate; second, implement quantitative easing, i.e., increase the size of the central bank's balance sheet beyond the level needed to maintain a zero policy rate; third, change the composition of the central bank's balance sheet in order to affect the relative supply of securities held by the public. Notably, several central banks have taken measures which are considered "unconventional", departing from the standard procedure, which would react to changes in inflation and output by changing short-term interest rates. These unconventional policy measures often have a quasi-fiscal nature; they are faithfully reflected in the changes in the size or composition, or both, of a central bank's balance sheet (see Graph II.1).

Given the rather limited experience central banks have with balance sheet policies, a natural question policymakers ask is whether such policies would be effective in the current situation, and if so, how effective these policies are and whether they bring benefits which would outweigh possible costs and risks. Early research on the impact and effectiveness of central bank balance sheet policies is scant, as such policies rarely came into serious consideration previously. One exception was the research on the impact of the 1961–1964 Operation Twist implemented by the Kennedy Administration, which relied on selling short-term but buying longer-term Treasury debt in order to modify the term structure of interest rates. Past studies including Holland (1969) and Modigliani and Sutch (1966, 1967) show that the operation had a relatively small impact on longer-term bond yields. This has been confirmed by event studies of Bernanke, Reinhart and Sack (2004) and Swanson (2011). A second strand of literature focuses on the Bank of Japan's 2001–2006 quantitative easing, and Ugai (2007) provides good survey of related empirical work.

The latest unconventional policy actions taken by central banks in a number of major advanced economies have led to a burgeoning literature. Most recent work on the effectiveness of quantitative easing has focused on its domestic effects, analysing several channels of domestic transmission.[2] The literature's emphasis on the domestic impact of balance sheet policies can be justified on the grounds that a refined knowledge of precise impact would be essential in order to correctly calibrate changes in the size or composition of central bank balance sheet policies and to exert the desired effects on the economy.

Much of the research has resorted to event studies analysing the announcement or surprise effects of quantitative easing on domestic asset markets, while a small number of papers have employed regression analysis. Among others, D'Amico and King (2010), Doh (2010), Gagnon, Raskin, Remasche and Sack (2010, 2011) and Krishnamurthy and Vissing-Jorgensen (2010, 2011) provide estimates for the US large-scale asset purchase programme, while Joyce, Lasaosa, Stevens and Tong (2010) and Meaning and Zhu (2011) do so for the Bank of England's asset purchases.

Yet very little has been done to investigate the impact of central bank balance sheet policies on real activity. On the one hand, monetary policy tends to have long and variable lags, and balance sheet policy may be no exception. Data availability is a major obstacle given that the sample following the implementation of unconventional policy measures remains very short,

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2 See the table in the Annex for a summary of the recent studies on the impact of central bank balance sheet policies.

and the effects remain to be fully spelt out in the coming years. On the other hand, the usual channels of monetary policy transmission may have been severely impaired following the recent global financial crisis and recession, and pre-crisis models could have simply become obsolete. Moreover, unconventional policy might be transmitted in rather different ways from the traditional channels for interest rate policy in normal times.

In addition, there is very little research on the international spillovers of central bank balance sheet policies, especially the impact on emerging markets. Relying on event studies of the effect of US asset purchases on domestic and international financial markets, Neely (2010) finds significant impact from US quantitative easing, which reduced Treasury bond yields by 100 basis points and corporate bond yields by 80 basis points; more importantly, US quantitative easing lowered bond rates in the other advanced economies by 20–80 basis points and the value of the US dollar by 4–11 percentage points. His results suggest that portfolio rebalancing effects were more significant than signalling effects, and that efforts for more international policy coordination could be helpful. Glick and Leduc (2011) showed that commodity prices fell on average on days of the Fed LSAP announcement, despite the decline in long-term interest rates and dollar depreciation.

In fact, having a better understanding of the international implications of quantitative easing is equally important for policymakers in emerging economies, so as to better cope with the challenges implied by such policies. There are two dominant views on likely cross-border effects. The first view, typically held by economies which have implemented such policies in order to revive the domestic economy, sees no major impact or externalities on emerging economies. If there is any effect, this view holds, stronger domestic growth spurred by quantitative easing would promote a more stable global macro and financial environment, and increase demand for exports by the emerging economies, thereby bringing major benefits to the global economy. The other view, held in many emerging economies, suggests that such policies could depreciate the domestic currency and inflate already significant risk-adjusted interest rate differentials vis-à-vis other economies, leading to potentially large capital inflows, credit growth, and consumer and asset price inflation pressures in these economies.

Nevertheless, the cross-border effects of the different stages of quantitative easing may have changed over time as the growth prospects of the advanced and emerging economies diverged. Initially, quantitative easing may have contributed to alleviating acute global funding difficulties and stabilising credit markets at a time of raging financial crisis and severe global recession. It may have helped stem large capital outflows and prevent a sustained decline in exports from emerging economies, by strengthening trade credit and supporting demand in the advanced economies. However, at a later stage, while emerging economies returned to solid growth, the latest actions, e.g. the US Federal Reserve asset purchases starting in November 2010, have been perceived as less benign, what with a two-speed global recovery, and already-rising CPI and asset price inflation pressures in the emerging economies. These actions were perceived to have encouraged speculative capital inflows and raised currency appreciation pressures, further increasing risks of overheating, inflation and asset market excesses in the emerging economies.

In this paper, we provide empirical evidence for the ongoing debate on the cross-border impact of quantitative easing in the major advanced economies, with a special focus on the US asset purchase programmes. We contribute to the existing literature in two ways: by examining the cross-border financial market impact of central bank balance sheet policies in a more systematic fashion, and by studying the real effects of quantitative easing, both domestic and international, using a global VECM model. We focus on the impact on a number of emerging economies in Asia and in Latin America, and compare it to the impact on the major advanced economies. Particular attention is paid to cross-border channels of transmission. We differ from previous research on cross-country interdependence relying on trade linkages, as we also use the locational bank lending statistics provided by the Bank for International Settlements to gauge the strength of financial linkages across economies.

We find that in the short run, US quantitative easing policy not only stimulated the US domestic economy, but also boosted asset prices globally and helped stabilise the financial markets following the global financial crisis. In particular, it had an expansionary impact on a broad range of assets across the world, including equity prices, government and corporate bond yields and CDS spreads. In addition, it helped the US domestic real economy recover.

However, the international spillovers in the longer run differed across economies. Lowering the term spread of the US Treasury bond yield raised equity prices significantly in the advanced economies, but the expansionary impact on growth and inflation was only around half of the effect on the US domestic economy. We find no evidence of capital inflow pressure or rapid credit growth in the advanced economies. In contrast, the effect on emerging economies was in general stronger and more diverse. For some economies, such as Hong Kong, Brazil and Argentina, the expansionary impact was greater than the domestic effects of US quantitative easing. US monetary easing has typically led to high capital inflow pressures, rapid domestic credit growth and inflationary pressures in some economies. The longer-run impact depended on the different ways in which each economy reacted or adjusted to the US policy shock, and was in part determined by its economic and financial structure, policy framework, and capital control and exchange rate regimes. We find that the sign and size of the medium-run impact differed across economies, implying that the costs and benefits of US quantitative easing policies have been unevenly distributed between the advanced and emerging economies.

The paper is organised as follows. Section II describes central bank balance sheet policies and their uses since the early 2000s. Section III contains a detailed account of both the domestic and cross-border channels of transmission of central bank balance sheet policies. Section IV presents empirical results of event studies on the impact on the emerging economies of quantitative easing in the advanced economies; it estimates impulse responses to a US quantitative easing shock, based on a global VECM; and it estimates likely cross-border spillovers of a US quantitative easing shock on output, inflation, credit, equity prices, and monetary policy. Section V concludes.

II. Central bank balance sheets policies

Central bank balance sheets have changed continuously, in many cases as a passive response to monetary policy actions such as open market operations. In addition, balance sheet policies can be seen as a regular feature of monetary policymaking in a number of emerging economies, if one takes into account the fact that many central banks actively intervene in the foreign exchange market, and as a consequence accumulate sizeable foreign exchange reserves that can disproportionately inflate a central bank's balance sheet.

On the other hand, the active management of the size and composition of central bank balance sheets as the main policy instrument has been much less common.[3] So far, besides Operation Twist in the US in the early 1960s, this has happened only in rather extreme circumstances of very stressful macro and financial conditions. Although in theory a central bank could carry out balance sheet policies irrespective of the existing level of the policy rate, in practice the recent experiments with balance sheet policies have been associated with policy rates constrained at the zero lower bound. One notable example was Japan. After a decade of anaemic growth and persistent deflationary pressures, the Bank of Japan implemented a "quantitative easing" programme from March 2001 to March 2006, expanding

3 See Bernanke and Reinhart (2004) and Bernanke, Reinhart and Sack (2004).

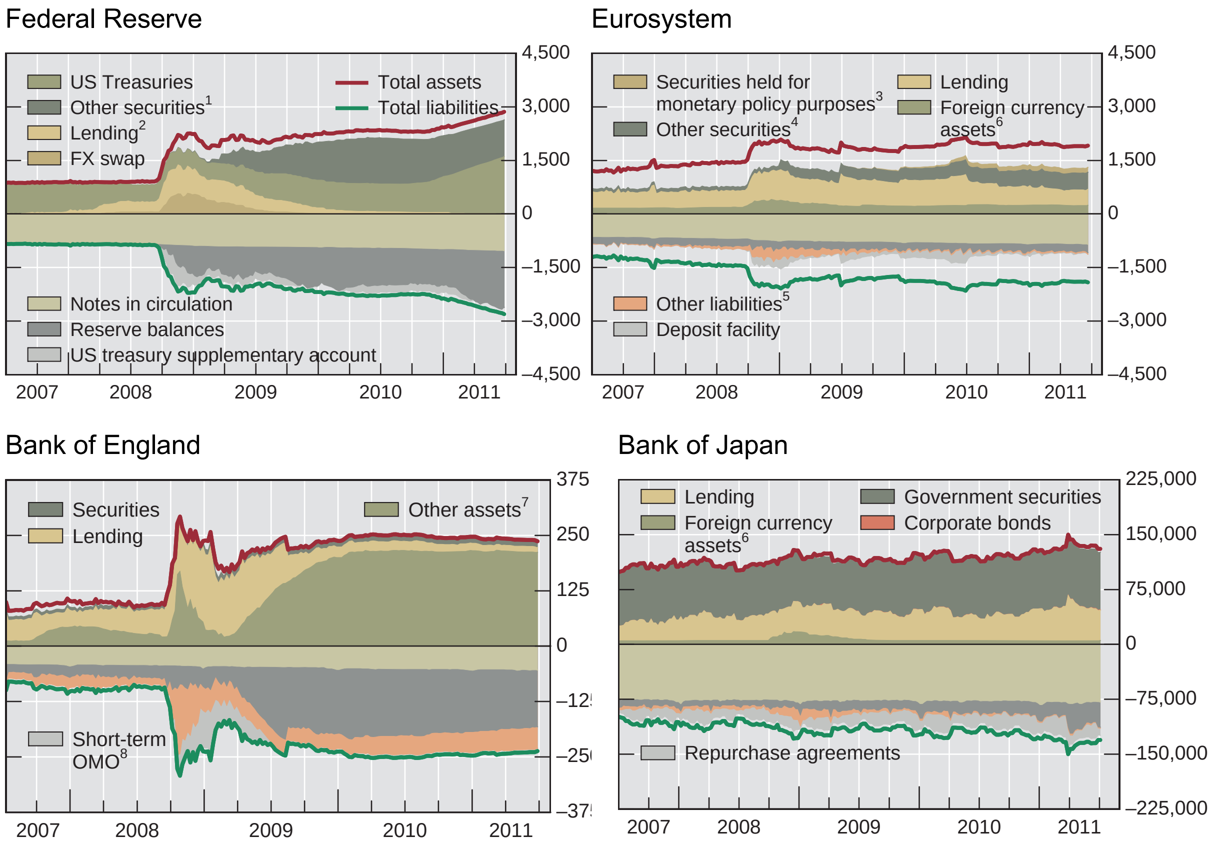
its balance sheet on the liability side by setting targets for current account balances held by financial institutions with the Bank. Eventually the BOJ purchased almost JPY 30 trillion of domestic government bonds.

Following the recent global crisis and prolonged economic weakness, several central banks in the major advanced economies implemented different programmes which could be considered balance sheet policy measures. Besides the Bank of Japan, which already had a sizeable balance sheet at the onset of the global crisis, the balance sheets of the US Federal Reserve, European Central Bank and Bank of England all recorded sizeable expansions in the second half of 2008 (See Graph II.1). Since then, quantitative easing has been conducted mainly through changes in the composition of central bank balance sheets. In fact, the Fed's holdings of securities rose from a mere USD 790 billion in mid-2007 to an estimated USD 2.6 trillion by mid-2011.

Graph II.1

Central bank assets and liabilities

In billions of respective currency units



[1] Includes federal agency debt securities and mortgage-backed securities held outright. [2] Repurchase agreements, term auction credit, other loans and CPFF. [3] Includes portfolios held under the Covered Bond Purchase Programme and Securities Market Programme. [4] Other securities of euro area residents denominated in euros. [5] Including central banks. [6] Including US dollar liquidity auctions. [7] Including US dollar liquidity auctions and asset purchase facility. [8] Open market operations, including issuance of Bank of England sterling bills.

Sources: Datastream; national data.

More recently, the US Federal Reserve and the Bank of England, among other central banks, established a number of asset purchase programmes in attempts to change the composition of their balance sheets on the asset side. The latter approach became known as "credit easing" or "qualitative easing", with the objectives of easing domestic financial conditions, restoring credit flows and repairing impaired monetary transmission.[4]

The Bank of England established its Asset Purchase Facility (APF) in January 2009 to "buy high-quality assets financed by the issuance of Treasury Bills", the aim being to "improve liquidity in credit markets". The announced £200 billion in asset purchases is concentrated in gilts (£198 billion), which accounted for 29% of the free float gilt market. Buyable assets include UK government securities (gilts) and "high-quality" private sector assets, including commercial paper and corporate bonds. The Bank of Japan's Asset Purchase Program (APP), announced in October 2010 as part of its Comprehensive Monetary Easing, was designed with the idea of "encouraging a decline in longer-term market interest rates and a reduction in various risk premiums to further enhance monetary easing". Through the programme, "the Bank purchases various financial assets and conducts fixed-rate funds-supplying operations against pooled collateral". On 4 August 2011, the Bank of Japan announced a decision to increase its asset purchase programme by 10 trillion yen, to 40 trillion yen.

The Eurosystem's covered bond purchase programme (CBPP), announced in May 2009 and implemented between July 2009 and June 2010 for a nominal value of EUR 60 billion, was aimed at supporting "a specific financial market segment that is important for the funding of banks and that had been particularly affected by the financial crisis". A total of 422 different bonds, mainly with maturities of three to seven years, were purchased, and 73% of these were bought in the secondary market. Despite the relatively small size (Graph II.1), empirical evidence suggests that CBPP helped lower banks' financing costs, stimulating a revival of the covered bond market and dampening euro area covered bonds about 12 basis points.

The implementation of balance sheet policies by the US Federal Reserve has evolved in three stages. In the first stage, many segments of capital markets became dysfunctional as the global financial crisis raged and a severe global recession set in. Since December 2007, the Fed has introduced the Term Auction Facility (TAF), the Term Securities Lending Facility (TSLF) and the Primary Dealer Credit Facility (PDCF) to support the market segments with severe liquidity shortages. [5] The use of such facilities would change mostly the composition, not the size, of the Fed's balance sheet.

The start of the second stage was marked by a sharp expansion of the Federal Reserve's balance sheet through a large-scale asset purchase (LSAP) programme, first announced in November 2008 and then extended in 2009. It allows the Federal Reserve to expand its open market operations to "support the functioning of credit markets through the purchase of longer-term securities". The announced total amount of asset purchases was USD 1.7 trillion, which represents 22% of the combined outstanding Treasuries, long-term Agency debt, and fixed-rate agency MBS, worth around $7.7 trillion at the beginning of the operation. Two phases of LSAP should be noted: Quantitative Easing Mark 1 (QE1) was carried out between November 2008 and March 2009, during the financial crisis, and later extended to March 2010; and Quantitative Easing Mark 2 (QE2), which started in November 2010 when the global recovery faltered, was intended to purchase an additional USD 600 billion in longer-term Treasury securities by mid-2011.

On September 21 2011, the Federal Reserve entered the third stage of balance sheet policy by announcing a new maturity extension (ME) programme, under which it would buy

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4 For ease of exposition, we use the terminologies "quantitative easing", "central bank balance sheet policy", "unconventional monetary policy" and "asset purchase programmes" interchangeably wherever the circumstances are clear.

5 See Campbell, Covitz, Nelson and Pence (2011) and Wu (2010, 2011) for assessment of the effectiveness of the US Federal Reserve term facilities.

longer-term Treasury securities for USD 400 billion by the end of June 2012. A distinct feature of the ME programme is that such purchases will be financed with the proceeds from selling shorter-term Treasury securities, instead of by increases in reserves. In other words, "Operation Twist" will only involve changes in the composition of Fed balance sheet. The aim is to extend the average maturity of the Fed's Treasury securities portfolio by 25 months to about 100 months by the end of 2012. The operation would put further downward pressure on the interest rates for longer-term Treasury securities and other financial assets that are close substitutes, thereby contributing to a broad easing in credit market conditions and supporting the economic recovery.

The role, objectives, instruments and corresponding operating procedures of central banks' balance sheet policies have changed over time, as the advanced economies have gone through different phases of the financial and economic cycle. Initially, such policies focused on providing ample liquidity to stabilise financial markets and shore up confidence, e.g. with various term facilities set up by the US Federal Reserve, and also currency swaps. As the crisis subsided, balance sheet policies placed a greater emphasis on lowering borrowing costs and easing credit conditions for the private sector, so as to promote growth and employment. Such policies have taken the form of asset purchase programmes, commitment to very low interest rates for a predetermined period of time, or even foreign exchange market interventions.

Given the elevated degree of financial integration and trade openness, economies have become ever more closely interwoven and highly interdependent on each other. Consequently, even though central bank balance sheet policies have been designed primarily to tackle domestic economic issues, they are bound to have wider cross-border spillover effects. Indeed, as economic recovery has solidified in the emerging economies, such effects have become a major concern for policymakers in many emerging Asian and Latin American economies, in particular since the asset purchase programmes (QE2) put in place by several central banks. The US Federal Reserve Bank's LSAP programme has stood out by its size and likely global impact. The focus of this paper is precisely on whether quantitative easing in the advanced economies has had a significant impact on the emerging economies, and if so, how large such cross-border effects have been.

III. Transmission of central bank balance sheet policies

Central bank balance sheet policies are designed to cope with domestic policy challenges, and domestic transmission may operate through a number of channels. First, quantitative easing may work through the traditional interest rate channel by reducing longer-term yields and subsequently real interest rates, as nominal prices and wages are slow to adjust. This encourages borrowing and spending by firms and households. Second, as financial assets are imperfect substitutes with distinct liquidity and risk characteristics, central bank asset purchases may change the relative demand and prices of different securities, thus influencing investors' portfolio decisions through the portfolio balance channel. This should cause size and composition changes in private sector asset holdings, leading to easier financial conditions more generally. In the third – signalling or expectations – channel, a central bank relies on quantitative easing to demonstrate its commitment to a specific future policy path, therefore shaping market expectations in such a way, for example, as to keep longer-term yields down. A credible commitment will also inspire confidence and drive down risk premia while supporting asset prices.

Fourth, through the bank lending channel, quantitative easing may help directly ease financial conditions and support bank lending to the private sector by improving the availability of funds. Direct asset purchases could help raise asset prices, strengthening bank and corporate balance sheets. Stronger balance sheets, lower borrowing costs and better access to credit stimulate business spending, output and employment. Similarly, quantitative easing could operate through the liquidity channel by reducing liquidity premia and hence borrowing costs for the private sector through central bank provision of abundant and cheap liquidity to financial institutions. In addition, through an asset price channel, abundant liquidity flows made available by quantitative easing and direct large-scale asset purchases may support equity and housing prices and encourage investors to move to riskier assets. For example, reduced mortgage rates could improve home affordability and lend support to property prices. This would boost household wealth and spending, making a positive contribution to consumption, output and employment.[6]

The focus of this paper is on the international spillover effect of central bank balance sheet policies. There are a number of cross-border transmission channels through which such policies may operate. First, the portfolio rebalancing channel operates in the global economy. For instance, foreign long-term sovereign debt may be an imperfect substitute for long-term domestic debt. In fact, US Treasury securities play a special role in the global economy, as the US dollar is the dominant reserve currency and no other sovereign or private debt instruments are seen as perfect substitutes. If quantitative easing lowers US long-term bond yields, investors could turn to emerging market assets of similar maturities for higher risk-adjusted returns. This would boost asset prices and lower long-term interest rates in the emerging economies, effectively easing financial conditions there. Indeed, in a globalised financial market, leakage from domestic monetary easing is unavoidable, and the size of such leakage may differ across countries depending on the strength of the cross-border transmission channels.

A second channel operates through international financial markets and is a combination of liquidity, asset-price and risk-taking channels. With a well-integrated global market, a sizeable quantitative easing in one economy would boost global liquidity. With the policy commitment implicitly or explicitly embodied in quantitative easing, the policy rate is expected to stay near zero in the foreseeable future in the major advanced economies. Large and rising interest rate differentials are expected to persist, relative to the emerging economies with supposedly sound macro fundamentals and solid growth. Quantitative easing could spur carry trades and capital flows into emerging economies with higher risk-adjusted rates of return, which in turn would push up consumer and asset prices. In addition, persistently low interest rates and abundant liquidity would create incentives for financial institutions in both advanced and emerging economies to search for yields, taking on greater risk for contractual or institutional reasons.[7] An extended period of suppressed interest rates could also lead banks to miscalculate risks.

While some of these channels are similar in nature to the domestic channels described earlier, others are distinctly international. Through a third – exchange rate – channel, quantitative easing may work in the form of exchange rate depreciation with respect to other economies. The impact on emerging economies can be large if the depreciation is to a major international reserve currency. Currency speculation can also play a role by increasing the size and volatility of capital flows. For instance, the Fed's LSAP programme could lower US longer-term interest rates, making USD-based investment less appealing, and leading investors to shift towards assets denominated in higher-yielding currencies. An extended period of extraordinary monetary easing by the Federal Reserve could put persistent appreciation pressure on emerging market currencies, particularly in Asian economies where currencies are somewhat pegged to the USD. Large foreign reserve accumulation, if not fully sterilised, could increase domestic money and credit.

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6 See Case, Quigley and Shiller (2005) and Lettau and Ludvigson (2004) for recent evidence.

7 See Borio and Zhu (2008) and Gambacorta (2009) for further details.

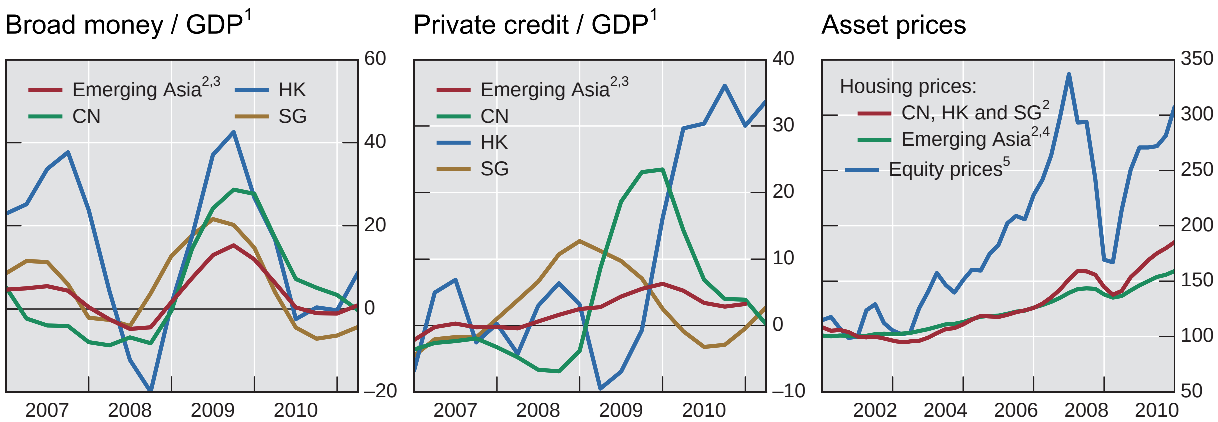
Moreover, real effects of quantitative easing in the advanced economies could spread directly through an external demand or trade channel. Quantitative easing could boost demand for emerging economy goods and services through easier trade credit and increased spending in the advanced economies. However, such effects depend on the level of import elasticity in the advanced economies, and must be balanced against the likely impact of an appreciation of emerging market currencies caused by the quantitative easing.

In addition, quantitative easing could solicit strong endogenous monetary policy response in the emerging economies. For instance, central banks in emerging economies have kept domestic monetary conditions accommodative, even as the economies recovered, inflation rose and asset prices rallied. In part, the policy response may have reflected fears that widening interest rate differentials would drive up exchange rates and create disruptive capital inflows.

Disparate conditions in the advanced and emerging economies could exert strong appreciation pressures on emerging market currencies and lead to disruptive capital flows. The evidence also suggests that the expansion of broad money and credit to the private sector may begin to exceed that of nominal GDP again (Graph III.1, left-hand and centre panels), which could lead to unsustainable asset price pressures in economies that have already experienced rapid broad money and credit in recent years.

Graph III.1

Broad money, credit and asset prices



[1] Annual changes in the ratio between broad money and bank credit to private sector (end of quarter) respectively and GDP (moving sum over four quarters); in percentage points. [2] Simple average. [3] China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand. [4] Economies listed except India and Philippines. [5] MSCI emerging Asia in local currency.

Sources: IMF IFS; national data.

IV. The impact of central bank balance sheet policies

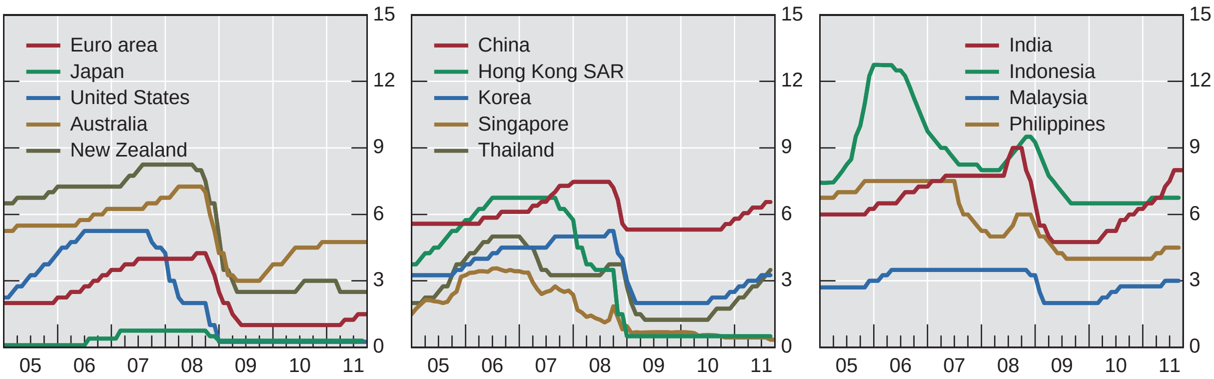
Has quantitative easing in the advanced economies brought significant international spillovers? If so, have such effects been beneficial or detrimental? The answer is not straightforward. While there is less discussion regarding spillovers to other advanced economies, there are two typical views on whether these policies have had a substantial impact on the emerging economies. The first view considers that central bank balance sheet policies are designed for domestic contingencies and should be mostly felt in the domestic economy, and any spillover beyond borders should be contained and of limited impact. The second view sees a major impact from such policies: quantitative easing has been conducted in some of the largest advanced economies with the most active financial markets and also major reserve currencies; in a world of integrated finance and trade, a large-scale and sustained monetary easing is bound to have significant impact on emerging economies.

Similar central bank balance sheet policies in the advanced economies could have rather different impact across emerging economies and over time, depending on varying economic conditions. During the global financial crisis and the ensuing recession, as well as in the earlier phase of recovery, such policies apparently helped stabilise global financial markets, support trade credit and prevent a collapse of demand and real activity in both the advanced and emerging economies. In a second phase, as recovery gathered speed in the emerging economies but languished in the major advanced economies, growth prospects have since diverged. Growth and interest rate differentials have risen (see Graph IV.1); cheap and abundant liquidity may have encouraged large capital flows, partly speculative, into a number of emerging economies.[8]

Graph IV.1

Policy rates[1]

In per cent



[1] Policy target rates or their proxies. For Australia, RBA cash target rate; for China, 1-year lending rate; for Euro area, ECB minimum bid refinancing 1-week rate; for Hong Kong SAR, discount window base rate; for India, reverse repo rate; for Indonesia, 1-month SBI rate; for Japan, uncollateralized overnight call rate; for Korea, overnight call rate; for Malaysia, overnight policy rate; for New Zealand, official cash daily rate; for Philippines, overnight reserve repo rate; for Singapore, 3-month SIBOR; for Thailand, 14-day repo rate before 17 January 2007 and overnight repo rate thereafter; for US, fed funds rate.

Sources: Bloomberg, Datastream.

This may aggravate the already mounting overheating, CPI and asset price inflation pressures in some emerging economies (see Graph IV.2). Quantitative easing in the advanced economies may have complicated policymaking by central banks in the emerging economies, and further easing could imply significant future challenges.

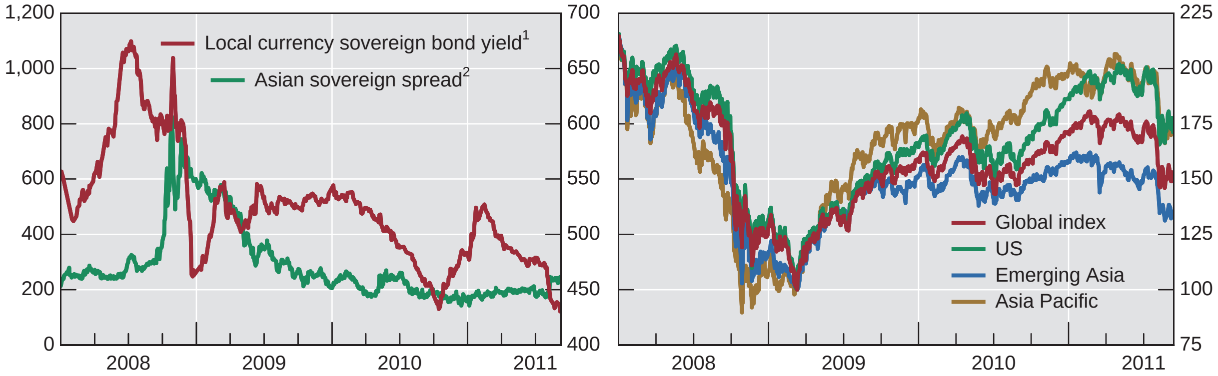
[8] De Nicolò, Dell'Ariccia, Laeven and Valencia (2010).

Graph IV.2

Bond yields and equity prices

Bond yields, in basis points

Equity price indices[3]; 9 Mar 2009 = 100



[1] Simple average of 10-year sovereign bond yield of China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand. [2] JPMorgan EMBI (Global) sovereign spread for Asia. [3] MSCI in local currency.

Sources: Bloomberg.

Additional domestic liquidity in the United States associated with the ballooning of the Federal Reserve's balance sheet could boost capital flows of various types to the rest of the world. Asia has been a favoured target of US capital outflows. While total outflows of capital from the United States have not been exceptional during the US QE period (Graph IV.3, left-hand panel), bank claims and inflows of securities have surged in Asia in 2010 and so far in 2011 (Graph IV.3, right-hand panel). Some of this likely reflects some bounce-back in activity from 2008–09.

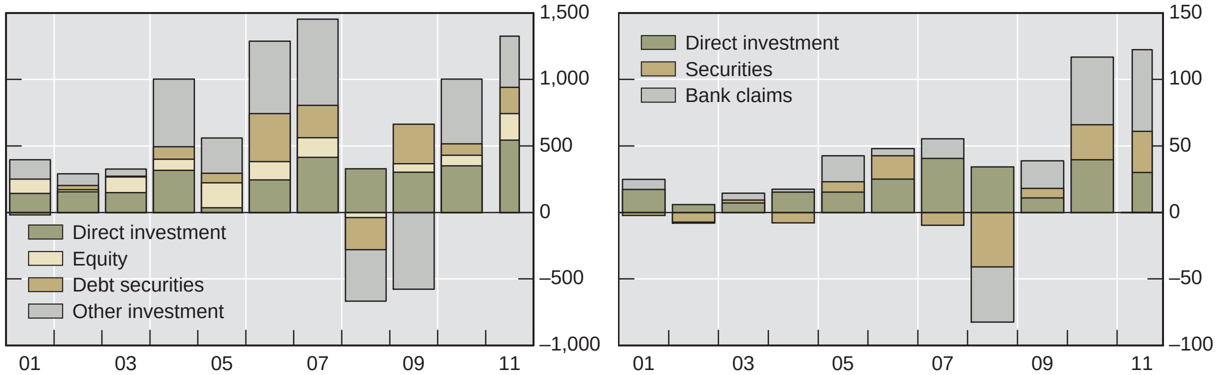
Graph IV.3

US capital outflows

In billions of USD

Total outflows[1]

Outflows to emerging Asia[1, 2]



[1] 2011 figure based on annualised Q1 data. [2] US-owned private assets vis-à-vis emerging Asia-Pacific.

Sources: IMF IFS; US Bureau of Economic Analysis.

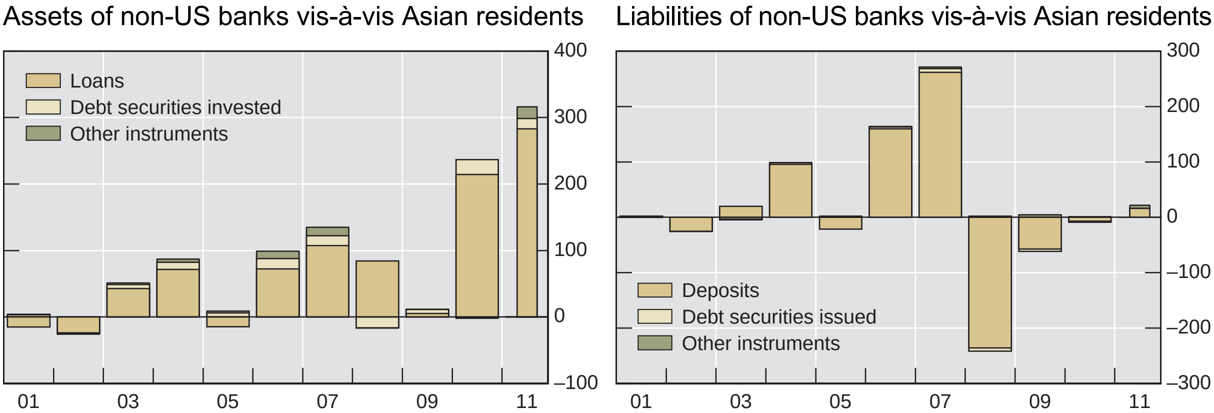
One additional channel of dollar funding in Asia is dollar funding originating outside the United States. Hong Kong SAR and Singapore, for example, are international financial centres in the region that respond to demand for dollar funding without relying on actual dollar flows from the United States. To the extent such demand at very low US interest rates is ample, this could lead to lending booms in the region. Indeed, Graph IV.4 shows a marked increase in US dollar credit to Asia emanating from non-US banks. Bank loans make up the lion's share of the increase. However, this surge in assets is not matched by a similarly sized increase in US liabilities (at the same reporting banks). A number of financial stability issues can arise in such circumstances, arising in part from credit booms and in part from the implied currency mismatches.[9]

We study the international impact of the central bank balance sheet policies in the advanced economies in two steps. First, we examine the more immediate impact of these policies on the financial markets of emerging economies using event study techniques – little discussed in the literature. Using an event study methodology to capture the impact in a short time window is justified, since the spillover effects are expected to rapidly transmit between the highly integrated financial markets through portfolio rebalancing, asset price or exchange rate channels. However, monetary policy has long and variable lags in affecting real activity, and quantitative easing is no exception. Therefore, in the second step, we assess the longer-lasting impact using a formal econometric model that is intended to capture relevant cross-country macro-financial linkages. The analysis could help us better understand the cross-border spillovers, in particular the two competing views on the cross-border impact of central bank balance sheet policies.

Graph IV.4

USD flows outside US[1, 2]

In billions of USD



[1] 2011 figure based on annualised Q1 data. [2] Estimated exchange-rate-adjusted changes of total positions of BIS reporting banks vis-à-vis all sectors in emerging Asia-Pacific.

Source: BIS locational banking statistics.

IV.1. Announcement effects of quantitative easing: an international perspective

This section offers evidence on the impact of US QE on the emerging economies, with a focus on emerging Asia. We examine the response in emerging financial markets to significant QE announcements by the US Federal Reserve. The results are compared to the impact of QE programmes by Japan, the United Kingdom and the European Central Bank.

[9] See Borio et al (2011) and He and McCauley (2010) on the growth of US dollar credit outside the United States and its policy implications.

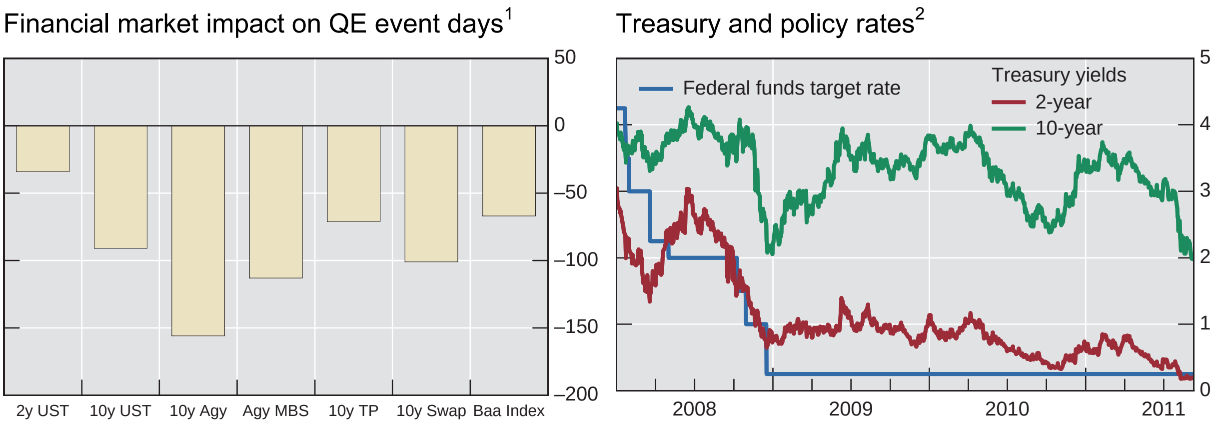
We find significant spillovers from US monetary policy actions to a wide range of emerging financial markets. Averaging across countries, US QE1 had a much larger cumulative effect than US QE2. By way of comparison, Japan's quantitative easing programme earlier in the decade had a somewhat greater impact on the region than did US QE2. This evidence offers clues about the transmission channels through which QE programmes work, and policy implications for the emerging economies going forward, as monetary authorities in the advanced economies contemplate additional monetary easing.

Event study methodology and results

We measure financial market responses to significant announcements about QE programmes, extending the methodology used in Gagnon, Raskin, Remasche and Sack (2010, 2011) to focus on international impact. One important finding of their research is that US QE had the effect of compressing the term spread of US Treasury securities; the 10-year Treasury yields fell much more than the 2-year Treasury yields at the time of the announcement dates (Graph IV.5). With the very short end of the term structure pinned down by the zero lower bound, the yield curve generally pivoted down; this had knock-on effects on other US fixed income securities too.

Graph IV.5

US interest rates



[1] In basis points; from Gagnon et al (2011); 2y UST = 2-year Treasury yield; 10y UST = 10-year Treasury yield; 10y Agy = 10-year agency debt yield; Agy MBS = current-coupon 30-year agency mortgage-backed security yield; 10y TP = 10-year Treasury term-premium; 10y Swap = 10-year swap rate; Baa Index = Baa corporate bond index yield. [2] In per cent.

Sources: Bloomberg; Gagnon et al (2011).

We focus on significant announcement dates associated with QE1 and QE2, making adjustments based on the opening and closing times of emerging financial markets. Then, we estimate the average cumulative 2-day percentage changes in a number of major financial indicators across various emerging financial markets. These include the 2- and 10-year sovereign bond yields, corporate bond yields, sovereign CDS spreads, the US dollar exchange rate and commodity prices. Table IV.1 reports our findings.

The cumulative impact of US QE was to lower EM Asian bond yields, boost equity prices and exert upward pressures on bilateral exchange rates against the USD. During QE1, 2-year yields fell on average across emerging Asia by about 45 basis points, and 10-year yields declined by almost 80 basis points, implying a downward twist at longer maturities; during QE2, 2- and 10-year yields edged down another 9 basis points. In other words, much of the yield curve shifted downwards. Yields on corporate bonds fell significantly, indicating that the programmes impacted risk premia in Asia.

Table IV.1

Cumulative two–day change around announcement days of QE for Asia[1]

	Announcement period	Total amounts (billions)	Gov't 2-year yields (bps)	Gov't 10-year yields (bps)	Corp bond yields[2] (bps)	Sov'gn CDS premia[3] (bps)	Equity prices (%)	FX against USD[4] (%)	Commodity prices[5] (%)
US QE1	Nov 08 to Nov 09	$1,400	–45.37	–79.70	–52.90	–46.92	10.75	4.49	–2.57
QE2	Aug 10 to Nov 10	$600	–9.06	–9.16	–14.84	–4.80	1.53	–0.36	–2.95
JP QE1[6]	Mar 01 to Mar 06	¥30,000	–39.91	–49.07	…	…	7.42	0.86	4.36
QE2	Oct 10 to Aug 11	¥50,000	–9.08	–13.17	–17.93	7.16	–3.89	–0.75	–5.81
BoE	Feb 09 to Feb 10	£200	5.58	18.42	–7.80	22.67	–3.54	0.43	4.64
ECB	Jul 09 to Aug 11	€60	–9.00	–10.91	5.59	15.46	–5.73	–0.73	–6.85

[1] Simple averages of China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. [2] Excluding Indonesia. [3] Excluding India and Singapore. [4] A positive change indicates an appreciation against the US dollar. [5] S&P GSCI composite index, in US dollar terms. [6] As a function of data availability, 2– and 10–year yields exclude China, Indonesia and Malaysia; for corporate bond yields and sovereign CDS premia, data are unavailable.

Sources: Bloomberg; Datastream; Markit; national data; BIS calculations.

In terms of perceived credit risk on sovereign debt, the announcements of the Federal Reserve during the QE1 period significantly reduced emerging Asian sovereign CDS spreads, especially when compared to responses during the QE2 period. One explanation is that the QE1 announcements were seen as a credible Federal Reserve commitment backed up with a demonstrated readiness to act on the balance sheet to combat the intense headwinds coming from the crisis and recession. In fact, QE2 could be seen as a follow-up to this initial commitment, and much of the surprise element was largely lost, as over time the market developed a better understanding of asset purchases.

In addition, the differences reflect the economic conditions at the time. Asian economies were in a much more precarious state at the time of QE1 than during QE2.[10] In the immediate aftermath of the Lehman bankruptcy, the financial meltdown in the advanced economies spread rapidly to emerging Asia, quickly casting a pall on the economy. In this context, QE1 played an important role in countering the forces behind an emerging self-reinforcing financial/macroeconomic downward spiral. At the time of QE2, however, emerging Asia had by and large been experiencing a strong recovery. Unsurprisingly, the impact of QE2 on credit default spreads was fairly muted.[11]

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[10] The chronology of the international financial crisis in Asia can be found in Filardo (2011).

[11] We focus on the aggregate impact of changes in a central bank's balance sheet, instead of the differences in the impacts that might be due to changes in the asset composition of the balance sheet.

Other asset markets have also been affected by QE announcements. Equity prices during QE1 rallied, and emerging Asian currencies experienced some appreciation. The extent of the actual appreciation has to be interpreted carefully. Some of the exchange rate pressure in Asia was addressed by foreign exchange intervention to resist appreciation, especially during the QE2 period. Notwithstanding initial concerns in the region regarding disruptive currency appreciation pressures, significant currency appreciation did not materialise following QE2 announcements. The impact on commodity prices remains a puzzle and hard to reconcile with the equity price movements. More research on the commodity price channel is called for.

One question concerning the effectiveness of central bank QE programmes is the per-dollar impact. Table IV.2 presents the results of converting the cumulative impacts of the QE programmes in Table IV.1 to a USD 1 billion (x 100) equivalent impact on Asian financial markets.

Table IV.2

Per-billion dollar (x 100) impact of QE for Asia[1]

	Announce-ment period	Total amounts (billions)	Gov't 2-year yields (bps)	Gov't 10-year yields (bps)	Corp bond yields[2] (bps)	Sov'gn CDS premia[3] (bps)	Equity prices (%)	FX against USD[4] (%)	Com–modity prices[5] (%)
US QE1	Nov 08 to Nov 09	$1,400	–3.24	–5.69	–3.78	–3.35	0.77	0.32	–0.18
QE2	Aug 10 to Nov 10	$600	–1.51	–1.53	–2.47	–0.80	0.25	–0.06	–0.49
JP QE1[6]	Mar 01 to Mar 06	$258	–15.45	–18.99	…	…	2.87	0.33	1.69
QE2	Oct 10 to Aug 11	$618	–1.47	–2.13	–2.90	1.16	–0.63	–0.12	–0.94
BOE	Feb 09 to Feb 10	$315	1.77	5.85	–2.47	7.19	–1.12	0.14	1.47
ECB	Jul 09 to Aug 11	$83	–10.87	–13.17	6.75	18.67	–6.92	–0.88	–8.27

[1] Simple averages of China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand of the cumulative 2-day changes around announcement days of QE, divided by the total dollar amount of QE x 100. [2] Excluding Indonesia. [3] Excluding India and Singapore. [4] A positive change indicates an appreciation against the US dollar. [5] S&P GSCI composite index, in US dollar terms. [6] As a function of data availability, 2– and 10–year yields exclude China, Indonesia and Malaysia; for corporate bond yields and sovereign CDS premia, data are unavailable.

Sources: Bloomberg; Datastream; Markit; national data; BIS calculations.

The results confirm the impression that US QE2 announcements had a smaller per-dollar impact than did the QE1 announcements. In terms of bond yields and equity returns, the per-dollar impact of QE1 was many times as strong as QE2; the QE2 per-dollar impact on the sovereign CDS spreads and exchange rates was also much smaller.

It is illustrative to compare the impact of the Federal Reserve's QE programmes on emerging Asian financial markets with those of the Bank of Japan, the Bank of England and the European Central Bank. The results indicate that announcements of Japan's past 2001–2006 QE programme had a sizeable per-dollar effect. This is consistent with the general lesson from this experience that the BOJ's unconventional monetary policies were important in preventing the financial system from falling deep into a self-reinforcing deflationary cycle.[12]

Some additional caveats against this type of event study relate to certain inherent limitations. First, by focussing on cumulative responses, one would inevitably include impact from other potentially important events surrounding the announcement dates. The sequence of these and QE events are not examined, hence one could not determine the direction of causality. A window of 2 days helps to reduce this contamination risk but cannot completely eliminate it. Besides, the results using 1-day or 2-day event windows are largely consistent. Second, the event study methodology does not account for co-movements of different financial markets and therefore cannot properly account for contagion that may run across emerging Asian markets.

Third, to the extent that some of the impact of QE programmes occurs outside the identified announcement dates, and QE policy could have non-negligible lags, our study may underestimate the impact of QE programmes on Asia. Inevitably and certainly, we missed some less dramatic announcements, and markets may have learned to better anticipate announcements and move accordingly in advance.

Despite these caveats, the results of the event study clearly suggest that the overall thrust of the results is consistent with the view that the Federal Reserve's QE programmes had an important cross-border spillover on emerging Asia. Moreover, the US QE programmes have had differential impacts across economies in Asia. Graphs IV.6 and IV.7 report the cross-economy cumulative 2-day changes in Asian financial markets. The results reveal a rather diverse set of impacts between QE1 and QE2. However, there are some patterns that emerge by focusing on the most and least affected thirds of Asian economies.

The relatively large estimated per-dollar impact of the ECB's programme and the somewhat counter-intuitive estimated impacts of the Bank of England's programme on Asian financial markets raise questions about the extent to which reliable inferences can be drawn from these event studies. Robustness tests are needed in future research.

It is clear that those economies most affected – both on the high side and the low side – differ across the two US QE programmes. In other words, QE1 and QE2 did not affect the region in a uniform way. Some economies that responded strongly in QE1 were not the ones that responded strongly in QE2. This suggests that the spillovers are context dependent.

For US QE1, Hong Kong SAR, Korea and Indonesia stand out as the economies most positively affected in terms of yields and equity returns. The latter two also saw big moves in CDS spreads and USD exchange rates. This is consistent with the fact that these economies were more heavily hit by the initial phase of the global financial crisis. For Hong Kong SAR and Korea, the impact reflects strong trade ties and the importance of cross-border financing with the United States. In the case of Indonesia, the credit rating and general vulnerabilities to the global economy via commodity exports appear to account for the sensitivity. The Philippines and Thailand, on the other hand, were much less affected than the rest of emerging Asia, at least in terms of financial market reactions to announcements during the QE1 period.

For the US QE2 announcements, the results are rather mixed. Sovereign CDS spreads declined in almost all the emerging economies under analysis, while the Philippines saw its yields drop much more than the others. China, Thailand, Hong Kong SAR and Argentina experienced a significant rally in their equity markets. One factor that might account for this was the pace of foreign reserve accumulation. In some of these economies, foreign reserve

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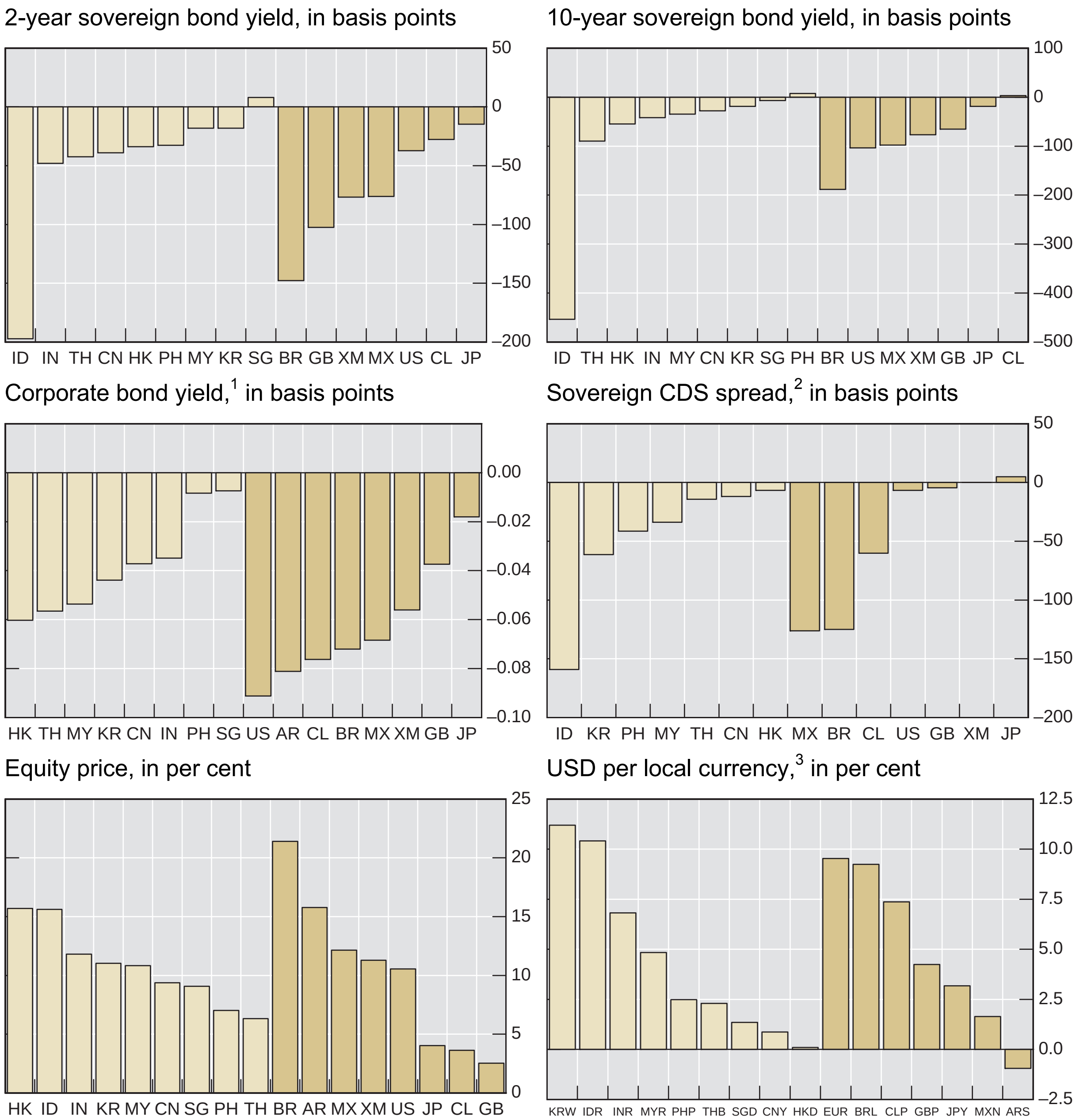
[12] For example, see Ugai (2007).

accumulation was rapid. Markets may have seen further QE as an indication that policy rates would stay low and foreign reserve accumulation continue. In contrast, those economies that found themselves in the bottom of the ordering were diverse, defying any obvious systematic interpretation.

Graph IV.6

Cumulative two-day changes around announcement days of QE1

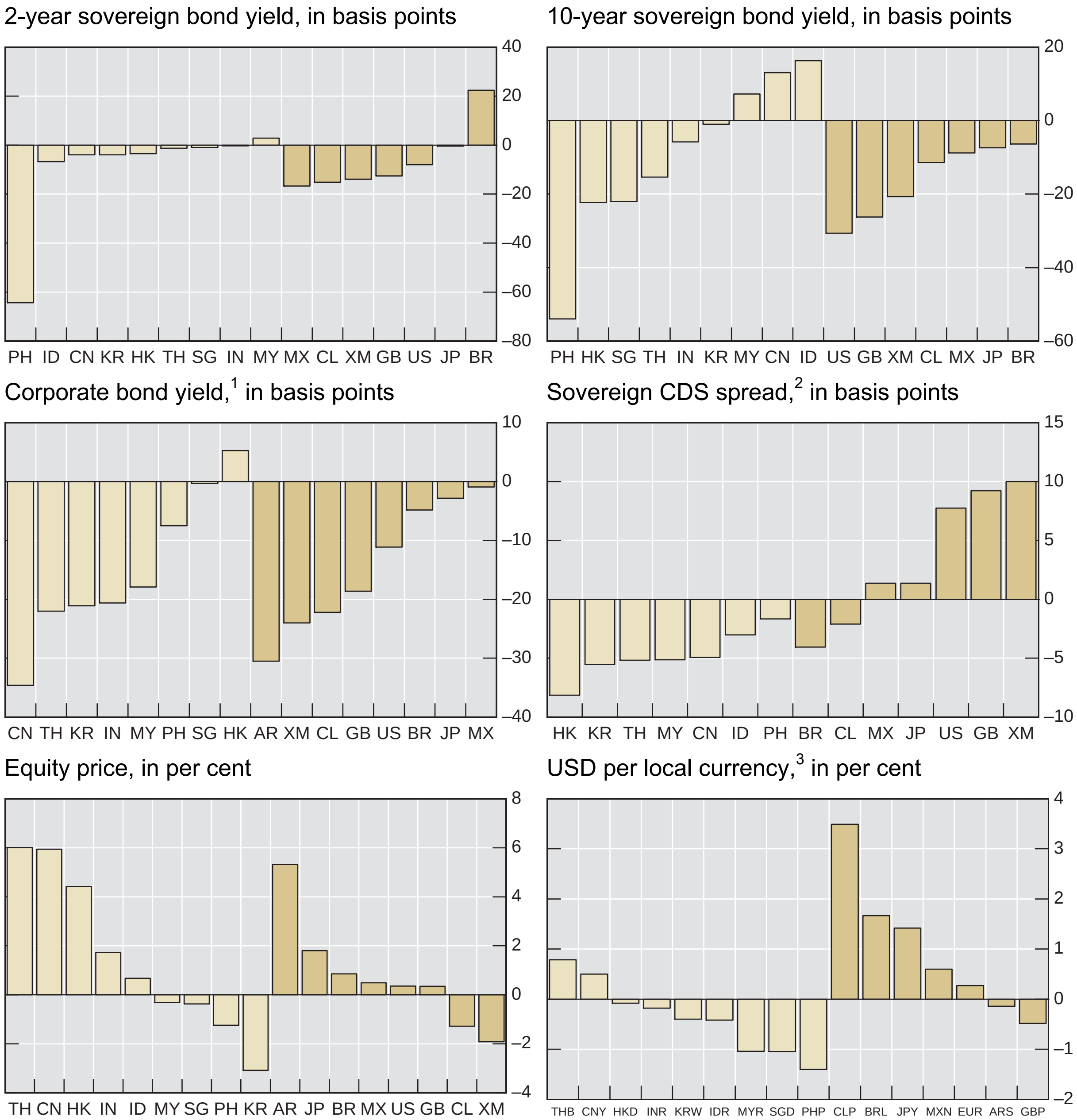


[1] Merrill Lynch AAA-bond yields for GB, JP, US and XM; JPMorgan Corporate Emerging Markets Bond Index (Broad) yield for others. [2] Senior 5-year CDS spreads. [3] A positive change indicates appreciation against the US dollar.

Sources: Bloomberg; CEIC; Datastream; JPMorgan; Markit; national data.

Graph IV.7

Cumulative two-day changes around announcement days of QE2



[1] Merrill Lynch AAA-bond yields for GB, JP, US and XM; JPMorgan Corporate Emerging Markets Bond Index (Broad) yield for others. [2] Senior 5-year CDS spreads. [3] A positive change indicates appreciation against the US dollar.

Sources: Bloomberg; CEIC; Datastream; JPMorgan; Markit; national data.

Tentative conclusions from financial market responses to QE programmes

Overall, the event study provides evidence that unconventional policy easing in the advanced economies has had an expansionary impact on the emerging economies. This is consistent with several channels through which QE works. The most direct channel is through the pricing of global financial assets. As the US term premium fell, interest rates fell globally.

QE also works through a confidence channel, as emerging financial markets deem the large-scale asset purchases credible and manage to deduce possible impact from such purchases. The QE1 and QE2 announcements themselves were seen as firm commitments to future actions. One reason the QE1 results were stronger than the QE2 results is that the Federal Reserve made it quite clear how far it was willing to go to backstop the private sector in the United States. Without a doubt, this had the effect of reducing the generalised aversion to risk globally, as seen in the large CDS spread movements at the time of QE1 announcements versus those seen during the QE2 period.

In sum, in this section we document the immediate impact of QE announcements by central banks in advanced economies on emerging financial markets. The results suggest US QE has spilled over geographical borders through various channels, especially through the role of the US term structure in setting a benchmark for pricing global assets, through a confidence channel reflecting perceptions of the strength of the global economy and international investor risk aversion, through an interest rate channel via US dollar credit created outside the United States, and, especially, through an endogenous monetary policy response channel in emerging Asia that captures policies aimed at narrowing international policy rate differentials. To further understand these channels and to consider the more enduring effects of QE policies, we now turn to a GVECM econometric method.

IV.2. Impulse response analysis

We estimate a global vector error-correction model (GVECM) to assess the longer-term effect of US central bank balance sheet policy on the emerging economies.[13] We examine the effects of a reduction in the US term spreads on real and financial variables in both the advanced and emerging economies, paying special attention to the relative strength of different channels of domestic and international transmission.

Changes in the US term spread between 10-year and 3-month Treasury yields may be a good indicator of US Federal Reserve balance sheet policies when the zero lower bound on nominal interest rates becomes binding, and when the major objective of Fed asset purchase programmes has been to reduce long-term bond yields.[14] Even in normal times, term spreads may be a useful indicator of interest rate policy, as central banks often act to shape public expectations of a specific policy path well into the future. We also use US corporate spreads as an indicator for US quantitative easing, and the results are not very different.

Domestic effect of a US term spread shock

We present in Graph IV.8 the impulse responses to a negative US term spread shock of about 20 basis points (one standard deviation from the shock) over 36 months, estimated on the basis of the pre-crisis sample (February 1995 to December 2006), the full sample (February 1995 to December 2010) and the crisis sample (January 2007 to December 2010). The crisis-sample impulse responses are derived from impulse responses estimated from the pre-crisis and full samples, assuming that the full-sample estimates are a weighted average of the pre-crisis-sample and crisis-sample estimates.

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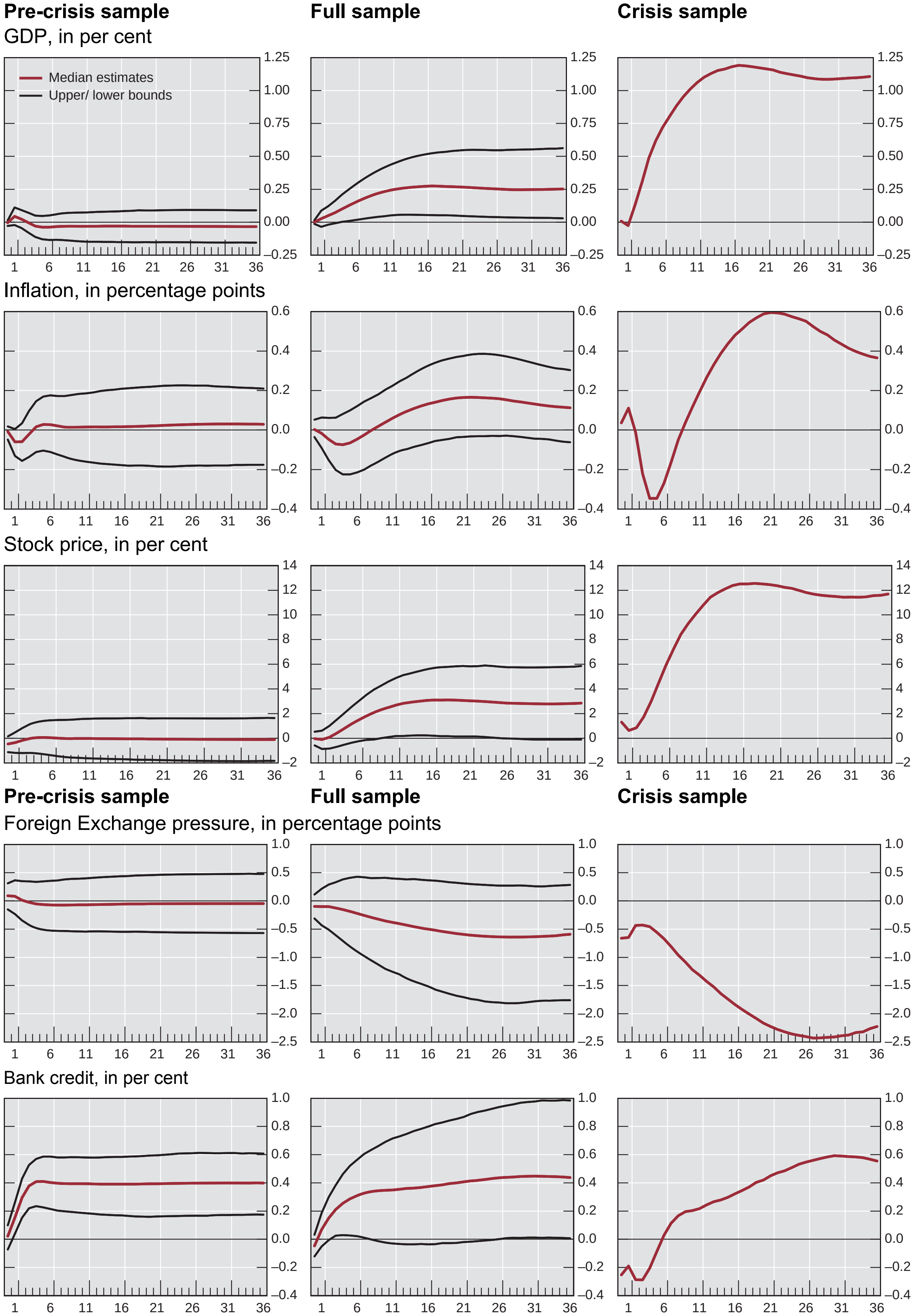
[13] See Appendix II for details of the model. We follow Pesaran, Schuermann and Weiner (2004).

[14] See Blinder (2010) for an analysis of central bank quantitative easing, and in particular, the attempts by central banks to lower both term premia and risk spreads with the unconventional policies.

Graph IV.8

Impulse response functions of US



Source: authors' estimation based on Global Error Correction Model.

Interestingly, impulse responses estimated from the pre-crisis sample are insignificant for almost all variables except for bank credit, suggesting that bank lending could be the main channel of monetary policy transmission in the 1995–2006 period. There are considerable differences in the impulse responses estimated from the full and pre-crisis samples, in terms of the sizes rather than the direction of responses. Full-sample estimates turn out to be clearly larger for all variables, and statistically significant for output, equity prices and bank credit. Assuming linearity, the estimates suggest that within one year, a 100-basis-point cut in US term spread leads to large increases in output (1.25%), equity prices (15%) and bank credit (2%).

The full-sample responses show the historical average impact of lowering the US term spread. Comparing results from pre-crisis and full samples suggests that the US economy reacted much more strongly to changes in US term spreads in the aftermath of the crisis. Small sample size prevents us from directly estimating post-crisis impulse responses with a global VAR model. To capture the effects of quantitative easing embedded in the post-crisis sample, we need to deduce the crisis-sample impulse responses from estimates based on the pre-crisis and full samples. More precisely, we assume that the estimated full-sample impulse responses are a weighted average of pre- and post-crisis sample estimates, and suppress the crisis-sample impulse responses accordingly. We can then infer the impact of term spread cuts induced by US quantitative easing, by examining differences between the two sets of estimated impulse responses – for samples before January 2007 and subsequently.[15] The results are shown in the third column of Graph IV.8.

In fact the more significant full-sample responses appear to have been a result of much greater crisis-sample impulse responses to variations in the US term spreads, precisely during the period when US quantitative easing was implemented. A 20-basis-point cut in the US term spread would increase output by over 1.1% in 12 months, and inflation by 0.6 percentage point in 20 months. Bank credit also rises by about 0.6% in 30 months, following an initial decline lasting about 5 months. Stock prices rise strongly by about 12% twelve months after the term spread shock. In addition, the US dollar depreciated immediately by over 0.6% and lost around 2.4% of its value by two years after the term spread reduction. Indeed, a permanent cut in the US term spread could have a sizeable impact on the domestic economy, and all major transmission channels seem to have come into play. In fact, a large cut in the US term spread could have a much greater impact.

International impact of a US term spread shock

We investigate the impact of US quantitative easing on the other major advanced economies, emerging Asia and Latin America in this section, focusing on the impulse responses computed for the crisis sample. Graph IV.9 shows the maximum impact of the crisis-sample impulse responses to a US term spread shock over a five-year horizon.

Three observations are warranted. First, the impact on the other major advanced economies is relatively muted. US term spread shocks do lead to a significant increase in equity prices in the euro area, Japan and the United Kingdom. The equity prices in these three countries rose in tandem with the US asset prices in the first year, but they seem less persistent and gradually fall back to the original levels afterwards. This means the confidence channel could have played the major role in the spillover among the advanced economies. Impulse responses (Graph IV.9.1) show that the trade channel is also non-negligible, although weaker. In addition, real GDP in the advanced economies rises in a pattern similar to the pattern in the United States, but by less. The weak impact on real GDP and inflation in these

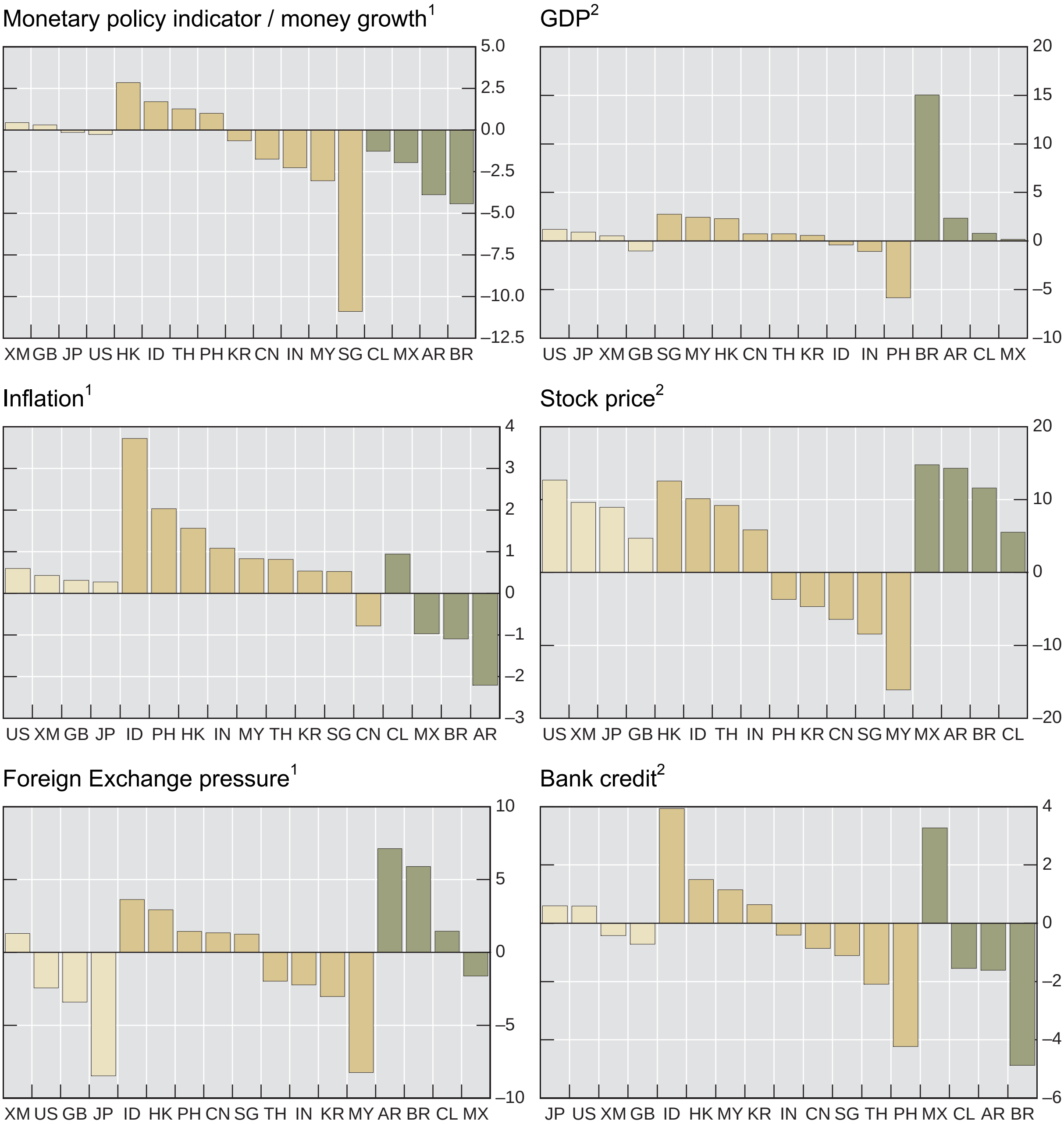
[15] The weights are determined by the lengths of the two sub-samples relative to the full sample.

economies could reflect their own domestic economic and financial market difficulties, and also the endogenous monetary policy responses to the US term spread shock. The euro area and UK tend to slightly tighten their policy rates in response to increases in equity prices and real GDP, moderating the impact of US monetary easing. In contrast, with a high degree of trade dependence, Japan lowered its term spread, and this led to a sharp depreciation of the yen and an output level slightly higher than the European economies in the medium run.

Graph IV.9

Maximum impulse response functions

Crisis sample



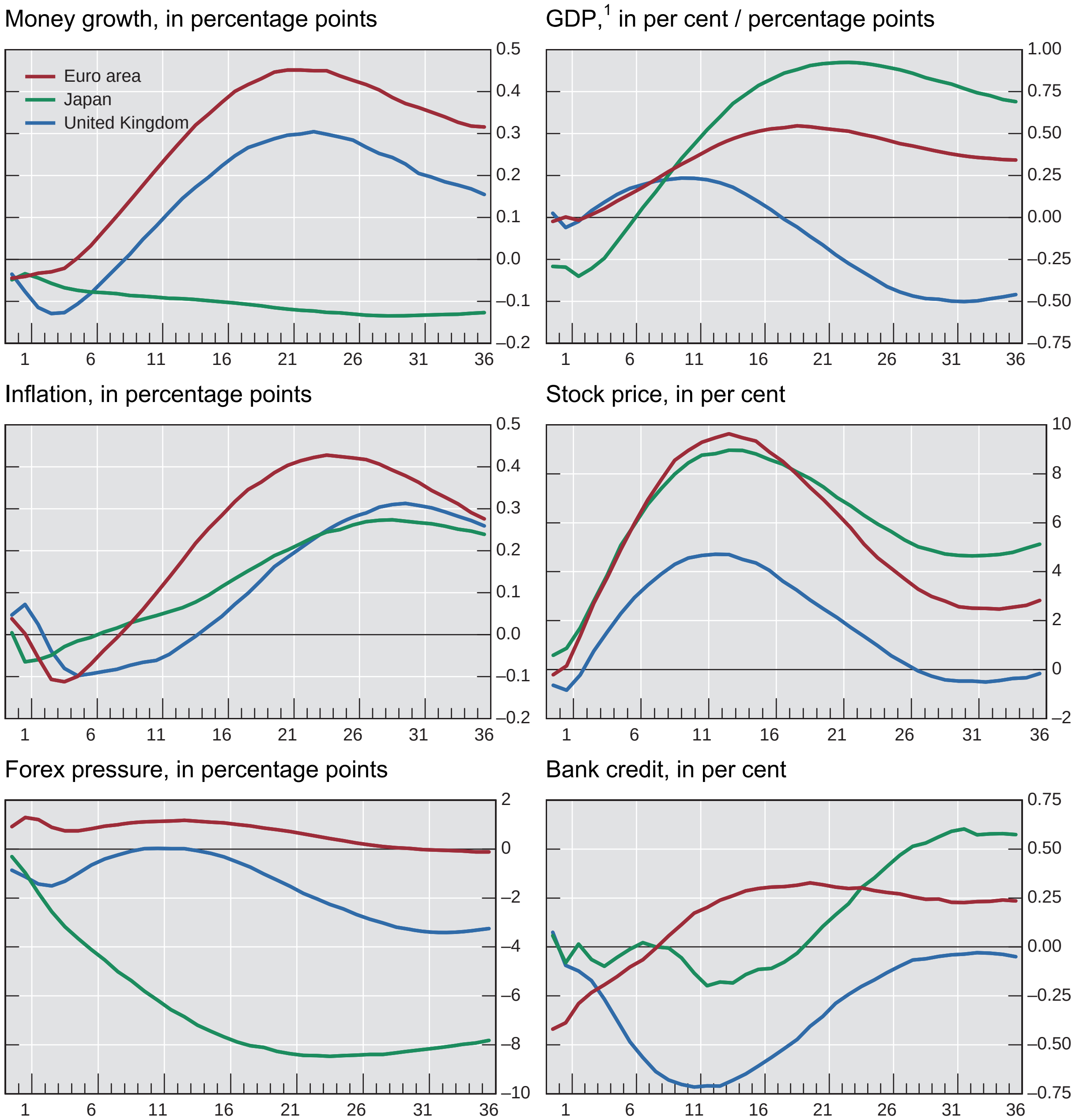
[1] In percentage points. [2] In per cent.

AR = Argentina; BR = Brazil; CL = Chile; CN = China; GB = United Kingdom; HK = Hong Kong SAR; ID = Indonesia; IN = India; JP = Japan; KR = Korea; MX = Mexico; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; XM = Euro area.

Source: Authors' estimation based on Global Error Correction Model.

Graph IV.9.1

Impulse response functions (median estimates) of advance economies



[1] Growth rate (in percentage points) for United Kingdom and level (in per cent) for others.

Source: Authors' estimation based on Global Error Correction Model.

Second, the impact on the emerging economies is significant and appeared to have been widespread. The US term spread shock affects all variables: real GDP, inflation, stock prices, bank credit, foreign exchange pressure and money growth. This indicates that several different transmission channels may have been at play.

Third, the impact of US quantitative easing may have differed significantly across economies and across variables, implying that different transmission and adjustment mechanisms might dominate in different economies. Moreover, the impacts on the US economy and on some emerging economies actually have opposite signs, suggesting that benefits and costs have not been distributed evenly. For instance, while the impact on real GDP is below 2.5% in most emerging economies, the US term spread shock increased output by 15% in Brazil and contracted it by over 5% in the Philippines. While the impact on inflation is positive for all emerging Asian economies except China, it is negative for the Latin American economies except for Chile.

In addition, compared to its domestic impact, US quantitative easing turns out to have far greater impact on most emerging economies. This is true for almost all variables except for stock prices, where the US domestic impact is also sizeable. Bank credit and inflation are two good examples. In the emerging Asian economies, the increase in inflation ranges from 0.5 in Singapore to almost 4 percentage points in Indonesia, while US inflation rises at most by 0.6 per cent.

How have the effects of US quantitative easing differed within emerging Asia and Latin America, and how have the policy responses in these economies affected the corresponding output and inflation dynamics? To address these questions, we first examine in greater detail the crisis-sample impulse responses in emerging Asia to a drop of about 20 basis points in the US term spread (Graph IV.10).

On the other hand, the impact on real GDP is muted in most emerging Asian economies. But Hong Kong, Singapore and Malaysia, the smaller and more trade-dependent economies, clearly benefit from US monetary easing, with output rising by more than 2% within two years. Curiously, in most economies, inflation drops in the first year, before rising slowly in the second year. The greatest inflationary impact is felt in Hong Kong, Indonesia and the Philippines.

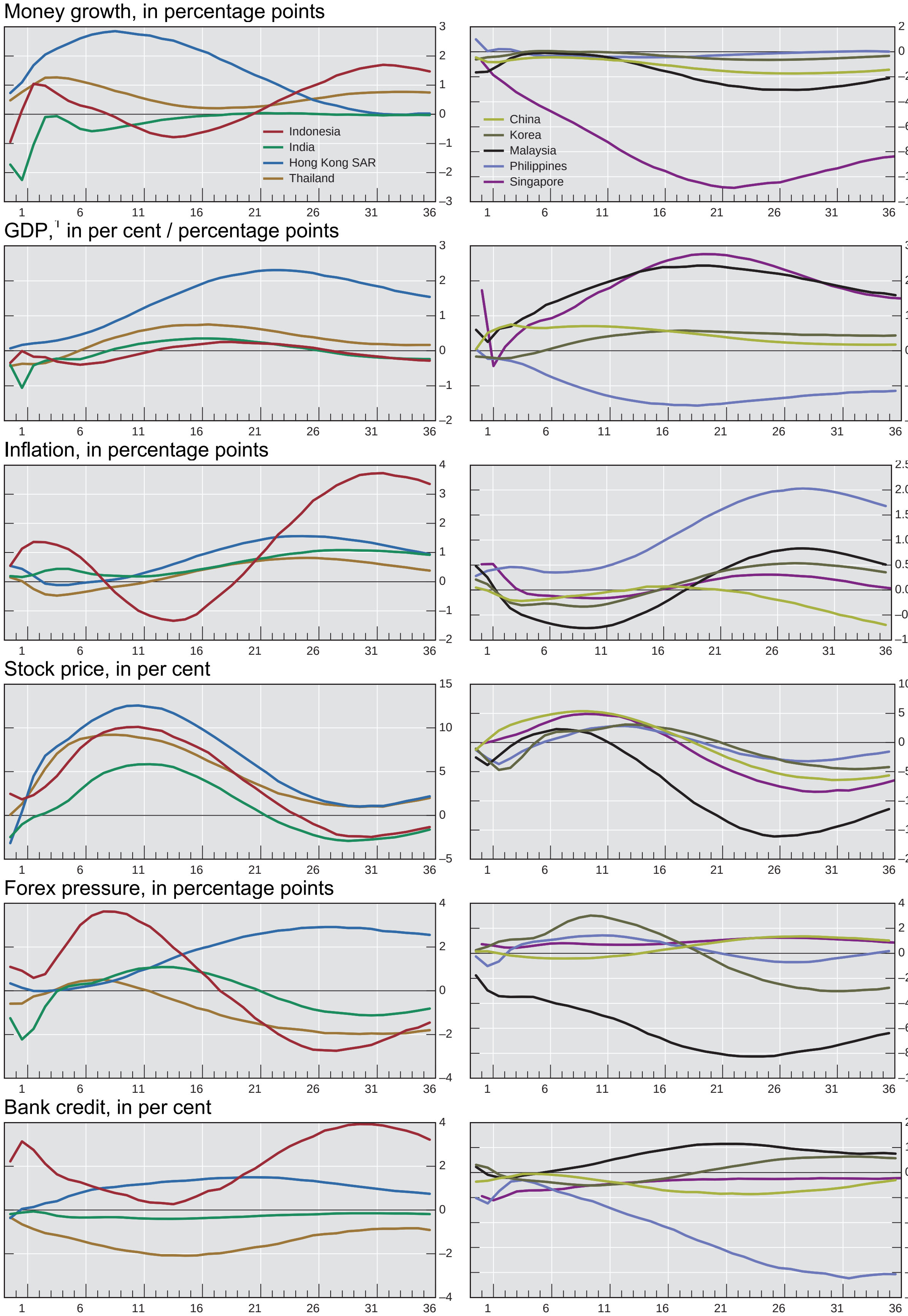
Third, the impulse responses in the form of foreign exchange pressure, money growth and bank credit in the emerging Asian economies do not seem to have uniform patterns. This probably reflects differences in the transmission channels and in the adjustment mechanisms each economy chooses to rely on. Unsurprisingly, with a currency board, Hong Kong's money growth increased at the fastest pace and to the largest extent in emerging Asia. Indeed, without an independent monetary policy, Hong Kong had no choice but to follow US monetary easing and increase money supply. In addition, bank credit in Hong Kong kept growing steadily at a strong pace over the 36-month horizon. Notably, foreign exchange pressure in Hong Kong actually rose in about six months, even though the HK dollar should have depreciated relative to currencies of most trading partners, as it is pegged to the US dollar. One might attribute this to the increased foreign reserve associated with strong capital inflows. In fact, the currency board regime implies that Hong Kong would not be able to adjust to the US term spread shock with its exchange rate, and that the adjustment might have to go through capital flows and growth in money and credit.

In India and Korea, foreign exchange pressures also rose in the first year and a half. Yet estimated impulse responses suggest that money growth in these countries did not increase, indicating a possible tightening of monetary policy. Responses in real GDP and inflation remained muted. Countries in which bank credit and money growth remained stable tended to see inflation rising two to three years after the US term spread shock. In Indonesia, bank credit and money growth rose, peaking in the third year, following a decline in the second year. Real GDP remained roughly unchanged. In Malaysia, the foreign exchange pressure declined, indicating a possible currency depreciation, while bank credit increased six months after the shock. Real GDP increased by about 2% in two years, and inflation climbed by around 0.8 percentage points.

In emerging Asia, Hong Kong, Indonesia and the Philippines appear to be among the economies reacting most strongly to the US quantitative easing, with China and Korea among the least affected. This may be attributed to differences in the size and nature of these economies.

Graph IV.10

Impulse response functions (median estimates) of emerging Asia



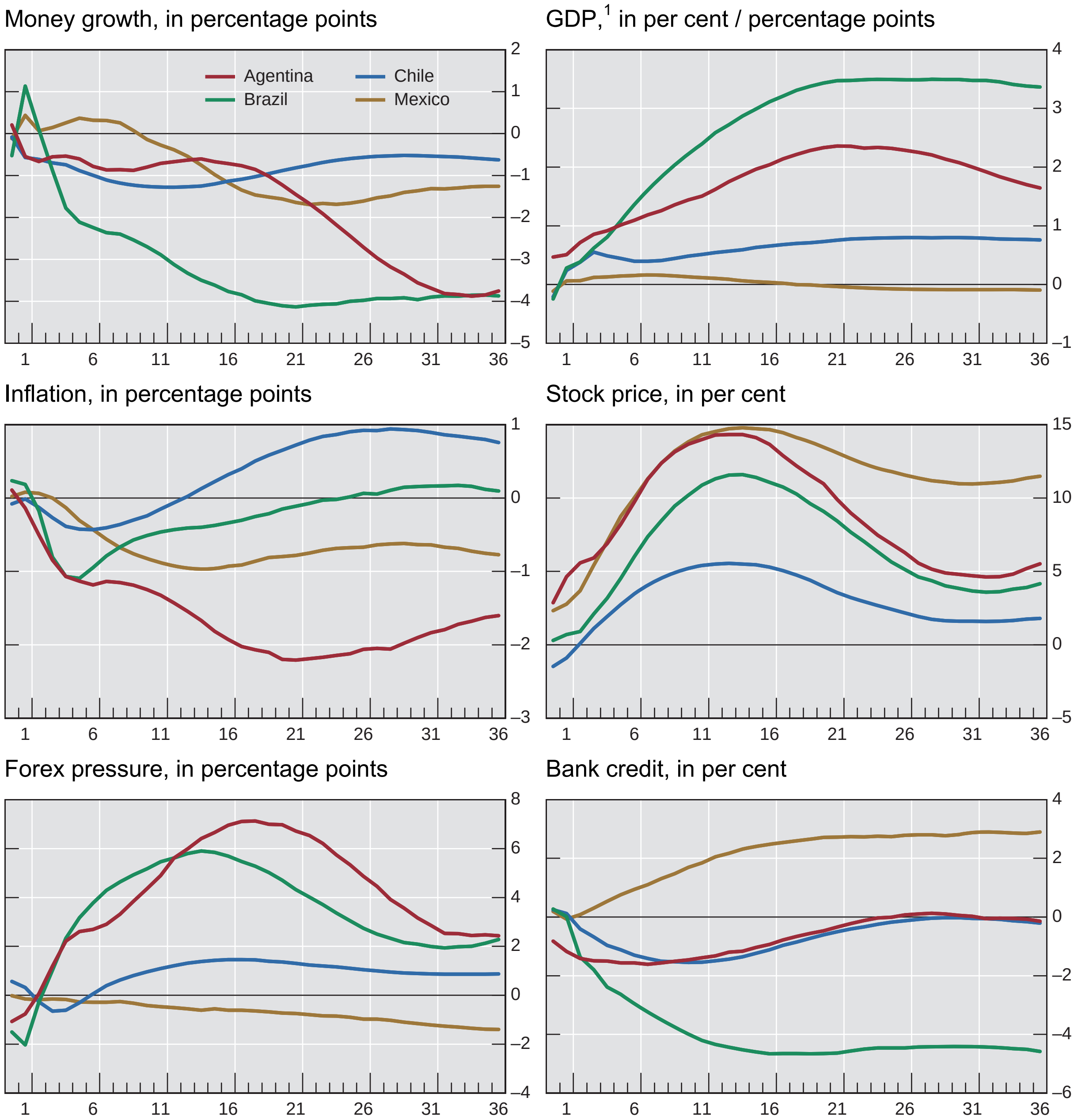
[1] Growth rate (in percentage points) for Philippines, and level (in per cent) for others.

Source: Authors' estimation based on Global Error Correction Model.

The impact of US quantitative easing in the Latin American countries was less diverse but also much stronger than in emerging Asia (Graph IV.11). Stock prices in all four economies rose strongly – by almost 15% in Argentina and Mexico and by over 11% in Brazil by the end of first year. Currency appreciation pressures appear strong and rising in Argentina, Brazil, and to a lesser extent Chile, supporting the claims of significant USD devaluation impact from US quantitative easing in economies with more flexible currency regimes. On the other hand, both bank credit and money growth declined in the latter three countries, which may imply a policy tightening. The impact on real GDP is most significant in Brazil, and the US quantitative easing seems to be deflationary for the Latin American economies, bar Chile.

Graph IV.11

Impulse response functions (median estimates) of Latin America



[1] Growth rate (in percentage points) for Brazil and level (in per cent) for others.

Source: Authors' estimation based on Global Error Correction Model.

Robustness check

The results of impulse response analyses are robust to different specifications of variables, including using base money growth instead of broad money growth, and using the US federal funds rate for the term spread instead of the 3-month Treasury bill rate. They are also robust to different ordering of the variables in our identification schemes for the unconventional monetary policy shocks. Specifically, the results change little if we assume that term spread reacts to stock price in addition to real GDP and inflation contemporaneously.

IV.3. Effects of quantitative easing per GVECM model

Given the very short period of time that has passed since the introduction of the large-scale asset purchasing programmes, the empirical results should be seen as work in progress and the conclusions as tentative. Uncertainties remain large surrounding both the strength and pace of transmission of US quantitative easing to financial and real activities. In fact, the pre-crisis norm of domestic and cross-border monetary policy transmissions may have been severely impaired following the global financial crisis. The ongoing experiments with balance sheet policies, a set of tools neither the practicing central banks nor the private sector is familiar with, could imply that it take time for economic agents to learn how such policies are transmitted and adjust their behaviour accordingly. All this adds difficulties to our work.

In this section, we try to gain a better understanding of the impact of quantitative easing by constructing different counterfactual scenarios about the US term spread, using the full-sample estimates of the impulse responses that we obtained in the previous section. We then compare the actual data with the counterfactual scenarios in order to gauge possible effects of the US quantitative easing supposedly reflected in the actual data. Nevertheless, we need to bear in mind that the actual data would also reflect many other factors affecting the global economy following the global financial crisis; these may include supply-side shocks such as euro area sovereign debt crisis and fluctuations in commodity prices.

Actual data indicate that, corresponding to US Federal Reserve asset purchases, the US term spread between 10-year and 3-month Treasury yields dropped sharply in December 2008, by 83 basis points, from 3.18% to 2.35%, remaining low in the subsequent months. In July 2009, the spread fell further by 19 basis points, from 3.53% to 3.34%.

We construct counterfactual scenarios in which the US Federal Reserve asset purchases were assumed to be zero, i.e., not implemented at all. We do so by assuming that the US term spread did not decline between December 2008 and June 2009, and then from July 2009 to April 2010. We design three scenarios: first, the term spread remained constant within each period at the average values of November 2008 (3.18%) and June 2009, respectively; second, within the above-mentioned two periods, US term spread is assumed to rise by 10 basis points in each and every month, e.g., the term spread rises to 3.28% in December 2008 and 3.38% in January 2009; third, the term spread has a jump of 200 basis points at the beginning of each period (e.g. 5.18% in December 2008) and then stays 200 basis points above the actual path of the US term spread. The three alternative policy paths are termed “constant”, “increasing” and “jump” scenarios respectively. The first panel of Graph IV.12 shows both the actual events and these three policy paths.

Domestic impact

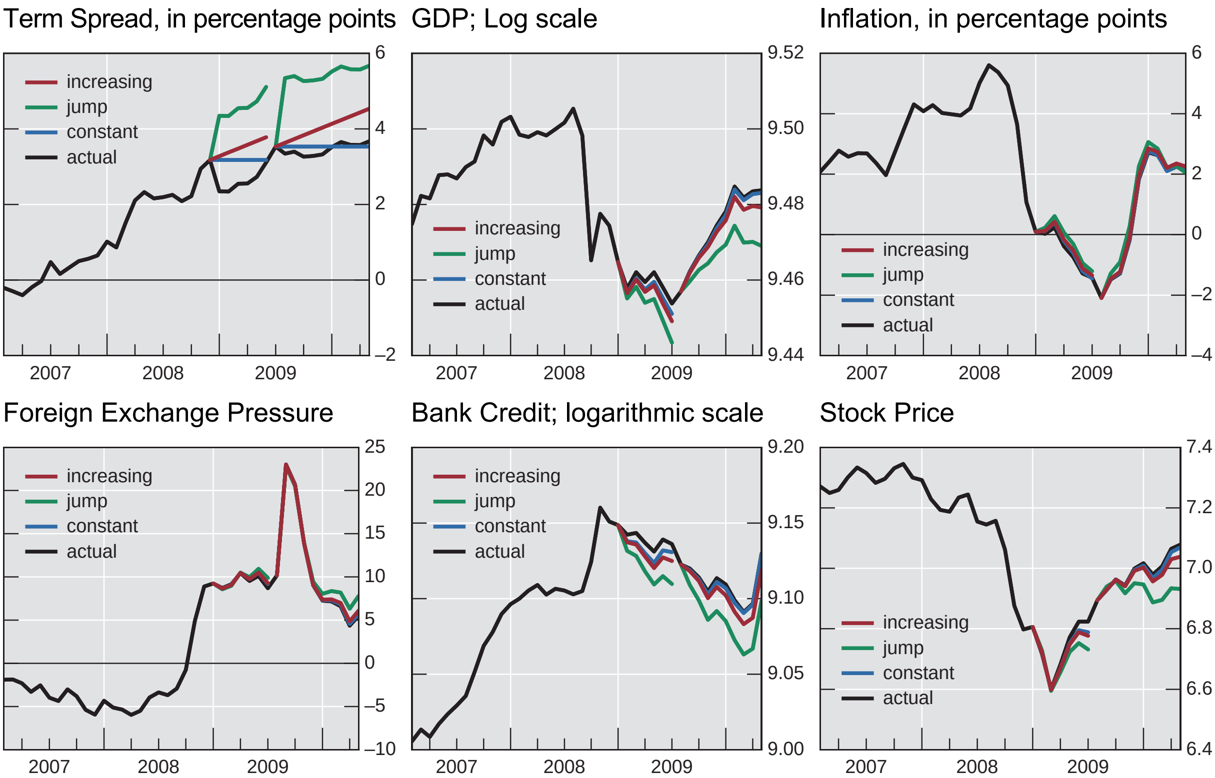
Counterfactual analysis suggests that US quantitative easing could indeed have had a significant domestic impact. Assuming that the two phases of asset purchases (December 2008 to June 2009, and July 2009 to April 2010) managed to keep US term spreads at levels lower than otherwise, such actions indeed facilitated the US recovery. Notice that in both periods, the US term spread actually drifted back midway through the asset purchases to levels higher than when the asset purchases began (see the black and blue lines in Graph IV.12). This means that such asset purchases did not quite manage to cut US term spreads below the levels that obtained when quantitative easing began. There are two possibilities: first, there were economic factors such as adverse supply shocks which counteracted the effects of asset purchases and pushed US term spreads higher than they would have been; second, the effect of US asset purchases on term spreads was short-lived and such effects diminished and died out even before each phase of the programme was completed.

Graph IV.12 compares the dynamics of US domestic variables in three counterfactual scenarios with their actual path. First, the most significant impact was probably on US stock prices, with actual values rising more rapidly and staying constantly above those in other scenarios. By June 2009, equity prices would have been 3.5% lower if the US term spread had remained at the 2008 November level, and 4.6% lower should the spread have continued to rise. Proportionally, the effect in the second phase was smaller, as the US term spread fell less than in the first phase.

Graph IV.12

Counterfactual analysis – United States

In per cent



Source: Authors' estimation based on Global Error Correction Model.

Second, lowering the term spread may have lent significant support to US bank credit in both periods. Judging this against the stated goal of boosting bank credit flows, the LSAP programmes could be seen as a success. Third, compared to the scenario of a "jump" in the US term spread, Fed asset purchases may indeed have led to a significant depreciation in the US dollar, as suggested by Yellen (2010). Finally, while lowering the term spread does not seem to have had much of an impact on US inflation, it did provide a strong boost to US real GDP, shaking off an otherwise rather severe decline in output in the first half of 2009, and promoting more solid growth since July 2009.

The results so far suggest that the domestic impact of US quantitative easing was sizeable, and that it could have been larger if not for certain major events which could have driven US long-term yields higher. Among the candidate factors driving up US sovereign yields were the euro area sovereign debt crisis and concerns with the US fiscal situation, which eventually led to a downgrading of the US credit rating by Moody's. Nevertheless, US quantitative easing appears to have worked pretty well through the confidence, liquidity, and bank lending channels, and currency depreciation may also have helped.

International impact

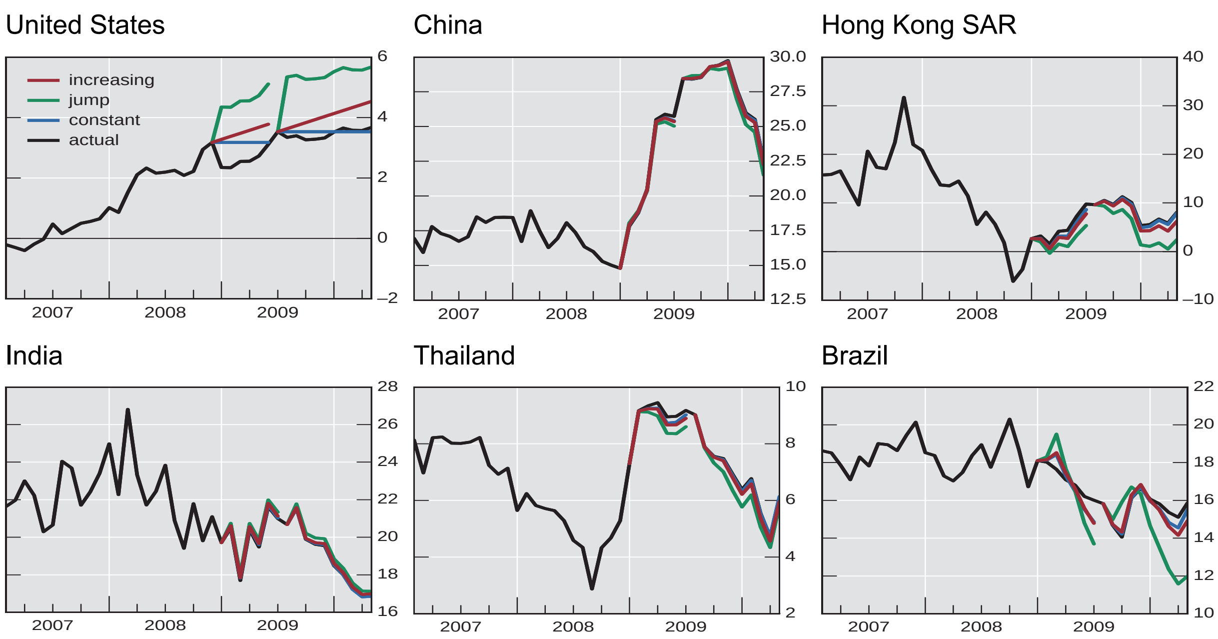
Counterfactual analysis in this section shows that US quantitative easing, through a reduction in the long-term bond yields or term spreads, indeed has had a significant impact on the emerging economies. Moreover, as we discussed in the previous section on the estimated impulse responses, the impact tends to be diverse both across economies and across variables, reflecting equally diverse policy responses, exchange rate regimes and economic structures.

Compared to the more stressful scenarios of a 200 basis point jump in the US term spread or a 10 basis point monthly increase, broad money growth turned out to be stronger in Brazil and Hong Kong, two economies with complete different exchange rate arrangements (Graph IV.13). The Hong Kong currency board forces the economy to maintain rather low interest rates, but money supply had to rise to accommodate low interest rates. On the other hand, with flexible exchange rates Brazil probably experienced significant capital inflows. But money growth in China and India remained basically the same as the actual path in all three counterfactual scenarios. In China, much of the capital inflow pressure may have been absorbed through foreign reserve accumulation, which could be completely sterilised.

Graph IV.13

Counterfactual analysis – monetary policy indicator[1]

In per cent



[1] Monetary policy rate for US and money growth for others.

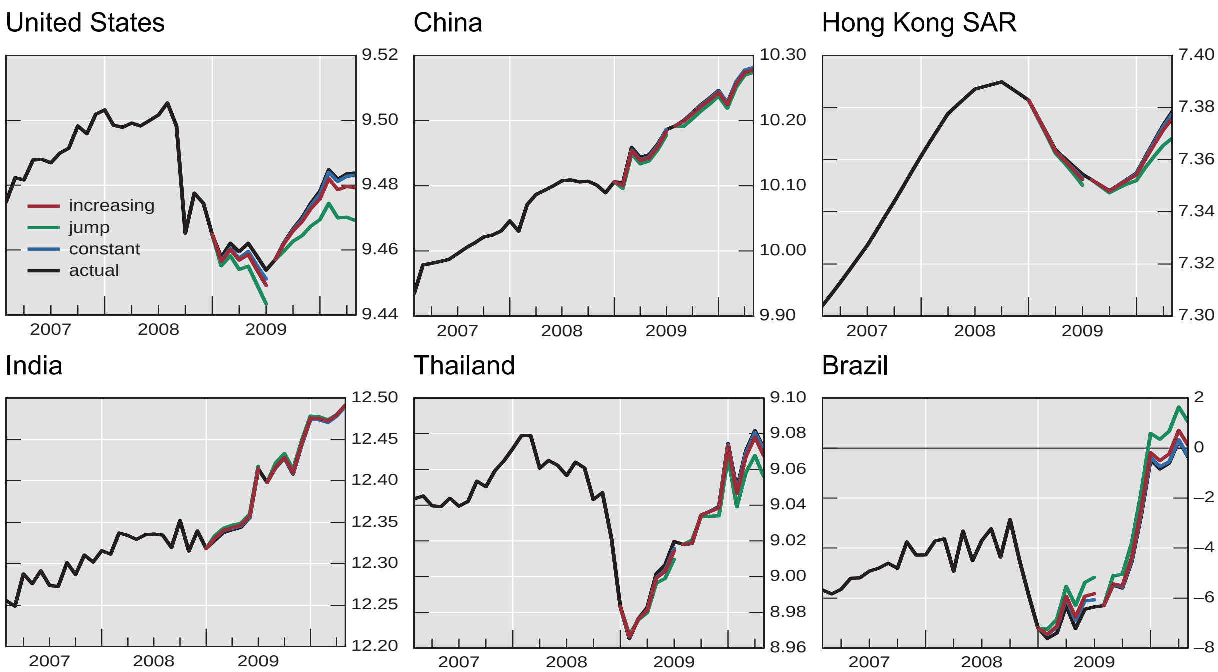
Source: Authors' estimation based on Global Error Correction Model.

Interestingly, the paths of real GDP in China and India were also little affected by changes in US term spreads (Graph IV.14). In fact, following the global recession, domestic demand became a main driver of growth in the two countries, and there was probably some degree of "decoupling" in their recovery from that of the advanced economies. However, in the smaller emerging Asian economies like Hong Kong and Thailand, output would be lower without a reduction in the US term spread. Curiously, in both phases of US asset purchases, real GDP would be higher in Brazil should the US term spread increase, suggesting a completely different mechanism at work. One possibility is that without US quantitative easing, the Brazilian real would not appreciate so much and external demand would support stronger output growth in Brazil.

Graph IV.14

Counterfactual analysis – real GDP

Natural logarithm of the level



Source: Authors' estimation based on Global Error Correction Model.

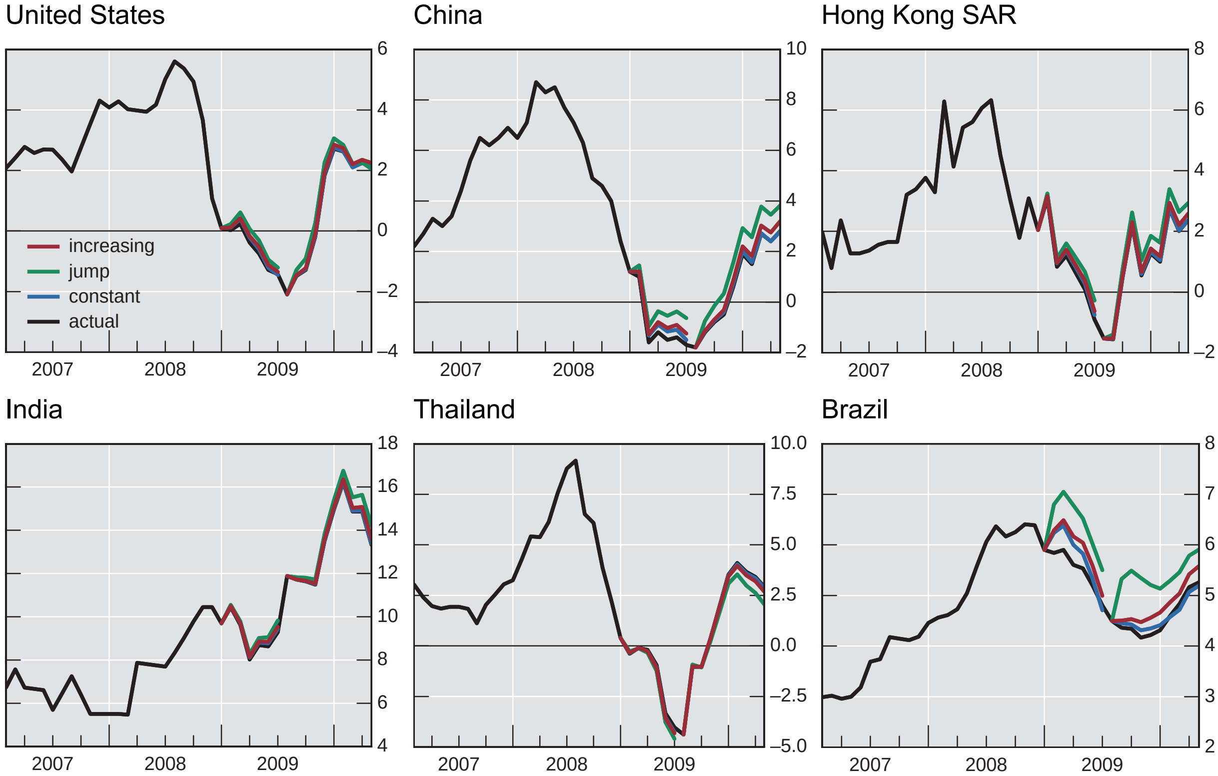
While US quantitative easing had little impact on US domestic inflation, its cross-border impact is diverse (Graph IV.15). The inflation impact in the first phase of asset purchases turned out to be smaller than in the second phase in Hong Kong, India and Thailand. More interestingly, while lowering US term spread led to inflationary pressure in Thailand, it caused deflationary pressures in the other economies. Indeed, such deflationary pressures were sizeable in Brazil and China. It is possible is that a significant reduction in the US term spread could reflect a bleak US economic outlook and be interpreted as indicating a prominent US recession, causing a downward adjustment in global growth prospects and in inflation. In Brazil, if a cut in the US term spread leads to sizeable appreciation of the real, this could imply lower inflation.

The impact of US quantitative easing conforms to expectation. The impact was not big on the emerging Asian economies (Graph IV.16), so capital inflows probably were not sufficient to cause major currency appreciation pressures. On the other hand, a cut in the US term spread did push up the Brazilian real very significantly in both periods of US asset purchases, confirming worries by Brazilian policymakers regarding the currency impact of US quantitative easing.

Graph IV.15

Counterfactual analysis – inflation

In per cent

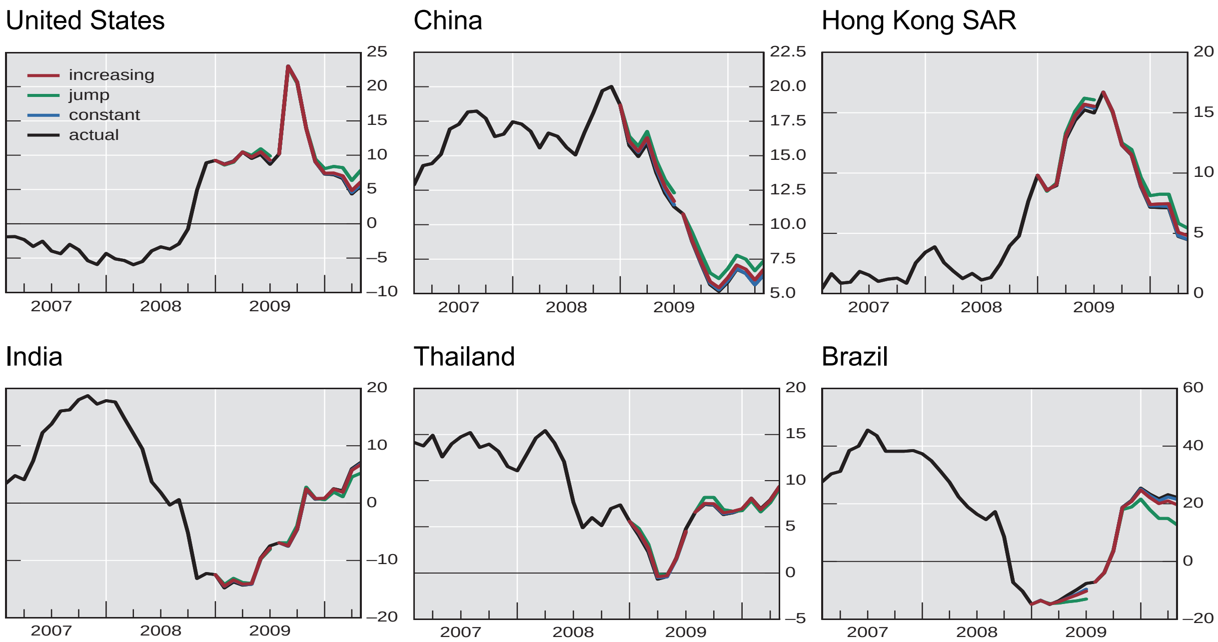


Source: Authors' estimation based on Global Error Correction Model.

Graph IV.16

Counterfactual analysis–foreign exchange pressure

In per cent

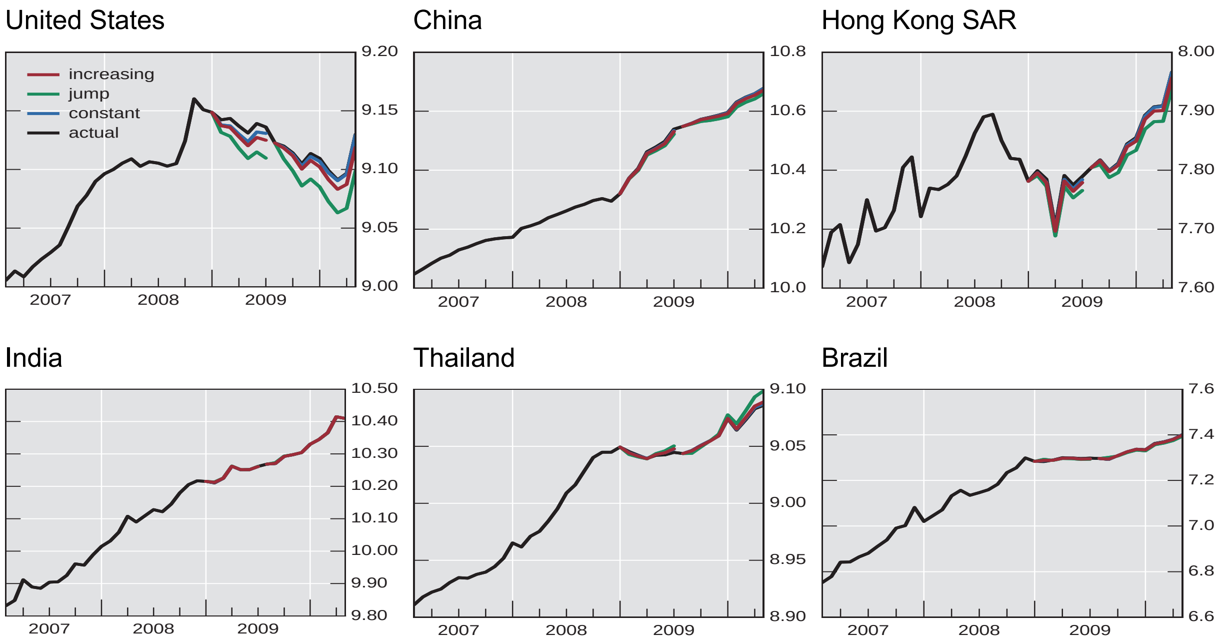


Our analysis suggests that the cross-border spillover effect of US easing on bank credit was very small, except probably for Hong Kong and Thailand (Graph IV.17). Bank credit would have been lower in Hong Kong without a cut in the US term spread in both phases of US asset purchases, but would have been slightly higher in Thailand. Evidence of any significant impact on bank credit is rather weak in Brazil, China and India.

Graph IV.17

Bank credit

Natural logarithm of the level



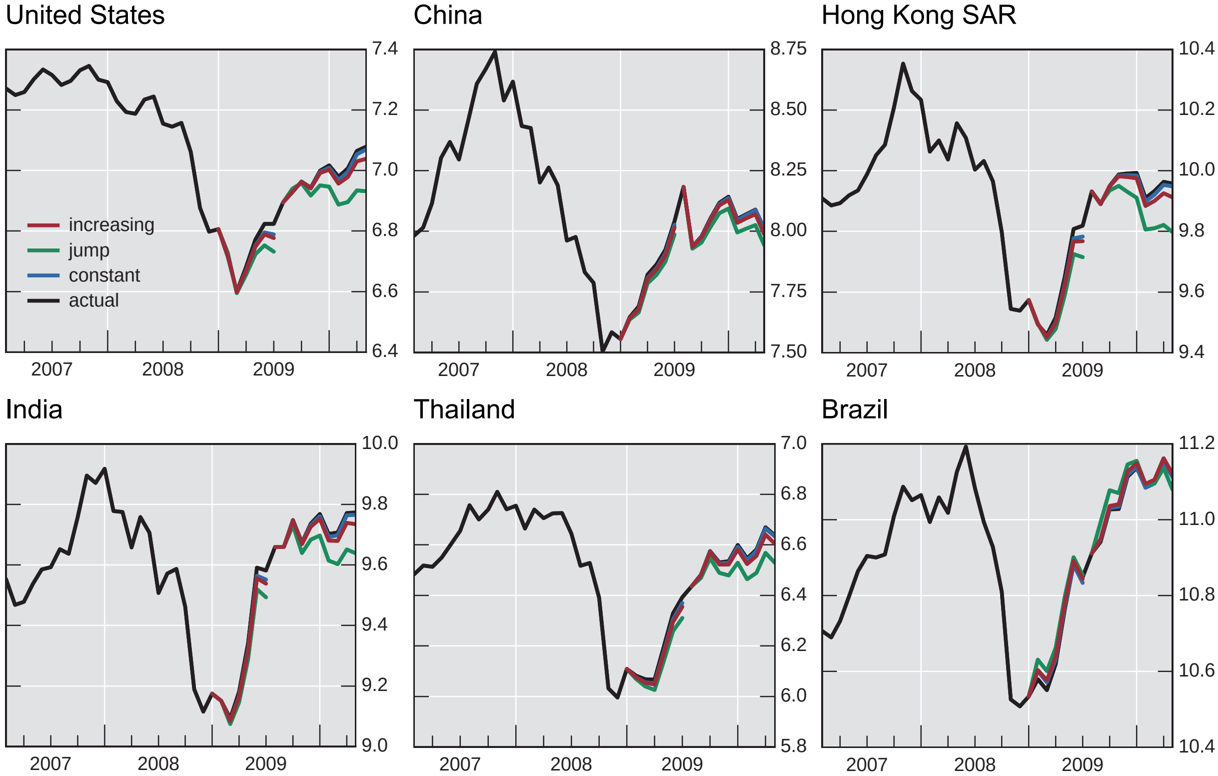
Source: Authors' estimation based on Global Error Correction Model.

Last but not least, liquidity and confidence channels could be a significant factor. Stock markets across the emerging economies were affected by the US term spread cut (Graph IV.18). Most emerging economies would have experienced slower recovery of equity prices or even recorded a significant decline without a lower US term spread. The impact was most obvious in Hong Kong, India and Thailand. For example, at the end of the first phase of US asset purchases, stock prices in Hong Kong would have been 3.6% lower without such actions, an impact larger than seen in the US stock market. For the same period, equity prices in India would have been 2.9% lower.

Graph IV.18

Counterfactual analysis – stock prices

Natural logarithm of the level



Source: Authors' estimation based on Global Error Correction Model.

V. Conclusion

In this paper, we examine the domestic and cross-border consequences of the recent central bank balance sheet policies, with a special emphasis on several advanced economies and the emerging economies in Asia and Latin America. We first use event study techniques to study the impact of such policies on the global financial markets. Then we rely on an estimated global VAR model to analyse the effects of Federal Reserve balance sheet policies on real activity in other economies, and to better understand both the domestic and international transmission of central bank quantitative easing policy.

Event studies reveal sizeable expansionary impact on the emerging economies from US quantitative easing, and the global asset price channel seems to play a significant role. The effects tend to be larger in the emerging economies than in the US domestic markets. Furthermore, such effects differed across economies, and the impact of US QE1 and QE2 also differed in the emerging economies. The US quantitative easing lowered emerging Asian bond yields, boosted equity prices and exerted upward pressures on bilateral exchange rates against the dollar. During QE1, 2-year yields fell across emerging Asia by about 45 basis points on average, and 10-year yields declined by almost 80 basis points, implying a downward twist at longer maturities; during QE2, 2- and 10-year yields edged down another 9 basis points. Corporate bond yields fell significantly, indicating a reduction of risk premia in emerging Asia.

Analyses based on an estimated global VAR model suggest that US quantitative easing has had a sizeable impact on emerging economies in the short and medium term. The computed impulse responses reveal significant differences across economies in how each endogenous variable evolves following a reduction in the US term spread, and also major differences in the behaviour of various endogenous variables within each economy. First, the impact on the other advanced economies is relatively muted, except for a significant increase in equity prices in the euro area, Japan and the United Kingdom. Second, the impact on the emerging economies is significant and appears to be widespread. In addition, the impacts on the US economy and on some emerging economies actually have opposite signs, suggesting that benefits and costs have not been distributed evenly. Third, compared to its domestic impact, the US quantitative easing turns out to have far greater impact on most emerging economies. In emerging Asia, inflation increases ranged from 0.5 in Singapore to almost 4 percentage points in Indonesia, while US inflation rose at most by 0.6 percentage points.

Counterfactual analysis suggests that in terms of domestic transmission of the US quantitative easing, the most significant impact was probably on US stock prices. Asset purchases were also transmitted through the bank lending and currency depreciation channels. The effect in QE2 was smaller than in QE1, as the US term spread also declined less in QE2. From an international perspective, Brazil and Hong Kong were among the economies most affected by the US quantitative easing, although not in the same way. Brazil suffered most from strong currency appreciation and CPI deflationary pressures, while the impact on Hong Kong was most strongly felt on equity prices, bank credit, and real GDP. Interestingly, Brazil has a flexible exchange rate while Hong Kong has a currency board. Both economies responded to the US quantitative easing with a significant increase in money growth. The results validate the view that US quantitative easing indeed could have a large impact on some emerging economies. But such impact is far from uniform, and may be small in other economies.

Differences in responses may reflect significant differences across economies in terms of stage of development; institutions; monetary, fiscal and financial policy frameworks; strength of trade and financial linkages; and exchange rate regimes, among many other factors. The emerging economies may use different adjustment mechanisms and react to US unconventional monetary policy measures in different ways. Looking forward, the results suggest that another round of quantitative easing would represent a challenge for some emerging economies.

Appendices:
Methodology and data

Appendix I: event studies of announcement effects: an international perspective

Contained in the main text.

Appendix II: structure of the GVECM Model

The Global Vector Error Correction model (GVECM) developed by Pesaran, Schuermann and Weiner (2004) provides a multilateral dynamic framework for the analysis of interdependence and international transmission of country-specific shocks among a large number of economies. The post-crisis sample would be too small to yield meaningful estimates of the impact the central bank asset purchase programmes on the merging economies. But assuming that the model itself and parameter estimates remain little changed after the global financial crisis and recession, such impact could still be studied using estimates from the pre-crisis sample or the complete sample. Indeed, our results confirm that international transmission of US monetary policy may have remained little affected following the crisis despite a potentially significant change to the domestic transmission of its policy.

The structure of the Global VAR (GVECM) model can be summarized as follows. Consider N+1 economies, indexed by i = 0, 1, 2, ..., N, and a vector xit of k_i domestic variables for each economy. Stacking the vectors of country-specific variables,

$$\mathbf{x}_t = \left(\mathbf{x}_{0t}', \quad \mathbf{x}_{1t}', \quad ..., \quad \mathbf{x}_{Nt}'\right) \tag{1}$$

a VAR in $\mathbf{x}_t$ would contain too many parameters to be estimated if the time dimension T of the data is not much larger than the number of economies N. Instead of regressing $\mathbf{x}_{i,t}$ on

$$\mathbf{x}_{-i,t} = \left(\mathbf{x}_{0t}', \quad \mathbf{x}_{1t}', \quad ,..., \quad \mathbf{x}_{i-1,t}', \quad \mathbf{x}_{i+1,t}', \quad ,..., \quad \mathbf{x}_{N,t}'\right) \tag{2}$$

without any restriction, GVECM links $\mathbf{x}_{i,t}$ to a $k_i^* \times 1$ vector $\mathbf{x}^*_{i,t}$, where

$$x^*_{\ell it} = \sum_{j=0}^{N} \omega_{\ell ij} x_{\ell jt}, \quad \ell = 1, 2, ..., k_i^*. \tag{3}$$

The weight ω_{lij} captures the spillover effect of variable l of foreign economy j on variable l of domestic economy i. Since ω_{lij} measures the relative importance of economy j to economy i, the spillover effect of variable l is in proportion to the weight chosen to measure the relative importance. Therefore, each economy's component of GVECM is given as a VARX (p_i, q_i):

$$\mathbf{x}_{it} = \mathbf{a}_{io} + \mathbf{a}_{i1} \cdot t + \sum_{s=1}^{p_i} \mathbf{\Phi}_{is} \mathbf{x}_{i,t-s} + \sum_{s=0}^{q_i} \mathbf{\Lambda}_{is} \mathbf{x}^*_{i,t-s} + \sum_{s=0}^{r_i} \mathbf{\Psi}_{is} \mathbf{d}_{t-s} + \mathbf{u}_{it} \tag{4}$$

with $u_{it} \overset{iid}{\sim} \left(0, \sum_i\right)$,

where $\mathbf{d}_{t-s}$ is the observed common factor of $q \times 1$ dimension and $\boldsymbol{\varepsilon}_{it}$ is iid across time. Country-specific vector $\mathbf{x}^*_{i,t-s}$ reflects interdependence among economies and serves as a proxy for the unobserved common effects across economies. The country-specific foreign variables and common factors are treated as weakly exogenous (if confirmed by statistical tests), i.e., they are "long-run forcing" country-specific domestic variables. The term "long-run forcing" means that in the equations for foreign variables, the coefficients on the error-correction terms are set to zero. The dynamics of foreign variables are not influenced by deviations from the long-run equilibrium path, in contrast to the dynamics of domestic variables.

The VARX can be estimated economy by economy using the ordinary least squares (OLS) method or rank-reduced approach if the cross-dependence of the idiosyncratic shock is sufficiently small; that is:

$$\sum_{j=0}^{N} Cov\left(\varepsilon_{\ell it}, \varepsilon_{sjt}\right)/N \to 0, \tag{5}$$

all $i \neq j$, *l and s.*

From equation (3), it can be seen that

$$\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_t \qquad i = 1, 2, \ldots, N \tag{6}$$

Where $\mathbf{z}_{it} = \left(\mathbf{x}_{it}^{'} \quad \mathbf{x}_{it}^{*'}\right)$, and where $\mathbf{W}_i$ is an appropriately defined weighting scheme. Thus, stacking (4) across i , the endogenous variables can be solved for in a global system:

$$\mathbf{G}\mathbf{x}_t = \mathbf{a}_{i0} + \mathbf{a}_{i1} \cdot t + \sum_{s=1}^{p} \mathbf{\Phi}_s \mathbf{x}_{t-s} + \sum_{s=0}^{r} \mathbf{\Psi}_s \mathbf{d}_{t-s} + \mathbf{u}_t \tag{7}$$

Thus:

$$\mathbf{x}_t = \mathbf{G}^{-1}\mathbf{a}_{i0} + \mathbf{G}^{-1}\mathbf{a}_{i1} \cdot t + \mathbf{G}^{-1}\sum_{s=1}^{p} \mathbf{\Phi}_s \mathbf{x}_{t-s} + \mathbf{G}^{-1}\sum_{s=0}^{r} \mathbf{\Psi}_s \mathbf{d}_{t-s} + \mathbf{G}^{-1}\mathbf{u}_t \tag{8}$$

where $p = \max\{p_i, q_i\}$, $r = \max\{r_i\}$, and

$$G = \begin{pmatrix} A_0 W_0 \\ A_1 W_1 \\ \vdots \\ A_N W_N \end{pmatrix}, \quad H_s = \begin{pmatrix} B_{s,0} W_0 \\ B_{s,1} W_1 \\ \vdots \\ B_{s,N} W_N \end{pmatrix}, \quad u_t = \begin{pmatrix} u_{0,t} \\ u_{1,t} \\ \vdots \\ u_{N,t} \end{pmatrix}. \tag{9}$$

Equation (8) is a VAR for the complete set of domestic variables for all economies.

The advantage of the GVECM model is that it makes the estimation of (8) feasible by accounting for interdependence among economies and then estimating the partial system on an economy-by-economy basis, which implies allowing for modelling a large number of economies. The impulse response is computed based on (8).

Appendix III: GVECM Model Specification

We rely on a GVECM model to examine the domestic and cross-border impact of central bank balance sheet policies, using data on 17 economies. These include four advanced economies: the United States, euro area, Japan and the United Kingdom; nine emerging economies in Asia: China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand; and four economies in Latin America: Argentina, Chile, Brazil and Mexico. Model estimation is based on monthly macroeconomic and financial data for the period ranging from February 1995 to December 2010.

In models for each individual economy, the set of endogenous variables include the following. On a logarithmic scale: real GDP, bank credit and equity prices; in terms of level: an indicator of monetary policy and a foreign exchange pressure index; and: inflation as year-on-year change in CPI.[16] The set of exogenous variables includes foreign financial variables, foreign real GDP and foreign inflation. For any economy, the foreign variables are constructed as the weighted averages of the corresponding variables in all other economies. Oil price, on a logarithmic scale, is included for each economy but with different specifications to account for different country dynamics.

The VARX are specified differently for the economies under analysis. First, in the US model, oil prices are assumed to be endogenous and depend on the dynamics of US domestic variables. But we exclude foreign financial variables as these are assumed to be weakly exogenous for the US economy: given the important impact of the US economy on global financial markets, non-US financial variables are less likely to be weakly exogenous to US domestic variables.

Second, for all non-US economies, oil prices are taken as weakly exogenous – as a common factor underlying the global economy which is assumed to be little affected by domestic conditions in the non-US economies.

Third, we use money growth as the monetary policy indicator for the emerging markets. This is due to the fact that, in the already short sample period we examine, some emerging economies have combined the use of several policy instruments and operation targets, and the relative importance of each instrument has changed over time as well. For the advanced economies, the term spreads between 10-year and 3-month government bond yields are used as monetary policy indicators for the US and Japanese economies. This is particularly useful to capture measures based on changes in a central bank's balance sheet.[17] Policy interest rates are used as the monetary policy indicator for the euro area and the United Kingdom.

Fourth, we use an exchange rate pressure index, a weighted average of changes in nominal effective exchange rates (NEER) and foreign reserves to measure possible tensions arising from capital flows. The index, a variant of the index proposed by Eichengreen, Ross and Wyplosz (1995), takes into account different exchange rate regimes as well policy interventions by the respective governments.

One key issue is how to faithfully measure the strength of cross-border transmission channels. In the past, cross-country linkages have been largely based on bilateral trade data, and financial linkages have tended to be ignored for want of accurate data. A more recent strand of literature has taken financial linkages into account but ignored important temporal evolutions in such linkages. One novelty of this paper is the use of BIS cross-border bank lending statistics data to gauge the time-varying strength of the financial channels of international spillovers. This is essential given the high degree of global financial integration and a large increase in all types of capital flows in the last two decades. Yet limitations on data, especially those on broader bilateral financial activities beyond bank lending, prevent us from measuring the financial linkages with greater precision. Details of weight construction and data sources are provided in Appendix III.A.

We use data on both bilateral trade and cross-border bank lending as weights to construct the foreign variables for each economy, which would reflect bilateral financial and real linkages. The weights are time-varying so as to take account of potentially large and volatile

[16] Real GDP growth rates are used for Brazil, the Philippines and the United Kingdom in order to satisfy the stability assumption of the GVECM model.

[17] See Blinder (2010) for an exposition of the issue.

movements in such linkages, especially in banking flows among the advanced and emerging economies. In addition, trade weights, computed on the basis of bilateral export and import, should reflect sizeable changes in the global trade pattern to reflect the rising shares and changing structure in the trade of several major emerging economies. See Appendix III.B for detailed information about data sources and transformations.

Appendix III.A: Construction of foreign exchange pressure index

The exchange pressure index EMP_t measures the pressure of capital inflow. In economies with flexible exchange rate regimes, strong net capital inflow pushes up the demand for domestic currency, which in turn leads to an appreciation of the domestic currency. If the authorities intervene in the foreign exchange market by purchasing foreign currency with domestic currency, we may not observe significant changes in exchange rate of the domestic currency, but rather an increase in foreign reserves of the authorities' balance sheet. In economies with fixed exchange rate regimes, strong net capital inflow is reflected in the increase of foreign reserves only. Therefore, the foreign exchange pressure index is constructed in the following way, which is a variation of the index proposed by Eichengreen, Ross and Wyplosz (1995):

$$EMP_t = 100 \cdot (w_{t,e} e_t + w_{t,rev} rev_t)$$

where

$w_{t,X} = \dfrac{\sigma_{t,X}^{-1}}{\sigma_{t,e}^{-1} + \sigma_{t,rev}^{-1}}$ for $X = e, rev$, with σ_t being the standard deviation of the corresponding variable in the previous five years, for weights of the sixth year onward. For weights of the first five years, the standard deviation computed from data covering the first five years is used.

Moreover, $e_t = \ln(E_t) - \ln(E_{t-12})$ and $rev_t = \ln(R_t) - \ln(R_{t-12})$, where E_t is the NEER and R_t denotes the foreign reserves.

Construction of time-varying weight for foreign variables

The weight of country I assigned to country j at year t is written as

$W_{ij,t}^{agg} = w_{i,t}^T W_{ij,t}^T - w_{i,t}^F W_{ij,t}^F$, for all $i \neq j$,

where $W_{ij,t}^T$ and $W_{ij,t}^F$ are the bilateral trade and financial weight computed based on the capital inflow and outflow in the previous year. $w_{i,t}^T$ and $w_{i,t}^F$ are the relative importance of trade flow and capital flow in a country respectively. They are computed according to the value of the respective aggregate trade flow (export and import) and capital flow (capital inflow and outflow) relative to the total value of these two types of flow in the previous year. The financial weight of countries without capital flow data in the 1990s is set to zero.

Appendix III.B: Data

Data sources include the IMF's International Financial Statistics, CEIC, Bank for International Settlement (BIS), Bloomberg and Datastream.

Variable	Description	Source	Notes
Real GDP		IMF IFS, national data	Real GDP of China is at 1990 prices, those of other countries at 2005 prices (billions of domestic currency units). The monthly time series are interpolated using method of Chow and Lin (1971) with industrial production series as a reference. Series for HK is interpolated using compound growth rate due to unavailability of monthly industrial production.
Inflation	Year-on-year change in consumer price index	CEIC, IMF IFS, national data	
Bank Credit			In billions of domestic currency units. Data before Sept. 1997 is computed using growth rate of banks' loan to non-government and non-banks; for China, data before Jun 1999 is interpolated from quarterly data, using monthly data on loans in China with Chow and Lin (1971) method.
Policy Rate	Short-term policy interest rate	Bloomberg, Datastream, BIS, national data	Bank of England base rate for UK and main refinancing operations, middle rate for euro area from 1999 onwards. Policy rate of Germany is used for euro area before 1999.
Term Spread	Interest rate spreads between 10-year and 3-month Treasury bill yield	CEIC, IMF, IFS, national data	Only data for United States and Japan are used.
Money Growth	Year-on-year M2 growth rate	CEIC, IMF IFS	Billions of domestic currency units.
Stock Price	Stock price index	Bloomberg	Index of stock prices in each country is in "List of Stock Price Index".
	Nominal effective exchange rate	BIS	Period average; 2005 = 100.
Foreign Exchange Pressure	Foreign Reserve	IMF IFS	Total reserves minus gold, in billions of USD. Euro area data starting from Jan 1999 are official reserves as published by ECB; data before 1999 either is estimated or is the aggregate reserves of 11 EU Member States participating in the euro area in 1999.
Oil price	spot oil price	IMF IFS.	Brent crude oil, US dollar per barrel; period end data.
Export/import		IMF IFS	Millions of USD.
Cross-border bank lending	BIS reporting banks' cross-border claims	BIS	
Capital inflow/outflow		IMF IFS	

List of stock price index

United Kingdom	FTSE 100 Index
Japan	Nikkei 225 Index
United States	S&P 500 Index
Euro area	Euro Stoxx 50 (Price) Index
China	Shanghai A-share Stock Price Index
Hong Kong SAR	Hang Seng Index
India	Bombay Stock Exchange Sensitive Index
Korea	KOSPI Index
Indonesia	Jakarta Stock Price Index
Malaysia	FTSE Bursa Malaysia KLCI Index
Philippines	Philippine Stock Exchange PSEi Index
Singapore	FTSE Straits Times Index
Thailand	Bangkok SET Index
Argentina	Buenos Aires Stock Exchange Merval Index
Brazil	São Paulo Stock Exchange Boverspa Index
Chile	Santiago Stock Exchange IGPA Index
Mexico	Mexican IPC Index

Annex table: empirical results on the impact of unconventional monetary policies

Paper	Methodology	Main results	Other interesting findings
Bernanke, Reinhart and Sack (2004)	Event study	• 400 bps (±370 bps) in Japan • 40 bps (±60 bps) in US	•
Blinder and Zandi (2010)	Moody's analytics' model, impact on real activity	• GDP ↑ 6 pps by 2011 Q2 • Unemployment rate ↓ 3 pps (or 5 million jobs) • Inflation ↑ 1.7 pps	• Moody's model is used to assess economic impact of monetary & fiscal stimulus. • The combined effect is larger than sum of the two. • Monetary stimulus has a bigger impact than fiscal boost.
Campbell, Covitz, Nelson and Pence (2011)		•	•
Chung, Laforte, Reifschneider and Williams. (2011)	DSGE model simulations, impact on real activity	• Unemployment rate ↓ 1.5 pps • Inflation ↑	•

Annex table: empirical results on the impact of unconventional monetary policies (cont)

Paper	Methodology	Main results	Other interesting findings
D'Amico and King (2010)	Event study and regression analysis of financial market impact	• 100 bps (±80 bps)	•
Doh (2010)	Regression analysis	•	•
Gagnon, Raskin, Remasche and Sack (2010, 2011)	Event study and regression analysis of financial market impact	• Tsy yields 30-100bps • Agency/MBS rates ↓ 100–150bps • Corporate/swap rates 60–100bps	• The key driving force for the yield reduction comes from falling term/ liquidity premium rather than lower policy rate expectations. • Announcement effect far outweighs operation effect (actual purchase).
Glick and Leduc (2011)		•	•
Goldman Sachs	Descriptive and regression analysis, on financial market and real impact	• $1 tri purchase will reduce Tsy yields ↓ 100 bps • GDP ↑ 7 pps • Mortgage rate 80 bps	• Announcement effect is more significant than the actual purchase.
Greenwood-Vayanos (2008)	Regression analysis for pre-crisis US sample	• 14 bps (±7 bps)	•
Hamilton and Wu (2011)	Affine and no-arbitrage mode	• 17 bps	•
Hancock and Passmore (2011)	Regression analysis of MBS purchases	• About 30 bps	•
Joyce, Lasaosa, Stevens and Tong (2010)	Event study and VAR analysis on financial market impact	• Gilt yields 55–120bps • Corporate bonds 70–150bps • Sterling 4% • Equity: unclear • Bond issuance & market liquidity improved	• Announcement effect is more significant than signalling. • BOE's QE had no impact on offshore bond yields. • QE helped improve market conditions: corporate issuance and market liquidity improved post QE announcements.
Krishnamurthy and Vissing-Jorgensen (2010, 2011)	Regression analysis	• 15 bps (±5 bps)	•

Annex table: empirical results on the impact of unconventional monetary policies (cont)

Paper	Methodology	Main results	Other interesting findings
Modigliani and Sutch (1966, 1967)	Regression analysis on impact of operation Twist	• 0 bp (±20 bps)	•
Neely (2010)	Event study on cross-border financial market impact	• Tsy yields 100 bps • Corporate bonds 80 bps • 30-year mortgage rate 40 bps • Foreign bond rates 20–80bps • US dollar 4–11 pps • Equity: unclear	• US QE had impact on foreign bond yields and the currency. • Portfolio rebalancing effect more significant than signalling effect. • The international effect argues for more policy coordination among central banks.
Taylor and Williams (2009)	No-arbitrage pricing model, impact of TAF	• No statistically significant effect on Libor-OIS spread	• Libor-OIS is sensitive to interest rate expectations and counterparty risk. • The no-arbitrage pricing model does not formally incorporate liquidity premium.
Stroebel and Taylor (2009)		•	•
Swanson (2011)	Event study on financial market impact of Operation Twist	• 15 bps (±10 bps)	•
Ugai (2007)		•	•
Wu (2010, 2011)	Regression analysis on financial market impact of TAF	• Libor-OIS spread 50–55 bps	• The TAF was effective in reducing liquidity premium, but not counterparty risk premiums. • Libor-OIS spread is also sensitive to counterparty (or default) risk.

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Comments on Qianying Chen, Andrew Filardo, Dong He and Feng Zhu's paper "The impact of central bank balance sheet policies on the emerging economies"

Jonathan A Batten[1] and Peter G Szilagyi[2]

Introduction

The paper by Chen, Filardo, He and Zhou (2012)[3] provides a rich and interesting insight into international spillover, or cross-border effects, from changes in the structure of central bank (especially U.S.) balance sheets through quantitative easing (QE). As the authors note (page 1), "[the current literature] has focused on its domestic effects". We agree with the authors that understanding these effects is vital for better policy-making, especially since some policies – well-intentioned as they may well be – may lead to speculative flows to emerging nations, which in turn could lead to concerns later on if, for example, as occurred in the Asian crisis of 1997–1998, the flows were suddenly reversed.

CFHZ (2012) utilise an event study and global VAR methodology to determine the cross-border channels of transmission. VAR methodology is not without criticism, although as noted by Lutkepohl's (2007) survey, for integrated and cointegrated variables it provides convenient parameterization for model specification and economic analysis. CFHZ's conclusion that these impacts vary and appear linked to heterogeneity in the economic, financial and regulatory structures of each economy appears at odds with a broader literature that has observed increasing financial and economic integration in recent years, especially in regional economic blocs such as those in the Asia-Pacific region, owing to the effects of technology and communication systems as well as deliberate strategies aimed at facilitating trade and capital movement.[4]

Our contribution is to shed additional insights into the CFHZ (2012) findings by drawing upon key features and experiences of financial markets, both in the U.S. and elsewhere. This includes further analysis of key time series variables, especially the U.S. term structure. We argue that the CFHZ findings may be partly explained by three main factors: (a) complexity in the transmission process across the U.S. risk-free term structure, and the flow-on effects of monetary policy changes vis-à-vis risky debt; (b) the matching of the quantities of assets and liabilities in the international balance sheets of banks; and (c) risk aversion arising from the temporal nature of the correlation structure of foreign exchange rates, which affects international position-taking by banks. These three factors will be discussed each in turn. However, before doing so we will provide some preliminary comments on the broader context of the study – central bank policy when there is a near-zero lower band on interest rates – and why this may be ineffective in the short term.

[1] Jonathan A. Batten, Department of Finance, Hong Kong University of Science & Technology, Clear Water Bay, Kowloon, Hong Kong, Tel: +852-2358 8202, Fax: +852-2358 1749, Email: jabatten@ust.hk.

[2] Peter G. Szilagyi, Judge Business School, University of Cambridge, Trumpington Street, Cambridge CB2 1AG, UK, Tel: +44 (0) 1223 764026, Fax: +44 (0) 1223 339701, Email: p.szilagyi@jbs.cam.ac.uk.

[3] Henceforth simply CFHZ (2012).

[4] For example, Bekaert and Harvey (1995), Gerard, Thanyalakpark and Batten (2003), and Bekaert, Harvey and Ng (2005).

1. The near zero interest rate policy dilemma

There are a number of papers which consider the policy alternatives faced by a central bank when confronting a zero lower band on nominal interest rates. These include well-known words by Bernanke and Gertler (1999), Bernanke and Reinhart (2004) and Bernanke, Reinhart and Sack (2004), amongst others. It is important to recognise that these authors were mindful of the quandary facing the Bank of Japan in the period from 1990–2000 in stimulating aggregate demand while nominal interest rates were near zero, and also the experience of the Kennedy Administration's 1961–1964 Operation Twist. These experiences are reflected in the policy options that these various papers considered – and of which CFHZ (2012) provides a recent assessment in terms of cross-border impacts, to wit: (a) the importance of shaping expectations of future interest rate directions; (b) quantitative easing via central bank purchases of securities; and (c) changing the composition and duration of the central bank balance sheet through risky asset purchases and the substitution of long for short bonds. More recently, Braun and Shioji (2006), Ito (2009) and Fukuda (2011) have also considered recent Japanese experience given the persistence of near zero short-term interest rates over the past decade.

Nonetheless, there are two main concerns with monetary intervention in the form of simple manipulation of the term structure of government securities. First, aside from capital adequacy and liquidity implications for banks in restricting supply, changing the government yield curve may prove insufficient in triggering new investment by financial intermediaries. In part, this implies a need to understand how changes in nominal risk-free yields flow through to the risky yields of corporate borrowers of equivalent maturity. For example, the theoretical prediction of structural credit spread models (e.g. Longstaff and Schwartz, 1995), where the difference in the risky and riskless yields is termed a credit spread, is that changes in riskless rates are negatively correlated with changes in credit spreads. Thus, lowering long rates through bond purchases may have the perverse effect of increasing the nominal yields on risky bonds.

In earlier work on Japanese bond markets, Pynnönen, Hogan and Batten (2002) and In, Batten and Kim (2003) also show that the interactions across and between risky and riskless yield curves of specific maturity and credit class are complex and temporal, and likely affected by liquidity and institutional factors such as the presence of futures contracts on specific bond maturities. Thus, the potential effects on economic growth via a financial markets channel, either from quantitative easing in its pure form through outright bond purchases or by changing expectations via the reshaping of the yield curve, may be compromised.

Second, while a yield curve twist may be sanitised in terms of overall market liquidity effects, outright quantitative easing via purchases of selected maturities is clearly not. Of potential concern is the risk-taking that this may encourage in investors with long-term liabilities (such as pension funds and insurance companies) who face supply-side restrictions on the availability of risk-free assets. Financial intermediaries may also have compromised their maturity gap positions as a result of the reshuffling of their securities portfolios. While new on-balance-sheet (gap) positions can be accommodated using interest rate derivatives, these off-balance-sheet transactions require an additional capital charge.

2. Some stylised facts on U.S. term structure behaviour

In their modelling of financial sector impacts, CFHZ utilise a term structure variable based on the difference between the 10-year and 3-month U.S. Treasury yield. One is mindful when reviewing their findings of the need for understanding the complex dynamics of the term structure relationship itself as well as the potential effects of interest rate effects on asset prices. To assist in forming better judgements of these relationships, this section provides three important insights into the behaviour of the U.S. Treasury term structure from 2000–2011: (a) the relationship between stock prices and changes in the shape of the yield curve; (b) the relationship between long- and short-term components of the yield curve; and (c) the relationship between changes in the shape of the curve and the business cycle. These issues are discussed in sequence.

A. The relation between stock prices and interest rates

The relation between the business cycle and changes in the interest rate term structure is a well-documented phenomenon, and in the case of the U.S. is clearly evident from Figure 1, which plots the nominal difference in yield between the 10-year and 5-year benchmark (U.S. Treasury) bonds. The two interest rate episodes when there are negative rates (10-year < 5-year yield) are associated with periods of recession. Thus, a positive gradient is typically associated with periods of economic growth, whereas a negative gradient is associated with an economic downturn (see also Ang, Piazzesi and Wei, 2006).

To highlight the link between expectations of changes in interest rates and asset prices, we begin by dividing U.S. Government bond yields (term structure) into two components: a short-term component (U.S. 5-year T-Bond yield minus the U.S. 13-week T-Bill yield) and a long-term component (U.S. 30-year T-Bond yield minus the 5-year T-Bond). A theoretical foundation for the relationship between changes in interest rates and stock prices may be found in structural models of corporate bond pricing, where rising asset prices relative to constant values of debt are linked to improved firm solvency and declining probabilities of default (Longstaff and Schwartz, 1995). Business cycle implications also need to be considered, since these episodes coincide with shifts in corporate default outcomes and investor preferences for riskless securities.

Figure 2 plots the rolling 66-day regression betas of the relationship between stock index returns, proxied by changes in the Dow Jones Industrial Average (DJIA) stock index, and changes in the two components of the U.S. term structure, for the period from January 2000 to December 2012 (2,995 daily observations). The blue line represents the DJIA correlation with changes in the short end of the yield curve (5y–13w), while the red line represents changes in the long end of the yield curve (30y–5y). It is clear from this figure that these two yield curve components appear negatively correlated to one another, while the degree of correlation with the DJIA index is time dependent.

B. The relation between the long and short end of the term structure

The next Figure (3) shows the 66-day correlation between the short and long end of the U.S. yield curve over the same 2000–2011 period. As is evident in the figure, rarely over the past decade have the short and long ends of the U.S. term structure moved together (characteristic of a parallel shift in the U.S. yield curve). Historically, the relationship is negative, although the degree of correlation is time-variant. One interpretation of this finding is that an accommodative monetary policy in the short term may be perceived as encouraging inflation in the longer term (see Gürkaynak, Sack and Wright, 2010). Note that the positive spike in the correlation in late 2011 may be linked to the combined effects of QE2 and Operation Twist.

The negative correlation between the long and short end implies that the yield curve typically pivots in response to economic news that is deemed maturity-specific, or due to liquidity factors brought about by the issuance maturities of new bonds and the on-the-run auction premiums paid by investors. These observations are consistent with more complex explanations of yield curve behaviour than provided by expectations or segmentation theories (see Gürkaynak and Wright, 2010), which suggests that "term structure movements cannot always be understood in terms of changes in expected short term interest rates, inflation or other macroeconomic variables, but that shifts to clientele demand and bond supply are also an important driver" (Greenwood and Vayanos, 2010: 585).

C. Time-varying yield curve volatility

The volatility relationships between yields in the U.S. term structure are estimated using two approaches. While it is commonplace to measure asset volatility based on a regular time interval (such as a day), we first utilise a more complex measure, the Garman and Klass (1980) estimator (GKe)[5], which measures volatility based on differences between the open, close, high and low prices within a particular time interval, which in this instance is one day. This estimator assumes that prices follow geometric Brownian motion with zero drift.

Table 1

Intraday volatility (GKe) estimates of U.S. 5-year, 10-year and 30-year T-Bonds 2000–2011

Year	N	μ(5Y-UST) GKe	μ(10Y-UST) GKe	μ(30Y-UST) GKe	σ(5Y-UST)GKe	σ(10Y-UST)GKe	σ(30Y-UST)GKe
2000	249	0.000013	0.0000110	0.000010	0.000023	0.0002317	0.000016
2001	248	0.000033	0.0000729	0.000012	0.000051	0.0002322	0.000022
2002	250	0.000057	0.0000722	0.000013	0.000060	0.0001253	0.000013
2003	252	0.000095	0.0000645	0.000019	0.000087	0.000074	0.000016
2004	252	0.000048	0.0000278	0.000011	0.000086	0.0000478	0.000013
2005	250	0.000021	0.0000244	0.000014	0.000026	0.0000258	0.000015
2006	251	0.000010	0.0000126	0.000009	0.000010	0.0000092	0.000009
2007	251	0.000028	0.0000249	0.000012	0.000039	0.0000326	0.000014
2008	253	0.000212	0.0001246	0.000043	0.000325	0.0001711	0.000057
2009	252	0.000156	0.0001247	0.000053	0.000190	0.0001741	0.000102
2010	251	0.000148	0.0000748	0.000026	0.000219	0.0000773	0.000043
2011	235	0.000235	0.0001442	0.000037	0.000281	0.0002403	0.000044
F-Statistic		65.33	26.94	34.04			
p-value		0.000	0.000	0.000			
Adjusted R^2		19.12	8.70%	10.83			

Source: Thomson-Reuters Eikon and Yahoo Finance: U.S. 30-year, U.S. 10-year and U.S. 5-year benchmark bond yields, January 1, 2000 – December 7, 2011. The Garman-Klass estimator is based on the daily open, close and high and low prices (yields).

The GKe for the U.S. 5-year, 10-year and U.S. 30-year bonds are reported in Table 1 and plotted in Figure 4. A One-Way ANOVA of mean differences in intraday volatility estimated

5 The GKe is $s^2 = 0.511(H-L)^2 - 0.019(C-0)(H+L-2C)(l-C) - 0.383(C-O)^2$.

by the GKe (for the 12 years from 2000 to 2011) is significant, with the *F-statistic* improving in size as the maturity decreases. Thus, intraday volatility is higher for shorter-term bonds, with the 5-year bond having the highest intraday volatility in all years. The sudden increase in intraday volatility (evident in Figure 4) in the past 3-4 years is unexpected and is likely due to the destabilising effects of the GFC, as investors sought risk protection through purchases of U.S. Government securities.

The volatility relationship between the short (13-week to 5-year) and long (5-year to 30-year) end of the yield curve was also measured as the interday difference in yield, and reported in Table 2. Overall, the short end of the yield curve was also more volatile than the long end, measured both in levels and differences. The long end of the U.S. Treasury term structure steepened from 2000 to 2003, declined to 2005 and then steepened again from 2006 to 2011. The short end steepened from 2000 to 2002, declined from 2004 to 2006, steepened from 2006 to 2009 and declined thereafter.

Yield curve inversion also occurred, and this phenomenon can be linked to business cycle expansions and contractions. The negative average of –0.2073 and the average of 0.1355 for $\mu(30y–5y)$ in 2000 and 2006 signalled the onset of the U.S. recessions of April 2001 and January 2008 as determined by the NBER Business Cycle Dating Committee. Note that banks typically face declining interest margins during periods of yield curve inversion. Apart from the rising relative costs of funding sources such as deposits or securities issuance, capital constrained banks can typically resort to securitisation to regain liquidity (see Estrella, 2002; Altunbas, Gambacorta and Marques, 2007). However, during the global financial crisis period, securitisation prospects diminished as market conditions deteriorated.

3. The recent scale and scope of bank internationalisation

One key area of investigation of the CFHZ paper is bank credit. Their analysis extends other recent work on the role of lending during the GFC and on the importance of the bank lending channel in stimulating economic growth (e.g. Altunbas, Gambacorta and Marques-Ibanez, 2007; Disyatat, 2010; Gambacorta and Marques-Ibanez, 2011). One potential cross-border transmission channel is through bank internationalisation as perverse domestic economic circumstances force domestic banks to seek investment opportunities abroad. Note that since recent changes in monetary policy have occurred against a background of ongoing banking sector disintermediation, consolidation, heightened competition and extensive political pressure to improve financial sector regulation, it may be difficult to disentangle which of these factors dominates or has the most important impact on bank lending.

Investigation of the international positions of banks nonetheless provides additional insights into the broader question of whether banks responded to the domestic monetary conditions by expanding internationally. We follow the approach adopted by Batten and Szilagyi (2011a, 2011b), who investigate the internationalisation of banks using data sourced from the Bank for International Settlements (BIS). These data show that there was an increase in total international assets from US$9,495.3 billion in 1995 to US$35,279.3 billion in March 2011, and an increase in international liabilities from US$9,306.8 billion to US$33,451.5 billion over the same period. Note that apart from two earlier episodes in the late 1980s and 1995, the share of non-bank assets has continued to increase, with the GFC providing only a minor interruption to this trend. Internationalisation provides benefits to the lending institution in the form of credit diversification, despite the costs of monitoring and the potential information asymmetries present in foreign markets.

Table 2

Levels and changes in the long end (5-year to 30-year) and short end (13 week to 5-year) of the U.S. term structure 2000–2011

Year	N	μ(30y-5y)	σ(30y-5y)	M(5y-13w)	σ(5y-13w)	μ(30y-5y)Δ	σ(30y-5y)Δ	μ(5y-13w)Δ	σ(5y-13w)Δ
2000	249	–0.2073	0.2733	0.3355	0.6100	0.00137	0.03821	–0.00779	0.08115
2001	248	0.9923	0.2958	1.1115	0.8280	0.0027	0.05446	0.01375	0.07250
2002	250	1.5301	0.3714	2.1572	0.5770	0.0036	0.03954	–0.00444	0.06916
2003	252	1.9910	0.1126	1.9352	0.3929	–0.00079	0.03612	0.00302	0.07188
2004	252	1.6162	0.2117	2.0490	0.4591	–0.00254	0.02932	–0.00349	0.06264
2005	250	0.5291	0.2203	0.9068	0.3317	–0.00408	0.02602	–0.00420	0.04658
2006	251	0.1355	0.0801	0.0288	0.2451	–0.00028	0.01995	–0.00227	0.08409
2007	251	0.4149	0.2967	0.0900	0.3627	0.00355	0.03191	0.00199	0.10365
2008	253	1.4830	0.2301	1.4596	0.5711	0.00051	0.06360	0.00443	0.12451
2009	252	1.8919	0.1881	2.0506	0.3658	0.00321	0.04903	0.00480	0.08143
2010	251	2.3357	0.2428	1.7855	0.4881	0.00155	0.03690	–0.00295	0.06170
2011	235	2.4226	0.2253	1.5042	0.4791	–0.00072	0.04673	–0.00409	0.05807

Source: Thomson-Reuters Eikon and Yahoo Finance: Daily U.S. 13-week T-bills, U.S. 30-year and U.S. 5-year benchmark bond yields, January 1, 2000–December 7, 2011. The long end of the U.S. yield curve is the difference in yield between the U.S. 30-year and U.S. 5-year bond, while the short-end is the difference in yield between the U.S. 5-year bond and the U.S. 13-week Treasury note.

The international positions may also be expressed as a ratio of international assets to international liabilities. This ratio ranges from 102.03 in December 1995 to 103.15 in March 2011 for total assets and liabilities, and a slightly higher ratio of 103.08 to 105.57 over the same period for external assets and liabilities. Figure 5 provides a quarterly plot of this ratio for the period from December 1977 to March 2011. Also plotted is a 2-year moving average to better show the trend in the ratio over time. Of particular significance in this graph is the sudden decline in the ratio following the GFC. This suggests a deliberate strategy by financial intermediaries to better match quantities of international assets and liabilities over the past decade.

Specific detail on the net positions of bank external assets, categorised by country and region, are reported in Table 3. The first key result is that external assets of BIS banks to all countries exceeded liabilities by about US$1.65 trillion in March 2011. Importantly, this amount is 18.09% less than in December 2007 and signals reduced on-balance-sheet risk. This outcome has come at the cost of reduced international lending and a preference for matching international assets and liabilities, which likely signals reduced risk-taking and bank profitability. The prospect of Basel III implementation also weighs on the banking system, and along with continued international economic uncertainty encourages risk aversion and more conservative lending and banking practices.

At a country level there is considerable heterogeneity in net positions amongst those developed nations shown in Table 3. For example, Germany reduced the size of its net deficit (meaning less lending). By comparison to these positions, Japan now has net borrowings of US$117 billion. Note that the major source for these funds is the offshore centres (US$564 billion) and the Africa-Middle East region (US$286 billion).

The second key result is the change in the positions of the U.K. and the U.S. The U.S. is especially relevant given the focus of QE by the U.S. monetary authorities in recent years. Historically, both the U.K. and the U.S. were net receivers of international bank funds (e.g. US$ 1.93 trillion in December 2007), with the U.S. being the larger of the two (US$ 1.42 trillion in December 2007). This situation has changed post-GFC: the U.S. remains a net receiver, albeit at a much lower level (US$729 billion in March 2011, which is a 48.8% reduction from 2007), whereas the U.K. is now a net international lender (US$ 29.8 billion in March 2011). The U.S. situation is therefore at odds with the view that U.S.-based banks internationalised to leverage cheap domestic funding, while there is limited evidence for the reverse applying to the U.K. Thus, despite similarities in the scale and scope of their international banking markets, they differ in that international banks lend significantly more to the US than is received, whereas the flows in and out of the UK tend to be more balanced.

Another point worthy of mention concerns the net flows through offshore centres, which have declined significantly since the GFC. For example, the preferred domicile location for U.S. SPVs, the Cayman Islands, has experienced a 754% reduction in the decline of net flows, to US$ 148 billion. Therefore, reduced domestic bank lending has also been associated with reductions in securitization and security issuance post-crisis. Table 3 also shows the net positions for developing countries and regions (lower panel). While the developing countries are historically net receivers of bank funds (US$788.1 billion in March 2011), the largest net inflow is emerging Europe, with US$473.9 billion in March 2010, while the region that provided the largest outflows was Africa-Middle East, with US$285.6 billion.

Overall, these tables show evidence of significant reductions – deleveraging – of international exposures after the onset of the GFC, though clear evidence of the reallocation of risky assets to other regions in order to diversify, or to reduce asset concentration, is not so apparent. This may in part be due to the role of financial centres in hiding the ultimate destination of lent (or borrowed) funds. Nonetheless, though significant, the flows through these centres were reduced as one consequence of the crisis.

Table 3

BIS Reporting Banks' Net Positions to Developed and Developing Countries and Offshore Centres (millions of US dollars)

Millions of US$	Dec. 2000	Dec. 2007	Dec. 2008	Dec. 2009	Sep. 2010	Dec. 2010	Mar. 2011	% Change 2000–2007	% Change 2007–2011
All countries	353,255	2,020,249	2,099,163	1,947,173	1,911,848	1,655,592	1,654,751	472	–18
Developed Countries	1,788,276	5,735,530	5,434,556	5,306,216	4,569,742	4,149,720	4,148,182	221	–28
(i) Euro area	1,250,946	3,671,326	3,628,012	3,716,696	3,307,020	2,979,959	2,866,627	193	–22
United Kingdom	43,675	510,287	458,559	254,686	–60	88,987	–29,854	1,068	–106
Germany	300,179	–287,150	–362,391	–253,370	–88,614	–42,632	–87,532	–196	–70
France	214,704	788,661	668,284	609,996	575,450	553,775	500,305	267	–37
ii) Other developed countries	642,016	1,789,936	1,436,229	1,288,022	1,236,160	1,051,771	1,296,473	179	–28
Japan	53,056	–97,737	–199,037	119,883	200,519	208,117	117,142	–284	–220
United States	462,038	1,424,537	1,230,716	708,332	618,699	411,299	729,047	208	–49
(iii) Offshore centres	–429,685	–1,119,908	–1,259,499	–979,139	–670,784	–604,340	–564,638	161	–50
Cayman Islands	–51,440	22,650	–296,692	–122,992	–37,709	–96,544	–148,230	–144	–754
Singapore	–56,748	–91,399	–38,074	–41,055	–11,824	14,859	43,994	61	–148
Hong Kong SAR	–153,595	–378,480	–293,604	–204,561	–117,494	–59,300	–13,412	146	–96
Developing countries	–126,231	–120,800	272,249	332,770	613,840	656,404	788,086	–4	–752
Africa & Middle East	–152,821	–413,675	–318,715	–275,006	–236,305	–240,533	–285,633	171	–31
Asia & Pacific	–65,751	–28,807	65,465	118,453	299,837	346,394	475,165	–56	–1,749
Europe	51,753	302,007	509,943	457,616	455,612	444,279	473,885	484	57
Latin America/Caribbean	40,588	19,675	15,556	31,707	94,696	106,264	124,669	–52	534

Source: BIS Quarterly Review: September 2011: Table 6A. Loans comprise those financial assets which are created through the lending of funds by a creditor (lender) to a debtor (borrower) and which are not represented by negotiable securities. Deposits comprise all claims reflecting evidence of deposit – including non-negotiable certificates of deposit (CDs) – which are not represented by negotiable securities. Thus, loans and deposits include interbank borrowings and loans and inter-office balances (BIS 2008, "Guidelines to the International Locational Banking Statistics", Monetary and Economic Department, November 2006 and update December 2008).

4. Time variation in the foreign exchange correlation structure

The final factor that helps to explain the CFHZ findings involves the identification of the degree of time variation in the correlation, or covariance, structure of foreign exchange rates. This variation will affect the propensity for risk taking by banks. For example, if the covariance structure remains stable over time then financial intermediaries can be more confident about their ability to diversify market risks. If a region becomes more integrated, in an economic or political sense, then the quandary for intermediaries is that idiosyncratic risks then become harder to diversify.

These observations lead to two related questions, which share aspects which are difficult to disentangle. First, to what extent has the GFC contributed to further economic integration of the Asia-Pacific region and second, did improved integration assist in the transmission of central bank balance sheet policies during the GFC episode?

While CFHZ also consider these questions in some detail, a simple measure of the scale and scope of the problem is to determine the degree of convergence, in the form of higher correlations, of exchange rate returns. This exercise should provide further insights into the problem faced by financial intermediaries in their efforts to diversify their assets across the Asia-Pacific region.

To assess these impacts, we form equally weighted currency portfolios comprising major Asia-Pacific and European currencies, with all currency pairs priced against the US dollar. Some basic statistics of these currencies are reported in Table 4A, while the correlation structure between the currency pairs is reported in Table 4B. Over the sample period the USD/NZD was the most volatile pair, while the USD/CNY was the least. A number of currency pairs displayed negative skewness (especially the USD/KRW and the USD/HKD) and positive kurtosis (USD/HKD, USD/KRW, and the USD/CNY). These higher moments add to the difficulty of diversifying currency portfolios based on a standard mean-variance framework.

The correlation matrix shows that the highest pairwise correlation was between USD/AUD and USD/NZD (0.852), followed by the correlation between USD/EUR and USD/SWF (0.809). The currency pair most highly correlated to other currency pairs was USD/SGD, whereas the least was USD/CNY. Interestingly USD/AUD and USD/NZD had no significant correlation to USD/JPY, despite evidence of carry-trade related capital flows.

These currencies were then used to form four portfolios comprising equally weighted component currencies: (a) European currencies: euro, Swiss franc and U.K. pound; (b) other Western currencies: Australian, Canadian and New Zealand dollars; (c) Northern Asia-Pacific currencies: China, Japan, Korea and Taiwan; and (d) Southern Asia-Pacific currencies: Hong Kong, Malaysia, Singapore and Indonesia. The descriptive statistics of these portfolios are reported in Table 4C, which shows that the least-risk portfolio was (d), while the most risky was (b). Portfolio (d) also had the highest kurtosis, while (c) had negative skewness. The correlation pairs reported in Table 4D show that the highest pairwise correlation (0.640) was between portfolios (a) and (b), whereas the least (0.385) was between portfolios (a) and (d). Importantly, the size of these correlations provides a simple measure of the extent of regional currency integration, and also highlights the difficulty of adequately diversifying currency portfolios, although selectively targeting individual currencies may offer more promise. Rolling 22-day correlations between these portfolios, plotted in Figure 6, do however highlight the time-dependent nature of the covariance structure.

Table 4A

Descriptive Statistics of Major Spot Currencies, January 1, 2000 to December 7, 2011

Variable	Mean	SE Mean	Standard Deviation	Minimum	Median	Maximum	Skewness	Kurtosis
USD/AUD	–0.00015	0.00016	0.00880	–0.07156	–0.00053	0.08	0.36	7.21
USD/EUR	–0.00009	0.00013	0.00701	–0.04102	–0.00013	0.04	0.08	1.92
USD/JPY	–0.00009	0.00012	0.00646	–0.03370	–0.00003	0.04	–0.06	2.71
USD/GBP	0.00002	0.00011	0.00623	–0.03387	–0.00008	0.05	0.49	4.89
USD/CHF	–0.00018	0.00014	0.00746	–0.03883	–0.00014	0.09	0.50	7.90
USD/NZD	–0.00013	0.00017	0.00911	–0.04747	–0.00069	0.05	0.38	2.33
USD/CAD	–0.00012	0.00011	0.00608	–0.06851	–0.00019	0.04	–0.26	7.50
USD/HKD	0.00000	0.00001	0.00030	–0.00375	0.00000	0.00	–1.21	23.86
USD/SGD	–0.00009	0.00006	0.00328	–0.02461	–0.00014	0.02	0.08	3.76
USD/MYR	–0.00006	0.00005	0.00292	–0.02295	0.00000	0.02	–0.12	7.71
USD/TWD	–0.00001	0.00005	0.00273	–0.03097	0.00005	0.03	–0.07	14.45
USD/KRW	0.00000	0.00013	0.00734	–0.12186	–0.00015	0.09	–0.98	45.04
USD/IDR	0.00008	0.00014	0.00788	–0.09660	0.00002	0.13	0.54	45.49
USD/CNY	–0.00009	0.00004	0.00230	–0.05947	0.00000	0.06	–0.15	599.21
USD/SDR	–0.00004	0.00006	0.00342	–0.03768	–0.00004	0.04	0.01	13.25

Table 4B

Spot currency correlation matrix January 1, 2000 to December 7, 2011

	USD / AUD	USD / EUR	USD / JPY	USD / GBP	USD / CHF	USD / NZD	USD / CAD	USD / HKD	USD / SGD	USD / MYR	USD / TWD	USD / KRW	USD / IDR	USD / CNY
USD / EUR	0.6290													
	0.0000													
USD / JPY	–0.0250	0.2110												
	0.1770	0.0000												
USD / GBP	0.5810	0.6640	0.1160											
	0.0000	0.0000	0.0000											
USD / CHF	0.4340	0.8090	0.3680	0.5290										
	0.0000	0.0000	0.0000	0.0000										
USD / NZD	0.8520	0.6000	0.0060	0.5600	0.4290									
	0.0000	0.0000	0.7630	0.0000	0.0000									
USD / CAD	0.6480	0.4930	–0.0350	0.4760	0.3370	0.5640								
	0.0000	0.0000	0.0540	0.0000	0.0000	0.0000								
USD / HKD	0.1230	0.1640	0.1110	0.1250	0.1450	0.1250	0.1140							
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
USD / SGD	0.6230	0.5930	0.2350	0.4940	0.4720	0.5780	0.5160	0.2060						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000						

Table 4B (cont)

Spot currency correlation matrix January 1, 2000 to December 7, 2011

	USD / AUD	**USD / EUR**	**USD / JPY**	**USD / GBP**	**USD / CHF**	**USD / NZD**	**USD / CAD**	**USD / HKD**	**USD / SGD**	**USD / MYR**	**USD / TWD**	**USD / KRW**	**USD / IDR**	**USD / CNY**
USD / MYR	0.4880	0.3820	–0.0730	0.3280	0.2470	0.4510	0.4420	0.1890	0.6240					
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
USD / TWD	0.4030	0.3570	0.1500	0.3140	0.2770	0.3820	0.3470	0.1440	0.5540	0.4330				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
USD / KRW	0.5040	0.3360	–0.0160	0.3080	0.2180	0.4230	0.4280	0.0860	0.5680	0.4600	0.5070			
	0.0000	0.0000	0.3770	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
USD / IDR	0.2710	0.1650	0.0110	0.1620	0.0970	0.2400	0.2310	0.0520	0.3320	0.2440	0.2240	0.2570		
	0.0000	0.0000	0.5450	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000	0.0000	0.0000	0.0000		
USD / CNY	0.0570	0.0800	0.0470	0.0810	0.0760	0.0410	0.0350	0.0470	0.1000	0.0930	0.0650	0.0340	0.0130	
	0.0020	0.0000	0.0110	0.0000	0.0000	0.0250	0.0560	0.0110	0.0000	0.0000	0.0000	0.0600	0.4740	
USD / SDR	0.1400	0.2660	0.1340	0.2200	0.2460	0.1590	0.0660	0.1190	0.1840	0.1250	0.1750	0.0940	0.0410	0.0500
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0100

Table 4C

Descriptive statistics of currency portfolios

Variable	Mean	SE Mean	Standard Deviation	Minimum	Median	Maximum	Skewness	Kurtosis
PRT(E-C-G)	–0.000251	0.000335	0.018312	–0.100676	–0.000239	0.103563	0.01	1.77
PRT(A-NZ-C)	–0.000396	0.000395	0.021582	–0.180694	–0.001224	0.142099	0.21	5.10
PRT(C-J-K-T)	–0.000184	0.000213	0.011651	–0.116242	–0.000230	0.069746	–0.38	7.13
PRT(H-S-M-I)	–0.0000668	0.000203	0.011077	–0.094778	–0.000167	0.128233	0.25	13.03

Table 4D

Correlation matrix of currency portfolios

	PRT(E-C-G)	PRT(A-NZ-C)	PRT(C-J-K-T)
PRT(A-NZ-C)	0.6400		
	0.0000		
PRT(C-J-K-T)	0.4540	0.4170	
	0.0000	0.0000	
PRT(H-S-M-I)	0.3850	0.5270	0.4500
	0.0000	0.0000	0.0000

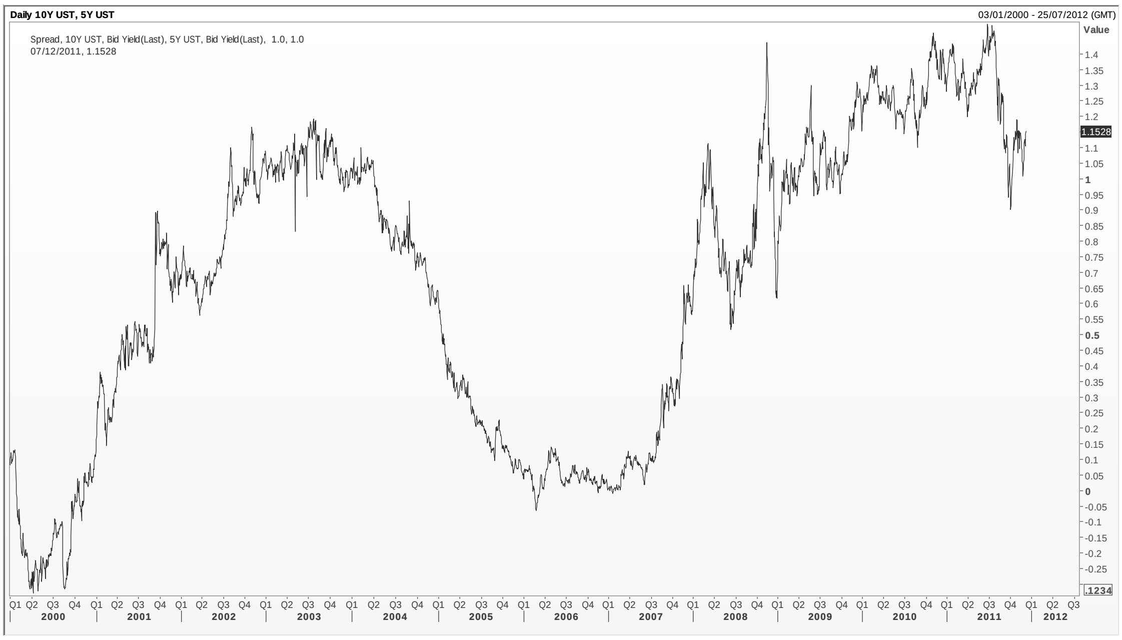
5. Discussion and concluding remarks

This discussion provides additional support for the cross-border impact of QE as evidenced by CFHZ (2012), in that the impacts varied and appear linked to heterogeneity in the economic, financial and regulatory structures of emerging economies in the Asia-Pacific and South American regions. We attribute this to three factors: First, time-dependent volatility and correlations along the US yield curve introduce complexity (and uncertainty) in the transmission mechanism between the U.S. term structure and others. Introducing the time-dependent covariance structure of exchange rates adds to market risk and so may limit the potential desire by domestic banks to internationalise their balance sheets. Second, bank net international positions highlight the dynamic nature of international asset/liability management and provide further evidence of more risk-averse lending strategies. Collectively these findings help explain the limited cross-border impact of quantitative easing. In addition, the segmented nature of Asian economies, evidenced by their exchange rate correlation structures, may also explain the heterogeneity in cross-border impacts of QE1 and QE2.

In sum, the CFHZ paper offers important insights into the cross-border effects of QE 1 and 2 and represents a first step in understanding the complexity of the international transmission process. The need for better understanding of these relationships cannot be understated, since despite multiple attempts at stimulus using a variety of conventional and unconventional monetary and fiscal means (despite obvious budgetary constraints), the international economy remains in a precarious state.

Figure 1

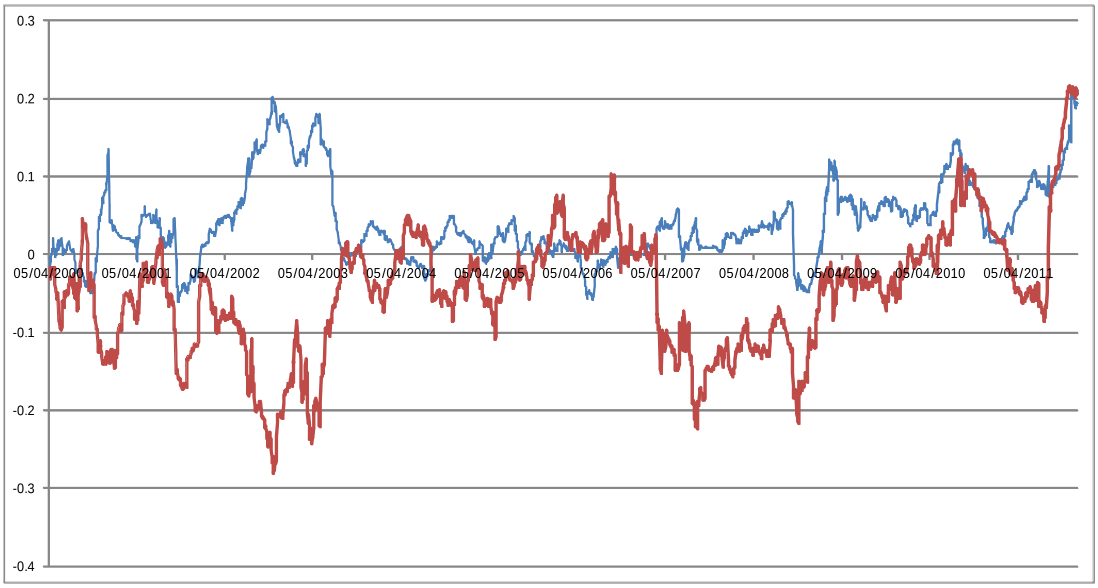
The business cycle and the U.S. term structure: The difference between 10-year and 5-year U.S. Treasury Bonds



Source: Thomson-Reuters Eikon. U.S. 10-year – U.S. 5-year benchmark bond yields, January 1, 2000 – December 7, 2011.

Figure 2

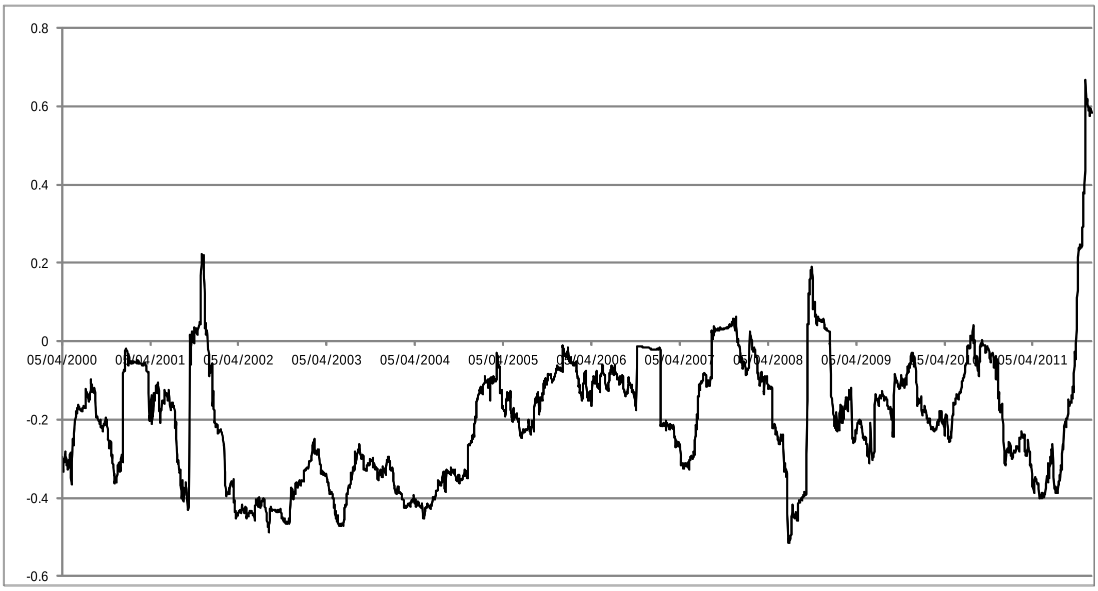
The relationship between changes in U.S. stock prices (DJIA) and changes in the long and short ends of the U.S. term structure



Source: Thomson-Reuters Eikon and Yahoo Finance: Daily U.S. 13-week T-bills, U.S. 30-year and U.S. 5-year benchmark bond yields, January 1, 2000 – December 7, 2011. The long end of the U.S. yield curve is the difference in yield between the U.S. 30-year and U.S. 5-year bonds, while the short end is the difference in yield between the U.S. 5-year bond and the U.S. 13-week Treasury note. The red line represents the DJIA correlation with changes in the long end of the yield curve, while the blue line represents changes in the short end of the yield curve.

Figure 3

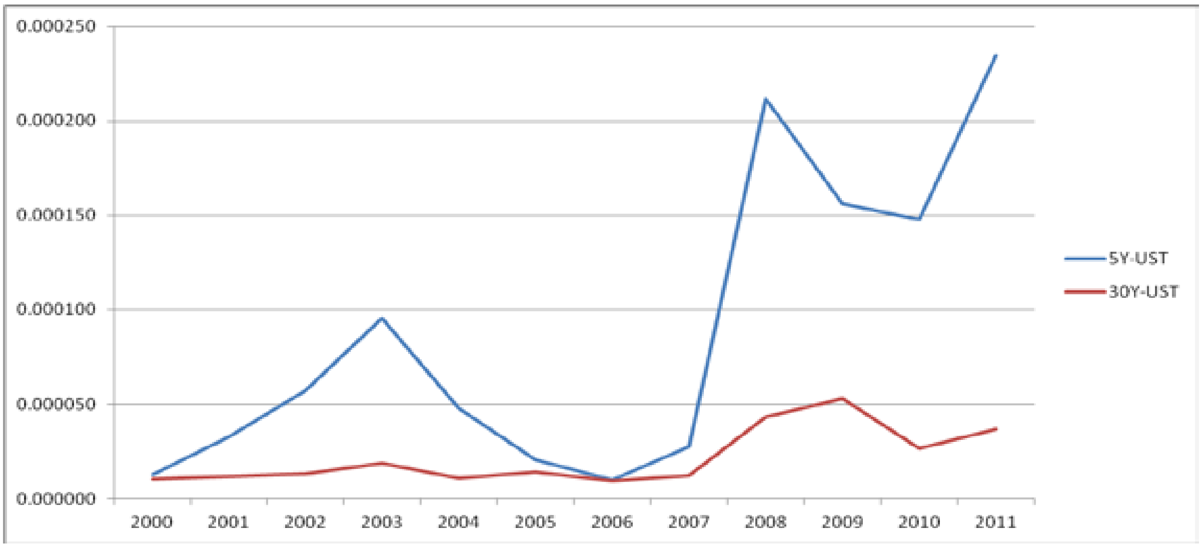
Correlation between long-end and short-end changes in the U.S. Term Structure



Source: Thomson-Reuters Eikon and Yahoo Finance: Daily U.S. 13-week T-bills, U.S. 30-year and U.S. 5-year benchmark bond yields, January 1, 2000 – December 7, 2011. The long end of the U.S. yield curve is the difference in yield between the U.S. 30-year and U.S. 5-year bonds, while the short end is the difference in yield between the U.S. 5-year bond and the U.S. 13-week Treasury note.

Figure 4

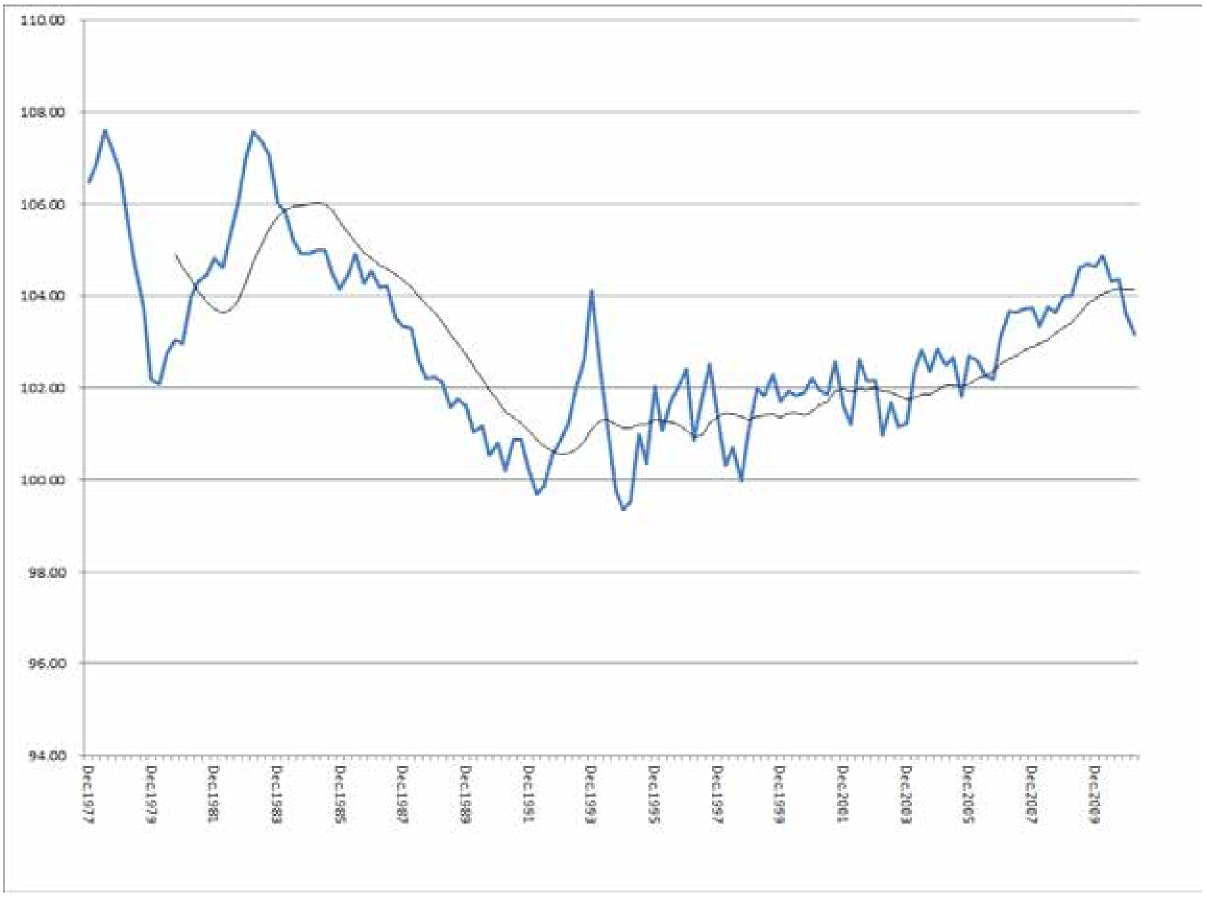
Plot of Garman-Klass intraday volatility estimates for the 5-Year and 30-Year U.S. T-Bonds



Source: Thomson-Reuters Eikon and Yahoo Finance: Daily U.S. 30-year and U.S. 5-year benchmark bond yields, January 1, 2000 – December 7, 2011. The Garman-Klass estimator is based on the daily open, close and high and low prices (yields).

Figure 5

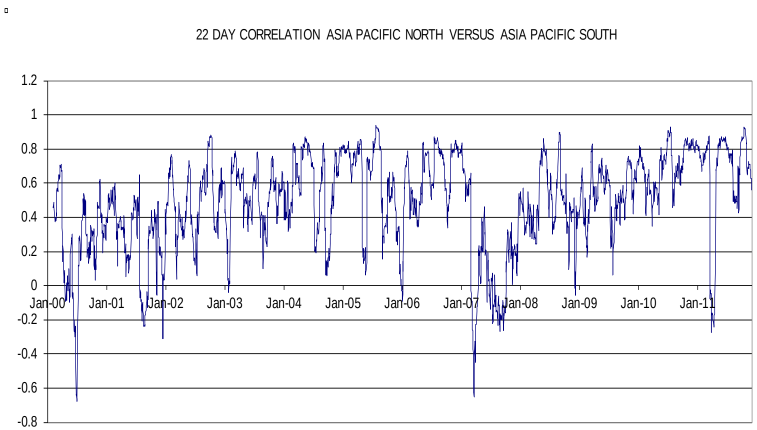
The Ratio of BIS Reporting Banks'International Assets to Liabilities 1977–2011

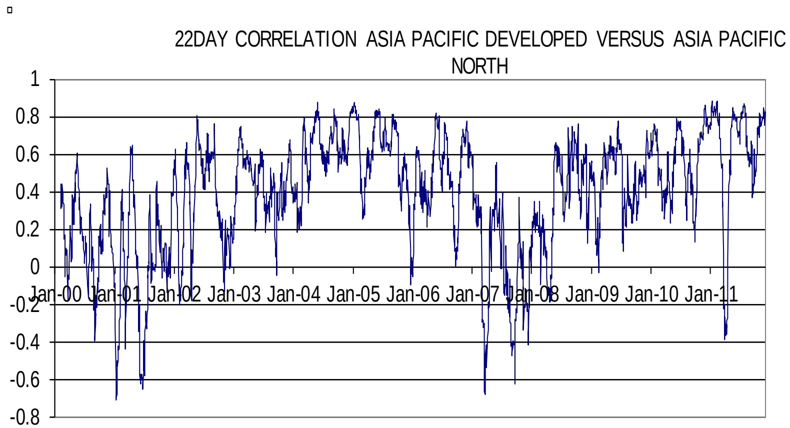


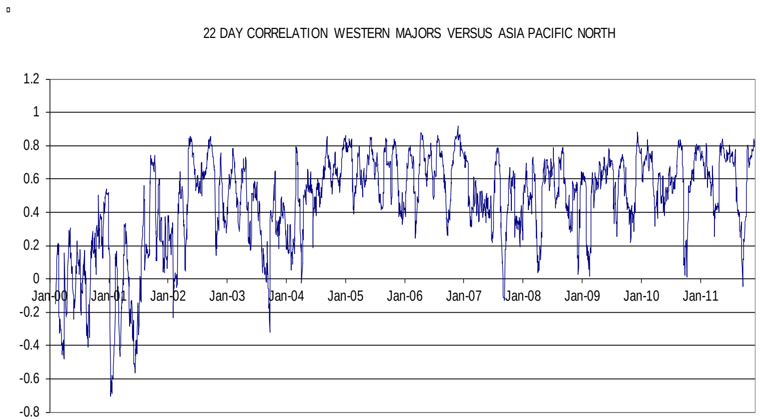
Source: Authors' calculations based on BIS (2011, September). In December 1977, the ratio of international assets to international liabilities was 106.46. This ratio has subsequently dropped to 103.15 as of March 2011. The blue (bold) line plots the quarterly ratio over this time period, while the grey (thin) line plots the 2-year (8 quarters) average. The y-axis shows the ratio of international assets to international liabilities.

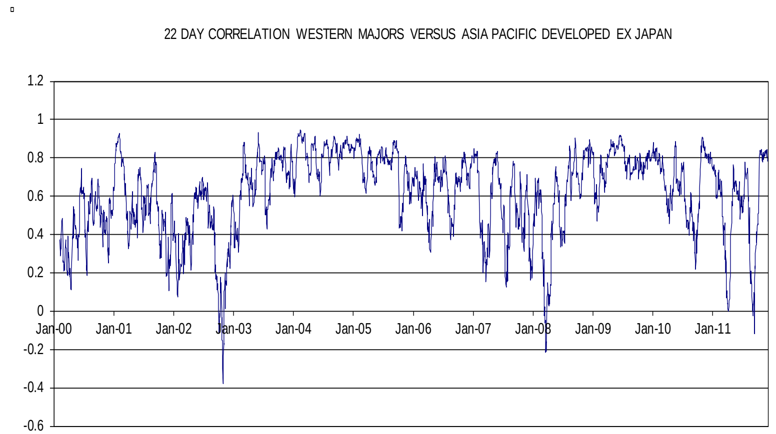
Figure 6

22-day rolling correlation between various currency portfolios
(Asia North, Asia South, Western Majors, Asia-Pacific Developed)









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Comments on Qianying Chen, Andrew Filardo, Dong He and Feng Zhu's paper "International spillovers of central bank balance sheet policies"

Roong Mallikamas[1]

First of all, I would like to thank the BIS Representative Office for Asia and the Pacific for inviting me to join this thought-provoking conference and, in particular, to be a discussant for the paper entitled "Central Bank Balance Sheet Spillovers to Asia and the Pacific" by Qianying Chen, Andy Filardo, Dong He and Feng Zhu, which I have found very interesting.

My comments are based on the October version of the paper. Since then, the authors have made some extensions to their work, but I think my comments are still very much relevant. So I will try to first highlight the strengths of this paper, elaborate a bit on some of the parts that the authors didn't touch upon so much in their presentation today, and then spend more time on suggestions that might make the paper even stronger.

So let me start with the strengths. To me, the paper extends the study on the impact of major economies' balance sheet policies in the right direction – that is, toward considering the impact of these policies on real activity, as opposed to only the impact on the asset markets, and at the same time toward considering the cross-border spillover effects, especially on emerging markets in Asia and Latin America. These two questions are important indeed to understanding the international implications of quantitative easing and the policy issues that follow. And given that previous research works on unconventional measures have focused largely on their impact on specific financial market indicators, the aim of this paper is commendable.

Another strong point is that the paper tries to capture the effects in a systematic manner, starting with an event study to gauge the importance of the asset price channel. Then comes the interesting section on estimating the impulse responses to a US quantitative easing shock, and this is done for many countries using the vector autoregressive (VAR) technique. In the October version of the paper, the authors used changes in the US term spread between 10-year and 3-month Treasury yields as an indicator of the Fed's balance sheet policies and estimated the VAR model based on data from February 1995 to December 2010, separating the full sample into ***the pre-crisis period*** up to December 2006 and ***the crisis period*** from January 2007 onward. Due to limited data availability, the crisis-sample impulse responses are *derived* from impulse responses estimated from the pre-crisis and the full samples, assuming that the full-sample estimates are a weighted average of the pre-crisis sample and crisis-sample estimates. The paper concludes with counterfactual simulations based on the VAR results.

The key findings are: (1) from the event study, the global asset price channel appears to be important, which is consistent with the conclusion reached by previous works based on event studies; (2) international spillovers of US balance sheet policies are large and, rather intriguingly, larger than their domestic impact; (3) the spillover effects, however, vary greatly from one emerging economy to another, both in terms of size and direction. The authors attribute this variation to the many channels of transmission in play.

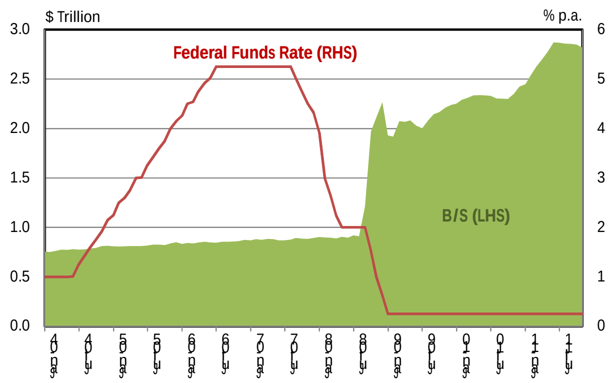
[1] Director, Monetary Policy Office, Bank of Thailand.

Since the VAR results are central to the paper's conclusions, I think it is important to take a good look at these VAR estimates. So my comments are in one way or another related to the estimated VAR model, and there are four points I would like to make here:

1. The first thing that strikes me is the imprecision of the VAR estimates, as indicated by the wide standard error bands. Understandably, there could be many reasons for this, even for the case of the US, such as impaired transmission channels during stressful times and different market reactions to policy shocks in different circumstances. That is to say that much of the effect of unconventional measures probably worked through the confidence channel, and this is difficult to measure. For emerging markets, the problem could be compounded by varying importance of transmission channels and different policy contexts in each country. So my first point is that the crisis sample estimates are, even at first glance, likely to suffer from poor accuracy, and I am not yet comfortable drawing strong conclusions from them. Perhaps we should look at what may contribute to the precision problem.

2. Given that the data used cover the years 1995 to 2010, it should be pointed out that most of this period is considered normal times, and the monetary policy instrument of choice for the US was the interest rate. The fact that in normal times central banks use the interest rate rather than balance sheet measures means that it is also likely to be a more potent instrument, and hence we cannot ignore the fact that prior to the adoption of balance sheet policies, the Fed did reduce the policy rate very aggressively [Figure 1]. With the long and variable lag of monetary policy transmission, the effects of such interest rate reduction would still take place in the economy within the crisis sample, and we definitely cannot attribute everything to the balance sheet measures. The paper did not seem to take this into account, so the results are not clean enough. To avoid mixing up the effects of interest rate and balance sheet measures, the paper would need to look at the impact of an innovation in the term spread that is *not* correlated with changes in the policy interest rate, and also other factors which could influence the term spread. Therefore, the paper should at least consider controlling for the policy interest rate in the VAR estimation.

Figure 1: Fed Balance Sheet & Policy Rate

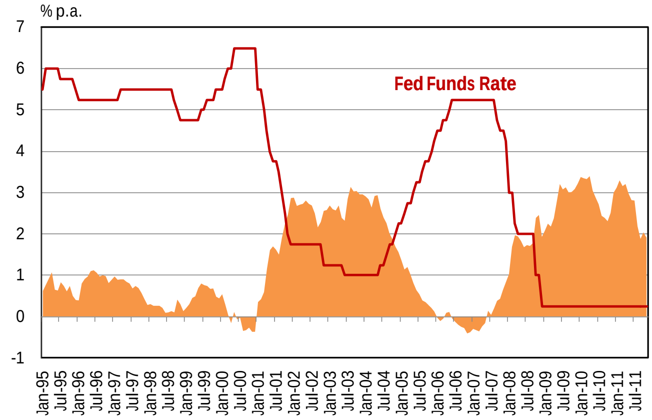


Source: Bloomberg

3. Another problem with using term spreads as a policy indicator as the paper does is that we are mixing two regimes in the full sample estimation – one regime under normal times when monetary expansion is associated with ***an increase*** in term spreads and another regime during the crisis period where unconventional

expansionary monetary policy leads to ***a reduction*** in term spreads [Figure 2]. Mixing the two regimes with opposite reactions of the term spread to the monetary policy direction in the same VAR estimation is troubling and could be a major problem for the accuracy of the results.

Figure 2: UST Spread (10Y – 1Y)



Source: CEIC

4. Now I come to my fourth and final comment. In my opinion, a VAR-type model may not be the most suitable approach in a situation like the one we are dealing with. It seems that the key shortcomings of the "no theory" or "let the data speak" philosophy of VAR become more serious in this situation. VAR requires a lot of data, but we have very limited data regarding the balance sheet policies. Even in normal times, VAR results can be hard to interpret due to the entangling of many monetary policy transmission channels. It is definitely harder when there are changes in the policy regime or changes in the relative significance of the transmission channels, and here we surely have those problems. Thus, I was thinking that a structured model that imposes some theoretical underpinnings on the transmission channels would be more appropriate in this context.

I leave the authors to consider whether they would like to use another type of model to confirm the results presented today. Thank you.

Changes in central bank balance sheets in response to the crisis: Dinner address for the BOT-BIS research conference

Randall Kroszner[1]

This conference has a very timely and important focus on the role of central bank balance sheets. Obviously, all of our countries have an enormous number of challenges ahead in dealing with central banking as well as with supervision and regulation. This conference will be memorable not only for the subject but also for the setting. For many of us, this may be one of the most, if not the most, wonderful conference setting we've been in. We need to be deeply grateful to Governor Prasarn, the Bank of Thailand, the BIS, and the organizers in the HK office of the BIS for arranging such a great conference in this special venue.

When I arrived at the Federal Reserve in 2006, the Fed's balance sheet was about $800 billion. By the time I left in 2009, the Fed's balance sheet had tripled. During this period, we introduced series of new facilities and expanded the types of securities purchased and collateral accepted. The Fed's balance sheet is even larger today – almost $3 trillion. This significant increase in the size of the central bank balance sheet is not unique to the United States. As we have been discussing earlier today, many central banks in both developed and emerging markets have seen their balance sheets grow significantly since the start of the crisis. The Fed's balance sheet, for example, is now around 20 percent of GDP, which is also roughly the average for central banks' balance sheets in developed countries. With a much larger fraction of total economic resources at the central bank, it is no surprise that the size and composition of central bank balance sheets and central bank activity in general are receiving much more attention and scrutiny than prior to the crisis.

One of the key questions is where and how to draw the distinction between monetary policy and fiscal policy. Traditionally, central banks tended to hold safe, liquid assets on their balance sheets. As I will describe in more detail, central banks have dramatically changed the composition of their portfolios and in many cases have the potential for much greater interest rate and credit risk. If the central bank takes a loss, who bears that loss? That loss ultimately will be borne by taxpayers, either directly through a recapitalization of the central bank or indirectly by the central bank returning less revenue to the Finance Ministry. Thus, the risks associated with the balance sheet are an important underlying element in many of the debates over the non-traditional activities of central banks.

We see this issue with great force today in the debates over whether the ECB should or should not be purchasing the debt of some of the riskier sovereigns in the Eurozone. Should such purchases be considered a natural outgrowth of central bank policies to provide liquidity or does this cross the line to be considered fiscal policy, which the ECB is prohibited from doing?

While I am not going to be able to resolve this fundamental question here, I do hope to shed light on how and why central bank balance sheets have changed and some of the key challenges going forward. I will focus first on the motivations for central banks to expand and alter the composition of their balance sheets in response to the crisis. In particular, I will emphasize the breakdown in traditional channels of intermediation during the crisis as

[1] Norman R Bobins Professor of Economics, University of Chicago Booth School of Business.

providing a foundation for a wider scope for central bank action. Second, I will try to make sense of the many varieties of "non-traditional" central bank responses by placing them into three broad categories related to the breakdown of traditional intermediation. Each involves additional risks for the central bank. Third, I will outline some of the key challenges going forward in managing the larger and more complex balance sheets that are likely to be with us for some time to come. Specifically, I will touch on central banks' exit strategy and communication strategy before concluding.

Motivation for non-traditional policies

Of course, one of the primary central bank responsibilities during a crisis is to provide liquidity. In normal circumstances, there is relatively little focus on central bank balance sheet composition. Part of the reason for this is that central banks tended to hold what Andrew Filardo has characterized as "lazy assets," that is, primarily short-term government securities. In normal times, central banks can hold such "lazy" assets but still have an important impact on the operation of the financial system and inflation due to the operation of the traditional transmission mechanism of monetary policy through the banking system. When the financial system is working properly, the central bank could buy virtually any asset or good in order to undertake monetary policy. The purchases by the central bank inject liquid reserves into the system. Rather than being "lazy," those reserves find their ways to intermediaries that then provide the financing wherever there is demand in the system. To avoid unintended or distributional consequences, central banks in normal times have tended to purchase short-term government securities from banks and primary dealers to provide the reserves directly to the banking system. Banks and other intermediaries then determine how to allocate credit throughout the system.

The traditional transmission mechanism presumes that credit can flow relatively freely to its highest-valued uses. In other words, if we think of the system of intermediation as providing the "plumbing" of the financial system, then in normal circumstances the liquidity and credit can flow through the "pipes" wherever there is demand.

When the system of financial intermediation breaks down, however, the plumbing becomes "clogged." Thus, the liquidity provided by the central bank may not generate credit that flows to its highest-valued uses. The liquidity may stay trapped where the central bank initially injects it, because many of the "pipes" that normally connect the various pieces of the system are blocked. When this happens, traditional monetary policy may be like pushing on a string, that is, more and more liquidity is provided but it doesn't create more credit and so has very little impact on the system as a whole. The "lazy" assets mentioned above really are quite lazy because the reserves do not move to generate credit flows through the system.

During the breakdown of intermediation in a crisis, hence the breakdown of the usual transmission mechanism, exactly what the central bank purchases can make a very big difference. A central bank must try to determine where the pipes in the system are "clogged" or "broken." Since the transmission mechanism is not working, the central bank must inject liquidity directly into where it is in high demand and where it can help provide the greatest benefit to the stability of the system. Otherwise, traditional monetary policy actions may be like pushing on a string. Simply buying short-term government securities to provide more reserves to the banking system may not translate into credit flowing to the housing sector, the corporate sector, etc., and activity may dry up. The central bank thus may need to use non-traditional means to revive the functioning of the financial system. Such non-traditional actions lead not only to an increase in the size of the balance sheet but typically dramatic changes in its composition in response to the crisis.

Three categories of non-traditional actions

More specifically, when the intermediation system is not functioning properly, what should the central bank do to have an impact? I will discuss the non-traditional policies in just a moment, but one very important thing that central banks as well as supervisors should do is to try to repair the intermediation process itself – repair the "pipes" of the financial infrastructure as much as possible. I will not go into the details here about how to make market infrastructure more robust (see my book with Robert J. Shiller entitled *Reforming U.S. Financial Markets*, MIT Press, 2011), but this is an important complement to the non-traditional actions that have transformed central bank balance sheets.

While there have been a large number of non-traditional actions undertaken by central banks around the world, I think that they fall under three main headings, each motivated by the breakdown the intermediation process described above: collateral, maturity, and counterparties. I believe this is also a useful way to think about non-traditional policies going forward, either for ongoing crises such in Europe or for future crises that might occur.

Collateral. What should a central bank consider appropriate collateral for lending? Traditionally, such collateral included instruments with low credit and interest rate risk, such as short-term government securities. When the intermediation system is not functioning, however, the central bank may have to broaden the acceptable range of collateral to provide liquidity directly into a variety of markets. The Fed, for example, ventured into new areas, including asset-backed commercial paper, mortgages, and commercial real estate. The ECB has also broadened the acceptable range of collateral, including a variety of types of government paper.

By expanding acceptable collateral, the central bank may be exposing itself to more credit risk than in the past. Protection against losses must be part of any new facility, otherwise bad assets simply flow to the central bank. Overcollateralization, higher interest rates, and other charges can help to mitigate the downside risk to the central bank. In addition, other sources or institutions could be put in a first-loss position. In the Term Asset Lending Facility (TALF), the Fed provided financing into a facility that was capitalized with funds from the Troubled Asset Repurchase Program (TARP), effectively putting the Treasury in the first-loss position. The Treasury provided a 10 percent cushion against potential losses. In Europe, there have been debates about whether there could be a similar leverage of funds from the European Financial Stability Fund (EFSF) with financing from the ECB.

When I was at the Fed, we were careful to ensure the quality of the collateral and protection in each non-traditional facility. I'm delighted that the Fed has not experienced losses related to any of its programs involving expanded collateral.

Maturity. What is the appropriate maturity for credit provision and for the portfolio? In normal times, central banks provide very short-term – typically overnight – financing against good collateral to institutions experiencing liquidity pressures. That's fine if it's a very short-term problem. If the problem turns out to be more persistent and market-wide, market participants want to make sure that the bank is financing itself, not just tomorrow and the day after, but the week after, the month after, and the year after. As part of the breakdown of intermediation, the horizons over which banks and other financial institutions could borrow become increasingly short.

And so at the Fed, we introduced much longer-term lending facilities. The ECB has just introduced a 3-year lending facility, the Long-Term Refinancing Operation (LTRO). Such maturities were unheard of for central banks in the past, but this is now something central banks need to be doing in response to the crisis, because if the concern is about liquidity, that liquidity concern is not just about tomorrow and the day after, but for a longer period of time.

In addition, some central banks are increasing the average maturity of the securities that they hold on their portfolio. The Fed, for example, has recently undertaken the so-called "Operation Twist," which involves selling short-term government securities and using the proceeds to purchase long-term government securities in order to try to bring down long interest rates.

While extending the maturity of lending is a sensible response to the disappearance of term financing during the crisis, it certainly involves greater risks for the central bank. Obviously, longer maturities mean more chances for something to go wrong in the loan over the longer time period, or something to go wrong with the collateral, and of course interest rate risk is greater over longer horizons. Once again, central banks need to be mindful of the new risks and exposures.

Counterparties. What entities should be eligible to receive credit directly from the central bank? The Fed is actually a very constrained institution in terms of to whom it can lend. Even with extending maturities and accepting more types of collateral, the Fed could generally lend only to institutions with commercial bank charters. Some other central banks also face exactly these kinds of constraints.

Given the importance of many non-bank entities as "pipes" linking various parts of the financial system, it was important for the Fed and other central banks to expand the set of counterparties in order to ensure credit was flowing throughout the system. A number of new facilities at the Fed involved credit provision that would get funding to investment banks, to money market mutual funds, etc., to "unclog" important "pipes" in the financial system.

Of course, there is a risk of generating a moral hazard problem: if you are always there to provide the funding if something goes wrong, then something is likely to go wrong more often because market participants won't take as much care. Thus, there is a trade-off. Bringing more entities into the safety net may be sensible in the short run when the intermediation system is frozen. In the longer run, however, changes to the regulatory and supervisory system will be needed to try to mitigate the potential moral hazard problem and prevent people from taking advantage of the safety net.

Key challenges in managing the balance sheets going forward

What, then, are the lessons going forward for crisis management and for the operation of central banks? I will focus on two key issues. The first is exit strategy from the extraordinary policies, an issue already raised by Governor Prasarn as well as by Jaime Caruana. Second is communication and transparency.

On exit strategy, it is crucial to consider how to exit when undertaking and structuring any new facility. During my time at the Fed (2006–09), when adopting the non-traditional policies I've just described, we had extensive discussions about how do we get out – that was a front and center question.

To illustrate this, consider that virtually all of the short-term lending facilities introduced by the Fed in late 2008 basically disappeared only a few months later. The Fed's balance sheet grew rapidly from $800 billion to $2.4 trillion in roughly three months, but then by mid-2009, almost all of those facilities ran off. (The subsequent decisions to undertake large-scale long-term asset purchases are what have driven the Fed's balance sheet higher.) I don't think that this "exit" from those facilities, involving roughly $1 trillion, has gotten what it deserves. That contraction was done through no action of the Fed in and of itself, because the way we structured the new liquidity facilities was that we charged an extraordinary premium – or, in ordinary times, what would have been an extraordinary premium – for market participants to borrow from the Fed. Because what we wanted was for the private markets to start working again. So we structured the programs so that people would turn to the Fed if there were extraordinary times. If the risk premiums in the private markets were so great that they were higher than the very high premiums we were charging at the Fed, market participants could borrow from the Fed.

But as markets normalized, however, market participants would naturally turn to private sources that were cheaper. This is why roughly a trillion dollars ran off rapidly in early 2009. In creating these programs, we very consciously structured them so that they could wind down without the Fed Board having another vote or taking any other action. Otherwise, it can become much more difficult to get out of these programs. Central banks can face a great degree of political pressure to continue a program and help support a particular area of the markets. If the program is designed to run off naturally, however, “the market has spoken” and there is less likelihood of pressure to maintain it.

Thus, the first lesson I draw is: Thinking about exit strategy from the beginning and structuring the policies in a way that leads to a natural, market-driven exit makes winding-down of the facility much more likely to occur.

The second issue I want to discuss concerns communication and transparency.

When you enter a new area, it is important to be especially transparent about what you are doing, why you are doing it, and what the costs and benefits are. Going forward, if central banks are going to be using the asset side of the balance sheet to conduct monetary policy, either through large-scale asset purchases or changes in the composition and maturity of the portfolio, central banks should provide the same type of guidance about the size and composition of the portfolio as they do about interest rates. Central banks often provide a great deal of guidance about the likely path of future rates, in some cases publishing the interest rate forecasts of individual monetary policy committee members. The Fed has undertaken a number of major steps recently to enhance communication about its intentions with respect to future interest rates.

When at or near the zero-lower-bound of interest rates, the size and composition of the balance sheet can become a primary tool of monetary policy. Very few central banks, however, currently provide much detailed guidance about their forecasts of how the size and composition of the balance sheet will change over time. Given the importance of the portfolio to monetary policy, however, providing information about the likely path of holdings of different types of securities, e.g. mortgage-backed securities and short- vs. long-term government debt, makes just as much sense as forward guidance on interest rates. I think it is important parallel information about intentions with respect to both the portfolio and interest rates.

Finally, on a related communications and transparency point, it is important to be clear what monetary policy can and cannot do. In other words, central banks should be careful not to claim too much. Earlier today, Deputy Governor Iwata and Mark Spiegel discussed perceived disappointments with respect to the large-scale asset purchase program by the Fed known as Quantitative Easing II (QE2). Whether it was a disappointment or a success depends on what the objective was. If the objective was for the U.S. to avoid the tail risk of deflation, to avoid a 1930’s outcome or to avoid what unfortunately has happened in Japan, then the policy was a great success. If the policy was to create employment, to get everyone happy, to cure baldness, to cure cancer as some people had suggested the policy could do, then that of course was going lead to a great disappointment.

Central banks, of course, have a lot of influence over inflation and deflation and over interest rates. In normal circumstances, that affects the desire of the private sector to borrow. In extraordinary circumstances, as we’ve seen, banks may be reluctant to lend and borrowers may not have much demand to borrow. And so you can get into a situation where you can be providing a lot more liquidity, you can be avoiding the downside risk and tail risk of deflation, but you may not be actually generating sufficient incentives for employment to grow rapidly or for investment to increase strongly.

Given the difficulties for operation of the traditional monetary policy transmission mechanism in extraordinary times, fiscal uncertainties, and regulatory uncertainties, central banks should be cautious in claiming how much monetary policy can accomplish in fostering economic revival. Sensible monetary policy may be necessary, but it may not be sufficient.

Thus, a second lesson that I draw is: Central banks should communicate as clearly as possible their intentions with respect to the size and composition of the balance sheet and what monetary policy can and cannot accomplish.

Thank you very much.

Reserves, liquidity and money: an assessment of balance sheet policies[1]

Jagjit S Chadha,[2] Luisa Corrado[3] and Jack Meaning[4]

Abstract

The financial crisis and its aftermath have stimulated a vigorous debate on the use of macro-prudential instruments both for regulating the banking system and for providing additional tools for monetary policymakers. The widespread adoption of non-conventional monetary policies has provided some evidence on the efficacy of liquidity and asset purchases for offsetting the zero lower bound. Central banks have thus been put in mind of the effectiveness of extended open market operations as supplementary monetary policy tools. These are essentially fiscal instruments, in that they entail the issuance of central bank liabilities backed by fiscal transfers. Given that these tools are written into fiscal budget constraints, we can examine the consequences of the operations in the context of a micro-founded macroeconomic model of banking and money, and we can simulate the responses of the Federal Reserve balance sheet to the crisis. Specifically, we examine the role that reserves for bond and capital swaps play in stabilising the economy, as well as the impact of changes in the composition of the central bank balance sheet. We find that such policies can significantly enhance the ability of the central bank to stabilise the economy. This is because balance sheet operations supply (remove) liquidity to a financial market that is otherwise short (long) of liquidity, and hence allow other financial spreads to move less violently over the cycle to compensate.

Keywords: Non-conventional monetary interest on reserves, monetary and fiscal policy instruments, Basel III

JEL classification: E31, E40, E51

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2 Professor of Economics, Chair in Banking and Finance, School of Economics, Keynes College, University of Kent, Canterbury, UK, CT2 9LP. E-mail: jsc@kent.ac.uk. Centre for International Macroeconomics and Finance, University of Cambridge.

3 Associate Professor of Economics, Department of Economics, University of Rome, Tor Vergata. E-mail: lc242@cam.ac.uk.

4 School of Economics, Keynes College, University of Kent, Canterbury, UK, CT2 9LP. E-mail: jm583@kent.ac.uk.

1. Introduction

The on-going financial and credit crisis has pushed existing monetary policy practices to their limit and created considerable interest in identifying an appropriate post-crisis operating framework for monetary policy, particularly as there has been an active parallel debate about the regulatory framework for commercial banking. What might ultimately be termed the first generation of micro-founded monetary policy models had little to say about the new monetary policy frameworks, since the short-term policy rate was sufficient to stabilise the economy. But during this crisis many types of extended open market operations have been used in efforts to affect longer-term interest rates and asset prices, given that the short-term rate was constrained at the zero lower bound. Thus, in this paper we seek to address the question of post-crisis monetary policy by considering the role of balance sheet operations in a model in which commercial banks, lending and external finance premia all affect the optimal formulation of monetary policy.

The Goodfriend-McCallum (2007) model represents a Calvo-Yun monopolistically competitive production economy with sticky prices, where households respect their budget constraints in planning consumption, but where households must hold bank deposits to effect transactions. Hence, loan technology for the banking sector takes centre stage in this model,[5] which addresses the requirements of the private sector subject to monitoring and quality of collateral constraints. Households can work either in the goods producing sector or in the banking sector monitoring loan quality. But in order to consider the implications of reserves, in the version of the model developed by Chadha and Corrado (2011) banks also have to make a choice regarding their asset mix in terms of reserves with the central bank versus loans with the private sector. The central bank in this model holds commercial bank reserves and sets the interest rate paid on them, and the government budget constraint is modified to include claims from reserves, as well as standard issuance of public debt to meet excess of expenditures over taxes. Reserves in this model are outside money and respond to the demand for liquidity from financial institutions.

A banking-sector-based model can both amplify and add persistence to a standard macroeconomic setup. This is because decision rules for output are shown to incorporate the equilibrium level of commercial bank assets and the price (or spread) at which those assets are provided. The recent boom and bust in advanced country debtor economies would seem to confirm the continuing relevance of this insight. First, we consider the non-standard monetary, or balance sheet, policies carried out by the Federal Reserve in response to the financial crisis, and examine how they can be modelled. Specifically, we model the injection of bank reserves in our model economy in three ways, either as a perfectly elastic supply of bank reserves meeting commercial bank demand, or as a swap for bonds or capital. Furthermore we consider the role of a policy rule for the supply of reserves to supplement or replace existing interest rate rules. It is shown that these one-off responses can stabilise the economy following a negative downward shock to asset prices.

The motivation for providing reserves is to address the liquidity preference for commercial banks. Gale (2011) shows that, given risk aversion, the market cannot supply sufficient liquidity to the financial system. This is because there is an incentive for savers to swap illiquid assets for liquid assets, which will leave the market as a whole short of liquid assets and long illiquid assets. The problem will tend to be exacerbated if there is a collapse in confidence in the interbank market, when distributional shocks to banks no longer get recycled around the system. Monetary authorities can offset this liquidity shortage by issuing short-term liabilities backed by fiscal transfers, ie interest bearing reserves or T-bills. This

[5] See Goodfriend and McCallum (2007) and Chadha, Corrado and Holly (2008) for an outline of this modelling device and its implications.

operation reduces private sector holdings of illiquid assets and increases the banking sector's reserve-deposit ratio. From a fiscal or debt management perspective, if we take the structure of debt as given, the swap of illiquid for liquid debt instruments hedges the private sector against liquidity risk and allows the fiscal policymaker to collect a return in the form of liquidity premia. The danger of the operation is that it is conducted at a time of fiscal deficits and so may be viewed as a change in the preferences of the monetary and fiscal policymaker, and thus lead to an expectation of lower interest rates and higher fiscal deficits (see Nordhaus, 1994).

Under the condition of coordination of monetary and fiscal policy, we can examine the case for the systematic use of balance sheet or reserve policies. For in contrast to a model that does not explicitly model bank balance sheets, this model can deliver an endogenous dynamic response for various risk premia and for the supply of loans and deposits. Using standard methods, we can also compare the responses of our artificial economy with and without reserve injections. We derive the approximate welfare criterion of the representative household and find that the economy in which commercial banks have an endogenous choice over reserve holdings (*qua* liquidity) performs better in welfare terms than an economy where commercial banks lack such an incentive. The holding of reserves over the business cycle acts as a substitute for more costly provision of commercial bank assets, and thus reduces the volatility of interest spreads in shock scenarios. Also, by varying the availability of reserves over expansions and contractions, it helps to stabilize the impulse from the monetary sector.[6]

The structure of this paper is as follows. Section 2 outlines by way of example the unconventional monetary policies of the Federal Reserve, and uses a simple framework for understanding a stylized flow of funds and the role of commercial banks in the monetary system. Our setup also incorporates the government's budget constraint in this section, showing that the payment of the policy rate on bank reserves will have a direct impact on the equation of motion for government debt. Section 3 sketches the implications of the loan production function approach for key macroeconomic decision rules, and outlines the determination of key market interest rates. Section 4 considers the implications of commercial banks' asset management in terms of reserve holdings, to account for the relative returns from holding reserves or producing loans and for liquidity concerns. Section 5 explains the standard calibration techniques used. Section 6 outlines the results of the impulse response analysis of various balance sheet operations, and undertakes welfare analysis of some key results. Section 7 presents conclusions and some final observations.

2. Unconventional Monetary Policy in the U.S.

The outbreak of the financial crisis in the U.S housing market in early 2007 and the way it spread to a full-blown, global financial meltdown by 2008 are well documented. In response to immense contractionary pressure, the Federal Reserve, like many other central banks the world over, cut its policy rate quickly and dramatically. The target federal funds rate fell from 5.25% in September 2007 to between 0% and 0.25% by January 2009, effectively reaching the zero lower bound (ZLB). With short-term nominal interest rates constrained, what was previously a largely theoretical discussion of how to gain traction for monetary policy at the ZLB became a real and practical problem. The Federal Reserve embarked on a number of unconventional policy initiatives in order to provide monetary stimulus to the U.S economy and reactivate frozen credit markets. Many of these measures were concerned directly with the Fed's balance sheet, reserves and asset holdings. These policies at the ZLB are

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6 Paying interest on reserves is thus a way to meet the Friedmanite maximum without deflation.

effectively fiscal policies, since they involve the issuance of short-term fiscal instruments, and hence we wish to integrate these monetary/fiscal instruments into our model.

2.1 Paying Interest on Reserves

An initial but important policy development was the payment of interest on reserves held by commercial banks at the central bank. The Federal Reserve had applied to Congress for the authority to pay interest on bank reserves on various occasions (Meyer, 2001; Kohn, 2004) and was granted permission in 2006 under the Financial Services Regulatory Relief Act. Originally, the policy was not due to become effective until 2011, as Congress had worries about its fiscal costs,[7] but as the economic conditions in the U.S. worsened, implementation was brought forward to 2008. There is strong theoretical backing for such a policy. Hall (2002) outlines a model in which the payment of interest on reserves can become a policy tool capable of controlling the price level in a world without money, whilst Chadha and Corrado (2011) show that paying interest on reserves at the policy rate can provide an incentive for financial intermediaries to vary their holdings of reserves cyclically, which in turn attenuates fluctuations in the external finance premium and helps stabilise the monetary economy. The issuance of such reserves is very close substitute for short-term T-bills, and because interest is payable these operations are in effect a swap of liquid assets for illiquid assets.

2.2 Large Scale Asset Purchases

Large Scale Asset Purchases (LSAPs) can be thought of as traditional open market operations in which the central bank changes the monetary base by buying and selling assets in exchange for reserves, but on a much larger scale and over a longer duration. Traditionally the central bank would use OMOs to meet the demand for reserves at its target interest rate, requiring relatively small, short-lived fluctuations in the level of reserves. In November 2008, the Fed announced that it would begin purchasing housing agency debt and mortgage-backed agency securities in the amount of $600bn in response to the housing crisis, and in order to promote the health of mortgage lending. In March 2009, this was increased to $1.25 trillion. The purchases were largely of maturities ranging from 3 months and 5 years. As they have reached maturity, principal has been reinvested to fund the purchase of Treasury securities and maintain the value of the agency debt and agency-backed securities section of the LSAP.

Accompanying this extension was the announcement that the Fed would begin to buy $300bn of Treasury securities, over 60% of which had maturities of 3 to 10 years. The purchase of Treasuries was designed to support falling asset prices by making the Fed present as a large buyer, and through the portfolio balance channel this was to spread to other assets in the economy. It also constituted a direct injection of liquid reserves into the economy to improve confidence and conditions in impaired credit markets. These large scale asset purchases were predominantly funded by the creation of over a trillion dollars of new reserves, making them the largest quantitative easing programme enacted since the crisis. In November 2010, in light of the continuing weakness predicted by economic forecasts, the purchase of longer-term Treasuries was extended by $600bn more under a second round of

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[7] Estimates by the Congressional Budget Office on the cost of paying interest suggest that the cost in the first year would be $253 million, and that this would rise to $308 million by the fifth year, with a total of $1.4 billion over five years. This is based on the assumption that the federal funds rate would average 4.5% from 2008 to 2016, and that the Fed would pay interest at a rate 0.1 to 0.15 percentage points below that. It projected required reserves of about $8.3 billion. If the Fed only paid interest on excess reserves held, then the cost would be considerably smaller, though it would rise if commercial banks made more use of the facility. See Goodfriend (2002) for a recent survey.

quantitative easing (QE2), which took the total LSAP to over $2 trillion. In September 2011, the FOMC announced a maturity extension programme under which it is to buy an additional $400bn of longer-dated treasuries but simultaneously sterilise these by selling short-term Treasuries in the same amount. The goal is to lower longer-term yields without increasing the size of the central bank's balance sheet, by "twisting" the yield curve and increasing the average maturity of the Fed's Treasuries portfolio by 25 months. More may follow.

2.3 Other Policies

2.3.1 Commercial Paper Funding Facility

One symptom of the financial crisis was the drying up of liquidity and a scarcity of available credit. This caused interest rates in commercial paper markets to rise, and the term that issuers of commercial paper could borrow shortened as investors moved away from longer-dated maturities in the face of uncertainty. In order to alleviate this situation, the Fed on 27 October 2008 began buying up high-rated, unsecured and asset-backed commercial paper through a special purpose vehicle, under financing provided by the Federal Reserve Bank of New York. The purchases were of newly issued, non-interest-paying 3-month-maturity commercial paper instruments, which were held for the full term, with the proceeds being used to repay the loan taken from the FRBNY to fund the original purchase. The CPFF was designed to realize the Fed's role as lender of last resort, assuring investors and issuers that firms would be able to meet their financing needs, and thus making them a more attractive investment and instilling confidence in credit markets. By easing liquidity pressure on firms and financial intermediaries, this could then also ease credit restrictions on households and businesses. After two extensions, the CPFF expired on 1 February 2010. At its largest, in January 2009, the facility held around $350bn of commercial paper, approximately two thirds of which was unsecured.[8]

2.3.2 TALF

Following the collapse of Lehman Brothers in September 2008, the already strained asset-backed securities (ABS) market froze, with interest rate spreads soaring. ABS markets are one of the key drivers of funding to the wider economy, supplying credit for all manner of activity to consumers and businesses. With this in mind, on 25 November 2008 the FRBNY announced that in order to support the issuance of ABS, borrowers would be able to request non-recourse loans of 3- or 5-year duration against AAA-rated ABS through the Term Asset-Backed Securities Loan Facility (TALF).[9] Initially the facility was granted permission to extend $200bn of loans, but with demand less than anticipated, only $70bn was actually lent while TALF was operational. Borrowers were eager to rid themselves of TALF financing since it came at a penalty. Thus, as conditions in credit markets improved, many paid back TALF loans early, securing funds privately. Because of this, the level of TALF credit currently outstanding is under $1bn. The non-recourse nature of these loans means that if the borrower cannot repay the loan, the collateral behind it, which can range from student loans and credit cards to small business loans or loans on commercial property, can be claimed by the Fed and sold. This had important implications for the risk faced by the Fed, helping to mitigate much of the risk that it could potentially incur by fulfilling this lender-of-last-resort role.

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8 For a more in-depth discussion of the CPFF, see www.newyorkfed.org/research/epr/11v17n1/1105adri.pdf.

9 For a fuller description and analysis of TALF, see Brian Sack's speech "Reflections on the TALF and the Federal Reserve's Role as Liquidity Provider", available at http://www.newyorkfed.org/newsevents/speeches/2010/sac100609.html.

2.3.3 TARP

The Federal Reserve was supported in its response to the crisis by the Treasury, which enacted a range of stimulus measures collectively dubbed the Troubled Asset Relief Programme (TARP). TARP consisted of a number of programmes, including $80bn of capital injections to U.S. automotive companies and $48bn to insurer AIG. The Treasury also provided credit protection totalling 10% of the Fed's TALF programme. By far the largest initiative in TARP was the Capital Purchase Programme (CaPP), which was launched on 14 October 2008 and accounted for over half of total TARP spending. Under CaPP, $250bn was extended by the Treasury to bolster the capital position of financially important firms. The elevated incidence of write-offs, defaults and under-performing loans which characterised the crisis left many financial intermediaries in a weakened capital position, negatively affecting their ability to extend credit and loans to the wider economy. This generated a loss of confidence in the institutions themselves, compounding the problem. CaPP sought to directly inject new capital into these organisations by purchasing preferred stock or securitised debt on which it received a dividend rate of roughly 5%. CaPP has provided a capital boost to 707 companies in the U.S., for a total of $205bn, but it has also received over $150bn in repayments as firms have found it possible to raise capital in the improved private markets and have paid back CaPP funds.

2.4 Credit Versus Quantitative Easing

The term quantitative easing first appeared in the lexicon to describe the Bank of Japan's policy of central bank reserve creation when it found itself constrained by the zero lower bound to the policy rate in the early 2000s. In a speech at the London School of Economics in January 2009, Federal Reserve Chairman Ben Bernanke tried to distance the unconventional policy of the Fed in 2007 from this largely unsuccessful policy by saying:

> In a pure QE regime, the focus of policy is the quantity of bank reserves, which are liabilities of the central bank; the composition of loans and securities on the asset side of the central bank's balance sheet is incidental.... In contrast, the Federal Reserve's credit easing approach focuses on the mix of loans and securities that it holds and on how this composition of assets affects credit conditions for households and businesses.

In theory, QE is a policy which seeks to change the size of the central bank's balance sheet, increasing liabilities through the creation of new reserves or other liquid fiscal liabilities. Often these reserves are then used to purchases assets from the financial or private sector. Credit easing (CE) differs in that it targets the asset side of the balance sheet, specifically the compositional mix of assets held by the central bank. In pure CE, the level of reserves and the subsequent size of the central bank's balance sheet do not change. In practice, most central banks' reactions to the crisis, including the Fed's, have elements of both quantitative and credit easing. In early 2008, the Fed began purchasing illiquid assets from private markets via liquidity swaps and the Term Auction Credit (TAC) programme, which it sterilised by selling its holdings of more liquid Treasury securities. Figure 1 shows that Fed holdings of U.S. Treasury securities fell from around $780bn in December 2007 to just $479bn by June 2008. This can be thought of as pure credit easing, as the sales of T-bills almost exactly offset the asset purchases, and the size of the balance sheet remained unaffected around $900bn, whilst reserves continued to be a tiny 0.01% of GDP. When the crisis worsened following the collapse of Lehman Brothers in September 2008, the Fed increased the provision of liquidity swaps and TAC, as well as introducing the CPFF and providing direct support to a number of systemically important institutions. Figure 1 shows that the Fed’s holdings of Treasury securities remained relatively constant over this period. Figure 2 shows how these increased purchases were funded in two ways. One was the introduction of the Supplementary Treasury Financing Account (STFA), where the Treasury brought forward its borrowing to exceed its current need and deposited the excess funds with the Federal Reserve. The second, and ultimately much larger, source of funds came from the creation of new reserves. These new, unsterilized purchases caused the Fed's balance sheet to grow rapidly. The Fed had now moved into QE, though it continued to assert that it was solely focussed on providing liquidity through its mix of assets, and that the increase in the size of the balance sheet was an incidental by-product of its credit easing policy.

However, with the LSAPs funded almost entirely through the creation of new reserves,[10] reserve holdings have increased by a factor of 158 from their previous level of around just $11bn in 2007 to $1.74tn, or 13% of GDP. Table 1 shows the consolidated balance sheet of all Federal Reserve Banks pre- and post-crisis to demonstrate the scale of the change. The central bank balance sheet is now 3 times the size it was in 2007, and reserves, which originally accounted for around 1.5% of the liabilities, now make up almost two thirds.

2.5 The Unconventional Policy Balance Sheet

We introduce a simple framework for analysing the effect of unconventional policies on the monetary balance sheet. For simplicity, since we abstract from other forms of central bank money and concentrate on bank reserves alone in our model, high-powered money is identical to reserves. More traditionally, the central bank controls the stock of fiat money (outside money), and financial intermediaries create other forms of money, which are claims on the private sector. Since financial intermediation allows alternative assets to serve as money, it offers a close substitute to (outside) fiat money, and the ability of the central bank to determine the overall nominal level of expenditure depends on the relationship between outside and inside money. The central bank has a powerful tool to regulate financial intermediaries and to affect the quantity of money in circulation, namely reserves, which may be fractional, voluntary or both.[11]

Private Sector	
Assets	Liabilities
Deposits D	Loans $(D-r)$
Bonds γB	Tax $\sum_{i=0}^{\infty} \beta^i t_i$
Capital $\gamma_k K$	K

Government	
Assets	Liabilities
Tax $\sum_{i=0}^{\infty} \beta^i t_i$	Bonds B

Commercial Banks	
Assets	Liabilities
Reserves r	Deposits D
Loans $(D-r)$	

Central Bank	
Assets	Liabilities
Bonds $(1-\gamma)B$	Reserves r
Capital $(1-\gamma_k)K$	

We first look at the private sector's balance sheet. The private sector has three forms of assets: deposits, *D*, held at banks, some fraction of bonds, γB, issued by the government, and a fraction of total capital.[12] Their liabilities are loans, *D-r*, provided by banks. The government sector has liabilities in the form of outstanding public debt, *B*, and assets, represented by the present discounted value of future taxation. The commercial banks' balance sheet liabilities are deposits, *D*. Some fraction of liabilities, *r*, is held as reserves, and

10 In November 2009, the Fed began reinvesting the returns it made on agency debt and other short-term assets it had bought to partially fund its further purchases of longer-term Treasury securities.

11 See Freeman and Haslag (1996) and Sargent and Wallace (1985).

12 In this example we assume that the private sector is represented by households.

the rest, D–r, is available to be lent to the private sector. The central bank holds assets in the form of some fraction of government bonds, $(1–\gamma)B$, and a fraction of capital, $(1–\gamma_k)K$, with liabilities determined by central bank money, which are reserves in this model.[13] The net assets of commercial banks and of the central bank are both zero. The private sector has net assets given by $D+\gamma B+\gamma_k K-(D-r+\sum_{i=0}^{\infty}\beta^i t_i)$, and thus, because $r=(1-\gamma)B+\gamma_k K$ and $\sum_{i=0}^{\infty}\beta^i t_i = B$, we can see that net private sector assets are also zero.

This flow of funds shows the mechanism by which unconventional policies operate. The central bank can perform quantitative easing by increasing the size of its balance sheet. It does this by extending an increased level of reserves to commercial banks. This must be backed by increased holdings of either bonds or capital, which in turn must be bought from the private sector. Alternatively, credit easing is conducted through the composition of the balance sheet. With their liabilities unchanged, the central bank can buy capital from the private sector, increasing its own holdings. It funds these purchases by selling bonds back to the private sector, leaving the net effect on the size of both the central bank and private sector's assets at zero. Due to the differing properties of bonds and capital as collateral in our model's loan production function, this exchange has implications for levels of deposit demand, which we shall discuss later.

2.5.1 Reserves and the fiscal position

How can paying interest on reserves change the fiscal position? It does so because paying interest rates on reserves will ultimately depend on the public sector's budget constraint. The per-period government budget constraint means that any excess of government expenditure, G_t, over tax receipts, T_t, and payment of interest on debt, $R_{t+1}^B\gamma B_{t+1}$, and/or reserves, $R_t^{IB} r_t$, will be financed by the issuance of bonds or central bank money, given the consumption-goods price index, P_t^A. Note that the interest paid to the private sector is R^B and the interest to commercial banks is R^{IB}, which is the policy rate in our model. Hence if we look at the consolidated budget identity for the government sector we note that:[14]

$$g_t - tax = \frac{r_t}{P_t^A(1+R_t^{IB})} - \frac{r_{t-1}}{P_t^A} + \frac{\gamma B_{t+1}}{P_t^A(1+R_{t+1}^B)} - \frac{\gamma B_t}{P_t^A}\,. \tag{1}$$

Thus, the government can finance its net expenditure by issuing government debt, γB, or by issuing reserves, r_t. However if interest rates are paid on reserves they will become interest bearing and therefore comparable to government debt. Clearly, any excess government expenditure can be financed by issuing bonds to the private sector or by supplying reserves to commercial banks at a differentiated interest rate. We leave the determination of the relative interest rates to section 3.1. Since we assume a stationary level of debt in this model, there are no implications for fiscal solvency in this setup, as all deviations from a steady-state debt-to-GDP ratio are strictly temporary. In effect, we are conditioning the issuance of reserves on a given path of public debt, which we simply assume to be optimal save for liquidity considerations.

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[13] If we operate in an open economy, central bank assets would also include foreign exchange reserves, r^f.

[14] In this setting, the government sector includes both the government and the Bank of England. We also assume that high-powered money comprises only reserves, not coin.

3. The General Equilibrium Monetary Model

As pointed out by Kiyotaki and Moore (2001), money aggregates should be reconnected to general equilibrium models, as they affect consumption decisions of liquidity-constrained households and the spreads across several financial instruments and assets. Similarly, open market operations or balance sheet policies will affect loans and therefore consumption. A simple way to incorporate money and spreads into a general equilibrium setting is to study the banking sector proposed by Goodfriend and McCallum (2007), which we extend to simulate the responses of the Federal Reserve balance sheet to the crisis. Specifically, we examine the role of reserves for bond and capital swaps in stabilising the economy, as well as the impact of changes in the composition of the central bank balance sheet.

The Goodfriend and McCallum model complements the traditional accelerator effect (Bernanke et al, 1999) with an attenuator effect, which is present in the model because monitoring effort is drawn into the banking sector in response to expanding consumption, which is accompanied by an expansion of bank lending that raises the marginal cost of loans and the external finance premium (EFP).The main feature of the model is the inclusion of households, production and monetary authority, alongside a banking sector which lends subject to monitoring costs, quality of capital and the availability of reserves.

3.1 Households and the Production Sector

Households are liquidity constrained and decide the amount of consumption and the amount of labour they wish to supply to the production sector and to the banking sector according to the utility function

$$U = E_0 \sum_{t=0}^{\infty} \beta^t [\phi \log(c_t) + (1-\phi)\log(1 - n_t^s - m_t^s)], \tag{2}$$

where c_t denotes real consumption, n_t^s is the supply of labour in the goods sector, m_t^s is the supply of monitoring work in the banking sector and ϕ denotes the weight of consumption in the utility function. They are subject to the budget constraint

$$\begin{aligned} & q_t(1-\delta)K_t + \frac{\gamma B_t}{P_t^A} + \frac{D_{t-1}}{P_t^A} + w_t(n_t^s + m_t^s) + c_t^A\left(\frac{P_t}{P_t^A}\right)^{1-\theta} + \Pi_t \\ & -w_t(n_t + m_t) - \frac{D_t}{P_t^A} - tax_t - q_t K_{t+1} - \frac{\gamma B_{t+1}}{P_t^A(1+R_t^B)} - c_t = 0 \end{aligned} \tag{3}$$

,

where q_t is the price of capital, K_t is the quantity of capital, P_t is the price of household's produced good, P_t^A is the consumption goods price index, n_t is the labour demanded by household as producer, m_t is the labour demanded by household's banking operation, w_t is the real wage, D_t is the nominal holding of broad money, tax_t is the real lump-sum tax payment, and R_t^B is the nominal interest rate on government bonds purchased in year $t+1, B_{t+1}$. We also assume that any profit from the banking sector, Π_t, goes to the household sector. The Lagrange multiplier of this constraint is denoted as λ_t, and θ is the elasticity of household demand. Households choose the level of monitoring work, m_t, and the level of employment work, n_t, that they wish to offer to the production sector and the banking sector.

At the same time households' consumption, given the cash-in-advance constraint, is affected by the amount of loanable funds they can obtain:

$$c_t = v_t D_t / P_t^A , \tag{4}$$

where v_t denotes velocity and D_t is deposits.

The production sector, characterized by monopolistic competition and Calvo pricing, adopts a standard Cobb-Douglas production function with capital K_t, and labour n_t, subject to productivity shocks. Firms decide the amount of production they wish to supply and the demand for labour, by equalizing sales to net production:

$$K_t^{\eta}(A1_t n_t)^{1-\eta} - c_t^A \left(P_t / P_t^A\right)^{-\theta} = 0 , \tag{5}$$

where η denotes the capital share in the firm production function, $A1_t$ is a productivity shock in the goods production sector whose mean increases over time at a rate γ, and θ denotes the elasticity of aggregate demand, c_t^A. The Lagrange multiplier of this constraint is denoted by ξ_t. By clearing the household and production sectors,[15] we can define the equilibrium in the labour market and in the goods market. Specifically, the demand for monitoring work,

$$m_t = \left(\frac{\phi}{\lambda_t c_t} - 1\right)\frac{1-\alpha}{w_t} c_t \, , \tag{6}$$

depends negatively on wages, w_t, and positively on consumption, c_t, where $1-\alpha$ is the share of monitoring in the loan production function. These two sectors also provide the standard relationship for the riskless interest rate and the bond rate.

3.2 Banking Sector

We now turn to the analysis of how the banking sector affects the economy. The production function for the quantity of loans is given by:

$$L_t / P_t^A = F\left(\gamma b_{t+1} + A3_t k q_t K_{t+1}\right)^{\alpha} \left(A2_t m_t\right)^{1-\alpha} \quad 0 < \alpha < 1 , \tag{7}$$

where $A2_t$ denotes a shock to monitoring work, $A3_t$ is a shock to capital as collateral and $b_{t+1} = B_{t+1} / P_t^A \left(1 + R_{t+1}^B\right)$. The parameter *k* denotes the inferiority of capital as collateral in the banking production function, while α is the share of collateral in the loan production function. Increasing monitoring effort is achieved by increasing the number of people employed in the banking sector and thereby reducing employment in the goods production sector.

While in standard Calvo-Yun models nominal consumption plans pin down the demand for money, in this model with banking, money is produced by banks, so any shift in the supply of lendable funds generated by shocks to monitoring effort or collateral also affects consumption. Specifically, the banking sector matches deposit demand from liquidity-constrained consumers with a technology to produce loans by substituting monitoring work for collateral in supplying loans. Also, we assume that loans are affected by the reserve/deposit ratio, rr_t:

$$L_t = \left(1 - rr_t\right) D_t . \tag{8}$$

[15] For details on the model's configuration, derivation and notation, see the technical appendix, available on request.

Note that while Goodfriend and McCallum (2007) assume a fractional reserve requirement where the reserve-deposit ratio is given, we analyse the implications of an approach that varies reserve holdings through balance sheet policies. Simple substitution of the bank's loan production function in the household's cash in advance constraint (4) leads to:

$$c_t = v_t \frac{F\left(\gamma b_{t+1} + A3_t kq_t K_{t+1}\right)^{\alpha}\left(A2_t m_t\right)^{1-\alpha}}{P_t^A\left(1-rr_t\right)}. \tag{9}$$

The differentiation of (9) with respect to K_{t+1} gives an expression $\Omega_t A3_t kq_t$, which is a function of the marginal value of collateralized lending:

$$\Omega_t = \frac{c_t \alpha}{\gamma b_{t+1} + A3_t kq_t K_{t+1}}, \tag{10}$$

which in turn depends on consumption, c_t, and on the value of the collateral, q_t and b_t. This expression also enters in the asset price equation:

$$q_t = \frac{\left(E_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1}\left(1-\delta\right)\beta + E_t \beta\eta\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{\xi_{t+1}}{\lambda_{t+1}}\left(\frac{A1_t n_t}{K_t}\right)^{1-\eta}\right]\right)}{\left(1-\left(\frac{\phi}{c_t\lambda_t}-1\right)\Omega A3_t k\right)}. \tag{11}$$

Finally, the Central Bank sets the policy rate, which affects banks' incentives to hold reserves.

3.3 Consumption, Monitoring Work and Asset Prices

We now describe in more detail the main log-linear relationships which characterize the model. In our notation, variables without time subscripts denote steady-state values, whereas those with a time subscript denote log-deviation from steady state. A log-linear formulation of (9) shows how loanable funds affect the consumption of liquidity-constrained consumers:

$$c_t = \left\{\begin{array}{l} v_t c + tt_t c + \left(1-\alpha\right)\left(m_t + a2_t\right) + \\ \alpha\left[\frac{b}{b+k_1} b_t + \frac{k_1}{b+k_1}\left(q_t + a3_t\right)\right]\end{array}\right\}\left(\frac{b+k_1}{b\left(1-\alpha\right)+k_1}\right) \tag{12}$$

With the presence of a cash-in-advance constraint, a shock to velocity, v_t, will increase consumption. Consumption, c_t, is also positively affected by the amount of monitoring work, m_t, where α is the share of collateral in the loans production function and (1–α) represents the share of monitoring costs. It is also affected by the amount of collateral represented by bonds, b_t, and capital, whose value is given by q_t. A positive shock to monitoring, $a2_t$, by increasing the efficiency with which banks produce loans, increases the supply of loans and therefore consumption. Similarly, a negative shock to collateral, $a3_t$, by reducing the price of capital, q_t, will negatively affect consumption. The parameters c, b and k_1 represent the steady-state fraction of consumption in output, the holding of bonds and a composite parameter reflecting the inferiority of capital as liquidity in comparison with bonds.[16]

The demand for monitoring work, which derives from (6), is given by:

$$m_t = -w_t - \frac{(1-\alpha)c}{mw}\left(c_t + \frac{\phi}{\lambda}\lambda_t\right). \tag{13}$$

A higher wage, w_t, will reduce the resources devoted to monitoring. Similarly, monitoring will be affected by the marginal utility of consumption and the marginal value of households' funds, λ_t. The steady-state parameters m,w and $\frac{\phi}{\lambda}$ represent the steady-state proportions of employment in the banking sector, the level of the real wage, and the ratio of the weight of consumption in the utility function relative to the steady-state shadow value of consumption. A key term here is the marginal value of collateralized lending, Ω_t, from (10), which increases as consumption rises, and falls as collateral becomes more widely available:

$$\Omega_t = \frac{k_2}{b+k_2}(c_t - q_t - a3_t) - \frac{b}{b+k_2}b_t \tag{14}$$

.

Ω_t depends on the value of the collateral, q_t and b_t, on a collateral shock, $a3_t$, and on consumption, c_t. Higher levels of consumption increase the marginal value of capital and hence the collateral value, q_t. The increase in collateral value leads to more borrowing and more consumption. The parameter k_2 is again a composite coefficient similar to k_1.[17]

The marginal value of collateralized lending also feeds back into the capital asset price, q_t, equation derived from (11):

$$\begin{aligned} q_t &= (\delta_1 + \gamma_1)(E_t\lambda_{t+1} - \lambda_t) + \delta_1 E_t q_{t+1} - \frac{k\Omega\phi}{c\lambda}(c_t + \lambda_t) + \\ &\quad k\Omega\left(\frac{\phi}{c\lambda} - 1\right)(\Omega_t + a3_t) + \gamma_1 E_t\left[mc_{t+1} + (1-\eta)(n_{t+1}1a1_{t+1})\right]. \end{aligned} \tag{15}$$

In (15), the marginal value of collateralized lending, Ω_t, potentially can amplify asset price volatility and magnify the response of the economy to both real and financial shocks. Both real shocks, $a1$, and financial shocks, $a3$, directly feed back into asset prices alongside the expected marginal productivity of capital $\left[mc_{t+1} + (1-\eta)(n_{t+1} + a1_{t+1})\right]$, where mc_{t+1} denotes marginal cost in period $t+1$, η is the share of capital in the goods production function and n is employment in the goods production sector. Similarly, expected asset prices, $E_t q_{t+1}$, the

16 The parameter $k_1 = \frac{(1+\gamma)kK}{c}$ is a function of the ratio of consumption to output, c, of the parameter reflecting the inferiority of capital as collateral, k, of steady-state capital, K, and of the trend growth rate, γ.

17 The parameter $k_2 = \frac{k_1 K}{c}$ is a function of k_1, of steady-state capital, K, and of the steady-state ratio of consumption, c.

change in the shadow value of households' funds $\left(E_t\lambda_{t+1}-\lambda_t\right)$ and the wedge between the marginal utility of consumption and the shadow value of funds also affect the value of capital, q_t. The parameter δ_1 is a composite function of the depreciation rate of capital, while the parameter γ_1 is a composite function of steady-state marginal costs, of steady-state employment in the goods sector and of the share of capital in the production of goods.[18]

3.4 Market Interest Rates

The decision of the banking sector is articulated in two stages. In the first one, interest rates are determined, and then, given the constellation of spreads, banks decide the optimal level of reserves and assets in order to maximize expected returns. The benchmark theoretical interest rate R^T is simply a standard intertemporal nominal pricing kernel, priced off real consumption and inflation. Basically it boils down to a one-period Fisher equation:

$$R_t^T = E_t\left(\lambda_t-\lambda_{t+1}\right)+E_t\pi_{t+1}. \tag{16}$$

The interbank rate or policy rate is set by a standard feedback rule responding to inflation, π_t, and output, y_t, with parameters, ϕ_π and ϕ_y, respectively. Policy rates are smoothed by $1>\rho>0$.

$$R_t^{IB} = \rho R_{t-1}^{IB}+\left(1-\rho\right)\left(\phi_\pi\pi_t+\phi_y y_t\right). \tag{17}$$

To find the interbank rate R^L, we must equate the marginal product of loans per unit of labour $\left(1-\alpha\right)\frac{L_t}{m_t}$ to their marginal cost $\frac{w_t}{P_t^A}$, with loans defined by the relationship $L_t = D_t\left(1-tt_t\right)=\frac{c_tP_t^A}{v_t}\left(1-rr_t\right)$. Therefore, in log-linear form, the interest rate on loans, R_t^L, is greater than the policy rate by the extent of the external finance premium.

$$R_r^L = R_t^{IB}+\underbrace{\left[v_t+w_t+m_t rr_t-c_t\right]}_{EFP_t}. \tag{18}$$

The external finance premium, EFP_t, is the real marginal cost of loan management, and it is increasing in velocity, v_t, real wages, w_t, monitoring work in the banking sector, m_t, and reserve requirements, rr_t, and decreasing in consumption, c_t. The yield on government bonds is derived by maximizing households' utility with respect to bond holdings, $R_t^T-R_t^B=\left[\frac{\phi}{c_t\lambda_t}-1\right]\Omega_t$. In its log-linear form it is the riskless rate, R_t^T, minus the liquidity service on bonds, which can be interpreted as a liquidity premium (LP):

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[18] The parameter $\delta_1=\frac{\beta(1-\delta)}{1+\gamma}$ is a function of the discount factor, β, of the depreciation rate of capital, δ, and of the trend growth rate, γ. The parameter $\gamma_1=\frac{\beta\eta mc}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}$ is function of steady-state employment in the goods sector, *n*, of steady-state marginal costs, *mc*, of steady-state capital, *K*, and of the parameter reflecting the capital share in the production function of the goods sector, η. Details of the derivation are reported in the technical appendix, available on request.

$$R^B R_t^B = R^T R_t^T - \underbrace{\left[\left(\frac{\phi}{c\lambda} - 1\right)\Omega\Omega_t - \frac{\phi\Omega}{c\lambda}\left(c_t + \lambda_t\right)\right]}_{LP_t}, \tag{19}$$

where $\left(c_t + \lambda_t\right)$ measures the household marginal utility relative to households' shadow value of funds, while Ω_t is the marginal value of the collateral. It is in fact these key margins – the real marginal cost of loan management versus the liquidity service yield – that determine the behavior of spreads. In the above expression, ϕ denotes the consumption weight in the utility function, whereas λ_t is the shadow value of consumption, c_t. The interest rate on deposits is the policy rate, R_t^{IB}, minus a term in the reserve-deposit ratio:

$$R_t^D = R_t^{IB} - \frac{rr}{1-rr} rr_t. \tag{20}$$

These spreads will be affected by the supply of reserves or liquidity in this model, and hence will impact the resulting path of consumption.

4. Central Bank Reserves and Commercial Banks

Monetary policy operates through the manipulation of short-term interest rates as the policy instrument, which affects the market clearing level of high-powered money, or reserves. The previous section shows that this short-term rate also impacts other interest rate spreads via the external finance premium and/or the liquidity premium, by changing the path of aggregate private or public demand. In this section, we outline the approach taken in Chadha and Corrado (2011) to consider the implications of introducing an incentive for commercial banks to hold reserves, in order to reflect the issue of relative returns from holding reserves or producing loans and the issue of liquidity concerns.

Commercial banks may decide to vary the mix of their assets, and central banks, through balance sheet operations, may allow them to do so. Chadha and Corrado (2011) derive a simple expression for the commercial bank's optimal level of bank reserves, in log deviation form:

$$\hat{r}_t - \overline{r} = \frac{\hat{\tau}_t}{\hat{R}_t^T} + \frac{\hat{R}_t^{IB} - \hat{R}_t^L}{\hat{R}_t^T}. \tag{21}$$

Hence, at the optimal profit rate, the reserve ratio, $\hat{r}_t$, is determined by the interbank loan rate (the return on reserves) minus the returns on collateralized loans, $\hat{R}_t^{IB} - \hat{R}_t^L$, scaled by the penalty uncollateralized loan rate, $\hat{R}_t^T$, if reserves are different from the target, $\overline{r}$, and a term reflecting a preference for reserves or liquidity, τ_t. With a sufficiently high preference for liquidity, τ_t, increasing quantities of reserves will be held. Another way to think about this expression is that the deviation of reserve requirements from steady state is the ratio of the cost of a liquidity shortfall to the opportunity cost of holding further deposits. Now let us examine the reserves in terms of market interest rates. Given (18), we can rewrite (21) as:

$$\hat{r}_t = \frac{\hat{\tau}_t}{\hat{R}_t^L} + \frac{\hat{R}_t^{IB} - L\hat{R}_t^L}{\hat{R}_t^L} + \overline{r}$$
$$= \frac{\hat{\tau}_t}{\hat{R}_t^{IB} + EFP_t} - \frac{EFP_t}{\hat{R}_t^{IB} + EFP_t} + \overline{r}, \tag{22}$$

which introduces the trade-off between reserves being driven down (up) by a higher (lower) external finance premium, and the need to offset changes in the probability of a liquidity shortfall. We shall return to the policy implications of this result in the conclusion.

Figure 3 shows the effect of a liquidity preference for reserves on bank asset allocation across reserves and loans. Having produced a quantity of loans, D_t, as a function of collateral and monitoring inputs, the banks lie on the line tangential between the production function and the allocation line. If there is a preference for liquidity over illiquidity, as necessitated by a financial intermediary that transforms maturity, reflecting *inter alia* the liquidity preference term, $\hat{\tau}_t$, the bank will be better off if excess reserves can be supplied, and this will be accomplished by swapping loans for reserves at some rate of transformation which reflects the relative interest rates on the two activities. Now let us consider a simple thought experiment in which the rate of return on reserves increases and the return on loans stays constant. The allocation towards reserves per unit of loans will increase and reserves relative to loans will rise, and hence so will the reserve-deposit ratio. Similarly, if the rate of return on reserves falls, the rate of allocation to reserves will fall, and accordingly the reserve-deposit ratio will fall. For comparison, Figure 4 plots the ratio of the behaviour of reserves relative to loans for a fixed reserve-deposit ratio (black dotted line) and for changes induced by changes in the return on reserves alone (red line). The basic mechanism is illustrated here, but what we find in the model will result from the interaction of both loan rates and policy rates (which are paid on reserves), as well as the movement in the loan production function, and so we turn to the calibrated model.

5. Calibration

Table 2 provides a complete list of the endogenous and exogenous variables of the model and their meaning, while Table 3 reports the values for the parameters and Table 4 the steady-state values of the relevant variables.[19] Following Goodfriend and McCallum (2007), we choose the consumption weight in utility, ϕ, to yield 1/3 of available time in either goods or banking services production. We also set the relative share of capital and labour in goods production η to be 0.36. We choose the elasticity of substitution of differentiated goods, θ, to be equal to 11. The discount factor, β, is set to 0.9, which is close to the canonical quarterly value, while the mark-up coefficient in the Phillips curve, κ, is set to 0.1. The depreciation rate, δ, is set to be equal to 0.025 while the trend growth rate, γ, is set to 0.005, which corresponds to 2% per year. The steady-state value of the bond holding level relative to GDP, b, is set to 0.56 as of the third quarter of 2005. The steady state of private sector bond

[19] The equations for the steady-state equations are listed in Section A.4 of the technical appendix, available on request.

holdings relative to GDP is set at 0.50, consistent with holdings of U.S. Treasury securities as of the end of 2006.[20]

The parameters linked to money and banking are defined as follows. Velocity at its steady-state level is set at 0.276, which is close to the ratio between U.S. GDP and M3 at fourth quarter 2005, yielding 0.31. The fractional reserve requirement, rr, is set at 0.1, which is higher than the value of 0.005 assumed by Goodfriend and McCallum (2007). The fraction of collateral, α, in loan production is set to 0.65 and the coefficient reflecting the inferiority of capital as collateral, k, is set to 0.2, while the loan production coefficient, F, is set to 9.14. The low value of capital productivity reflects the fact that banks usually use a higher fraction of monitoring services and rely less on capital as collateral.

With these parameter values we see that the steady state of labour input, n, is 0.31, which is close to the required 1/3. The ratio of time working in the banking service sector, $\frac{m}{m+n}$, is 1.9% under the benchmark calibration, not far the 1.6% share of total U.S. employment in depository credit intermediation as of August 2005. As the steady states are computed at zero inflation, we can interpret all the rates as real rates. The riskless rate, R^T, is 6% per annum. The interbank rate, R^{IB}, is 0.84% per annum, which is close to the 1% per year average short-term real rate. The government bond rate, R^B, is 2.1% per annum. Finally, the collateralized external finance premium is 2% per annum, which is in line with the average spread of the prime rate over the federal funds rate in the U.S.[21] The model is solved using the methods of King and Watson (1998), who also provide routines to derive the impulse responses of the endogenous variables to different shocks, to obtain asymptotic variance and covariances of the variables, and to simulate the data.[22] For the impulse response analysis and simulation exercise we consider the real and financial shocks described in Table 5, which reports the volatility and persistence parameters chosen for the calibration and simulation exercise. These are standard parameters in the literature and simulate a fall in output consistent with the crisis.

6. Impulse Responses From Balance Sheet Policies

To understand the dynamics of this model, in this section we outline the impact of a negative shock to the value of collateral in the context of various adaptations of the original framework. Our financial sector shock operates through the asset price and can be thought of as a primitive representation of the shock which hit the U.S. housing market towards the end of 2007. This had a negative impact on the value of assets that households were able to post as collateral in exchange for loans in the form of housing. The securitisation of these mortgage loans, and their subsequent trade by financial intermediaries, meant that this also

[20] The steady state of the transfer level, the Lagrangian of the production constraint and base money depend on the above parameters. The steady state of the marginal cost is $mc=\frac{\theta-1}{\theta}$.

[21] The equations for the steady states are listed in the Technical Appendix.

[22] The log-linearized equations for the model are listed in section C of the Technical Appendix. King and Watson's MATLAB code is generalized, in that for any model we adapt three MATLAB files. The three files for the solution of our benchmark model, gmrsys.m, gmrdrv.m and gmrcon.m, are available on request. King and Watson's package includes standardized auxiliary programs, impkw.m, to generate the impulse responses to different shocks to the endogenous variables, as well as the program fdfkw.m to obtain the filtered autocovariances and the filtered second moments from the model solution. The program impkwsimu.m simulates the artificial series and makes it possible to generate HP-filtered data.

affected the value of collateral that banks themselves held, damaging their ability to raise funds.

We also analyse a case in which we negatively shock productivity in the manufacturing sector before briefly discussing the response of the system to a change in the composition of assets held on the central bank's balance sheet, in order to provide a simplistic insight into credit easing policies. Figures 5-9 plot the log deviation from steady-state responses of real consumption, inflation, the external finance premium, the liquidity premium, the policy rate, real deposits, real reserves, real loans, the reserve-deposit ratio, private sector bond holdings, the level of monitoring work employed, employment in the goods sector, asset prices, the bond rate and the loan rate.

6.1 The Role of Reserves

We first show the mechanism through which reserve decisions can affect the real economy in our framework. Figure 5 shows the effects of our negative collateral shock under a regime of a fixed reserve-deposit ratio, compared to one in which reserves are decided endogenously by profit-maximising banks. In the first instance, when the shock hits there is an initial fall in asset prices, which reduces the efficiency of producing loans, as households have less collateral to post. As bonds are fixed, producing the same amount of loans would require an increase in monitoring effort on the part of the banks, and thus make loan production more expensive. This causes the external finance premium to increase, and through the cash-in-advance constraint we see a fall in consumption and deposits, which increases the EFP yet further. Since the reserve/deposit ratio is fixed, the fall in deposits leads to a proportional fall in loans and reserves. In response to the fall in output and inflation, the central bank cuts the policy rate and the economy returns to equilibrium.

Alternatively, if the reserve decision is endogenised and the reserve-deposit ratio is allowed to fluctuate, then as the cost of providing loans increases, banks demand more reserves and the central bank supplies them perfectly elastically. This allows banks to shed the now more costly loans, pushing up the reserve-deposit ratio, which means that the EFP rises less, with monitoring effort actually falling and with a smaller contraction in consumption. The smaller decline in consumption is mirrored by a smaller decline in deposits, and the policy rate now follows a much smoother path as reserve policy takes some of the burden of stabilising the economy. Thus, we can see that reserves have a significant role to play in our economy due to their financial attenuation effects.

In the recent crisis, policymakers were faced with having to respond to a contractionary shock, whilst their default policy tool, the short-term nominal interest rate, was constrained by the zero lower bound. To investigate this in the context of our model we deactivate the Taylor rule, holding the policy rate constant, and subject the model to the same negative collateral shock. What we see in Figure 5 is that because the policy rate does not fall in response to the downturn in consumption and inflation, the return from holding reserves is even higher, increasing the level of demand from financial intermediaries. This creates an even larger response in reserves than we saw under an active interest rate policy, which attenuates the rise in the external finance premium to such an extent that it temporarily falls before returning to equilibrium. The strength of this attenuation is enough to bring consumption and inflation back to equilibrium along more or less the same path as when interest rate policy was unconstrained. This suggests that altering the level of reserves on commercial banks' balance sheets can stabilise the economy, even in the absence of interest rate policy.

6.2 Open Market Operations

In practice, changes in the level of reserves are effected via open market operations. The central bank buys (sells) assets from the private sector in exchange for an increased (decreased) level of reserves. Recent quantitative easing policies are theoretically just extensions of these operations, differing only in their unprecedented magnitude.

In order to realistically model OMOs, we must augment the original endogenous reserves framework to take account of this swap of reserves for assets. Reserves, which are the central bank's only liability, must be backed by equally valued asset holdings. Initially, we assume the central bank holds only government bonds, the total supply of which is fixed unless exogenously shocked. This means that in order to increase the level of reserves, the central bank must buy bonds from the private sector, increasing the fraction of total bonds it holds, and decreasing the amount held by the private sector.

To model this, we define total bond holdings as the sum of private sector and central bank bond holdings:

$$b_t = b_t^{CB} + b_t^{P}, \tag{23}$$

and as central bank bond holdings must equal reserves, we can substitute and rearrange to give the log linear relationship

$$b_t^{p}\hat{b}_t^{p} = b_t\hat{b}_t - r_t\hat{r}_t, \tag{24}$$

which we add to our system of equations. It is this newly defined variable b^p which determines the amount of collateral that households have available, so we substitute it for b in the equations for loan supply and marginal value of collateralized lending.[23]

An alternative is to swap the other type of asset in our economy, capital. This is less liquid and less efficient as collateral, but could be bought by the central bank in exchange for new reserves in the same way that bonds are. For this operation, we introduce an equation defining total capital holdings as a function of an exogenous shock, in the same way as we did for bond holdings. The central bank can now hold two assets on its balance sheet, so we hold the level of bonds fixed, as before, and set the steady-state value of capital held by the central bank at zero. By defining private sector capital holdings in a log linear form as

$$k^{p}\hat{k}_t^{p} = b\hat{b}_t - r\hat{r}_t, \tag{25}$$

what we model is a situation where the central bank buys and sells illiquid assets/capital in exchange for reserves.

In Figure 6 we can see how a negative collateral shock propagates in the presence of each type of OMO when the short-term nominal interest rate is constrained. It appears that the type of asset exchanged has very little impact on the path taken by key variables or on the mechanism through which the policy works. This poses no deep problem in itself, as one of the core motivations for making these adaptations to the model is to ensure that the policy we model can be related as closely as possible to the practical conduct of real world policies. However, during our welfare analysis in the following section we see that there are differences between the implications of differing styles of OMOs. This suggests a channel by which OMOs such as those carried out by central banks post-crisis can be an effective and practical means to stabilise the economy, even in the absence of an active interest rate policy.

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[23] As we deal with a consolidated government budget constraint, the net effect of interest payments on bonds held by the central bank is zero. Therefore, it is appropriate to change the terms in b to terms in b^p in this equation as well.

6.3 The Role of Policymakers

Having demonstrated a clear role for reserves in this model, the next question is how to control this policy tool. If the central bank chooses to supply reserves perfectly elastically to meet the demand of the banking sector, then banks will set that demand at the level which is optimal for them in terms of profits. This can be thought of as a financially optimal path for reserves. It may not, however, be consistent with the macroeconomic optimum desirable to policymakers. To test this, we compare the model where reserves are determined by the banking sector's demand to one where the central bank determines reserve levels in response to a simple policy rule dependent on inflation:

$$\hat{r}_t = \left(\rho_r - 1\right)\phi_\pi \hat{\pi}_t + \rho_r \hat{r}_{t-1} \tag{26}$$

Figure 7 shows that in response to a negative collateral shock, as far as stabilising key macroeconomic variables is concerned, even an incredibly simple policy rule can outperform the situation where bank set the level of reserves. This is because the central bank is at first more aggressive, forcing the financial intermediaries to take on more reserves than would be profit-maximising for them, and this provides a greater attenuation of the EFP via the same mechanisms that an increase in reserves works through when chosen by banks. This brings the economy back to equilibrium more quickly, and the level of reserves returns more quickly to its steady state.

The key point to be taken from Figure 7 is that the financially optimum path for reserves and the macro-optimal path are not always the same, suggesting an important role for policymakers in monitoring and setting the reserve levels of financial institutions, which have an incentive to try and keep reserve levels away from the macro optimal level.

This result holds true when we constrain the policy rate, and also when we vary which of the exogenous shocks we put through the system, with one exception: a productivity shock. Figure 8 shows that if our contraction is caused by an exogenous fall in productivity in the manufacturing sector, then our policy rule causes a deeper and more prolonged fall in real consumption/output. This is due to the fact that under a productivity shock, inflation and output move in opposite directions, causing a conflict of objectives for the central bank. As the central bank follows its policy rule and cuts reserves to curb the higher inflation, this simultaneously induces a fall in consumption, worsening the contraction already experienced.

6.4 The Implications of Balance Sheet Composition

So far we have considered policies which can be loosely termed quantitative easing, where reserve levels, and thus the size of the central bank's balance sheet, are allowed to fluctuate. In practise, however, many central banks carried out at least a degree of credit easing (CE) alongside their quantitative easing programmes, especially in the U.S. CE differs from QE in that the overall level of reserves doesn't need to change, but the central bank changes the mix of assets on its balance sheet, buying up less liquid assets and selling off more liquid ones, to increase liquidity to the private sector. Eggerston and Woodford (2003), among others suggest that this should have no impact on the wider economy, as there is no reason for it to change agents' long-term expectations regarding monetary policy.

In the context of our model, with reserves determined by commercial banks' demand, we can outline a very basic credit easing policy by simulating a swap, exogenously increasing the level of liquid bonds held by the private sector and simultaneously reducing the level of less liquid capital. When we run this credit easing swap (Figure 9), what we find is that the marginal value of collateralized lending decreases since there are more liquid assets available to be put up as collateral by the private sector, increasing the efficiency of loan production. This causes consumption to rise and the level of monitoring effort needed by banks to fall, both of which decrease the EFP. The liquidity premium drops as consumption rises and the marginal value of collateralized lending falls, whilst the central bank raises the policy rate in response to the increase in inflation and output. The improved economic conditions subsequently lead to an increase in reserves, but one that is less than the increase in lending. This result implies that if credit easing were employed countercyclically, it would be a useful tool in limiting rises in the EFP and liquidity premium, such as those much of the world has experienced recently, even if the policy rate is constrained by increasing the quantity of more liquid assets available to be used by banks as collateral for loans, thus increasing their loan production efficiency.

6.5 Welfare Analysis

Table 6a shows the asymptotic standard deviation and the contemporaneous cross-correlation with consumption from a simulation of the model, allowing us to compare a fixed reserve-deposit ratio regime with one in which reserves are determined by commercial banks and one in which they are set by a central bank policy rule. We also show the results for each type of reserve setting policy with the policy rate constrained, so as to highlight the efficacy of policies should the policymakers find themselves unable to use interest rate policy.

What we find is that endogenising reserves can dramatically lower the standard deviation of inflation, asset prices and the policy rate, but at the expense of increased standard deviation in output and monitoring work. There is also an increased deviation in the external finance and liquidity premia. Perhaps counterintuitively, the standard deviation of reserves falls. This is due to the fact that under a 'fixed' regime, reserves have to constantly move in order to maintain a constant reserve-deposit ratio, whilst in a scenario of endogenous reserve setting this is smoothed. By introducing a reserve policy rule we manage to reduce the standard deviation in inflation and asset prices even further, but manage to negate some of the trade-off with monitoring work, the EFP and liquidity premium, and especially consumption, which has a lower standard deviation under a reserves rule than under a fixed reserve-deposit ratio. It is worth noting that when the nominal interest rate is constrained, there is an increase in the standard deviation of output, inflation asset prices and other variables, but in an almost equal amount regardless of which of the two policy rules is implemented.

Table 6b shows the same information for models in which open market operations are present, responding to endogenous, bank-determined reserve levels. We see here that conducting OMOs by swapping reserves for bonds results in much lower standard deviations, in all but one variable, than occurs when the OMOs are conducted through swaps for capital, even when the interest rate is constrained. The standard deviation of private sector bond holdings logically increases since bonds are now part of an active policy tool. Figure 10 shows the middle segment, as an illustration, from a simulation of 10,000 data points (with the first 500 observations discarded) of key macroeconomic variables under each policy regime. The simulated data are HP-filtered $(\lambda = 1600)$. Plotting the reserve-deposit ratio we see that endogenising reserves causes the reserve-deposit ratio to fluctuate as it responds to commercial bank demand. These fluctuations can be smoothed, and a degree of volatility removed, by the central bank's taking control of reserve policy with an active reserves rule.

6.5.1 Approximating the welfare function

The welfare approximation derived from the canonical New Keynesian model finds that welfare of the representative household only depends on the variance of output and inflation (Galí, 2008). We wish to investigate whether this result continues to hold when applied to our richer class of model. The use of the approximation allows us to quantify precisely the welfare rankings arising from each of our policy rules, possibly allowing some normative statements. Thus, we derive a quadratic loss function using a second-order Taylor approximation to utility by using the labour demand function, marginal cost function and sales production constraint to substitute for household consumption.[24] Once this is reordered and simplified, we are left with a loss function with relevant terms in the variances of consumption, inflation, wages, employment in the goods sector and marginal cost.[25]

$$U_t - U = -\frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t L_t + O3$$

$$\text{with } L_t = \frac{1}{2}\left[\begin{array}{c} \sigma_c^2 + \left[\dfrac{\theta}{\mathrm{X}(1-\eta)}\left(\dfrac{w}{c}\left(1+\eta^2\right) - \dfrac{n}{c}\right)\right]\sigma_\pi^2 + \\ \dfrac{w}{c}\sigma_w^2 - \dfrac{n}{c}\sigma_n^2 + \dfrac{mc}{c}\sigma_{mc}^2 \end{array}\right] \tag{27}$$

$$\text{where } \mathrm{X} = \frac{(1-\theta)(1-\beta\theta)}{\theta}\frac{1-\eta}{1+\eta(\theta-1)}.$$

Remark: The welfare of the representative household in this model, as in the original New Keynesian framework, is approximated by standard variables on the supply side rather than those specifically attributable to financial factors. This means that changes in financial conditions do not directly impact utility, but only impact the variance of consumption, inflation, wages, labour supply hours and marginal costs.

Having obtained the welfare approximations, we can calculate the loss under each policy rule at the benchmark calibration and then rank the losses using the metric laid out by Gilchrist and Saito (2006), which is defined as the ratio between the loss obtained from implementing a given policy rule χ versus a benchmark policy rule, and the loss obtained under the most stabilising policy rule versus the same benchmark.

$$Gain(\chi) = \frac{L(\text{Benchmark Policy}) - L(\text{Policy } \chi)}{L(\text{Benchmark Policy}) - L(\text{Most Stabilising})} \tag{28}$$

If this relative gain criterion is less (more) than one, then the given policy can be said to be worse (better) than the most stabilising policy. If it is negative, then the given policy actually performs worse than the benchmark. This metric allows us to explicitly rank our policies. For our calculations we chose an active interest rate policy rule under a fixed reserves system as our benchmark, and our most stabilising reference policy is an active interest rate policy alongside a central bank reserve rule responding to inflation. Table 7 confirms that whilst all endogenous reserve policies outperform a fixed reserve system, our best welfare outcome is reached by allowing the central bank to control both the policy rate and the reserve level in response to macroeconomic factors. Within this framework, OMOs conducted by swapping reserves for bonds have better welfare implications than OMOs carried out via a swap for capital, but they only marginally outperform our benchmark endogenous reserves model. An interesting aspect of this analysis is that we can see the relative loss in welfare caused by the short-term nominal interest rate's becoming constrained (CIR), by comparing an endogenous reserves system that incorporates interest rate policy with one of just

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[24] The additive nature of our household's utility function allows us to take a Taylor expansion of each term and substitute it back into the original function. The labour demand function is then rearranged for monitoring work, a second-order expansion taken and a substitution made. This process is then repeated for the marginal cost equation. Following Galí (2008), we substitute the resulting linear term in goods sector employment for a second-order term in inflation, using the sales equal to net production constraint.

[25] The welfare approximation is derived in Section F of the Technical Appendix.

endogenous reserves. The size of the loss suggests that when confronted with the ZLB, policymakers operating an active reserve strategy may be able to limit welfare losses despite not being able to use their major policy tool.

The supply of liquidity through the issuance of reserves alongside an active interest rate would appear to reduce the welfare losses faced by the representative household over the business cycle. Reserves attenuate the fluctuations in the external finance premium in response to demand (consumption) and supply (loans) responses to shocks. A banking sector with a liquidity preference is better off when liquidity is supplied over the business cycle, and because the requirement for loans from the private sector can in part be met by increasing reserves rather than by increasing costly monitoring. Reserves as a monetary/fiscal instrument allow the banks to hedge liquidity risk and also improve macroeconomic outcomes, so there is not necessarily a trade-off between financial and monetary stability.

6.6 Balance Sheet Policy and the Business Cycle

Table 8 shows the asymptotic standard deviation and contemporaneous cross-correlation with real consumption (output) of the reserve-deposit ratio and nominal spending under each policy regime. What we see is that, as with consumption, inflation and asset prices, we can lower the standard deviation on nominal spending by endogenising our reserve decision, and still further if we allow reserves to be set by a policy rule. The fixed nature of the reserve-deposit ratio in the first regime means that by design we have zero standard deviation, but as we allow it to fluctuate and take on an active role as a policy tool, our reserves rule, which gives the best welfare option, actually has the lowest standard deviation.

To contextualize these movements in terms of the business cycle, we can analyse how the movements of these variables are correlated with real GDP, or in the case of our model, consumption. Endogenising the reserves decision creates a deal of procyclicality in the reserve-deposit ratio, suggesting that in a boom period commercial banks build up their stock of reserves relative to loans and then run them down in an economic downturn. This is a key part of the mechanism by which the financial attenuator works as a systematic policy tool. Under a reserve rule this procyclicality is mostly removed, as reserves react to inflation, not output. Nominal spending also becomes more procyclical as we endogenise reserves, since we dampen fluctuations in the price level, bringing real consumption and nominal spending much closer together.

7. Conclusions

This paper uses a micro-founded macroeconomic model to consider the implications of balance sheet, or non-conventional, monetary policies in which bank lending, interest rate spreads and the variance of the central bank balance sheet are shown to matter. To the model of Goodfriend and McCallum (2007) we append velocity shocks in the demand for money function (see Chadha, Corrado and Holly, 2008) as well as a process for commercial bank reserve accumulation (see Chadha and Corrado, 2011), and then show that these policies can map onto central bank balance sheet policies. The issuance of reserves swaps short-term debt obligations for long-term obligations and thus improves the liquidity of the banking sector. The converse is also true. We then find that varying the central bank balance sheet attenuates the excessive volatility in the external finance premium that would otherwise ensue. We also solve for commercial banks' optimal levels of illiquid (loan) and liquid (reserves) asset holdings, and for the government's budget position, by allowing two forms of debt liabilities to be issued: one-period debt to finance any excess in government expenditures over tax receipts, and debt to finance the issuance of reserves. We are then able to consider the implication of one-off balance sheet operations as well as systematic adoption of balance sheet policies.

We find that balance sheet policies can also contribute to the stabilisation of the economy when the interest rate rule is constrained. Our impulse responses show that policies that expand the central bank balance sheet can stabilise the economy. Rules that swap reserves for assets perform well compared to a straight injection of reserves. We also examine the welfare implications of balance sheet policies and find that when reserves are set countercyclically – ie expanding when the economy contracts – then, generally speaking, the welfare of the representative household is better than under an active interest rate rule alone. This is because by setting both the quantity and price of central bank money the central bank can amplify control of a monetary economy. Rather than just setting interest rates and letting the money supply be elastically shaped by demand, some extra incentives are placed on financial activity to prevent the exacerbation of the cycle (Walsh, 2009). Encouraging the central bank to alter the size of its balance sheet will not only increase the efficacy of standard interest rate policy but also help prevent excesses of financial intermediation. However, ultimately these operations are fiscal and require the debt authority to accept the responsibility of hedging liquidity shortages or gluts in the financial sector.

Table 1

Consolidated Federal Reserve Balance Sheet Pre- and Post-Crisis

Assets	Value (Millions of Dollars)	
	December 2007	**July 2011**
Gold Certificate Account	11,037	11,037
Special Drawing Rights Certificates Account	2,200	5,200
Coin	1,017	2,096
Securities, Repurchase Agreements and Loans	815,979	2,660,990
Securities Held Outright	779,640	2,648,438
U.S. Treasury Securities	779,640	1,624,515
Bills	267,019	18,423
Notes & Bonds[1]	512,621	1,606,092
Federal Agency Debt Securities	–	115,070
Mortgage Backed Securities	–	908,853
Repurchase Agreements	35,000	0
Loans	1,338	12,552
Net Portfolio Holdings Maiden Lane I, II & III	–	59,637
Net Portfolio Holdings TALF LLC	–	757
Items in Process of Collection	7,235	419
Bank Premises	2,079	2,199
Other	37,244	131,714
Total[2]	876,791	2,874,049
Liabilities		
FR Notes (Net of FR Bank Holdings)	778,611	990,861
Reverse Repo Agreements	35,098	67,527
Deposits	16,112	1,741,336
Held by Deposit Institutions	11,286	1,663,022
U.S. Treasury Account, General	4,489	67,270
U.S. Treasury Supplementary Financing Account	–	5,000
Foreign Official	97	127
Other	241	5,918
Deferred Availability Cash Items	6,509	2,074
Other Liabilities and Accrued Dividends	6,066	20,584
Capital Accounts	34,345	51,667
Total	876,791	2,874,049

[1] Includes nominal, inflation-indexed and inflation-compensated. [2] Preferred interests in AIA Aurora LLC and ALICO Holdings LLC do not appear, as they were repaid as of January 2011. Likewise, CPFF has been fully repaid and no longer appears.

Table 2

The Variables

Variable	Description
c	Real Consumption
n	Labour Input
m	Labour Input for Loan Monitoring, or 'Banking Employment'
w	Real wage
q	Price of Capital Goods
P	Price Level
π	Inflation
mc	Marginal Cost
r	Reserves
rr	Reserves/Deposit Ratio
D	Deposits
L	Loans
P^A	Aggregate Prices
b	Real Bond Holding
b^p	Real Private Sector Bond Holdings
Ω	Marginal Value of Collateral
EFP	Uncollateralized External Finance Premium $\left(R^T - R^{IB}\right)$
LSY^B	Liquidity Service on Bonds
LSY^{KB}	Liquidity Service on Capital $\left(kLSY^B\right)$
R^T	Benchmark Risk Free Rate
R^B	Interest Rate for Bond
R^{IB}	Interbank Rate
R^L	Loan Rate
R^D	Deposit Rate
λ	Lagrangian for Budget Constraint (shadow value of consumption)
ξ	Lagrangian for Production Constraint
T	Real transfer (%)

Table 3

Parameterisation

Parameter	Description	Value
β	Discount factor	0.9
κ	Coefficient in Phillips curve	0.1
α	Collateral share of loan production	0.65
ϕ	Consumption weight in utility	0.4
η	Capital share of firm production	0.36
δ	Depreciation rate of capital	0.025
γ	Trend growth rate	0.005
ρ	Interest rate smoothing	0.8
ϕ_π	Coefficient on Inflation in Policy	1.5
ϕ_v	Coefficient on Output in Policy	0.5
F	Production coefficient of loan	9.14
k	Inferiority coefficient of capital as collateral	0.2
θ	Elasticity of substitution of differentiated goods	11

Table 4

Steady States

Steady State	Description	Value
m	Banking Employment	0.0063
n	Labour Input	0.3195
R^T	Risk Free Rate	0.015
R^{IB}	Interbank Rate	0.0021
R^L	Loan Rate	0.0066
R^L	Bond Rate	0.0052
b/c	Bond to Consumption Ratio	0.56
b^p/c	Private Sector Bond Holdings to Consumption Ratio	0.50
c	Consumption	0.8409
T/c	Transfers over consumption	0.126
w	Real Wage	1.9494
λ	Shadow Value of Consumption	0.457
v	Velocity	0.31
Ω	Marginal Value of Collateral	0.237
K	Capital	9.19
K^P	Private Sector Capital Holdings	9.19
rr	Reserve ratio	0.1
r/c	Reserves to Consumption	0.36

Table 5

Properties of Exogenous Shocks

Shock Name	Standard Deviation	Persistence
Productivity	0.35%	0.95
Monitoring	1.00%	0.95
Collateral	0.35%	0.9
Monetary Policy	0.82%	0.3
Mark Up	0.11%	0.74
Bond Holdings	1.00%	0.9
Velocity	1.00%	0.33
Liquidity	1.00%	0.33

Table 6a

Impact on the Economy of Endogenising Reserves

Policy	Fixed[1]		Endogenous[2]		Endogenous CIR[3]		Reserve Rule[4]		Reserve Rule[5]	
	St. Dev.[6]	Corr.[7]	St. Dev.	Corr.	St. Dev.	Corr.	St. Dev.	Corr.	St. Dev.	Corr.
Real Consumption/Output	1.03	1	1.14	1	1.17	1	0.75	1	0.78	1
Inflation	0.89	0.79	0.40	0.65	0.42	0.67	0.33	0.51	0.35	0.55
Employment in Monitoring	2.01	–0.46	4.27	–0.81	3.58	–0.85	2.61	–0.56	2.25	–0.66
Employment in Goods Sector	1.63	0.95	1.72	0.96	1.77	0.96	1.13	0.90	1.19	0.91
Real Wage	1.77	0.99	1.80	0.99	1.87	0.99	1.20	0.98	1.26	0.98
Private Sector Bond Holdings	1.30	0.21	1.30	0.07	1.30	0.07	1.30	0.1	1.30	0.11
Asset Prices	0.93	0.98	0.92	0.98	0.97	0.98	0.63	0.97	0.66	0.97
Loans	2.81	0.24	1.00	0.29	1.08	0.33	0.91	–0.08	0.90	–0.07
Reserves	2.81	0.24	2.00	0.76	1.79	0.07	0.20	–0.13	0.20	–0.15
Policy Rate	1.30	–0.04	1.28	0.17	0.80	–0.1	1.13	–0.13	0.80	–0.22
Loan Rate	0.68	0.30	0.80	–0.89	0.80	–0.88	0.47	–0.77	0.51	–0.78
Bond Rate	0.68	0.30	5.19	0.60	3.78	0.60	3.72	0.23	2.99	0.27
Deposit Rate	1.30	–0.04	1.19	0.07	0.78	–0.23	1.10	–0.14	0.78	–0.22
External Finance Premium	1.25	0.20	1.66	–0.56	1.04	–0.60	1.26	–0.18	0.79	–0.28
Liquidity Premium	0.02	–0.14	5.77	–0.66	4.31	–0.69	3.97	–0.30	3.15	–0.38

[1] Refers to the model with a fixed reserve-deposit ratio and an unconstrained interest rate policy. [2] Refers to the model with an endogenous reserve-deposit ratio set by demand from profit-maximising banks with an unconstrained interest rate policy. [3] Refers to the model with an endogenous reserve-deposit ratio set by demand from profit-maximising banks with a constrained interest rate policy. [4] Refers to the model with endogenous reserves set by the central bank according to a reserves policy rule, along with unconstrained interest rate policy. [5] Refers to the model with endogenous reserves set by the central bank according to a reserves policy rule with constrained interest rate policy. [6] St. Dev. denotes the asymptotic standard deviation of the relevant variable derived from the filtered second moments of the solution obtained from the given model. [7] Corr. denotes the contemporaneous cross-correlation with consumption derived from the filtered autocovariance of the solution obtained from the given model.

Table 6b

The Impact on the Economy of Different Methods of Conducting Open Market Operations

Policy	Bond OMO[1]		Bond OMO CIR[2]		Capital OMO[3]		Capital OMO CIR[4]	
	St. Dev.	Corr.	St. Dev.	Corr.	St. Dev.	Corr.	St. Dev.	Corr.
Real Consumption/Output	1.03	1	1.07	1	1.21	1	1.24	1
Inflation	0.39	0.61	0.41	0.64	0.50	0.70	0.54	0.72
Employment in Monitoring	4.08	–0.77	3.44	–0.82	4.25	–0.73	3.69	–0.68
Employment in Goods Sector	1.56	0.95	1.62	0.95	1.83	0.96	1.89	0.96
Real Wage	1.62	0.99	1.70	0.99	1.94	0.99	2.03	0.99
Private Sector Bond Holdings	1.83	–0.35	1.79	–0.32	1.30	0.33	1.30	0.33
Private Sector Capital Holdings	–	–	–	–	1.30	0.30	1.31	0.30
Asset Prices	0.84	0.98	0.88	0.98	1.00	0.98	1.05	0.99
Loans	0.96	0.16	1.03	0.21	1.52	0.34	1.66	0.36
Reserves	1.83	0.70	1.64	0.71	1.97	0.68	1.78	0.65
Policy Rate	1.24	0.11	0.80	–0.12	1.35	0.22	0.80	–0.09
Loan Rate	0.71	–0.87	0.71	–0.86	0.78	–0.76	0.79	–0.73
Bond Rate	4.90	0.54	3.63	0.54	5.38	0.62	3.80	0.59
Deposit Rate	1.16	0.03	0.78	–0.25	1.30	0.16	0.80	–0.16
External Finance Premium	1.55	–0.49	0.96	–0.53	1.68	–0.53	1.03	–0.49
Liquidity Premium	5.39	–0.61	4.07	–0.63	5.89	–0.67	4.28	–0.65

[1] Refers to the model in which OMOs are carried out via an exchange of reserves for bonds to meet endogenous reserve demand of banks, along with unconstrained interest rate policy. [2] Refers to the model in which OMOs are carried out via an exchange of reserves for bonds to meet endogenous reserve demand of banks with constrained interest rate policy. [3] Refers to the model in which OMOs are carried out via an exchange of reserves for capital to meet endogenous reserve demand of banks, along with unconstrained interest rate policy. [4] Refers to the model in which OMOs are carried out via an exchange of reserves for capital to meet endogenous reserve demand of banks with constrained interest rate policy.

Table 7

Relative Welfare Analysis

Policy Regime	Welfare Loss	Gain Criterion
Fixed	24.21	0
Endogenous	10.48	0.73
Endogenous CIR	11.38	0.69
Reserve Rule	5.53	1
Reserve Rule CIR	6.14	0.97
Bond OMO	9.01	0.81
Bond OMO CIR	9.94	0.76
Capital OMO	13.57	0.57
Capital OMO CIR	15.24	0.48

Table 8

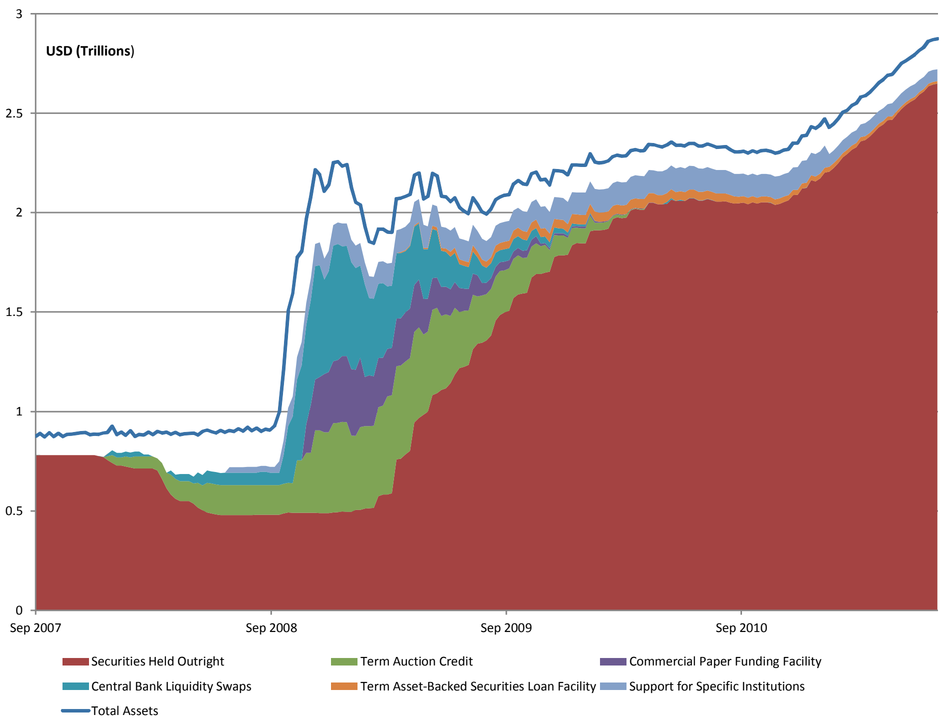
Balance Sheet Policies and the Business Cycle[1]

		Reserve-Deposit Ratio	**Nominal Spending**
Fixed			
	St. Dev.	0	2.84
	Corr.	0	0.40
Endogenous			
	St. Dev.	1.70	1.51
	Corr.	0.65	0.82
Endogenous CIR			
	St. Dev.	1.52	1.58
	Corr.	0.61	0.81
Reserves Rule			
	St. Dev.	0.93	1.03
	Corr.	0.05	0.68
Reserves Rule CIR			
	St. Dev.	0.94	1.08
	Corr.	0.03	0.67
Bond OMO			
	St. Dev.	1.72	1.39
	Corr.	0.59	0.78
Bond OMO CIR			
	St. Dev.	1.54	1.47
	Corr.	0.56	0.78
Capital OMO			
	St. Dev.	1.94	1.82
	Corr.	0.38	0.75
Capital OMO CIR			
	St. Dev.	1.96	1.92
	Corr.	0.25	0.73

[1] Corr. denotes the contemporaneous cross-correlation of the given variable with real consumption/output.

Figure 1

Federal reserve assets[1]



[1] Total may differ from constituent parts, due to rounding.

Figure 2

Federal reserve liabilities

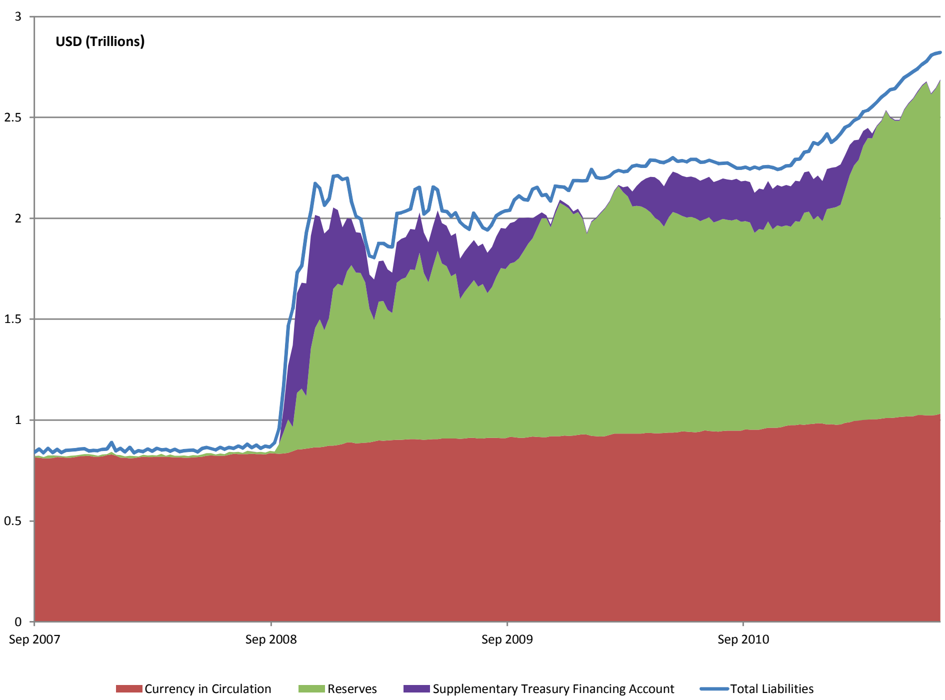


Figure 3

Production of loans and liquidity preference of banks

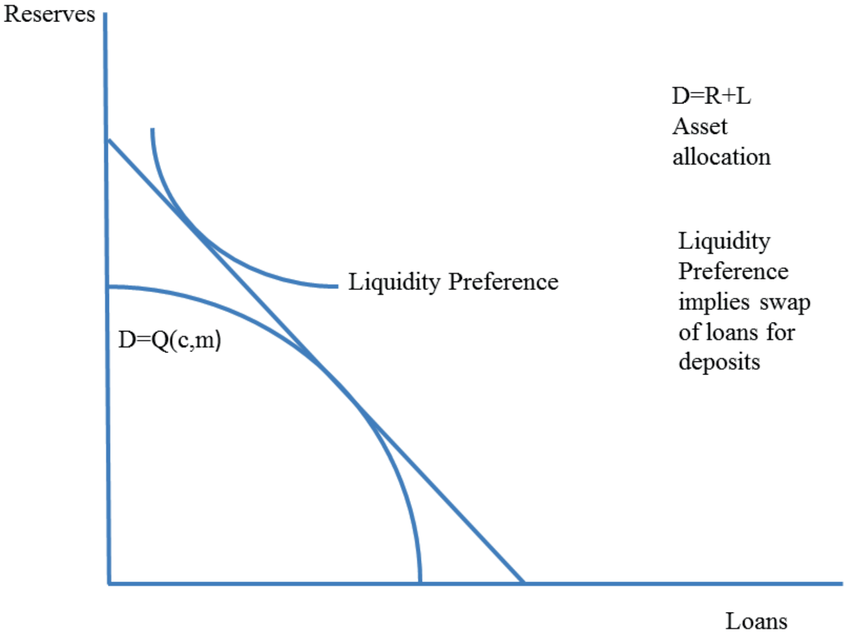


Figure 4

Reserves over the business cycle

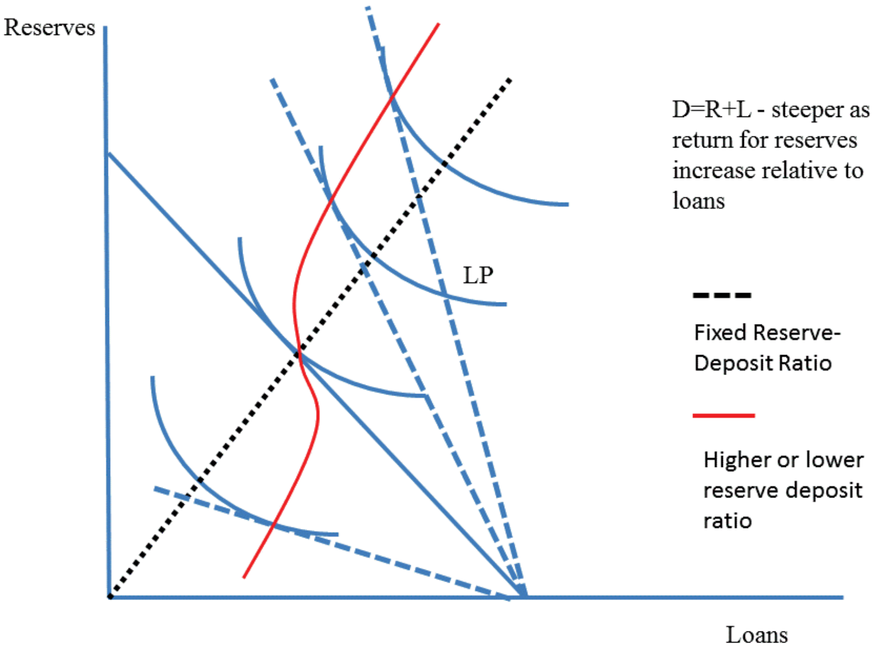


Figure 5

Response to negative 1 standard deviation shock to the value of collateral under fixed and endogenous reserve-deposit ratios and with the nominal interest rate constrained

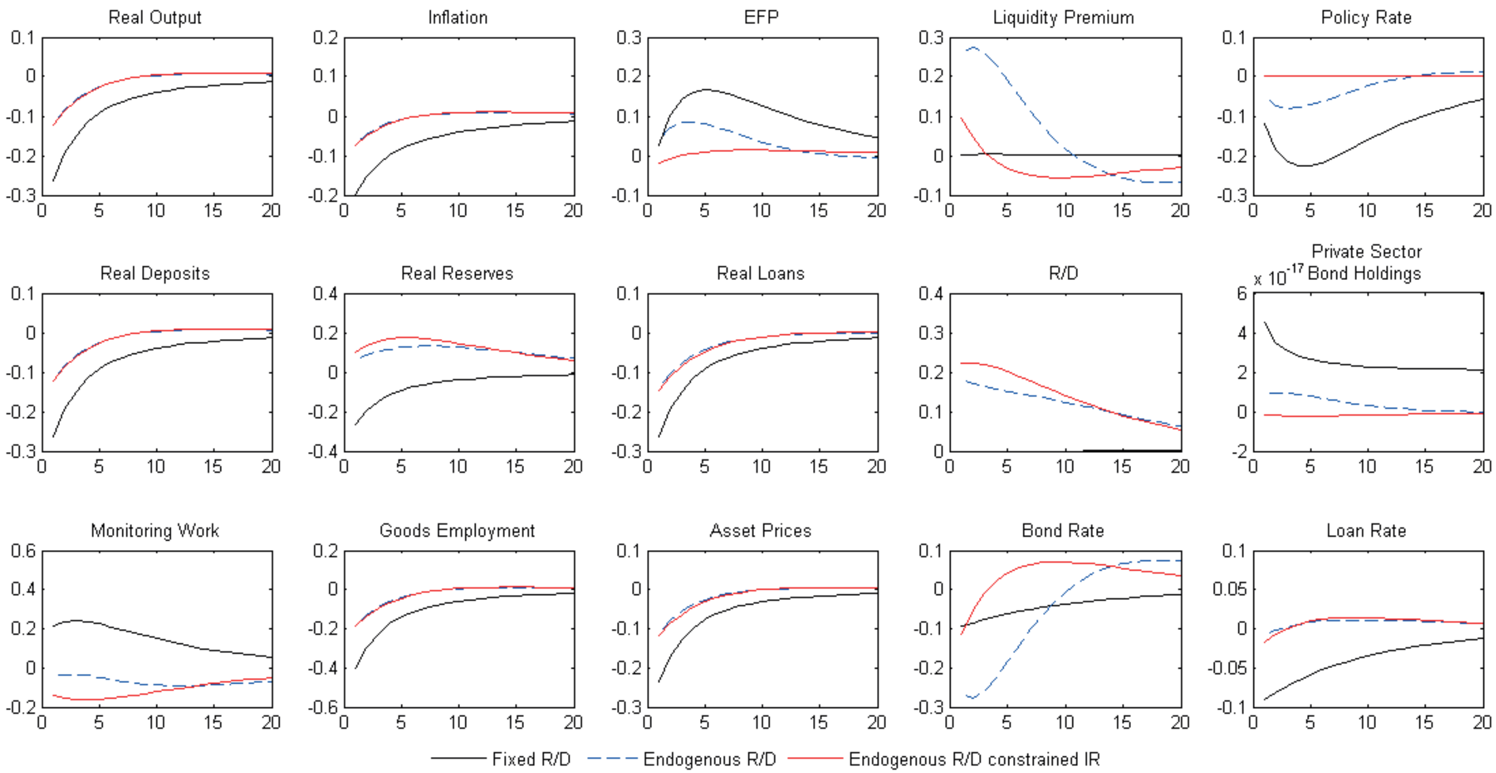


Figure 6

Response to negative 1 standard deviation shock to the value of collateral under different styles of OMO with a constrained short-term nominal interest rate

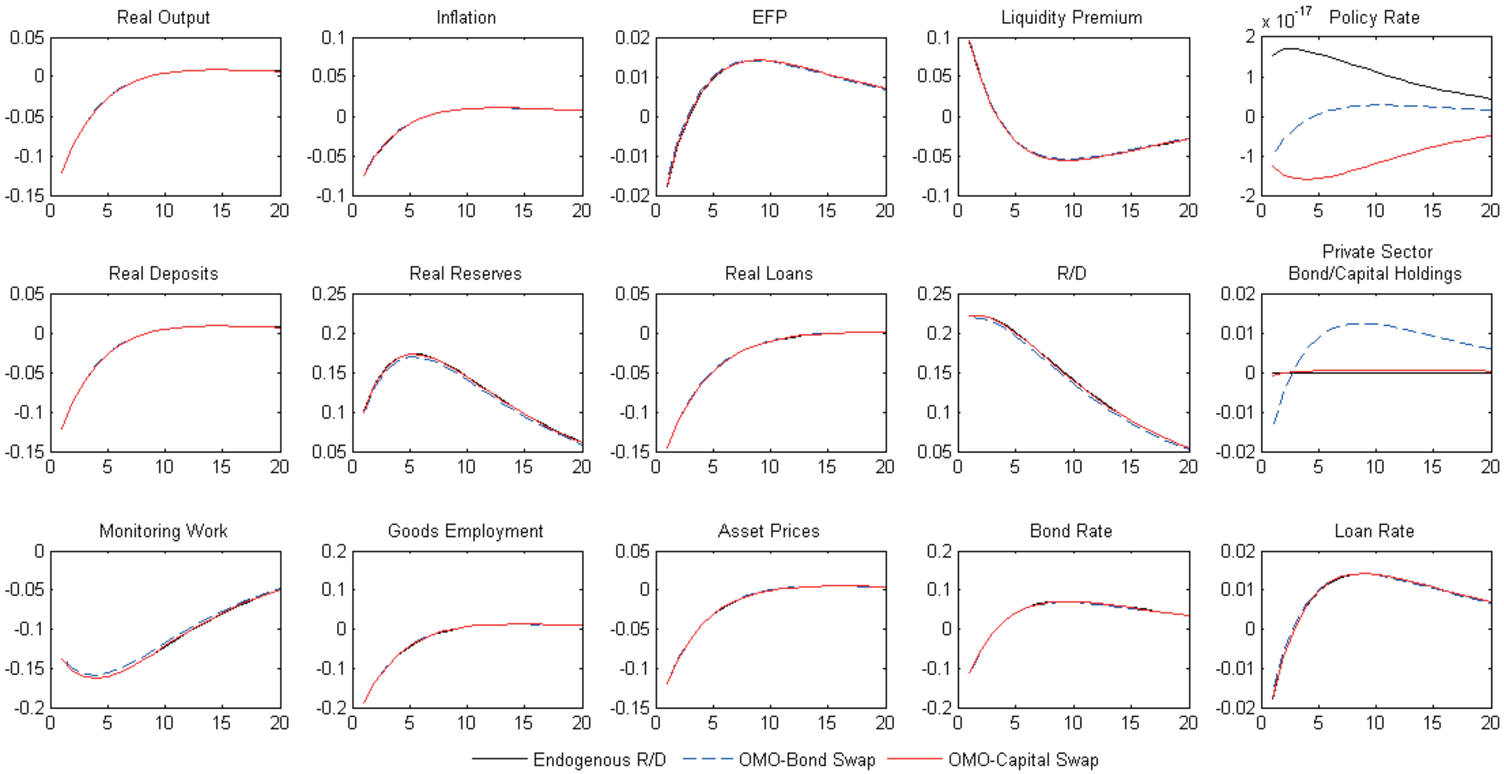


Figure 7

Response to negative 1 standard deviation shock to collateral under different reserve setting regimes

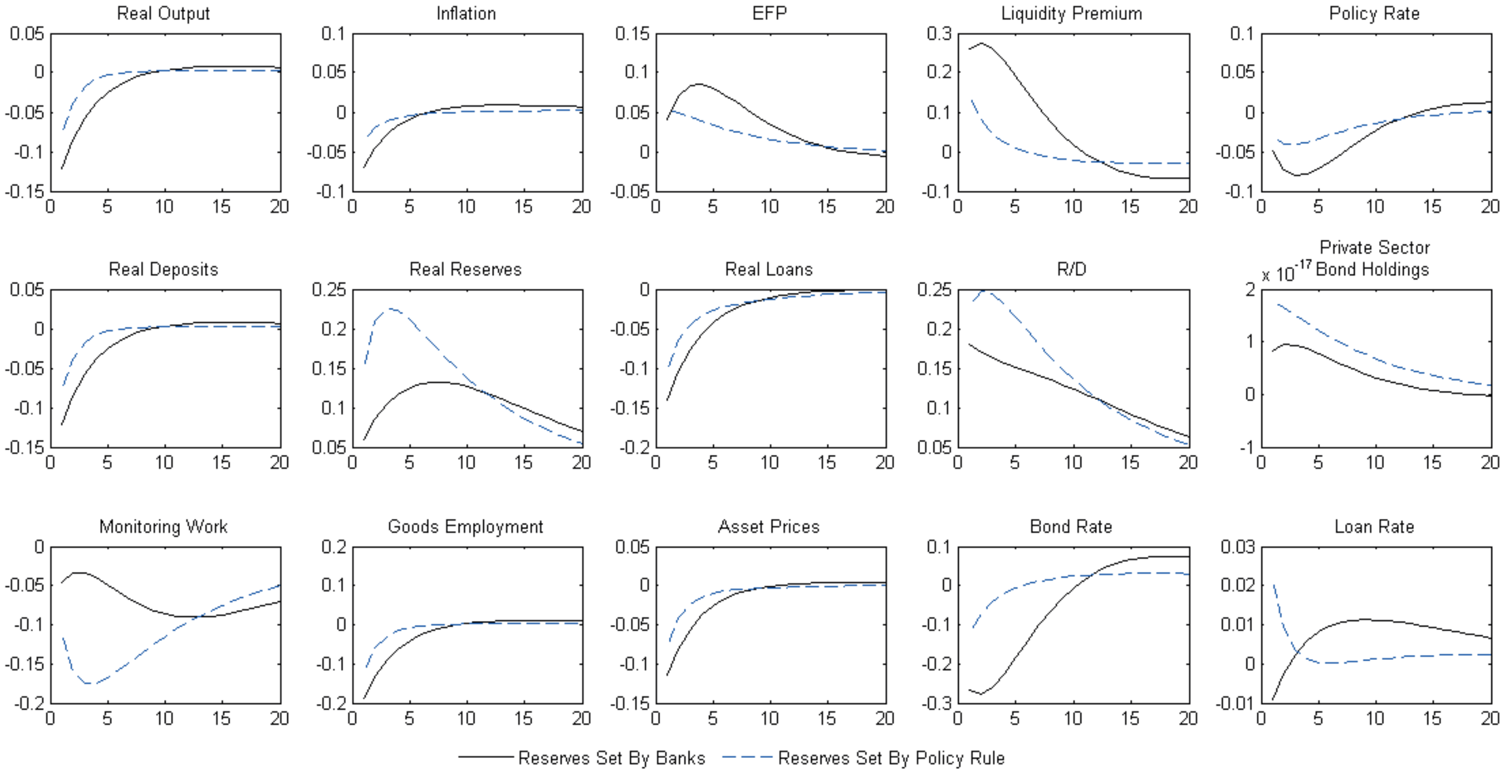


Figure 8

Response to negative 1 standard deviation shock to productivity in manufacturing under different reserve setting regimes

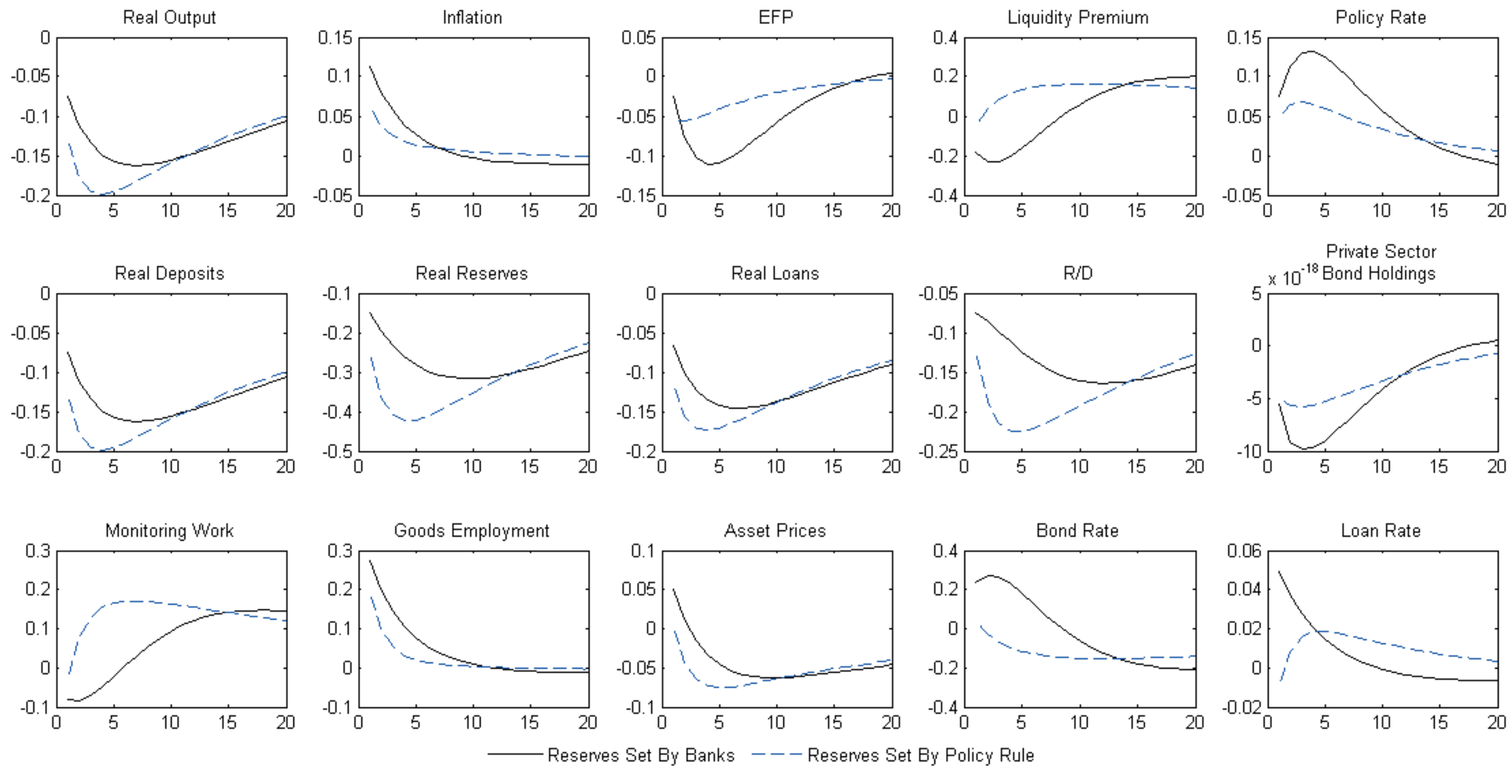


Figure 9

Response to a primitive credit easing policy controlled by equal and inverse exogenous shocks to private sector bond holdings and private sector capital holdings

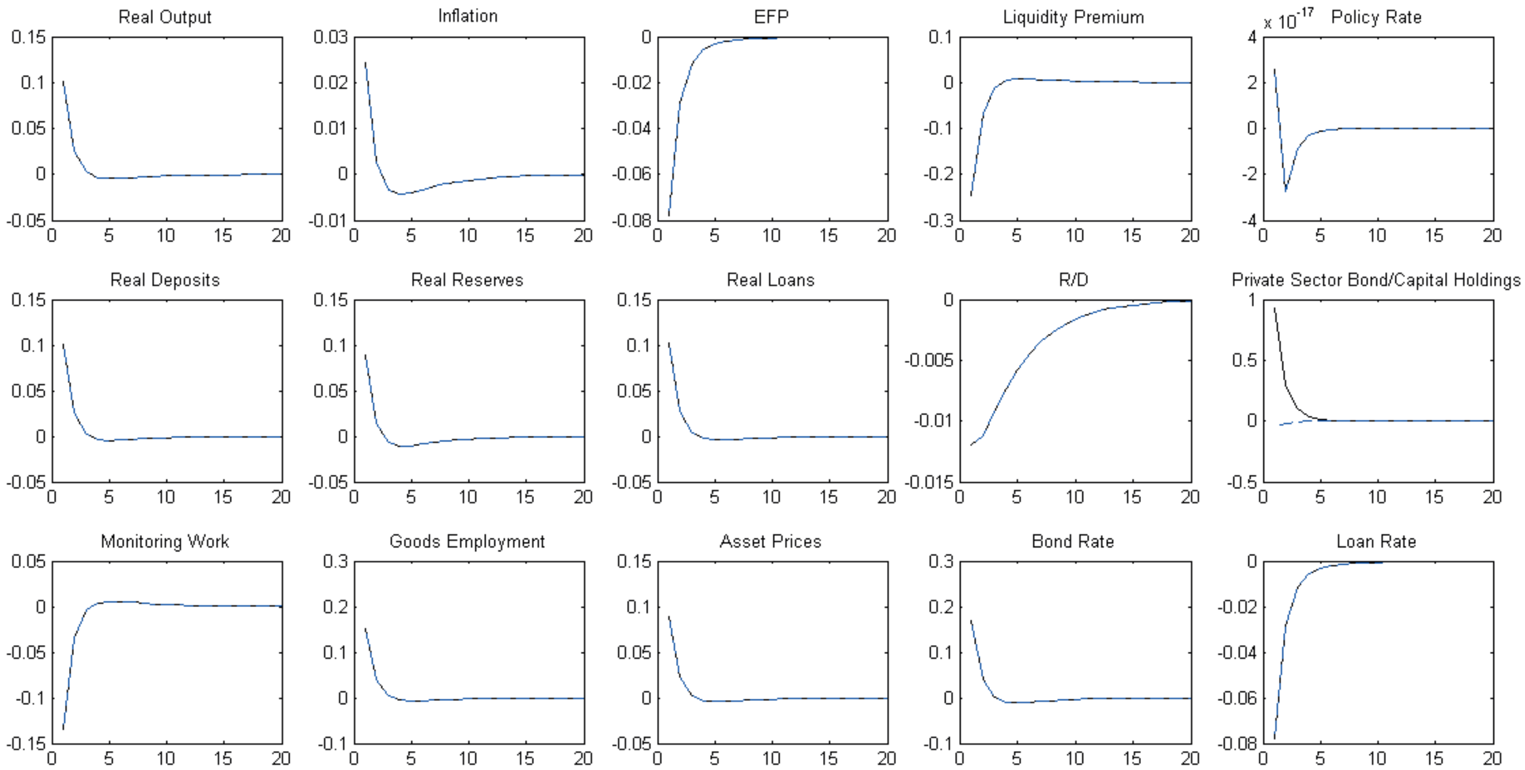
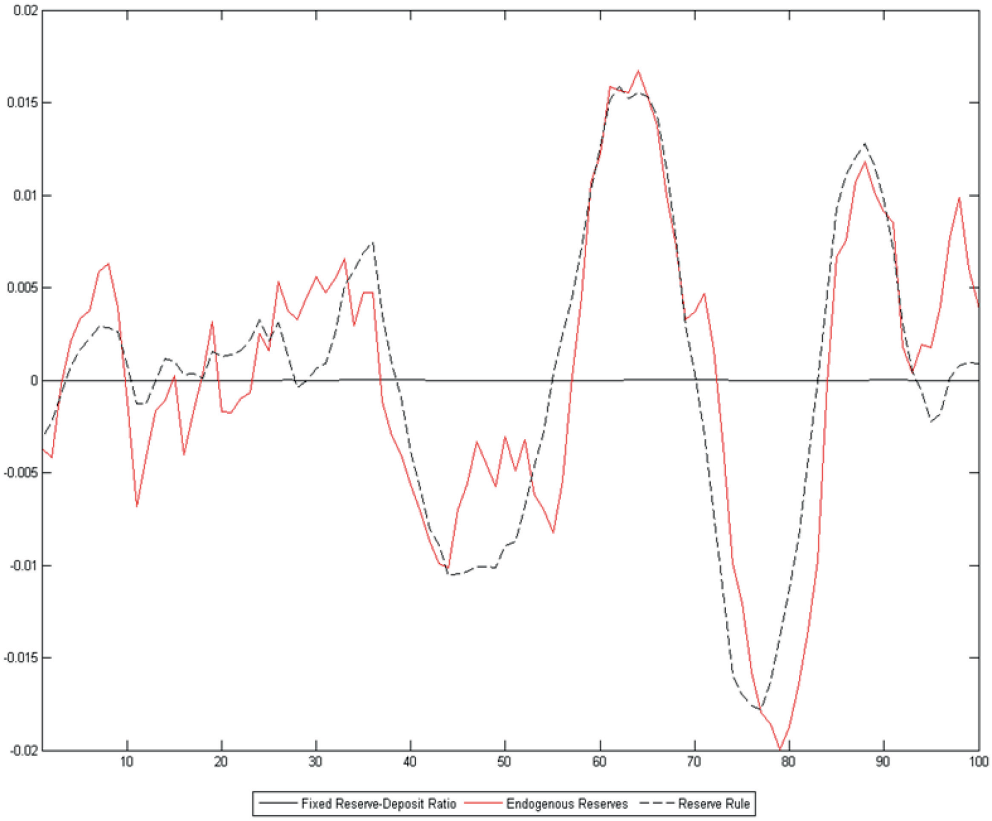


Figure 10

Simulation of two-year moving average series of HP-filtered reserve-deposit ratio under three reserve regimes[1]



[1] Figure 10 shows the middle segment of a simulation of 10,000 data points based on each reserve setting model. The simulated data are HP-filtered (λ =1600).

Technical Appendix

A. Model Setup

This is a modified version of the Goodfriend and McCallum (2007) model, incorporating a government (including bank) budget constraint and a cash-in-advance constraint with stochastic velocity of money demand from Chadha and Corrado (2011).

- Utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left[\phi \log(c_t) + (1-\phi)\log\left(1 - n_t^s - m_t^s\right) \right] \tag{29}$$,

where c_t denotes real consumption, n_t^s is supply of labour in goods sector and m_t^s is the supply of monitoring work in the banking sector.

- Budget constraint:

$$\begin{aligned} & q_t(1-\delta)K_t + \frac{\gamma B_t}{P_t^A} + \frac{D_{t-1}}{P_t^A} + w_t\left(n_t^s + m_t^s\right) + c_t^A\left(\frac{P_t}{P_t^A}\right)^{1-\theta} + \Pi_t \\ & -w_t\left(n_t + m_t\right) - \frac{D_t}{P_t^A} - tax_t - q_t K_{t+1} - \frac{\gamma B_{t+1}}{P_t^A\left(1+R_t^B\right)} - c_t \end{aligned} \tag{30}$$,

where q_t is the price of capital, K_t is the quantity of capital, P_t is the price of household's produced good, P_t^A is the consumption goods price index, n_t is the labour demanded by household as producer, m_t is the labour demanded by household's banking operation, w_t is the real wage, D_t is the nominal holding of broad money, tax_t is the real lump-sum tax payment, R_t^B is the nominal interest rate on government bonds purchased in $t+1$, B_{t+1}. We also assume that any profit from the banking sector, Π_t, goes to the household sector. The Lagrangian multiplier of this constraint is denoted as λ_t.

- Sales equal net production constraint:

$$K_t^{\eta}\left(A1_t n_t\right)^{1-\eta} - c_t^A\left(P_t / P_t^A\right)^{-\theta} = 0. \tag{31}$$

$A1_t$ is a productivity shock in the goods production sector whose mean increases over time at a rate γ. In (18) and (19) the superscript A indicates that the variable is an aggregate taken as given from each household. The Lagrangian multiplier of this constraint is denoted as, ξ_t.

- Government (including bank budget constraint):

$$g_t - tax_t = \frac{r_t}{P_t^A\left(1+R_t^{IB}\right)} - \frac{r_{t-1}}{P_t^A} + \frac{\gamma B_{t+1}}{P_t^A\left(1+R_{t+1}^B\right)} - \frac{\gamma B_t}{P_t^A} \tag{32}$$,

where g_t is real government expenditure. We define:

$$b_{t+1} = B_{t+1} \Big/ P_t^A \left(1 + R_{t+1}^B\right)$$
$$re_t = r_t \Big/ P_t^A \left(1 + R_t^{IB}\right) \tag{33}$$

So the budget constraint can be rewritten as:

$$T_t = re_t - re_{t-1} \frac{P_{t-1}^A}{P_t^A}\left(1 + R_{t-1}^{IB}\right) + b_t - b_{t-1} \frac{P_{t-1}^A}{P_t^A}\left(1 + R_t^B\right), \tag{34}$$

where $T_t = g_t tax_t$.

- Deposit/money constraint:

$$c_t = v_t D_t \big/ P_t^A, \tag{35}$$

where v_t denotes velocity and D_t are deposits.

- Loans:

$$L_t = D_t \left(1 - rr_t\right), \tag{36}$$

where $rr_t = \frac{r_t}{D_t}$ is the reserve-deposit ratio and t_t is high-powered money.

- The bank's problem (see Baltensperger, 1980) is to maximize intra-period profits subject to the returns from loans, L_t, which are lent out at the collateralized interest rate of R^L, to the returns from reserves held at the central bank, R_t, which are assumed to pay the interbank (policy) interest rate, R^{IB}, and the payment of deposit interest, R^D, to deposits:

$$\max_{r_t} \Pi_t = R_t^L L_t + R_t^{IB} r_t - R_t^D D_t, \tag{37}$$

$$\text{s.t. } C_t = \frac{1}{2} R_t^T \left(\bar{r} - r_t\right)^2 + \tau_t \left(\bar{r} - r_t\right). \tag{38}$$

Production function pertaining to management of loans:

$$L_t \big/ P_t^A = F\left(\gamma b_{t+1} + A3_t kq_t K_{t+1}\right)^{\alpha} \left(A2_t m_t\right) 1 - \alpha \quad 0 < \alpha < 1. \tag{39}$$

From (35):

$$c_t = v_t \frac{F\left(\gamma b_{t+1} + A3_t kq_t K_{t+1}\right)^{\alpha} \left(A2_t m_t\right)^{1-\alpha}}{P_t^A \left(1 - rr_t\right)}, \tag{40}$$

where $A2_t$ denotes a shock to monitoring work, and $A3_t$ is a shock to capital as collateral. The parameter k denotes the inferiority of capital as collateral in the banking production function, while α is the share of collateral in the loan production function. For a complete list of all variables and parameters in the model, see Tables 1 and 2 in the main text.

A.1 First-order conditions

- Derivative with respect to m_t^s and n_t^s of (29) and (30):

$$-\frac{(1-\phi)}{1-n_t^s-m_t^s}+w_t\lambda_t=0 \tag{41}$$

- Derivative with respect to m_t:

$$\begin{aligned}&\frac{\phi}{c_t}\frac{\partial c_t}{\partial m_t}-\lambda_t w_t-\lambda_t\frac{\partial c_t}{\partial m_t}=0\\ &w_t=\left(\frac{\phi}{\lambda_t c_t}-1\right)\frac{\partial c_t}{\partial m_t},\end{aligned} \tag{42}$$

given that

$$c_t=\frac{v_t D_t}{P_t^A}=\frac{v_t L_t}{P_t^A(1-rr_t)}=\frac{v_t F\left(\gamma b_{t+1}+A3_t kq_t K_{t+1}\right)^{\alpha}\left(A2_t m_t\right)^{1-\alpha}}{(1-rr_t)}. \tag{43}$$

Then

$$\frac{\partial c_t}{\partial m_t}=\frac{1-\alpha}{m_t}c_t,$$

so (42) becomes:

$$w_t=\left(\frac{\phi}{\lambda_t c_t}-1\right)\frac{1-\alpha}{m_t}c_t. \tag{44}$$

- Derivative with respect to n_t:

$$\begin{aligned}\lambda_t w_t&=\xi_t A1_t(1-\eta)\left(\frac{K_t}{n_t A1_t}\right)^{\eta}\\ w_t&=\frac{\xi_t}{\lambda_t}A1_t(1-\eta)\left(\frac{K_t}{n_t A1_t}\right)^{\eta}.\end{aligned} \tag{45}$$

- Derivative with respect to K_{t+1}:

$$\frac{\phi}{c_t}\frac{\partial c_t}{\partial K_{t+1}}+E_t\lambda_t q_{t+1}(1-\delta)\beta-q_t\lambda_t-\lambda_t\frac{\partial c_t}{\partial K_{t+1}}+E_t\xi_{t+1}\beta\eta K_t^{\eta-1}\left(A1_t n_t\right)^{1-\eta} \tag{46}$$

given

$$\begin{aligned}\frac{\partial c_t}{\partial K_{t+1}}&=\frac{c_t\alpha A3_t kq_t}{\gamma b_{t+1}+A3_t kq_t K_{t+1}}\\ &=\Omega_t A3_t k_t\end{aligned} \tag{47}$$

with

$$\Omega_t=\frac{c_t\alpha}{\gamma b_{t+1}+A3_t kq_t K_{t+1}}. \tag{48}$$

So

$$\left(\frac{\phi}{c_t\lambda_t}-1\right)\Omega A3_t kq_t+E_t\frac{\lambda_{t+1}}{\lambda_t}q_{t+1}(1-\delta)\beta-q_t+E_t\beta\eta\left[\frac{\lambda_{t+1}}{\lambda_t}\frac{\xi_{t+1}}{\lambda_{t+1}}\left(\frac{A1_t n_t}{K_t}\right)^{1-\eta}\right]. \tag{49}$$

- Derivative with respect to P_t:

$$0 = \lambda_t \left(1-\theta\right) c_t^A \left(P_t\right)^{-\theta} \left(P_t^A\right)^{-(1-\theta)} + \theta \xi_t c_t^A \left(P_t\right)^{-\theta-1} \left(P_t^A\right)^{\theta} \tag{50}$$

$$\frac{\xi_t}{\lambda_t} = \frac{\theta - 1}{\theta} \frac{P_t}{P_t^A}.$$

- Derivative with respect to B_{t+1}:

$$\frac{\phi}{c_t} \frac{\partial c_t}{\partial B_{t+1}} - \lambda_t \frac{\partial c_t}{\partial B_{t+1}} + E_t \beta \gamma \frac{\lambda_{t+1}}{P_{t+1}^A} - \frac{\gamma \lambda_t}{P_{t+1}^A \left(1 + R_t^B\right)} = 0,$$

where

$$\frac{\partial c_t}{\partial B_{t+1}} = \frac{\gamma \Omega_t}{P_t^A \left(1 + R_t^B\right)}.$$

So

$$\begin{aligned} &= \left[\frac{\phi}{\lambda_t c_t} - 1\right] \frac{\gamma \Omega_t}{P_t^A \left(1 + R_t^B\right)} + \gamma \beta E_t \frac{\lambda_{t+1}}{P_{t+1}^A} - \frac{\gamma \lambda_t}{P_t^A \left(1 + R_t^B\right)} \\ &= \left[\frac{\phi}{\lambda_t c_t} - 1\right] \Omega_t - 1 + \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{P_t^A}{P_{t+1}^A} \left(1 + R_t^B\right)\right]. \end{aligned} \tag{51}$$

- Derivative wrt r_t of (37) and (38):

$$\frac{\partial \Pi_t}{\delta r_t} = -R_t^L + R_t^{IB} - R_t^T \left(\overline{r} - r_t\right) - \tau_t = 0. \tag{52}$$

$$r_t = \frac{\tau_t + R_t^{IB} - R_t^L}{R_t^T} + \overline{r}. \tag{53}$$

A.2 Interest Rates

FOC with respect to c_t gives:

$$\left(\frac{U_{c,t}}{\lambda_t} - 1\right) = 0, \tag{54}$$

where $U_c = \frac{\phi}{c_t}$. Substituting in (51) gives riskless rate R_t^T:

$$1 + R_t^T = E_t \frac{\lambda_t P_{t+1}^A}{\lambda_{t+1} P_{t+1}}. \tag{55}$$

The interest rate on bonds, R_t^B, is derived from (51):

$$R_t^T - R_t^B = \left[\frac{U_{c,t}}{\lambda_t} - 1\right] \Omega_t = \left[\frac{\phi}{c_t \lambda_t} - 1\right] \Omega_t. \tag{56}$$

So $\frac{u_c}{\lambda}$ measures the household marginal utility relative to household's shadow value of funds, Ω_t being the marginal value of collateral,

while

$$R_t^L - R_t^B = \left[\frac{U_{c,t}}{\lambda_t} - 1\right] k\Omega_t \quad (57)$$
,

where k determines the degree to which capital is collateralizable.

To find the interbank rate, R_t^{IB}, we must equate marginal product of loans per unit of labour $(1-\alpha)\frac{L_t}{m_t}$ to their marginal cost, $\frac{w_t}{P_t^A}$, where loans are defined as $L_t = D_t(1-rr_t) = \frac{c_t P_t^A}{v_t}(1-rr_t)$. So the difference between rates is equal to the real marginal cost of loan management:

$$R_t^T - R_t^{IB} = \left[\frac{v_t m_t w_t}{(1-\alpha)(1-rr_t)c_t}\right]. \quad (58)$$

Since $(1-\alpha)$ is the factor share of monitoring, the marginal cost of loan production is multiplied by $(1-\alpha)$ and the relevant relationship becomes:

$$R_t^L - R_t^{IB} = \left[\frac{v_t m_t w_t}{(1-rr_t)c_t}\right]. \quad (59)$$

The interest rate on deposits is simply:

$$R_t^D = R_t^{IB}(1-rr_t). \quad (60)$$

B. Steady State

For the productivity and monitoring shocks, we assume a trend growth rate equal to $A2_t = A1_t = (1+\gamma)^t$. In steady state $q=1$, $A2 = A1 = (1+\gamma)$, λ shrinks at rate γ, so $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{(1+\gamma)}$ and there is no inflation, and so $P = P^A = 1$ while K is constant.

From (40):

$$1 = \frac{vF}{1-rr}\left(\frac{b}{c} + \frac{kqK}{c}\right)^{\alpha}\left(\frac{m}{c}\right)^{1-\alpha}. \quad (61)$$

From (48):

$$\Omega = \frac{\alpha}{\left(\frac{b}{c} + \frac{kqK}{c}\right)}. \quad (62)$$

From (41):

$$\frac{1-\phi}{1-n-m}=w\lambda \quad (63)$$

From (44):

$$w=\left(\frac{\phi}{c\lambda}-1\right)\frac{(1-\alpha)c}{m} \quad (64)$$

From (50): $\frac{\xi}{\lambda}=\frac{\theta-1}{\theta}$. Replacing in (45):

$$w=\frac{\theta-1}{\theta}(1-\eta)\left(\frac{K}{n}\right)^{\eta} \quad (65)$$

From (49):

$$\begin{gathered}\left(\frac{\phi}{c\lambda}-1\right)\Omega kq+\frac{1}{1+\lambda}q(1-\delta)\beta-q+E_t\beta\eta\left[\frac{1}{1+\gamma}\frac{\xi}{\lambda}\left(\frac{n}{K}\right)^{1-\eta}\right]= \\ \left(\frac{\phi}{c\lambda}-1\right)\Omega kq-1+\frac{\beta}{1+\gamma}\left[(1-\delta)+\eta\frac{\theta-1}{\theta}\left(\frac{n}{K}\right)^{1-\eta}\right]\end{gathered} \quad (66)$$

From the overall resource constraint that incorporates (30), (31) and (32):

$$1=\left(\frac{K}{c}\right)^{\eta}\left(\frac{n}{c}\right)^{1-\eta}-\frac{\delta K}{c} \quad (67)$$

Equations (61) to (63) give the steady-state value for $m, n, c, K, \lambda, w, \Omega$.

The steady-state value for deposits is:

$$D=\frac{c}{v} \quad (68)$$

The steady-state value of reserves is:

$$r=rrD=rr\frac{c}{v} \quad (69)$$

and the steady-state value for re is:

$$re=\frac{r}{\left(1+R^{IB}\right)}=\frac{rr\,c}{v\left(1+R^{IB}\right)}$$

From the reserve equation setting $r=\overline{r}$ we derive the steady-state value for τ:

$$\tau=-R^{IB}+R^{L} \quad (70)$$

Finally, the collateralized and uncollateralized external finance premia in steady state are defined as:

$$EFP=\frac{vmw}{(1-\alpha)(1-rr)c} \quad (71)$$

$$CEFP=\frac{vmw}{(1-rr)c} \quad (72)$$

From (56), (71) and (59) we derive the steady-state values for the interbank rate, the loan rate and the bond rate, as follows:

$$R^{IB} = EFP + R^{T} \tag{73}$$

$$R^{L} = CEFP + R^{IB} \tag{74}$$

$$R^{B} = R^{T} - LSY^{B} \tag{75}$$

From (34) we derive the steady-state value for transfers:

$$T = r\left(1 - \frac{\left(1+R^{IB}\right)}{\left(1+\pi\right)}\right) + b\left(1 - \frac{\left(1+R^{B}\right)}{\left(1+\pi\right)}\right) \tag{76}$$

C. The Linearized Model

The model is composed with the following linearized equations.[26]

Supply of labour (from (41)):

$$\frac{n}{\left(1-n-m\right)}\widehat{n}_t + \frac{m}{\left(1-n-m\right)}\widehat{m}_t - \widehat{\lambda}_t - \widehat{w}_t = 0 \tag{A1}$$

Demand for labour (from (44)):

$$\widehat{m}_t + \widehat{w}_t + \frac{\left(1-\alpha\right)c}{mw}\left(\hat{c}_t + \frac{\phi}{\lambda}\hat{\lambda}_t\right) = 0 \tag{A2}$$

Supply of banking services (combining (36) and (39))[27]:

$$\begin{aligned} \hat{c}_t &= \hat{v}_t c + \widehat{rr}_t c + \left(1-\alpha\right)\left(a2_t + \widehat{m}_t\right) + \\ &\alpha\left[\frac{bc}{bc+\left(1+\gamma\right)kK}\left(\hat{c}_t + \hat{b}_t\right) + \frac{kK\left(1+\gamma\right)}{bc+\left(1+\gamma\right)kK}\left(a3_t + \hat{q}_t\right)\right] \end{aligned} \tag{A3}$$

reported in the main text as:

$$c_t = \left\{v_t c + rr_t c + \left(1-\alpha\right)\left(m_t + a2_t\right) + \alpha\left[\frac{b}{b+k_1}b_t + \frac{k_1}{b+k_1}\left(q_t + a3t\right)\right]\right\}\left(\frac{b+k_1}{b\left(1-\alpha\right)+k_1}\right)$$

CIA constraint (from (35)):

$$\hat{c}_t + \widehat{P}_t = \widehat{H}_t + \hat{v}_t - \widehat{rr}_t \tag{A4}$$

[26] The model is defined in the Matlab file gmvsys.m. Standard deviation and persistence structure of the stochastic variables are defined in the driver file gmvdrv.m.

[27] The relationship is derived by setting $b = \frac{B}{P\left(1+R^{B}\right)c}$ and $b_{t+1} = b_t c_t$, where b_{t+1} is as defined in (33).

Aggregate supply:

$$\hat{c}_t = (1-\eta)\left(1+\frac{\delta K}{c}\right)\left(a1_t + \hat{n}_t\right) - \frac{\delta K}{c}\hat{q}_t \qquad \text{(A5)}$$

Marginal cost:

$$\widehat{mc}_t = \hat{n}_t + \hat{w}_t - \hat{c}_t \qquad \text{(A6)}$$

Mark-up (from (50)):

$$\widehat{mc}_t = \hat{\xi}_t - \hat{\lambda}_t \qquad \text{(A7)}$$

Inflation:

$$\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1} \qquad \text{(A8)}$$

Calvo pricing:

$$\hat{\pi}_t = \kappa\widehat{mc}_t + \beta E_t \hat{\pi}_{t+1} + a5_t \qquad \text{(A9)}$$

Marginal value of collateralized lending (from (48)):

$$\hat{\Omega}_t = \frac{kK}{bc+kK}\left(\hat{c}_t - \hat{q}_t a3_t\right) - \frac{bc}{bc+kK}\hat{b}_t \qquad \text{(A10)}$$

reported in the main text as:

$$\hat{\Omega}_t = \frac{k_2}{b+k_2}\left(\hat{c}_t - \hat{q}_t - a3_t\right) - \frac{b}{b+k_2}\hat{b}_t \qquad \text{(A11)}$$

Asset Pricing (from (51))[28]:

$$\begin{aligned}\hat{q}_t\left[1-k\Omega\left(\frac{\phi}{c\lambda}-1\right)\right] = {} & \left[\frac{\beta(1-\delta)}{1+\gamma}+\frac{\beta\eta mc}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}\right]\left(E_t\hat{\lambda}_{t+1}-\hat{\lambda}_t\right)+\frac{\beta(1-\delta)}{1+\gamma}E_t\hat{q}_{t+1}+ \\ & \frac{k\Omega\phi}{c\lambda}\left(-\hat{c}_t-\hat{\lambda}_t\right)+k\Omega\left(\frac{\phi}{c\lambda}-1\right)\left(\hat{\Omega}_t+a3_t\right)+ \\ & \left(\frac{\beta\eta mc}{1+\gamma}\left(\frac{n}{K}\right)^{1-\eta}\right)E_t\left[\widehat{mc}_{t+1}+(1-\eta)\left(\hat{n}_{t+1}+a1_{t+1}\right)\right]\end{aligned} \qquad \text{(A12)}$$

reported in the main text as:

$$\begin{aligned}\hat{q}_t = {} & (\delta_1+\gamma_1)\left(E_t\hat{\lambda}_{t+1}-\hat{\lambda}_t\right)+\delta_1 E_t\hat{q}_{t+1}-\frac{k\Omega\phi}{c\lambda}\left(\hat{c}_t+\hat{\lambda}_t\right)+ \\ & k\Omega\left(\frac{\phi}{c\lambda}-1\right)\left(\hat{\Omega}_t+a3_t\right)+\gamma_1 E_t\left[\widehat{mc}_{t+1}+(1-\eta)\left(\hat{n}_{t+1}+a1_{t+1}\right)\right].\end{aligned}$$

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[28] Note that in steady state $\frac{\xi}{\lambda} = mc$ and $\frac{\lambda_{t+1}}{\lambda_t} = \frac{1}{1+\gamma}$.

Government budget constraint[29]:

$$T\hat{T}_t = \frac{rr\,c}{v\left(1+R^{IB}\right)}\left(\widehat{re}_t + \left(1+R^{IB}\right)\left(\hat{\pi}_t - \widehat{re}_t - \hat{R}^{IB}_{t-1}\right)\right) + b\left(\hat{b}_t + \left(1+R^{B}\right)\left(\hat{\pi}_t - \hat{b}_{t-1} - \hat{R}^{B}_t\right)\right)$$

Bond holding:

$$\hat{b}_t = a6_t \tag{A13}$$

Riskless interest rate (from (55)):

$$\hat{R}^T_t = \hat{\lambda}_t + E_t\hat{\pi}_{t+1} - E_t\hat{\lambda}_{t+1} \tag{A14}$$

Liquidity service of bonds (from (51))[30]:

$$\frac{1+R^B}{1+R^T}\left(\hat{R}^B_t - \hat{R}^T_t\right) = \frac{\phi\Omega}{c\lambda}\left(\hat{c}_t + \hat{\lambda}_t\right) - \left(\frac{\phi}{c\lambda} - 1\right)\Omega\hat{\Omega}_t \tag{A15}$$

External finance premium (from (58)):

$$\widehat{EFP}_t = \hat{v}_t + \hat{w}_t + \hat{m}_t - \hat{c}_t + \widehat{rr}_t \tag{A16}$$

Other interest rates:

$$\hat{R}^{IB}_t = \hat{R}^T_t - \widehat{EFP}_t \tag{A17}$$

$$\hat{R}^{L}_t = \hat{R}^{IB}_t + \widehat{EFP}_t \tag{A18}$$

$$\hat{R}^{D}_t = \hat{R}^{IB}_t - \widehat{rr}_t\frac{rr}{\left(1-rr\right)} \tag{A19}$$

Policy feedback rule:

$$\hat{R}^{IB}_t = \left(1-\rho\right)\left(\phi_\pi\hat{\pi}_t + \phi_y\widehat{mc}_t\right) + \rho\hat{R}^{IB}_{t-1} + a4_t \tag{A20}$$

Velocity:

$$\hat{v}_t = a7_t \tag{A21}$$

Reserves:

$$\hat{r}_t = \frac{1}{r\,R^T}\left[-\left(\tau + R^{IB} - R^L\right)\hat{R}^T_t + R^{IB}\hat{R}^{IB}_t - R^L\hat{R}^L_t + \tau\hat{\tau}_t\right] \tag{A22}$$

---

29 We define the percentage deviation from steady state of flow and stock variables by $\ln x_t - \ln x$, while for interest rates and ratio variables the formulas are $R_t = R + \hat{R}_t$ (rates) and $r_t = r + \hat{r}_t$ (ratio, assuming $r_t = x_t/y_t$). It can be shown that the approximation comes from the first-order Taylor expansion $e^x \approx 1 + x$, while for the rate variable $\hat{R}_t \approx \ln\left(1+R_t\right) - \ln\left(1+R\right)$ and for the ratio variable $\hat{r}_t = r_t - r = \ln\left(x_t/y_t\right) - \ln\left(x/y\right) = \hat{x}_t - \hat{y}_t$.

30 Log-linearization of interest rate is defined as difference from steady state: $R_t = R + \hat{R}_t$.

Liquidity:

$$\hat{\tau}_t = a8_t \tag{A23}$$

Loans:

$$L_t = \frac{1}{1-rr} D_t - \frac{rr}{1-rr} r_t \tag{A24}$$

For notational convenience the relevant log-linearized equations with variables denoting deviation from steady state are reported in the main text without the $\hat{}$.

The benchmark model has 22 endogenous variables $\{c, n, m, w, q, P, \pi, mc, H, b, \Omega, E, F, P, R^T, R^B, R^{IB}, R^L, R^D, \lambda, \xi, T, r, re\}$, 6 lagged variables $\{P_{-1}, H_{-1}, c_{-1}, b_{-1}, re_{-1}, R^B_{-1}\}$ and 8 exogenous shocks $\{a1, a2, a3, a4, a5, a6, a7, a8\}$. The equations (A1) through (A24) plus 6 lagged identities construct the model to be solved by the King and Watson (1998) algorithm. For the simulation, we consider contemporaneous shocks to $a_1, \ldots, a_8$. To obtain the simulated series, we have produced 10,000 draws from a normal distribution, discarding the first 500 and considering the middle 100.

D. OMO Model

In the bond-OMO variant, as central bank bond holdings must equal reserves, we can substitute and rearrange to give the log-linear relationship

$$b^p \hat{b}^p_t = b\hat{b}_t - r\hat{r}_t \,, \tag{77}$$

which we add to our system of equations. It is this newly defined variable b^p which determines the amount of collateral that households have available, so we substitute it for b in the loan supply and marginal value of collateralized lending equations.[31]

In the capital-OMO variant, capital could be bought by the central bank in exchange for new reserves in the same way that bonds are. For this we introduce an equation defining total capital holdings as a function of an exogenous shock in the same way as we did for bond holdings. The central bank can now hold two assets on its balance sheet, so we hold the level of bonds fixed as before and set the steady-state value of capital held by the central bank at zero. By defining private sector capital holdings in log-linear form as

$$k^p \hat{k}^p_t = b\hat{b}_t - r\hat{r}_t \tag{78}$$

what we model is a situation where the central bank buys and sells illiquid assets/capital in exchange for reserves.

The bond-OMO model introduces b^P_t and its one-period lag as additional variables, whilst the capital-OMO model introduces K_t and K^P_t, so each has 31 endogenous variables.

[31] As we deal with a consolidated government budget constraint, the net effect of interest payments on bonds held by the central bank is zero. Therefore, it is appropriate to change the terms in b to terms in b^p in this equation as well.

E. Credit Easing

Our simulation of a credit easing process is modelled simplistically by adding a positive shock to equation (77) and an equal negative shock to equation (78). In this way, when we run that shock we are increasing (decreasing) the amount of private sector bond holdings by the same amount as we decrease (increase) private sector holdings of capital. This effectively amounts to a swap and has a mirror impact on the central bank's holdings of the two types of assets. However, it leaves the overall size of the private sector and the central bank balance sheet unchanged.

F. Taylor Approximation

This section outlines the process of approximating a utility function through a first-order Taylor expansion. Our initial utility function is given by:

$$U = E_0 \sum_{t=0}^{\infty} \beta_t \left[\phi \log(c_t) + (1-\phi) \log\left(1 - m_t^s - n_t^s\right) \right] . \tag{79}$$

As our function is additive, we can estimate our Taylor approximations separately for each term and then bring them together. First we derive our approximation of $\log(c_t)$:

$$\log(c_t) \approx U_c \breve{c}_t + \frac{U_{cc}\breve{c}_t^2}{2} + O^3 , \tag{80}$$

where O^3 represents all terms higher than second order. This then expands to

$$\approx \frac{1}{c} c\left(\hat{c}_t + \frac{1}{2}\hat{c}_t^2 \right) - \frac{1}{c^2}\frac{c^2 \hat{c}_t^2}{2} + O^3 \tag{81}$$

and we can cancel out like terms to simplify this to:

$$\log c_t \approx \hat{c}_t + O^3 . \tag{82}$$

The same process for our second argument yields

$$\log(1 - m_t - n_t) \approx U_{(1-m-n)}(1 - \breve{m}_t - \breve{n}_t) + \frac{U_{(1-m-n)(1-m-n)}(1 - \breve{m}_t - \breve{n}_t)^2}{2} + O^3 , \tag{83}$$

which expands to

$$\begin{aligned} &\approx \frac{1}{(1-m-n)}(1-m-n)\left[(1 - \breve{m}_t - \breve{n}_t) + \frac{1}{2}(1 - \breve{m}_t - \breve{n}_t)^2 \right] - \\ &\quad - \frac{1}{(1-m-n)^2}\frac{(1-m-n)^2(1 - \breve{m}_t - \breve{n}_t)^2}{2} + O^3 , \end{aligned} \tag{84}$$

which in turn simplifies to:

$$\log(1 - m_t - n_t) \approx (1 - \breve{m}_t - \breve{n}_t) + O^3 . \tag{85}$$

Putting these back into equation (79), we get:

$$U_t - U = \phi \hat{c}_t + (1-\phi)\left(1 - \widehat{m}_t - \hat{n}_t\right) + O^3 , \tag{86}$$

which is our initial approximation of the deviation of current utility in any given period, compared to steady-state utility. However, our aim is to find our function in terms of variances (first-order terms), so the next step is to simplify this and eliminate as many first-order terms as we can through substitution of other equations within our model. We have three first-order terms to deal with: $\hat{c}_t$ $\widehat{m}_t$ and $\hat{n}_t$.

Let us begin with our labour demand function, converting it to log deviations from steady state:

$$\widehat{m}_t = -\widehat{w}_t - \frac{(1-\alpha)c}{mw}\left(\hat{c}_t + \frac{\phi}{\lambda}\hat{\lambda}_t\right). \tag{87}$$

If we assume that $\frac{(1-\alpha)c}{mw}$ is equal to one in order to simplify the analysis, and substitute this back into equation (86), we get:

$$U_t - U = \phi\hat{c}_t + (1-\phi)\left(1 + \widehat{w}_t + \hat{c}_t + \frac{\phi}{\lambda}\hat{\lambda}_t\right) - \hat{n}_t + O^3 \ . \tag{88}$$

We can then bring together our terms in $\hat{c}_t$, and this cancels to give:

$$U_t - U = \hat{c}_t + (1-\phi)\left(1 + \widehat{w}_t + \frac{\phi}{\lambda}\hat{\lambda}_t\right) - \hat{n}_t + O^3 . \tag{89}$$

Next we can use our marginal cost function:

$$\hat{c}_t = \widehat{w}_t + \hat{n}_t - \widehat{mc}_t . \tag{90}$$

If we take a first-order approximation of this equation we get:

$$c\left(\hat{c}_t + \frac{1}{2}\hat{c}_t^2\right) = w\left(\widehat{w}_t + \frac{1}{2}\widehat{w}_t^2\right) + n\left(\hat{n}_t + \frac{1}{2}\hat{n}_t^2\right) - mc\left(\widehat{mc}_t + \frac{1}{2}\widehat{mc}_t^2\right). \tag{91}$$

Solving for $\hat{c}$:

$$\hat{c}_t = \frac{w}{c}\left(\widehat{w}_t + \frac{1}{2}\widehat{w}_t^2\right) + \frac{n}{c}\left(\hat{n}_t + \frac{1}{2}\hat{n}_t^2\right) - \frac{mc}{c}\left(\widehat{mc}_t + \frac{1}{2}\widehat{mc}_t^2\right) - \frac{1}{2}\hat{c}_t^2 . \tag{92}$$

Bringing like terms together and ordering our equation so that first-order terms are together and first-order terms are grouped together, we get:

$$\begin{aligned} U_t - U = {} & \left(\frac{w}{c} + (1-\phi)\right)\widehat{w}_t + \left(\frac{n}{c} + (1-\phi)\right)\hat{n}_t - \frac{mc}{c}\widehat{mc}_t + \frac{(1-\phi)\phi}{\lambda}\hat{\lambda}_t \\ & + \frac{w}{2c}\widehat{w}_t^2 + \frac{n}{2c}\hat{n}_t^2 - \frac{mc}{2c}\widehat{mc}_t^2 - \frac{1}{2}\hat{c}_t^2 + O^3 \end{aligned} \tag{93}$$

The term in $\hat{n}_t$ can be approximated using the two lemmas described in Galí (2008), to give:

$$\hat{n}_t = \frac{1}{1-\eta}\left(\hat{c}_t + \frac{1}{2}\frac{\theta}{\chi}\hat{\pi}_t^2\right), \tag{94}$$

where $\chi = \frac{(1-\theta)(1-\beta\theta)}{\theta}\frac{1-\eta}{1+\eta(\theta-1)}$. If we substitute this back into our equation we eliminate the term in $\hat{n}_t$ but replace it with a first-order term in $\hat{c}_t$.

$$U_t - U = \left(\frac{w}{c} + (1-\phi)\right)\widehat{w}_t + \frac{\left(\frac{n}{c} - (1-\phi)\right)}{1-\eta}\hat{c}_t - \frac{mc}{c}\widehat{mc}_t + \frac{(1-\phi)\phi}{\lambda}\hat{\lambda}_t$$
$$+ \frac{w}{2c}\widehat{w}_t^2 + \frac{n}{2c}\hat{n}_t^2 - \frac{mc}{2c}\widehat{mc}_t^2 - \frac{1}{2}\hat{c}_t^2 + \frac{1}{2}\frac{\theta}{\chi}\hat{\pi}_t^2 + O^3 \quad (95)$$

.

We can eliminate the term in lambda by using our mark-up equation:

$$\widehat{mc}_t = \hat{\xi}_t - \hat{\lambda}_t \quad (96)$$

.

Solving for lambda, and noting that there is no deviation in ξ:

$$\hat{\lambda}_t = -\widehat{mc}_t \quad (97)$$

,

so our equation can be written:

$$U_t - U = \left(\frac{w}{c} + (1-\phi)\right)\widehat{w}_t + \frac{\left(\frac{n}{c} - (1-\phi)\right)}{1-\eta}\hat{c}_t - \left[\frac{mc}{c} - \frac{(1-\phi)\phi}{\lambda}\right]\widehat{mc}_t$$
$$+ \frac{w}{2c}\widehat{w}^2 + \frac{n}{2c}\hat{n}^2 - \frac{mc}{2c}\widehat{mc}_t^2 - \frac{1}{2}\hat{c}_t^2 + \frac{\left(\frac{n}{c} - (1-\phi)\right)}{1-\eta}\frac{1}{2}\frac{\theta}{\chi}\hat{\pi}_t^2 + O^3 \quad (98)$$

,

leaving only 3 first-order terms. We can now replace $\widehat{w}$ as a function of terms of $\hat{n}$, $\hat{c}$ and $\widehat{mc}$, leaving us 3 terms still, but one of which is $\hat{n}$. We can convert this $\hat{n}$ term into a term in the volatility of inflation and $\hat{c}$, leaving us with just two first-order terms: one in $\hat{c}$ and one in $\widehat{mc}$. We therefore rearrange to make $\widehat{w}$ the subject, leaving us with a first-order term in $\hat{c}$ and a first-order term in $\widehat{mc}$, but with everything else being second order or higher.

$$U_t - U = \left[\left(\frac{w}{c} + (1-\phi)\right) + \frac{\left(\frac{n}{c} - (1-\phi)\right)}{1-\eta} - \frac{\left(\frac{w}{c} - (1-\phi)\right)}{1-\eta}\right]\hat{c}_t$$
$$- \left[\frac{mc}{c} - \frac{(1-\phi)\phi}{\lambda} - \left(\frac{w}{c} + (1-\phi)\right)\right]\widehat{mc}_t$$
$$+ \frac{w}{2c}\widehat{w}_t^2 + \frac{n}{2c}\hat{n}_t^2 - \frac{mc}{2c}\widehat{mc}_t^2 - \frac{1}{2}\hat{c}_t^2$$
$$+ \left[\frac{\left(\frac{n}{c} - (1-\phi)\right)}{1-\eta}\frac{1}{2}\frac{\theta}{\chi} - \frac{\left(\frac{w}{c} - (1-\phi)\right)}{1-\eta}\frac{1}{2}\frac{\theta}{\chi}\right]\hat{\pi}_t^2 + O^3 \quad (99)$$

We can see that the welfare function contains linear terms in $\hat{c}_t$ and $\widehat{mc}_t$. They might tend to dominate the first-order terms. We therefore choose weights $(1-\phi)$ and ϕ, so that first-order terms disappear in the welfare approximation. The particular weights to choose are those that solve the system:

$$\left(\frac{w}{c}+(1-\phi)\right)+\frac{\left(\frac{n}{c}-(1-\phi)\right)}{1-\eta}-\frac{\left(\frac{w}{c}+(1-\phi)\right)}{1-\eta}=0$$
$$-\frac{mc}{c}+\frac{(1-\phi)\phi}{\lambda}+\left(\frac{w}{c}+(1-\phi)\right)=0 \qquad (100)$$
,

leaving us with the welfare approximation

$$U_t-U=\frac{w}{2c}\widehat{w}_t^2+\frac{n}{2c}\widehat{n}_t^2+\frac{mc}{2c}\widehat{mc}_t^2-\frac{1}{2}\widehat{c}_t^2$$
$$+\left[\frac{\left(\frac{n}{c}-(1-\phi)\right)}{1-\eta}\frac{1}{2}\frac{\theta}{\chi}-\frac{\left(\frac{w}{c}-(1-\phi)\right)}{1-\eta}\frac{1}{2}\frac{\theta}{\chi}\right]\widehat{\pi}_t^2+O^3 \qquad (101)$$
,

where $(1-\phi)=\dfrac{\frac{w}{c}(1-\eta)+\left(\frac{n}{c}-\frac{w}{c}\right)}{1-\eta}=\dfrac{\frac{n}{c}-\eta\frac{w}{c}}{1-\eta}$ and $\phi=\lambda\left[(1+\eta)\dfrac{\frac{mc}{c}+\frac{w}{c}}{\frac{n}{c}-\eta\frac{w}{c}}+1\right]$. Therefore our welfare approximation can be written as:

$$U_t-U=\frac{w}{2c}\widehat{w}_t^2+\frac{n}{2c}\widehat{n}_t^2-\frac{mc}{2c}\widehat{mc}_t^2-\frac{1}{2}\widehat{c}_t^2$$
$$-\frac{1}{2}\left[\frac{\theta}{\chi(1-\eta)}\left(\frac{w}{c}\left(1+\eta^2\right)-\frac{n}{c}\right)\right]\widehat{\pi}_t^2+O^3 \qquad (102)$$
.

The above welfare function can be expressed in terms of the quadratic loss function:

$$U_t-U=-\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t L_t+O^3$$
$$\text{with } L_t=\frac{1}{2}\left[\begin{array}{c}\sigma_c^2+\left[\frac{\theta}{\chi(1-\eta)}\left(\frac{w}{c}\left(1+\eta^2\right)-\frac{n}{c}\right)\right]\sigma_\pi^2- \\ \frac{w}{c}\sigma_w^2-\frac{n}{c}\sigma_n^2+\frac{mc}{c}\sigma_{mc}^2\end{array}\right] \qquad (103)$$
.

This is equation (27) in the text.

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Sovereign debt management and the central bank: an emerging market perspective

Sanjay K Hansda[1]

Global rethinking and post-crisis lessons

In the past, the functions of sovereign debt management (SDM), monetary policy and financial stability have often been looked upon as an ‘impossible’ duality or trinity. Post-crisis, their interdependence is increasingly being recognized. In the developed world, central banks’ operations are now extended to the long end by way of quantitative easing and open market operations. Similarly, government debt managers are also operating at short end. This has intensified the interaction between SDM and monetary/financial stability operations, warranting greater coordination for the purpose of policy credibility.

Designing an effective coordination mechanism between the debt management office (DMO) and the central bank, however, remains a challenge. In many countries, lack of proper coordination has resulted in competing auctions and in market confusion regarding the true signals of monetary policy (Das et al, 2010). Thus, government bond auctions have at times failed to mobilise the notified amount in many countries, including the UK, Germany, China, Netherlands and Hungary, leading to reputation risk for both the DMO and the central bank.

Historically, SDM has been one of the primary functions of central banks. With the creation of the European Central Bank, the establishment of independent and autonomous DMO was encouraged in the euro area. In the background of the European sovereign debt crisis, the concern regarding short-term/foreign debt has been highlighted as contributing to rollover risk, sovereign risk and financial instability. We should not, however, lose sight of the fact that, while institutional arrangements for SDM are important, they are a poor substitute for a stronger fiscal health.

SDM has since shifted back to the central bank in Iceland in 2007, as happened in Denmark in 1991. In Canada, SDM continues to be handled by the central bank jointly with the Ministry of Finance, while the plan to separate SDM from the central bank has been abandoned in Kenya, Zambia and Sri Lanka. The pre-crisis framework of a single objective and single instrument for the central bank, which was the foundation for the separation of SDM and monetary/financial stability functions, is no longer the mainstay. Central banks are now being entrusted with multiple responsibilities even in the developed world, in view of a confluence of interests far outweighing perceived conflicts. In this context, Goodhart (2010) has advocated restoring SDM responsibility to the central bank.

Indian experience

Collaborative management of SDM and monetary/financial stability is critical for emerging markets like India, given the stage of financial development, the limited absorptive capacity

[1] Director, Reserve Bank of India, Internal Debt Management Department, Central Office, Mumbai. The views expressed are the discussant’s, not those of the institution to which the discussant belongs.

of the financial market and the high fiscal deficit. In this regard, CGFS (2011) has observed that ‘‘In developing systems, where the central bank might also issue debt for sterilization purposes or manage government-related cash balances, policy coordination has been more common, including some cases where the central bank is responsible for some SDM functions or involved in SDM oversight.’’ At present, the SDM operations in the Reserve Bank of India (RBI) are carried out by the Bank’s Internal Debt Management Department (IDMD), which is functionally separate from monetary management. The SDM strategy is formulated by the Monitoring Group on Cash and Debt Management, which is the apex entity for coordination between the RBI and the Ministry of Finance.

Given the magnitude of government borrowing, SDM is much more than a resource-raising exercise in India. The extent and dynamics of government borrowing have a much wider influence on interest rate movements, systemic liquidity and credit growth through crowding out. SDM therefore must be seen as part of broader macroeconomic management, involving various tradeoffs. Once this is recognized, the centrality of central banks in this regard becomes quite evident. Only central banks have the pulse of the market and the instruments needed to make contextual judgments that would be difficult for a DMO driven by narrow objectives (Subbarao, 2011).

With the Fiscal Responsibility and Budget Management (FRBM) Act, the basic source of conflict between SDM and monetary policy has been removed in India, as the central bank is precluded from subscribing in the primary market. The central bank’s interest rate signalling is performed by the repo rate under the Bank’s Liquidity Adjustment Facility (LAF) rather than by the primary market yield, which is auction driven. In line with the IMF-World Bank’s guidelines, the central bank as debt manager strives to minimize cost of borrowing over the medium term as well as the rollover risk of debt. Thus, with the average maturity of federal government debt at around 10 years, India has one of the longest maturity profiles in the world, which proved to be a source of strength and comfort during the crisis. A higher domestic saving rate, coupled with calibrated capital account management and liquidity ratios for financial intermediaries (along the lines of Basel III), has made largely domestic holding of government debt possible, insulating SDM from potential volatility from foreign holding.

Contrary to popular perception, the debt manager is supposed to minimise cost over the medium term, rather than the immediate cost, in view of the rollover risk. Therefore, SDM by the central bank need not necessarily be in conflict with monetary management. Indeed, we look upon price stability as the core of debt management, without which it would be difficult to sell fixed coupon bearing instruments like government securities. Price stability since the mid-1990s has facilitated the lengthening of the sovereign yield curve up to 30 years in India. Thus a central bank in charge of SDM could be equally committed to price stability, particularly when SDM is its statutory responsibility. Moreover, the central bank, through its numerous development measures for widening and deepening the market, is focused upon the cost of government borrowing over the medium term. The system in place for trading, payment and settlement in India, namely the Negotiated Dealing System (NDS), NDS-OM (NDS-Order Matching), Delivery versus Payment III, Real Time Gross Settlement (RTGS) and Straight-Through Processing (STP), is world class. The multi-pronged initiatives for development of the government securities market have also facilitated monetary transmission and made it possible to pursue indirect as opposed to direct instruments of monetary control. As inflationary pressures surfaced, the central bank did not hesitate to signal interest rate hardening, despite large government borrowing requirements (eg an increase in the repo rate on 13 occasions since March 2010).

In a situation of excess capital inflows/outflows requiring forex intervention and sterilization/unwinding through Market Stabilisation Scheme (MSS) bonds, SDM needs to be integrated with these operations. In 2007-08, the volume of MSS issuance was comparable to that of SDM issuance in India. With the reversal of capital flows in 2008-09 and the large increase in the government’s market borrowing programme, there was significant unwinding of the MSS, and the Reserve Bank was able to manage the situation non-disruptively by carrying out liquidity management seamlessly, as both functions are entrusted to it. We can expect that volatility in cross-border capital flows will continue on a global basis, and hence we need to continue using MSS as required.

The cash management of the government interfaces closely with monetary policy and financial stability on a day-to-day basis. The debt manager should strive to maintain a stable cash balance with the central bank, avoiding absorption/injection of market liquidity, which may not be in tune with the monetary policy stance. Success in doing so, however, critically depends on the commitment/efficiency of various government departments in managing their cash flows. To incentivise the process, government cash balances, if any, may be remunerated up to a limit. Auctioning of government cash balances when the market has a liquidity surplus is best avoided in the interest of stabilisation and the central bank balance sheet. Furthermore, recourse to central bank money for intra-year requirements of the government needs to be limited as leading to the creation of primary liquidity.

In the Indian context, the SDM of provincial governments, currently being performed by the central bank, adds another dimension. It is imperative to harmonise the SDM of the federal and the provincial governments, as the latter has reached a critical mass vis-à-vis the absorptive capacity of the market. Assigning a countercyclical role to the sub-sovereign governments also calls for greater coordination and information sharing with the monetary and financial stability authorities. Also, bearing the federal polity in mind, the provinces' sensitivity to entrusting SDM to an agency of the federal government needs to be considered.

The smooth conduct of the government's huge borrowing programme in recent years has been facilitated by the RBI's having a broad range of responsibilities – regulation and surveillance of financial markets in general and the government securities market in particular under the RBI Act and the Government Securities Act, oversight over market infrastructure (eg Clearing Corporation of India Limited) for government securities and money market instruments, custodial functions, responsibility as banker and debt manager to both federal and provincial governments, thus calibrating debt issuances as a function of market conditions, determining what instruments will be offered to the market and their timing, handling of institutional matters and interactions with investors, and consideration of investors' risk constraints at every point in time – all of which affect financial stability. This is also very relevant since the banks are predominant investors in government securities, and the Reserve Bank as the regulator and supervisor of the banking system has hands-on experience with the functioning of banks.

Summing up

Following fiscal consolidation during 2003-07, a Middle Office for debt management was set up in the Ministry of Finance in 2008. The Union Budget (2011-12) has now proposed to introduce the Public Debt Management Agency (PDMA) of India Bill during 2011-12 as a step towards establishing an independent DMO. It may be recalled that the RBI itself termed the separation of SDM from monetary management a desirable medium-term goal as early as 2001. However, the recommendation was qualified by three preconditions: (i) development of the government securities market, (ii) durable fiscal correction and (iii) an enabling legislative framework. In the context of global crisis, the government had to carry out a countercyclical role, leading to a high fiscal deficit and large market borrowings. Further, the issue of SDM is now being rethought globally. The emerging post-crisis wisdom recognizes the interdependence of functions linking monetary policy, financial stability and SDM, and the need for a close association of the central bank with SDM. The foregoing assessment regarding the issue of SDM needs to be seen in this light.

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Debt and monetary policy: comments on Jagjit S Chadha, Luisa Corrado and Jack Meaning's paper "Reserves, liquidity and money: an assessment of balance sheet policies", and further thoughts

Alec Chrystal[1]

It is interesting to return to the topic of debt and monetary policy after a gap of around 13 years. When the Bank of England held a conference on this topic in 1998, the world seemed very different (see Chrystal (1999a)). In the United Kingdom, a very large national debt had been problematic in the period after the Second World War, but by the late 1990s the size of the debt was not even a minor concern and the composition of debt was thought to be orthogonal to monetary policy. The ballooning debt and the interest-rate-lower-bound problem that succeeded the 2007-8 financial crisis changed all that. The scale of public debt has returned as a major concern, debt purchases have become a monetary policy instrument (viz. QE and LSAPS) and the composition of debt has been added to the agenda of monetary policy makers (viz. "Operation twist").

My conference invitation came with a request to make some broader remarks and I plan to do just that, though I will start with a few thoughts about the Chadha et al (2012) paper. I will then offer some comments on the sustainable size of public debt, followed by a discussion of the composition of debt. Finally, I will make a few remarks on the incentives faced by different agencies relating to debt management.

Chadha et al discussion

This paper is a very impressive piece of work. It contains a detailed DSGE model. It then adds liquidity constraints and shows (by means of calibration) what happens to the economy following a liquidity injection. The clear result is that the liquidity boost stimulates real activity, and the implication is that a liquidity injection, such as via QE or LSAPs, would do the same.

There are three main comments that I wish to offer on the paper. Firstly, I am no theorist, but I do have some worries about attempts to make DSGE appear better able to deal with real world financial problems. The whole point of this type of model is that it assumes long-lived representative agents who have solved an inter-temporal optimisation problem. Finance has no direct role in this world and debt structures do not matter. As Robert Lucas has observed, such models are incapable of explaining financial crises, viz:

> *"The problem is that the new theories, the theories embedded in general equilibrium dynamics of the sort that we know how to use pretty well now—there's a residue of things they don't let us think about. They don't let us think about the U.S. experience in the 1930s or about financial crises and their real consequences in Asia and Latin America. They don't let us think, I don't think, very well about Japan in the 1990s. We may be disillusioned with the Keynesian*

[1] Cass Business School, London.

apparatus for thinking about these things, but it doesn't mean that this replacement apparatus can do it either. It can't."[2]

This statement was written before the 2007-8 financial crisis, but the inability of this standard model to deal with these events led to widespread criticism of the economics profession.

The whole point of developing DSGE-style models was to get away from arbitrary assumptions that had been common in Keynesian-style models, such as that consumers were constrained by their current income. So the question that comes to mind is: is it better to try to make DSGE models more realistic by adding some (arbitrary) financial constraints such as cash-in-advance or a liquidity shortage, as Chadha et al do? Or should we be building a new generation of models that have fragile financial structures at their core, and where crises or banks runs are one of the equilibria (as, for example, if Diamond and Dybvig (1983) could be embodied in a macro model)? Indeed, does it make sense to use a DSGE framework at all if agents are going to be arbitrarily constrained? I have no problem with the research agenda that builds models with firm micro foundations, but I feel that we have to be cautious about applying these models to solving the types of crisis that the model set-up essentially assumes away.

My second point on Chadha et al is that the simulations of the calibrated version of their model should come as no surprise. If liquidity constraints have been imposed so that consumption and investment spending are reduced in some way, then injecting liquidity in a QE-style operation will obviously boost spending, and thus activity. This does nothing to prove that QE works, or even how it works, but it does show how liquidity constraints affect the outcome in the model and what happens in the model when they are reversed. This may well give insights into some real-world mechanisms that might operate from time to time, but cannot confirm whether QE really did work this way, or worked at all.

Thirdly, the injection of liquidity into the banking system plays a key role in the Chadha et al model, and the liquidity injection works primarily through increases in bank lending. However, in the UK experience of QE this does not appear to be the main channel. As Chart 1 shows, bank loans to UK private non-financial companies (PNFCs) fell sharply in the quarters after March 2009 when QE was introduced, and bank lending to the corporate sector continued to fall throughout 2009, 2010 and 2011. The corporate sector did raise external finance but this was through securities issues. Chart 2 shows that this fall in bank loans applied to small and large firms alike even though SMEs are much less able to access external finance other than through the banking sector. Chart 3 shows that bank lending to the household sector was also static in the period after QE, and thus this does not look like a major channel of impact either.

It is worth bearing in mind at this point that if QE is to affect GDP it must lead to some boost in at least one of the categories of aggregate demand: consumption, investment, government spending or net exports. Charts 1 to 3 suggest that there was no boost to C or I coming via bank lending as a result of QE. G would not have been affected either. A decline in sterling may have helped to boost net exports. BUT the fall in sterling that certainly did follow the financial crisis started in 2007 and was over by early 2009. (This is shown in a chart offered by another presenter at the conference.) If anything, sterling strengthened somewhat after the introduction of QE in March 2009. This suggests that sterling weakness was not the result of QE, but may instead be associated with the massive disintermediation flows that hit the City of London from the summer of 2007 and peaked in late 2008.

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[2] Lucas, Robert E., Jr. Keynote Address to the 2003 HOPE Conference: My Keynesian Education, in *History of Political Economy* (2004) 36(4), pp. 12-24.

A further point worth noting is that while QE may not have increased bank lending, it may have worked by keeping it from falling even further. This is a possibility, and this clearly does apply to the effects of emergency intervention to save the banks in 2007 and 2008. However, by the end of 2008 the banking system had been stabilised and seemed in no further danger of collapse (at least in the United Kingdom and the United States). It is much less clear that the introduction of QE in March 2009 can be thought of as stopping bank lending from falling even further and faster than it would otherwise have done. Thus, I repeat my doubts that QE worked in the UK case by encouraging bank lending. While QE certainly did raise bank deposits and bank reserves relative to where they would otherwise have been, there is nothing that the banks could do collectively to reduce the level of their reserves: only actions from the Bank of England can do that. Indeed, there were widespread claims in the media that banks were continuing to contract their balance sheets and in the process tightening their loan criteria. In short, I am sceptical that QE (in the United Kingdom) worked via a stimulus to bank lending. There are, however, other channels through which it might work.

Joyce et al (2011) list five possible channels:

1. The policy signalling effect.
2. The portfolio balance effect.
3. The liquidity premium effect.
4. The confidence effect.
5. The bank lending effect.

The mechanism in Chadha et al seems closest to the fifth of these channels, the bank lending effect, though it may also have some elements of the third channel, the liquidity premium effect. Chart 4 shows a measure of the risk premium in the UK interbank market as indicated by the £ LIBOR-OIS spread. This was at its peak in late 2008 following the Lehman collapse. It could be, however, that QE played some role in the last leg of this spread's reduction, between March and September 2009, though it had no further effect after that. But as we have seen, this did very little to encourage banks to increase their lending (or narrow their own spreads), and thus could have had little effect on aggregate demand.

None of this is intended to suggest that QE had no effect at all. Chart 5 shows that there was a sharp pick-up in equity prices after March 2009, and this coincided with the introduction of QE in the United Kingdom and LSAPs in the United States. The likely channel here is the portfolio balance channel (channel 2 above). The way this is likely to work is that sellers of bonds receive an increase in their bank balance and they then decide to spend some of this on other assets such as equities and corporate bonds. Joyce et al report a 400bp fall in investment-grade corporate bond yields, a 2,000bp fall in junk bond yields and a 50 per cent rise in equity prices in the three months after QE started. Unfortunately, this cannot all be attributed to the UK QE operation, as the US introduced LSAPs at about the same time, and US equity prices moved in line with UK equity prices. However, it does seem plausible to conclude that QE did have some effect via the portfolio balance channel, and this might have been accompanied by a policy signalling effect and a confidence effect, though these are rather hard to disentangle.

So far, my comments have been responses to the stimulating paper by Chadha et al, but my remaining remarks will be more general thoughts on the conference theme.

The size of government debt

The dramatic build-up of public debt that followed the financial crisis (especially in Europe and the United States) has returned the size of sustainable public debts to the top of the political and economic agenda. In several countries, including the UK, a process of fiscal consolidation has been initiated in order to restore public debts to what are perceived to be manageable levels. The Eurozone has been gripped with a public debt crisis that has been rumbling on for over a year. This has led to the introduction of fiscal austerity measures in many countries, including Ireland, Greece, Italy, Spain and Portugal. So what level of debt is manageable? There is no simple answer to this question except that it depends.

It is worth bearing in mind that in virtually no country was the build-up of debt a deliberate plan ahead of the crisis. However, in all cases it was thought essential to avoid cutting public spending and raising taxes at exactly the moment when economies were at their most vulnerable. Indeed, tax smoothing is why periodic rises in public debt have been thought to be optimal.[3] No one would question the need for a build-up of public debt at time of war when the very survival of the state may be in doubt – so is a cataclysmic financial crisis that threatens the real economy via a failing banking system that much less serious a threat? Most governments took the view that they had to do whatever was necessary to halt the collapse and then work on repairing their own balance sheets slowly over time as the economy recovered.

The problem for some then turned out to be that bond markets came to doubt that the public debt trajectories were sustainable. As in the second generation of currency crisis models, debt crises can be generated by self-fulfilling expectations, rather than by the inevitability implied by key fundamentals.

Somewhat arbitrary ratios of debt to GDP are often quoted as being "sustainable". The 1997-2010 UK Labour Government had a target public debt level of 40 per cent of GDP (on average over the cycle), while the EU Maastricht Treaty specified a maximum of 60 per cent (even though this level was consistently exceeded by some EU member countries). Reinhart and Rogoff (2009) provide evidence for the view that debt levels start to get problematic once they exceed 100 per cent of GDP, viz:

"[E]merging market countries with overall ratios of public debt to GNP above, say, 100 per cent run a significant risk of default" (page 22). But Japan currently has a debt ratio of around 200 per cent without any obvious financing issues, and the United States' debt ratio is around 100 per cent of GDP and heading upwards. The United Kingdom had a debt to GDP ratio around 250 per cent of GDP at the end of the Second World War but managed to work its way out of this situation without coming close to default. So clearly the tipping point is not any specific number, but depends on many other factors.

One of these factors is probably who holds the debt. Niall Ferguson (2008) neatly describes the origin of bond markets in the wars between the Italian city states of the Middle Ages. Armies were often manned by mercenaries, and they had to be paid. Taxes were unpopular and hard to collect, so the rulers issued bonds:

> *"The cost of incessant war had plunged Italy's city-states into crisis. Expenditures even in years of peace were running at double tax revenues. ......Florence was drowning in deficits. You can still see in the records of the Tuscan State Archives how the city's debt burden increased a hundred-fold from 50,000 florins at the beginning of the fourteenth century to 5 million by 1427. It was literally a mountain of debt---hence its name: the monte commune or communal debt mountain. The mountain was equivalent to more than half the Florentine economy's annual output. From whom could the Florentines possibly have borrowed such a huge sum? The answer is from themselves. Instead of paying a property tax, wealthier citizens were effectively obliged to lend money to their own city government.*

[3] Lucas and Stokey (1983) is the *opus classicus* on this theme.

> *"A crucial feature of the Florentine system was that such loans could be sold to other citizens if an investor needed ready money....even though the bonds were no more than a few lines in a leather bound ledger.......In effect, then, Florence turned its citizens into its biggest investors. By the early fourteenth century, two thirds of the households had contributed in this way to financing the public debt, though the bulk of the subscriptions were accounted for by a few thousand wealthy individuals"* (pages 70-72).

Similarly, the United Kingdom financed its Napoleonic and World Wars by bond sales to domestic residents.[4] In these circumstances many of the debt holders are subscribing out of a sense of patriotism and are typically holders for the long term. This clearly helps to make the debt sustainable, and at affordable interest rates. In some cases insurance has been provided by exchange controls, which prevent domestic residents from switching their savings into overseas assets, and other credit controls. Direct controls may be needed as a further weapon in the Eurozone debt crisis, as they could be preferable to defaults.[5]

High public debt has been reduced in the past (as a proportion of GDP) not by running budget surpluses but rather by a combination of inflation, real growth and artificially low interest rates (or cheap money policies). The latter have been aided by exchange controls and/or direct controls on credit flows. These are all achievable when the debt is domestically held and denominated in local currency.

Matters are much less straightforward when the debt is externally held and/or denominated in foreign currency, or indeed in the currency of a supranational monetary union, as in the Eurozone. Governments have ways of encouraging domestic banks and long-term savings institutions to hold their debt, but they have no such hold over foreigners. Foreign holders are much more likely to wish to move their funds elsewhere or demand a substantial risk premium. Foreign currency debt externally held is even more problematic, as it cannot be inflated away, and home currency depreciation simply raises the home currency value of the debt. This was an important factor in the Eurodollar debt crisis of the early 1980s, the Mexican debt crisis of 1995, the Asian crisis of 1998, the Argentine crisis of 2001-2, and the Icelandic crisis of 2008.[6]

All of this suggests that very careful attention needs to be paid to the size of external holdings of public debt, and not just to its total size. The evidence of Reinhart and Rogoff (op. cit.) supports this suggestion:

> *"Over half of the observations for countries with a sound credit history are at levels of external debt to GNP below 35 percent...By contrast, for those countries with a relatively tarnished credit history, levels of external debt to GNP above 40 percent are required to capture the majority of observations" (*page 25).

Further work may be required to determine if foreign currency debt makes a country even more vulnerable than external debt in domestic currency, but it would seem highly likely that it does. Even the United States might be much less sanguine about its external debts if it had to borrow in foreign currency, and Japan would be much more concerned about the size of its debt if it could not borrow at low interest rates in domestic currency from its own citizens. However, many smaller countries have no option but to borrow in foreign currency if they can

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[4] During the Second World War, the UK had bilateral loans from the US, but this was inter-governmental and not part of any international market issue.

[5] It is worth recalling that Malaysia successfully deployed capital controls in September 1998 in order to protect itself from contagion during the 1999 Asian crisis.

[6] In the cases of the Asian and Icelandic crises much of the external debt was private, but this did not make it less problematic.

borrow at all, and at rates determined in world markets (apart from any borrowing from supranational organisations, such as the IMF). Also worthy of further study is the impact of external private, as opposed to public, debt, and a part of this story must be the extent of currency mismatch which can transfer an exchange rate shock into a balance sheet shock.

I now return to the issue of the sustainability of sovereign debt. One aspect of this has not received the attention it deserves, but is rather left implicit in much of the discussion. This is the size of the debt service costs. Clearly, the real constraint on sovereign debt size is the cost of servicing the debt, as this either has to be paid out of tax revenues or leads to further accumulation of debt. Debt to GDP ratios can fall so long as nominal GDP grows at a rate higher than the interest rate on the debt, even if there is no attempt to pay down the debt by running budget surpluses.

Chart 6[7] shows the UK's public net debt, and the debt interest as a percentage of GDP from 1692 to 2011. There is clearly some correlation between these two series, but not a perfect one. Debt clearly rises at times of war, and debt service costs rise as a result. UK net debt and the debt service ratio both peaked at the time of the Napoleonic war with France. Debt also rose sharply during the First and Second World Wars, but the debt service ratio was much lower after the Second World War than the First, even though the size of the debt was much greater. This was achieved by the "cheap money" policy of the time, which was maintained in the early post-War period by a policy of rationing and direct controls behind a wall of foreign exchange controls. Private credit was subject to controls that ensured that the public sector was able to finance its own needs without forcing its interest costs unsustainably high. This policy was later criticised as having "crowded out" private investment, but at least it succeeded in avoiding a disrupting sovereign debt crisis such as many other countries have faced with much lower debt levels.

An interesting feature of the UK evidence is that the peak debt service ratio was around 10 per cent of GDP. This might be close to the limit of sustainability, though ratios below 5 per cent would seem to be the range to which they tend to return, and debt service ratios of about 2 to 3 per cent of GDP seem to be around the level where governments appear happy to let debt alone without seeking to cut it further.

Comparable data for the US debt level and debt service ratio are shown in Chart 7.[8] These data are from 1862, with projections added for the years from 2011 to 2016. Again the main surges in debt are associated with the Civil War, the First and Second World Wars, the New Deal of the 1930s and the recent financial crisis. However, the peak in debt-service ratio came in the 1980s with the combined effects of the Reagan deficits and the Volker tight money policies, which sharply raised borrowing costs at a time of growing (but not exceptional) debt. Even here the debt service ratio never much exceeded 3 per cent of GDP, and currently, while the debt to GDP ratio is expected to settle at a little above 100 per cent, the debt service to GDP ratio is not projected to reach 3 per cent by 2016. Clearly, this outcome is contingent on the United States Government's being able to continue to issue debt at interest rates in the 2 to 3 per cent range, but market conditions could change, as they did for countries like Greece and some others in the Eurozone.

I have already mentioned the self-fulfilling nature of some sovereign debt crises. However, it should be obvious that Greece would not have the problems it does if it could borrow on the same terms as Germany or the United States. Public debt at 150 per cent of GDP is clearly

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[7] The data source is: http://www.ukpublicspending.co.uk/index.php. Please note that the data from this source show an upward blip in debt service in 1715. This is plausible, as this was the year of the First Jacobite Rebellion; however, the data reported in Goodhart (1999) do not show a surge of the same magnitude, so this information needs to be used with due caution.

[8] The data source for this chart is: http://www.usgovernmentdebt.us/.

unsustainable if the interest rate on the debt is 20 per cent (as has been the yield on Greek bonds recently), because this would require a debt service ratio around 30 per cent of GDP, but at 3 per cent interest, the debt service ratio would be 4.5 per cent of GDP and would be manageable, at least for a while.

One of the puzzles in the Eurozone debt crisis is why the debt of all the member countries traded on virtually identical yields right up to late 2008. Chart 8 shows this, as well as how the divergence grew sharply once the markets formed a belief that some countries could default or even leave the Eurozone. It also becomes clear why some commentators have proposed a collectivisation of Eurozone debt in the form of Eurozone bonds which would be collectively guaranteed by the member states. With credible collective agreements this could lead to all member states being able to borrow on similar terms to Germany, as they could before the financial crisis. At such interest rates, the debt crisis would be transformed, in that it would buy time to get budgets back under control.

Debt composition

In 1998 the consensus was that debt composition was of minor importance and was of no real concern to the monetary authorities. Some may still hold that view, but they are presumably in the ranks of academia rather than in the corridors of power. For QE to have any effects it must be true that central bank liabilities are not perfect substitutes for central government liabilities, and for Operation Twist to have any effects it must also be true that short-term government debt is not a perfect substitute for long-term government debt. The jury is probably still out on what these effects are, but the policy makers must think that these shifts are stimulative of aggregate demand through some channel.

Since we are talking largely about net public debt, it may also be worth including public assets in this story, since direct capital formation may also be one of the tools at the disposal of policy makers (not the central bank but the fiscal authorities in this case). This presumably comes under the heading of “credit easing”, but it does suggest that debt composition may not be the only game in town if asset composition can also be used as an instrument. The direct transmission to aggregate demand can easily be seen here, so this type of policy may be more effective, even if it does not classify as monetary policy.

I want to make some other points in the time available.

It used to be the standard view in the United Kingdom that there was a difference between debt sales to banks and debt sales to the non-bank private sector. The logic of this was based on the “counterparts identity” which linked changes in the broad money supply to various sectoral deficits. Budget deficits financed by debt sales to banks were thought to increase the money stock and thus be more inflationary than deficits financed by debt sales to the non-bank public. This view led to some strange policies (especially in the days of monetary targeting) like “overfunding”, where more debt was sold than was strictly needed to finance the deficit, in order to compensate for debt sales to banks (see Chrystal (1999b)). This way of thinking about debt sales never seemed to catch on outside the United Kingdom (except in the extreme form of what happens when deficits are funded by debt sales to the central bank). Indeed, the evidence provided for the United States by Kuttner and Lown (1999) suggested that debt sales to banks actually reduced bank loans to the non-bank private sector and thus had a negative effect on private demand. The UK QE policy from March 2009 was not targeted on buying gilts from banks, as banks held very few to start with, but banks have subsequently built up their holdings in order to comply with regulatory liquidity requirements. Hence it seems safe to conclude that funding budget deficits by debt sales to banks should not be a special concern, though QE-type purchases of debt (of any kind) from banks may well contribute to some form of credit channel of monetary policy, as banks will then be likely to look to buy substitute assets – as, indeed, would any other financial institution (as discussed above).

A different literature sees the composition of debt as in part a commitment device to ensure that the fiscal authorities have incentives to maintain fiscal discipline. In this context it is clear that issuing index-linked debt gives the authorities an incentive to keep inflation under control. However, it also provides inflation insurance for long-term savings institutions such as pension funds whose future liabilities (at least for defined benefit plans) are linked to future money wage growth. In general, governments seem unwilling to issue a significant proportion of their debt in indexed form and this may be precisely because of worries that this would make it harder to inflate the debt away. But there is clearly a social benefit in having some inflation-linked debt in existence, as it provides one possible measure of a risk-free real interest rate, even if this is distorted by the thin market turnover in this type of debt.

Some of the debt literature also concludes that short-term debt is a better commitment device than long-term debt. This is presumably because the authorities have to worry about rollover risk. They have to stick to fiscal discipline as they know they will have to be returning to the market on a regular basis. However, from a debt manager's perspective it would seem preferable to issue more long-term debt, as this reduces worries about short-term adverse market movements. In general, though, debt managers will want to fund at minimum cost and the optimal policy will depend to some degree on the term structure of interest rates. The incentives for shorter-term funding will increase if the yield curve is steeply sloped. Balancing this, however, should be the efficiency benefits of having a deep and liquid market in government debts instruments at all maturities. The private sector prices off the gilt curve (or equivalent in each national market), and so it is important for financial market participants to have this benchmark.

Rather less obvious is why, for any given debt structure, it will have any measurable effect on aggregate demand if the central bank buys long debt and issues short debt instead. This could work through the channels listed above, but it is tempting to consolidate the balance sheets of the central bank and Treasury, and conclude that nothing much is changed by central bank "twist" operations, so effects will be minimal.

A final thought on debt composition is that there may be other goals that the authorities could achieve through innovative types of debt issuance. A longevity bond is one such that would offer a payout that varies with life expectancy. It is obvious why pension funds would want to buy such bonds. Government may also want to be buyers, as this enables them also to hedge against pension and social security risks. Life insurance companies would be the obvious issuers of such instruments. However, the only point to be made here is that there are many possible reasons for thinking about government (or central bank) sponsored debt issues as having a variety of purposes, and myriad possible structures (or linked derivatives).

Conflicting incentives

Finally it is worth raising some issues about potential conflicting incentives. These could be conflicts between the monetary policy and financial stability (or regulatory) functions of central banks, or conflicts between the interests of central banks and those of the fiscal authorities.

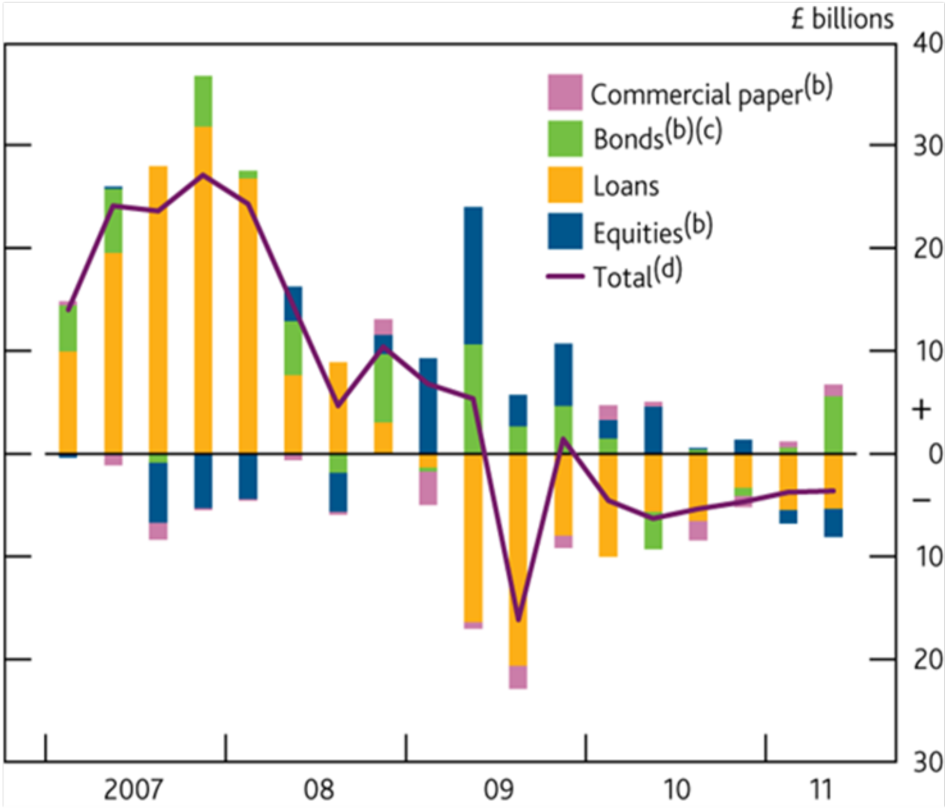
Monetary and fiscal authorities always say that they are working together, and central banks always say that there is no conflict between their monetary policy and financial stability roles. However, it is not hard to think of situations where conflicts of interest could arise. Fiscal authorities will generally want to keep their debt-service costs low, but monetary authorities may wish to see high interest rates in order to keep inflation under control. Tight monetary policy can also threaten financial stability, so different parts of the central bank may be pulling in different directions. Of course, all the authorities will have the same long-run interest, which is to achieve a steadily growing economy that is at potential, with low and stable inflation. However, their incentive mismatch may result from deviations from trend and may depend on the causes of those deviations. An example of this conflict arose in the United States in the late 1970s and early 1980s when Paul Volker's tight monetary policy led to very high interest rates and high funding costs for the US Treasury.

A contemporary difference could arise about the term structure of debt. Monetary authorities seem to want to shorten the duration of outstanding debt (at least that held outside the public sector). However, many fiscal authorities with big debts may be wise to fund at the long end of the yield curve if they can, as this will minimise rollover risk. Problems may also arise if the QE and twist episodes are being unwound at a time when the fiscal authorities still have to finance or refinance large debts. Central bank sales of debt could make it harder for the fiscal authorities to refinance cheaply when yields are on the rise.

Conclusion

Overall, the message is that the debt level and debt structure are now of great interest to monetary policy and fiscal policy makers alike. This makes monetary policy much harder to separate from fiscal policy, and the overlap is much greater now than it has been for several decades. These concerns seem likely to be with us for a long time, and certainly for at least the next decade. Much research work remains to be done to understand more fully how debt and monetary policy interact, but what is clear is that the dividing lines between monetary and fiscal policies are now much harder to draw than they seemed only five or so years ago.

Chart 1: PNFCs' net external finance raised[(a)]



(a) Includes sterling and foreign currency funds.

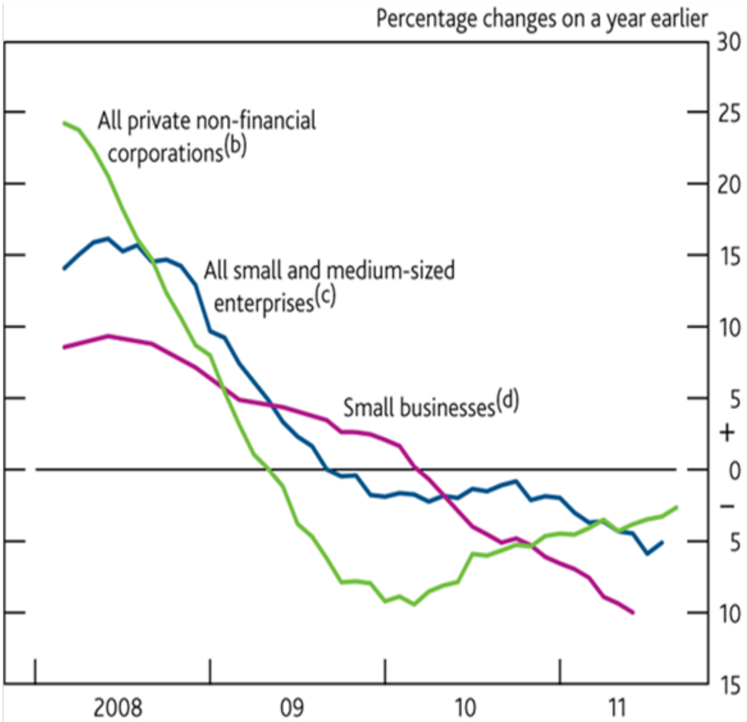
(b) Non-seasonally adjusted.

(c) Includes stand-alone and programme bonds.

(d) As component series are not all seasonally adjusted, the total may not equal the sum of its components.

Source: Bank of England, *Inflation Report*, August 2011.

Chart 2: Loans to UK businesses by size[a]



(a) Rate of growth in the stock of loans. Data are non-seasonally adjusted.

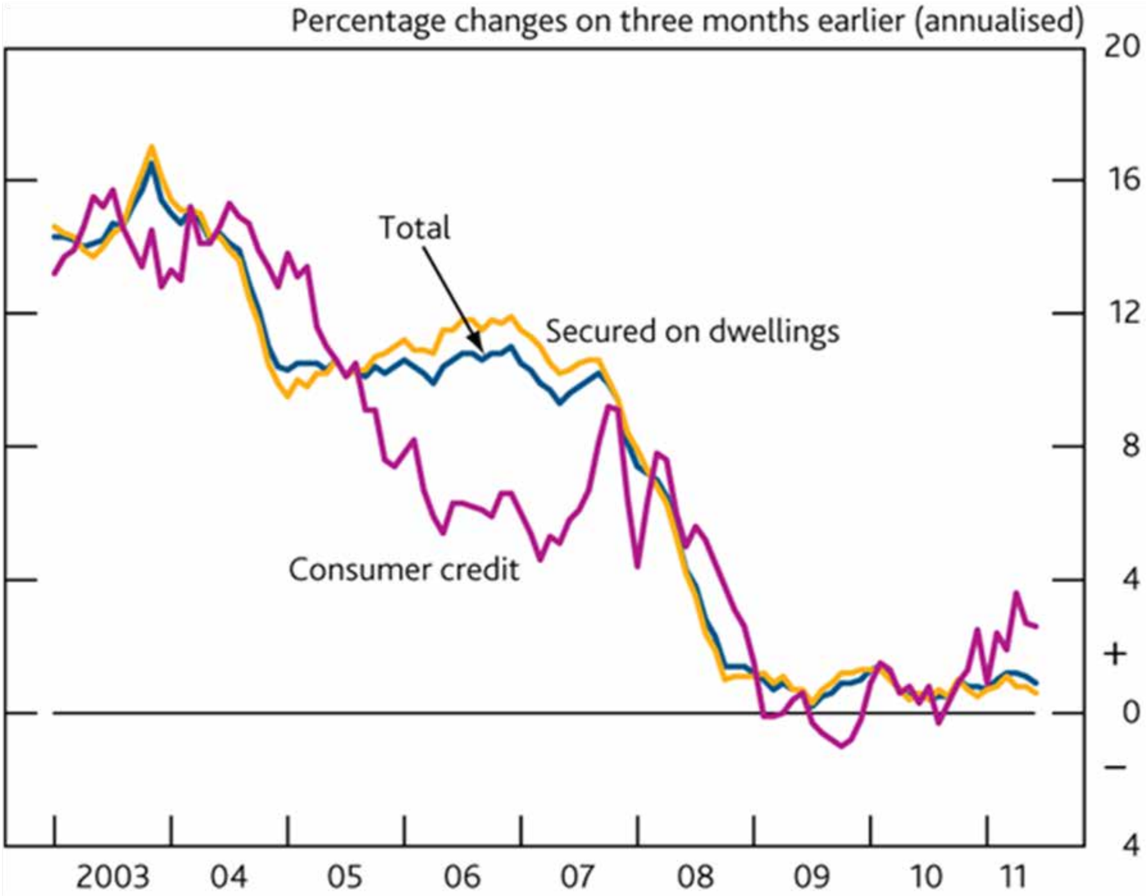
(b) Data cover both sterling and foreign currency loans. The latest observation is September 2011.

(c) BIS data and Bank calculations. Stock of sterling and foreign currency lending, expressed in sterling terms, by four UK lenders to enterprise with an annual bank account debit turnover of less than £25 million. The latest observation is August 2011.

(d) BBA data. Stock of sterling lending by seven UK lenders to commercial businesses with an annual bank account debit turnover of up to £1 million. Data are quarterly until September 2009 and monthly thereafter. The last observation is June 2011: www.bba.org.uk/statistics/article/small-business-support-december-2010/small-business/.

Source: Bank of England, *Inflation Report*, November 2011; British Banker's Association (BBA), Department for Business, Innovation and Skills (BIS) and Bank calculations.

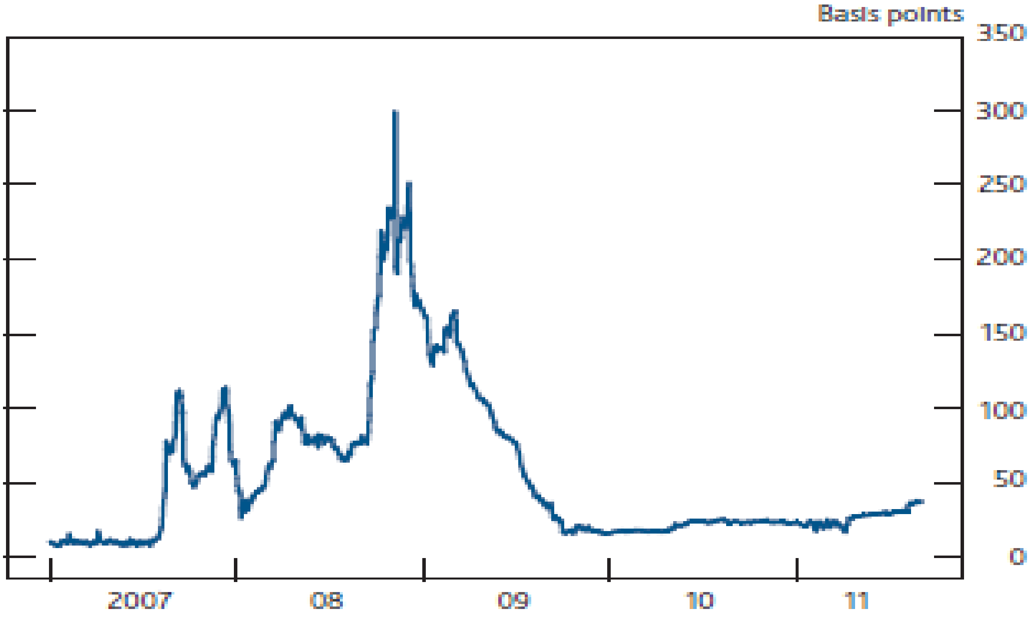
Chart 3: Loans to individuals



Source: Bank of England, *Inflation Report*, August 2011.

Chart 4

Sterling three-month Libor-OIS spreads



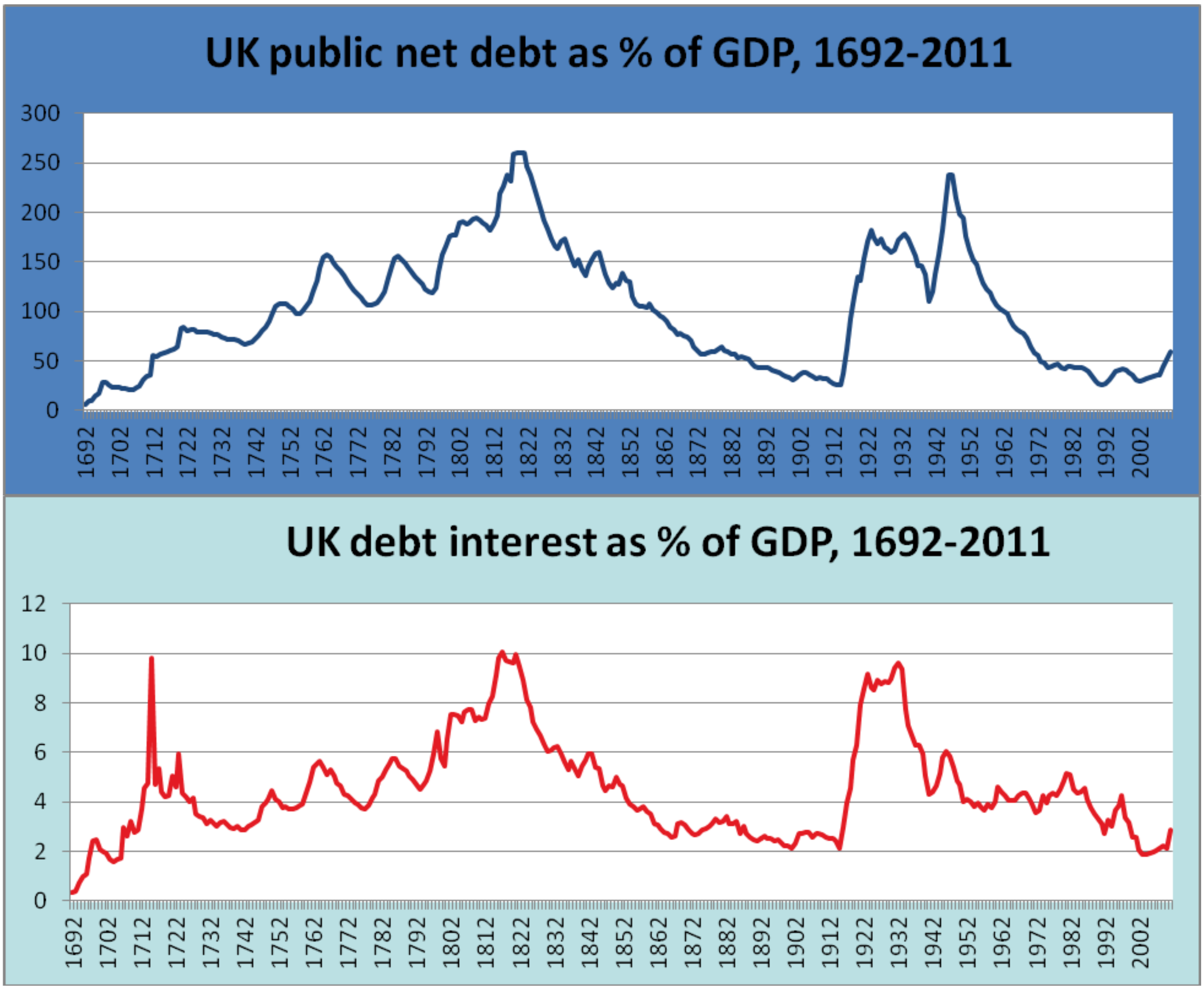
Sources: Bloomberg and Bank calculations; Joyce et al, 2011.

Chart 5: International equity prices[(a)]

(a) In local currency terms.

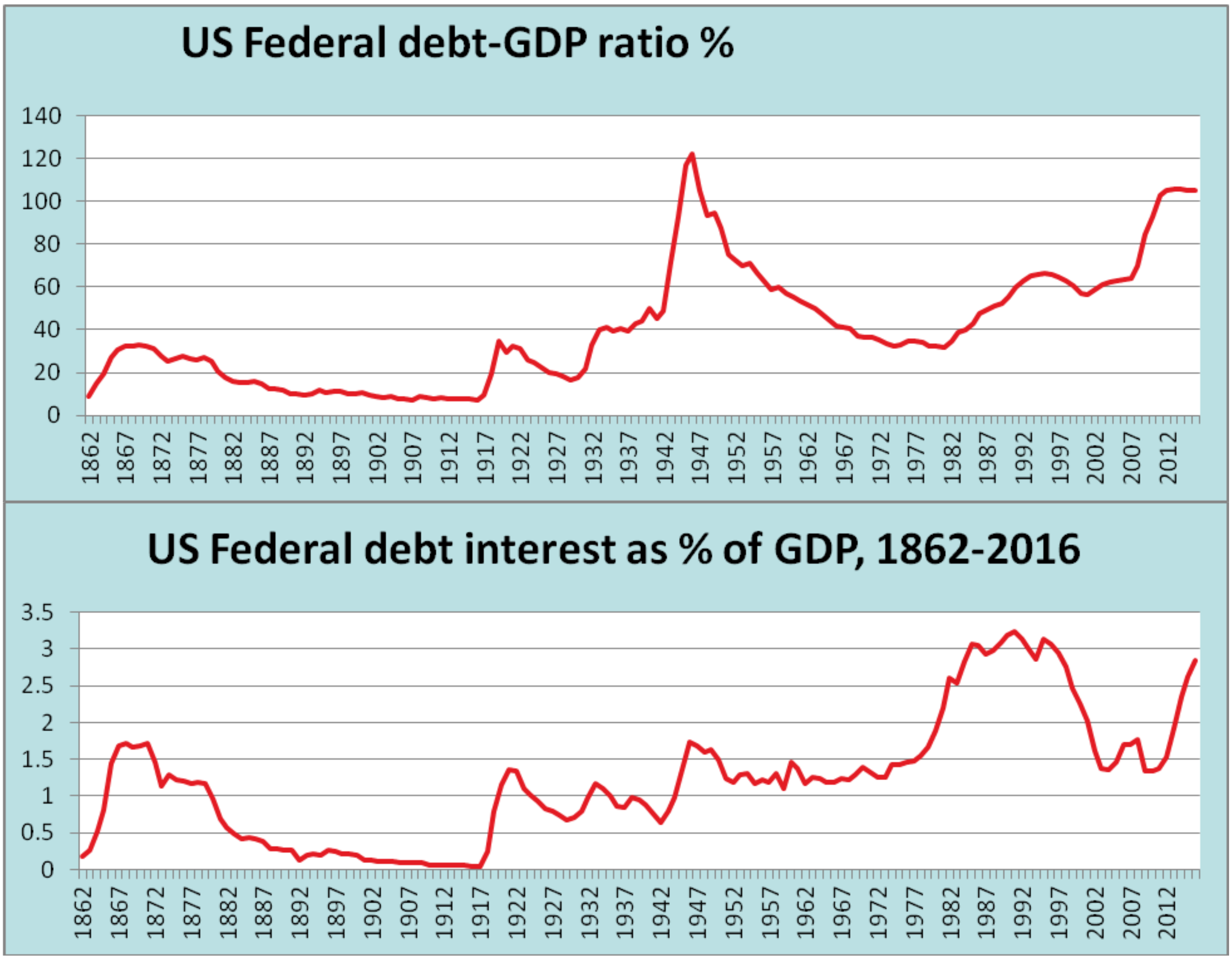
Sources: Bank of England, *Inflation Report*, November 2011; Thomson Reuters Datastream.

Chart 6



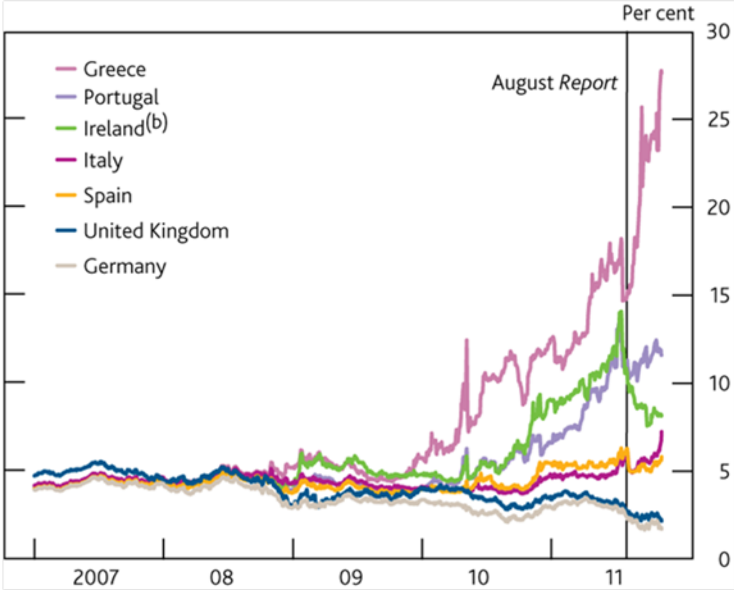
Source: http://www.ukpublicspending.co.uk/index.php

Chart 7



Source: http://www.usgovernmentdebt.us/

Chart 8: Selected European ten-year spot government bond yields[a]



(a) Yields to maturity on ten-year benchmark government bonds, unless otherwise stated.

(b) Yield to maturity on the nine-year benchmark government bond between 16 March and 25 October 2007, and from 12 October 2011 onwards.

Source: Bank of England, *Inflation Report*, November 2011; Bloomberg.

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Dealing with volatile capital flows in Korea

Myung Hun Kang[1]

Ladies and Gentlemen,

I am truly delighted to share Korea's experience in dealing with volatile capital flows. I would like to focus on three issues. My first theme is the patterns of capital flows during the Asian currency crisis, during the global financial crisis, and in recent months. The second theme is a description of some Korean policy measures in response to rapid increases in capital flows, and evaluations of them. In conclusion, I will discuss some future policy challenges.

First, then, let me describe capital flow patterns in Korea, and compare them with those of 10 other Asia and Pacific countries. I will then try to identify reasons why Korea experiences high volatility of capital flows.

Korea has seen steady growth in its volume of capital flows for many years, and this has increased further during times of crisis. The volume of capital flows during crises has risen remarkably, from about 12 billion dollars during the 3 months of the Asian currency crisis starting in November 1997 to about 48 billion dollars during the 4 months of the global financial crisis starting in September 2008. We have seen a net capital outflow of 10.8 billion dollars during the recent three months (Aug–Oct 2011), when global financial market instability re-erupted following the US credit rating downgrade and the euro-zone sovereign debt crisis emerged.

As to types of capital, flows were led by bank borrowings both around the time of the Asian currency crisis and at the time of the global financial crisis, but they have been driven by portfolio funds since 2009. At the end of 2010, portfolio investment represented 57.2% of total capital inflows, while bank borrowings and FDI represented 27.4% and 15.4% respectively. In line with the growing volume of capital flows, volatility has increased. The standard deviations of net capital inflows as a percentage of GDP rose sharply during the Asian currency crisis, the global financial crisis, and the recent European sovereign debt crisis. Since May 2010, portfolio fund flow volatility has also been gradually increasing.

When compared with 10 other Asia and Pacific countries (APCs), the volume of Korea's capital outflows as a percentage of GDP was not huge during the currency crisis. (The APCs are nine Asian countries – Korea, Hong Kong, Singapore, Indonesia, Malaysia, the Philippines, China, Thailand and Japan – and two Oceanian countries: Australia and New Zealand). Korea's capital outflow as a percentage of GDP ranks fourth among the 11 APCs, but the absolute volume of the outflow is in the midrange (Korea: –4.7%; average: –4.9%). The figures represent 1997–Q4 through 1998–Q3. However, the level was higher during the global financial crisis, ranking third among the APCs in 2008–Q4 (Korea: –6.2%; average: –2.1%).

As regards the recent European sovereign debt crisis, Korea has proven relatively sensitive to global shocks, ranking second among the APCs in terms of the volume of global equity fund outflows (–0.11% of GDP in 2010). The figures represent August 4 to October 12 of this year (2011).

As regards type of capital, the outflows from most APCs were driven by foreign borrowings immediately after the Asian currency crisis. After the global financial crisis, however, these

[1] MPC Member, Bank of Korea.

countries showed many different types of capital outflows. Four countries (Korea, Hong Kong, Malaysia and Thailand) experienced large outflows of foreign borrowings after the Lehman failure, while the capital outflows from six countries (Australia, Indonesia, Japan, New Zealand, the Philippines and Singapore) were driven by portfolio funds. Meanwhile, Korea saw the largest outflows of foreign borrowings, amounting to 35 billion dollars.

In terms of volatility, in comparison with the APCs overall, Korea experienced a relatively large increase in capital flow volatility during the global financial crisis. Korea's foreign trade dependence grew by 25.5 percentage points in the post-crisis period (2008–2010) – from a 62.6% pre-crisis level (2000–2007) to 88.1% – while its capital flow volatility rose 0.96% points, from 0.56% to 1.52%. Recently, volatility has remained high with the rise of volatility in global equity fund flows.

Let me talk about why Korea has high capital flow volatility. I think that there are three main reasons. The first is Korea's high degree of capital market openness. If a country has a high degree of capital market openness, it is easy for foreign investors to invest or withdraw capital. According to the Heritage Foundation, Korea's capital market openness increased remarkably (20 index points: from 50 in 1997 to 70 in 2010) after the Asian currency crisis, and ranks high among emerging market countries.

The second reason is Korea's favourable investment environment. The Korean capital market is relatively advanced among those of emerging market countries, and has ample liquidity. Therefore, easy and prompt withdrawal of funds invested in the Korean capital market is available upon any worsening of global financial market conditions. The volumes of its stock market and bond market ranked 11th and 10th respectively among 25 major countries as of 2009. Moreover, its stock market turnover ratio ranked second as of 2010, and the country ranks second on the Milken Institute's Capital Access Index.

The last reason is the sustained foreign currency liquidity risk in the banking sector. Korea maintains the status of a net external creditor from the perspective of the entire economy. However, there is a serious currency mismatch issue in the banking sector. The holders of the massive amounts of foreign currency assets and liabilities differ. Also, external assets of the banking sector are concentrated in the external liabilities of currency authorities. In comparison with the exposure of other emerging market countries, the external exposure of Korea's banking sector is very high.

Let's move now to the second theme. Drastic capital inflows have caused lots of risks in terms of the macroeconomy and financial stability. Countries experiencing capital inflows can implement macroeconomic policies to cope with these risks, and can adopt macroprudential policies and capital controls to tackle systemic risks. In this context, I will describe three policy measures by Korea in response to increases in capital flows, and evaluations of them. They are macroprudential policies, expansion of official foreign reserves, and reduction of exchange rate volatility.

The macroprudential measures are judged effective in reducing systemic risk by changing the composition of capital inflows such as inflows of highly volatile short-term capital. Based on experience in the global financial crisis, Korea has introduced new macroprudential measures to try to maintain its open capital market framework while at the same time reducing capital flow volatility.

First, to prevent an increase in short-term borrowing overseas resulting from excessive forward selling by shipbuilders and asset management companies (or forward buying by banks), Korea introduced ceilings on the FX derivatives positions of financial institutions in October 2010. Second, in January 2011, in order to ease excessive inflows of foreign bond investment funds, exemptions from tax withholding for foreigners investing in treasury bonds and MSBs were eliminated, and flexible tax rates were introduced. Finally, in August 2011, a macroprudential stability levy was adopted to curb excessive growth in financial institutions' borrowings overseas.

Generally speaking, the macroprudential measures in Korea are seen as having lengthened the maturity composition of capital inflows by cutting short-term borrowing by domestic branches of foreign banks, and by reducing foreigners' holdings of short-term bonds.

Due to the ceilings on FX derivatives positions, currency forward trades and short-term external debt have decreased greatly, especially where the domestic branches of foreign banks are concerned. Currency mismatches have also declined, since the funds to repay short-term external debt are raised mainly through the redemption at maturity (or sales) of domestic bonds.

As regards the revival of taxation on bond investment, this measure reduces foreigners' incentives to hold domestic bonds, and lengthens the terms of their investment by causing investment returns to fall and making investment procedures more complicated.

As far as the macroprudential stability levy is concerned, it is too early to accurately assess the policy's effects, since it was introduced not long ago. However, this measure is expected to reduce incentives for domestic branches of foreign banks to conduct arbitrage and cause a shift in debt term from short to long.

We can also use official foreign reserves. Most APCs have expanded their official foreign reserves to cope with growing capital inflows in the wake of the global financial crisis. Their central bank balance sheets have consequently expanded. For example, the total assets of APCs' central banks (excluding those of Australia and New Zealand) registered annual average growth of 5%–25% between 2009 and 2010, due mostly to increases in overseas assets.

Korea ranked fifth among the APCs in terms of the volume increase in its official foreign reserves, which expanded by 98.1 billion US dollars between end-March 2009 and end-June 2011. The expansion of official foreign reserves provides us some positive effects. After the global financial crisis, the importance of securing foreign currency liquidity in advance as a buffer for responding to crises is clear. Such action may have provided a backstop to mitigate the procyclicality of capital flows, and provided foreign currency liquidity during the financial crisis. The expansion of official foreign reserves may also have a positive influence on sovereign credit rating, since international credit rating agencies use the official foreign reserve level as an important yardstick when calculating a nation's credit rating. However, excessive expansion of a nation's official foreign reserves is accompanied by side effects such as increases in their holding costs and increased global imbalances.

Sterilized intervention has brought about imbalances in the central bank balance sheet, and a consequent exposure to risk from changes in interest rates and exchange rates. If domestic interest rates are higher than overseas rates, carrying costs are incurred by the official foreign reserves. As of end-2010, the carrying costs of the APCs are estimated to have stood at around 0.25–1.3% of GDP.

With the official foreign reserves of emerging countries increasing, global imbalances, which narrowed right after the global financial crisis, have been widening again since 2010.

Last but not least, it is important to reduce exchange rate volatility. The exchange rate volatility of most APCs rose during the global financial crisis. It then eased in 2010, but has recently expanded again with the increase in capital flow volatility due to the international financial market. A large increase in exchange rate volatility will negatively impact real economic activities such as exports and investment as a result of increased uncertainty.

A majority of APCs in principle leave it to the market to autonomously determine the exchange rate, and have conducted constraining smoothing operations when the exchange rate deviates from economic fundamentals and changes sharply in a short time. However, if capital flow volatility increases as a result of global financial market unrest, smoothing operations alone have limitations. This implies a need for complementary policy instruments to mitigate capital flow volatility, including macroprudential policies.

I would like to conclude my presentation by mentioning future policy challenges. Policy responses to capital flows should be multi-layered networks of facilities. They could have four layers: country-specific, bilateral, regional and global. At the individual country level, it is important to establish economic stability and engage in capacity building. Sound macroeconomic policies are the first line of defence in reducing economies' vulnerability to external shocks. Crisis-triggering events should also be eliminated in advance. We can use lots of macroprudential measures. However, we have to keep in mind that capital flow regulations need to be introduced cautiously. Properly designed and well implemented prudential regulations may play an effective role in alleviating capital flow problems.

At the bilateral level, we can consider bilateral swap lines. The network of bilateral swap lines was proven to be highly effective during the last financial crisis. In consideration of the heightened uncertainty of the global economy caused by the European sovereign debt crisis, BOK increased the size of its swap arrangements with BOJ and the People's Bank of China. In October 2011, Korea and Japan increased the maximum amount of their bilateral won-yen swap arrangement from 3 billion US dollars to 30 billion US dollars. Korea and China also increased the size of their bilateral swap arrangement, from 38 trillion to 64 trillion Korean won.

At the regional level, cooperation is very necessary to expand the scale of the existing regional financial safety nets. In this connection, we can think of lots of programmes, such as enhancing financial collaboration by expanding CMIM (Chiang Mai Initiative Multilateralisation), establishing an information exchange system to strengthen monitoring of capital flows, expanding multilateral liquidity arrangements, and promoting the development of regional financial markets.

Lastly, on the global level, the need for an international lender of last resort (ILLR) as a backstop for global financial stability has become apparent. The FRB took on the role of *de facto* ILLR during the last crisis. For example, in May 2010, the FRB reauthorized dollar liquidity swap lines with five foreign central banks in response to the re-emergence of strains caused by the European sovereign debt crisis. Recently (30 November 2011), BOC, BOE, BOJ, ECB, FRB and SNB announced coordinated actions to enhance their capacity to provide liquidity support to the global financial system.

Thank you so much for your attention.

Policy panel: Regional challenges ahead – dealing with capital flows, prolonged exchange rate intervention and their consequences in Asia and the Pacific

Prasarn Trairatvorakul

Capital flows are an old and recurrent problem exacerbated by the global crisis.

- Inflows posed challenges to Asia during the run-up to the 1997 Asian crisis. For much of the last decade, in the middle of the Great Moderation – or the Great Bubble, depending on your point of view – inflows were also strong. And after the global financial crisis, extraordinarily accommodative monetary policy in advanced economies and strong fundamentals in Asia set the stage for inflows to return in force.
- Why do inflows pose a problem for Thailand, and for many emerging market economies? The primary reason is that for small open economies with developing capital markets, ***large sustained capital inflows can significantly affect domestic monetary and financial conditions***. Most directly, capital inflows can have outsized effects on the ***exchange rate***. Rapid currency appreciation threatens export competitiveness and overall growth. To the extent that capital inflows fuel a rise in asset prices and lower long-term interest rates, they can also exacerbate ***financial imbalances***. Large inflows also increase the ***risk of abrupt reversal*** and associated economic disruptions.
- Adjusting monetary policy in response to the impact of capital inflows is challenging. For example, ***reducing policy rates to offset rapid exchange rate appreciation could lead to higher domestic inflation, and may worsen growing financial imbalances***. On the other hand, raising interest rates to stem the impact of capital inflows on asset prices and domestic credit conditions ***may invite more inflows***. And a ***policy of benign neglect*** is unlikely to be practical, because exchange rate appreciation ***may reinforce market expectations of further appreciations, and attract more inflows***. An appreciation large enough to mitigate such dynamics could be too much for the private sector to bear in the short term.
- Indeed, it is worth noting that there are perceptions ***even in advanced economies*** with large capital markets that ***capital flows can compromise domestic monetary conditions***. A prime example of this is debates in the US about the 'yield conundrum' and 'global savings glut'.

Thailand's strategy for dealing with capital inflows

- Before I turn to the use of ***exchange rate intervention***, which is the focus of this session, I would like to stress that this ***is only one element of our overall approach to dealing with capital inflows***. Our integrated policy responses can be described as a combination of the following: (i) exchange rate adjustment as a first buffer; (ii) exchange rate intervention to deal with excessive movements; (iii) liberalisation of outward investments by residents to help balance out the inflows; (iv) the use of macroprudential tools to mitigate financial stability concerns; and (v) development of deeper capital markets to enhance absorptive capacity.

- Against this backdrop, let me turn to the issue of exchange rate intervention.
- ***In Thailand, our managed float system is based primarily on curbing undue volatility in the short run.*** Volatility management is designed to help cushion the private sector in the short run from potential under-/overshooting of the exchange rate in the context of incomplete hedging instruments. We do not have level targets and are fully committed to allowing the exchange rate to reflect economic fundamentals in the long run.
- Clearly, then, we do not aim to limit volatility over the long term. At the same time, very high frequency fluctuations in the exchange rate, daily or weekly, typically reflect a high degree of noise that is unlikely to materially hamper economic activity. ***We are more concerned about unwarranted volatility that may cause distortions to economic activity and/or about overly sensitive inflation developments.*** While it is clearly difficult to pin down exactly the frequency over which such risks are greatest, movements over months and quarters serve as a good starting point for making such assessments.

Intervention is a second-best solution in a second-best world, and is not without costs.

- The accumulation of reserves that results from intervention exposes central banks to the ***risk of significant losses***. Foreign reserves typically constitute by far the riskiest asset on central banks' books, given that the exchange rate risk cannot be hedged without undermining the original purpose of the intervention. If losses do occur, they can hurt the credibility of the central bank and expose it to considerable political pressure.
- A large war chest of reserves may ultimately backfire. Large reserves may constitute a temptation for ***government appropriation of reserves*** to set up a sovereign wealth fund or to fund other initiatives. The temptation is especially acute if fiscal room is dwindling. This is a real issue for emerging markets, as demonstrated by the recent experience in Argentina, and it is also a challenge that the Bank of Thailand is grappling with today. Our experience has been that ***it's exceeding difficult to counter popular belief that foreign reserves constitute unencumbered national wealth as opposed to what they really are – borrowed funds***.
- ***Sustained reserve accumulation and sterilisation can also become operationally complex*** as the amount of central bank debt rollover becomes large, potentially creating a 'gorilla' in the markets that may create distortions. For example, outstanding Bank of Thailand bonds issued to sterilise foreign currency purchases accounted for over a third of total outstanding bonds in Thailand at the end of 2010. To be frank***, we do not fully comprehend the impact of such an abnormally large central bank balance sheet – particularly on the liability side – on market function and the banking sector***. This is an issue that our colleagues in the US, Japan, and UK are currently grappling with as well.

The problem of capital inflows is not new. In the aftermath of the global crisis, now is the time to rethink and to propose bold solutions to old problems.

- The rise of global banking has arguably reinforced the transmission of global liquidity conditions across borders, thus intensifying the trade-offs facing monetary policy from global liquidity.
- We have reached an undesirable equilibrium. The maintenance of ultra-loose monetary policy in advanced economies, combined with sustained intervention by emerging economies, is a bad equilibrium. Strong sustained inflows and a desire to avoid being ahead of the pack in terms of currency appreciation compel emerging markets to intervene. These interventions collectively reduce the effectiveness of the exchange rate channel in helping advanced economies to rebound, reinforcing the need for monetary authorities there to supplement exceptionally low interest rates with extensive quantitative easing.
- There are two ways to break the bad equilibrium
  - First, unilaterally. For example, emerging economies can cease intervention. Of course, this route would be more effective if large economies were to take action first. First movers would bear the cost of adjustment disproportionately, but in the long run all would gain if subsequent regional appreciation lessened the need for large-scale intervention, and allowed for a lower degree of monetary accommodation in advanced economies.
  - Second, multilaterally. The major economic blocs of the world, advanced and emerging, could form an international forum which would serve as a platform to internalise the externalities associated with monetary policy spillovers across currency areas. The G-20 Mutual Assessment Process (MAP) offers a good starting point, as it provides a representative forum designed precisely to improve the mutual compatibility of national policies, and could be further institutionalised. Likewise, the initiation of the IMF's reports on outward spillovers is a step in the right direction.
- To really make headway on the multilateral front, though, we need to revisit the conceptual underpinnings of how policy is conducted in the context of a highly interconnected global financial system. In such a world, purely country-centric approaches to understanding the workings of the economy and formulating policies are bound to be inadequate. A more globe-centric approach is called for. A more top-down approach in which the role of common factors and inter-linkages are emphasized will minimise the risk of actions that may appear reasonable from an individual country's perspective but result in undesirable outcomes (eg a fallacy of composition). This applies especially to considerations regarding cross-border financial flows, exchange rate policies, and financial stability.
- These issues have become more pressing in the current global context. A fundamental side-product of rapidly worsening fiscal problems in the advanced economies is that the universe of safe assets has shrunk significantly. As doubts emerge over previously perceived safe sovereign debt, investors have become more fickle in their portfolio allocations. The end result is more capital-flow volatility and more intense appreciation pressure on currencies that are still perceived as safe, notably the Japanese yen and Swiss franc. The fact that both countries have been pushed to intervene despite long-standing traditions of abstaining from such actions is a testament to the economic and political pressure that safe-haven flows can generate. Emerging markets as an asset class, while largely being innocent bystanders, have nonetheless felt the full force of these intense swings in global asset allocations. This constitutes additional examples of unsustainable forces at play in the global monetary system that need to be tackled at the global level.

Notes for wrap-up panel discussion

Andrew Sheng[1]

I would like to thank Governor Prasarn and Jaime Caruana for hosting this wonderful conference in this beautiful setting. I thought I was coming here for a holiday. I think we have worked reasonably hard in the last two days on this complex topic despite the festive environment. I think Jaime said it right. Central bank balance sheets have been expanding, and are even larger in Asia than in advanced markets. They are crucial tools, and we really need to think about exit strategies.

Basically, I am going to be very blunt, because I want to make you think about the issues from a wider perspective. First of all, central bank balance sheets must be seen in the context of national balance sheets. If you don't think like that, you are not dealing with the problem. Secondly, you need to think of the context and the dynamic interaction between the central bank balance sheet and the rest of the economy. As you know, when you adjust the portfolio of the central bank, there are at least four accounting entries (debit and credit) in the rest of the market, with the interaction with the commercial banks and the interaction with the real economy. Thirdly, for international currencies, there are second-order impacts on the foreign exchange market and other economies, since foreigners now own a significant proportion of national debt, especially in the advanced countries.

In short, this is a systemic problem where central banks attempt to change market behaviour through adjustments in their own balance sheets.

Now, the fundamental problem is that we are dealing with an over-leveraged system, where the corporate sector appear to be reasonably stable, but in some economies the household, public sector and financial sector are clearly over-leveraged. Furthermore, the financial sector is serving its own interests very well, but not necessarily serving the real sector very well. So are we bailing out the financial sector, or are we going to bail them in so that they actually get back to helping the real sector?

We have very, very important lessons, both at the micro level and the macro level, that we need to think through. The point I really want to make is this: central bank balance sheet adjustments are only providing liquidity to an economy that is basically suffering from overconsumption through over-leveraging of finance. This is like giving liquidity to an athlete who appears to be suffering from dehydration – you rehydrate him but you haven't dealt with the fundamental problem which could be due to exhaustion or a weak heart.

So don't make the mistake of thinking that juggling the central bank balance sheet will solve the problem in the real economy.

The second real issue is that we are dealing with loss allocation. We are already in this mess – so who pays? Central bank adjustment of the balance sheet affects the real economy through three channels – through inflation, real sector deflation, or postponement of the problems. The burden-sharing is by whoever holds the domestic debt and will be hurt by inflation, and by foreigners who may lose through devaluation, or else the losses are postponed to the future by increasing debt. So the issue is: are we dealing with the structural problems in the real economy or simply buying time so that the politicians will gather the will to deal with the painful adjustments?

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[1] President, Fung Global Institute.

As you know, the Ingves Report on Central Bank Governance is very helpful to our debate. The recommendations are very clear on undertaking unconventional central bank balance sheet expansions – you need to be transparent to the market and you need to understand what you are trying to achieve. Alec Chrystal makes the point very well that I want to stress: If your national balance sheet is problematic and if the real interest rate rises to a certain level, the national balance sheet is insolvent. The additional liquidity provided only helps you to reduce that interest rate, provided there is no capital flight or restrictions on credit.

The Asian financial crisis experience was that if the net foreign liability to GDP ratio (of the crisis economies) was greater than 50% and the debt servicing ratio was above 10%, they're bust. The crisis economies could not deal with the capital flight because they could not print foreign exchange. But G4, the four reserve currency countries (US, Eurozone, UK and Japan), have one special advantage. They can print their money to get out of this. Emerging economies cannot print their own money to service their foreign debt, because foreigners will not accept them as stores of value.

I think Alec Chrystal's point is very relevant. Furthermore, Deputy Governor Herrera makes the point that central bank action is no substitute for sound macroeconomic policy. Are central bank actions essentially a pain killer or addressing the structural problems of a huge fiscal debt overhang, a net foreign debt overhang, and additionally the shadow banking/traditional banking nexus problem[2]? If we entrench the moral hazard in continually bailing out the shadow banking system, we're going to be in deep trouble. I think the Japanese experience is very relevant, but I don't have the time to go deeper into this issue here. In Table 1, I split the world into balance sheets from the G4 countries, the reserve currencies, and the rest of the world. The G4 countries account for 55% of the World's GDP and comprise 11-12% of the world's population, and owe the rest of the world ex-Japan 6.4 trillion dollars, or 20% of GDP. So far, because they're reserve currencies, there's no way the emerging markets can pull the plug. So it really is up to the G4 countries to make the adjustment to achieve external balance.

But if you really look at the total financial assets divided by GDP, which is effectively total liabilities divided by GDP, there is no question about the over-leverage problem in the G4 countries. The fundamental issue is that, looking at the near future, emerging markets are growing at 4-6% per annum while the G4 are growing at near zero rates of growth. Consequently, the capital flows are flowing from the G4 to the emerging markets in search of growth and profit opportunities.

If we believe in the Law of One Price and a frictionless global economy, then there will be so much capital flowing into emerging markets that they would have a massive revaluation, an asset bubble followed by massive crash, so that we would have balanced recession globally. The emerging markets are, of course, resisting this – through capital controls and other measures – so hopefully the emerging markets will grow while the G4 countries sort out their structural issues and you have an imbalance in growth leading out of that situation. In other words, the trade-off is between unbalanced growth and balanced recession.

So the bottom line is that central bank balance sheet adjustment is really about trying to rebalance at the national and global level. But the collateral damage is that the capital flows will continue to add volatility, and probably make macroeconomic management much more difficult. Let's not make a mistake about that. The bulk of financial capital flows are highly leveraged. According to recent McKinsey studies, 15% of the banks' profits are made from foreign exchange derivative products and proprietary trading of volatility in foreign exchange. This incentive created what the Zoltan/Singh IMF working paper calls the non-bank/bank

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[2] Zoltan Pozsar and Manmohan Singh, *The Non-Bank-Bank Nexus and the Shadow Banking System*, IMF Working Paper WP11/289, December 2011.

nexus: the way primary brokers finance the asset managers, creating liquidity (and leverage) in the system that we have not measured in the past.

The best way to think about this is to understand that the traditional financial intermediation framework has now changed. This is because the asset managers are now the most important players in the wholesale banking game. What has happened is that the prime brokers take their assets and use them as collateral to repo with the asset managers in order to obtain funding that they can use to buy further assets as collateral for further credit. Thus, in using different types of collateral (including asset-backed securities) or borrowing them from the market to lend out, the prime brokers are creating dynamic credit that is not measured anywhere. If Goldman Sachs lends somebody money to do a dollar-yen foreign exchange trade, is this measured in the US monetary survey or the yen monetary survey or what? This isn't clear.

Furthermore, when there was a flight to quality from poor weak collateral like subprime derivatives to high-quality government paper, it was the central banks that began to replace the prime brokers in providing liquidity to the market.

However, since the same collateral, because it is all book entry transactions, can go from the hedge fund to broker dealer to broker dealer, with margin settlements, trade settlements and margin settlements taking place rapidly, including offshore, there is lack of transparency on where the risks are. That is what happened to MF Global. Where did all their purported collateral disappear to? Well, they took money from their clients, but when the music stops you suddenly find that the money has disappeared. The collateral is just not there.

So we now have a very complex shadow banking system right in between the traditional banks and the asset managers, and that leverage is something that we are not measuring very well.

What does it mean? It means that excess consumption is ultimately financed through complex leverage that we are not measuring and monitoring very well. At the structural level, in the international monetary system, we have a situation whereby, because of the Triffin dilemma, the reserve currency countries are continuing to run current account deficits and debt levels that cannot be sustained. If we don’t change this fundamental structure, the imbalance is embedded in the structural system.

We can temporarily replace the lost liquidity in the wholesale market through central bank intervention, but the central bank cannot replace the bank intermediation function forever.

The problem is, if the reserve currency countries don’t sort out their long-term over-consumption and over-leverage problem, emerging markets cannot deal with this on their own. That is my bottom line. If the emerging markets cannot deal with these leveraged capital flows – this bank/shadow bank nexus – then we have serious problems on our hands, because we are not looking at this (or measuring the risks) properly.

So what does all this tell us? You really need a systemic framework to think with on this. We have always looked at global problems using a national framework. But the global money supply is not a simple adding-up of national money supply, because there is global offshore banking credit and off balance sheet credit that nobody measures at the moment. I think this is an area that demands a lot more work. We really need to think about the global credit glut that has been the major driver that has financed global liquidity, and why we now have a situation of simultaneous excess global liquidity and yet periodic system illiquidity.

The system illiquidity comes from the dynamic adjustment at the bank/shadow bank nexus. When I am afraid that MF Global will fail, I cut all credit lines, I seize my collateral where I can, and the whole system seizes up with real interest rates rising, which drives the self-fulfilling bankruptcy of major (over-leveraged) players. This is the crowded exit problem that we have now recognized. When you extend that analysis to the sovereign debt level, you find that the whole bank/shadow bank nexus, including the asset managers, through leverage, have enough firepower to destabilize whole national economies.

Consequently, we really need to look at the central bank balance sheet adjustments in the context of international financial system and monetary system reform. If, for example, one of four major reserve currencies undergoes major depreciation, what are the impacts and pressures on the other players and financial institutions? There is a risk that if we don't have a way to monitor the systemic risks in the international monetary system using perhaps global monetary data, we are exposing ourselves to systemic failures that we do not fully understand.

I think this conference has brought in many good ideas for us to do further research. We do need to look at global money now. We have moved beyond national balance sheets. We now need to look at the global balance sheet, the liquidity, and also how the financial sector must serve the real sector. In this area, the work of Professor Richard Werner is very useful. He says that credit is divided into two parts, the credit that is good for the economy, like good cholesterol, and the credit that is speculative, which is bad cholesterol. Using this analogy, there is a risk that central bank provision of liquidity has only bailed out bad cholesterol. If you look at what all the recent data have been showing, the credit to the real economy is still declining. So the equity, debt and derivative markets are still bubbly, and we have not dealt with the major problem. In one nutshell, central bank balance sheet is only part of the whole global balance sheet system, where there are still major vulnerabilities. Until we solve our understanding of the structural issues, we haven't solved any problems. I hope I've at least provoked your thinking in this area. Thank you very much.

Table 1

Reserve Country Positions vs. Rest of the World

% of Global total (2010)	G4 – USA, Eurozone, Japan, UK	Rest of the World
Global GDP	54.6%	45.4%
Global Population	11.7%	88.3%
Current Acct deficit (2008)	2.2%	
Ex-Japan	3.1%	
Net Foreign Liability	$3.9 trn. (11% of GDP)	
NFA (ex-Japan)	$6.4 trn. (20.8% of GDP)	
Total Reserves Minus Gold	16.1%	83.9%
Stock Market Capitalisation	56.7%	43.3%
Public Debt Securities	79.6%	20.4%
Private Debt Securities	81.1%	18.9%
Total Debt Securities	80.4%	19.6%
Bank Assets	65.4%	34.6%
Total Financial Assets (TFA)	69.2 %	30.8%
TFA/GDP (%)	503.2	270.1

Source: IMF Global Financial Stability Report, Statistical Appendix: Table 1 – Author Calculations

Wrap-up panel discussion

Athanasios Orphanides[1]

When I arrived in this beautiful setting, for which I want to thank the organizers, some people suggested that this must be a respite from thinking about the euro area. There was a point to that, perhaps. But it was then suggested to me that maybe we should talk a little more about the present difficulties in the euro area at this conference, so why don't I focus my comments on that.

With respect to the broader topic of the conference, it should be noted that in the euro area we have been pursuing balance sheet policies at the ECB which are not qualitatively different from those pursued by the Federal Reserve and the Bank of England. As elsewhere, these policies have succeeded in significantly lowering interest rates, as reflected, for instance, in government yields perceived to be nearly risk free.

But that is not the issue. The issue is that the major problem we are facing right now, and that is having an impact on the rest of the world, is that the euro area is not a single country and the government debt of a number of member states is no longer perceived to be nearly risk free. Following the creation of the ECB and the single monetary policy in 1999, the euro area did indeed behave as a common currency area where the single monetary policy was transmitted in pretty much the same way in all member states. As of 2009, however, this increasingly no longer works. This can be easily seen by plotting the two-year government yields for different countries in the euro area. By plotting the two-year yield, we can focus on a rate that is closely associated with the transmission of monetary policy in macro models.

The chart plots the yields of the six largest member states of the euro area, which make up almost 90% of the economy. What can be observed in the last couple of years is a divergence in yields suggesting increasing problems with the ability of the single monetary policy to function properly. Note that Greece, Portugal and Ireland are not included in this chart. That is, the chart does not include the countries that have experienced such severe difficulties that they have had to ask for assistance from the IMF and their European Union partners.

Let me briefly provide you with my take on the problem and the steps towards a solution. Let's start with some fundamentals. For a currency union to function properly, some minimal fiscal policy coordination is necessary. This can occur with a fiscal union, which in the European Union, we decided not to have. The European Union treaty prohibits member states from assuming the debts of other member states, and prohibits monetary financing by central banks in all member states.

The alternative approach that was adopted is to try to have strict limits on debts and deficits. This was the idea behind the Stability and Growth Pact. The idea was to have such a tight control of fiscal policy in each individual member state that no member state would run into trouble. Indeed, in order to avoid any moral hazard issues, no crisis management mechanism was set up at the beginning. It was assumed that the strict fiscal rules and the absence of any crisis management mechanism would be sufficient to prevent any country from getting into trouble.

[1] Governor, Central Bank of Cyprus.

Unfortunately, the fiscal framework was not properly enforced. In addition, the market discipline that might have worked to help limit large deficits in countries with a large debt did not work, because prior to the crisis every member state was able to finance its deficit at virtually the same rate—there was no differentiation. During the crisis in 2009, it became clear that some member states—Greece is the most important example—had been running deficits that were too large, and were not limiting the size of their debt. So the question was: once this was observed in 2009, how could the problem be solved?

It was no longer feasible to say we could not have a crisis mechanism in place—one now had to be created in a hurry. Then two things happened in the spring of 2010. First, a makeshift mechanism to help Greece by providing it with loans was set up. The second was to create the EFSF as the temporary crisis management mechanism. But the problem was how to provide help in a way that would avoid moral hazard in the future.

Here I want to focus on two options. The first option would have been to focus on strengthening prevention and credible enforcement—specifically, by introducing even stricter fiscal rules or constitutional amendments for balanced budgets, and to consider limiting the sovereignty of member states that misbehave, to ensure compliance. The second option would have been to raise the cost a country would face during a crisis. The first approach was not chosen in 2010 because some of the decision-making countries did not want to tighten the rules and did not want to limit their own sovereignty. So the second approach was chosen—to significantly raise the costs of handling a crisis, including the present one.

This was a very critical decision. Throughout 2010, and since then, there have been discussions about whether one way to enforce better discipline would be to introduce the concept of private sector involvement (PSI) in euro area debt. The concept was that an investor buying euro area sovereign debt would have to worry that if the country misbehaved, a haircut on the debt would be implied, even if there was no issue regarding the sustainability of the debt. Following its adoption in October 2010, this approach proved quite effective in raising the cost of financing of any country that was perceived as facing a potential difficulty. Unfortunately, it was quite damaging and was probably a key factor behind the difficulties faced by Ireland and Portugal in the few months after its introduction.

Surely, the idea of introducing PSI in euro area sovereign debt markets was meant to raise the cost of a crisis for the country involved and serve as a deterrent, helping countries avoid getting into trouble. However, it wasn't such a good idea to introduce PSI during the current crisis. Even worse were two decisions taken this year, the first on 21 July and the second on 26 October, to impose haircuts on Greek debt. I will not dwell on whether Greek debt was sustainable or not. As discussed in an earlier presentation, this assessment is sensitive to underlying assumptions and is subject to great uncertainty. What is certain is that creating the precedent that a member of the euro area would be forced to impose a haircut on the holders of its debt reinforced to investors how the PSI concept would be applied in the euro area. This is very costly. As can be seen in the chart, the spreads of Spain and Italy rose following the first decision on 21 July. Following the second decision on 26 October, which increased the size of the Greek haircut, the spreads of Belgium and France rose.

The chart shows clearly the resulting problem. Once the political decision was taken to impose haircuts on one country, international investors had to allow for the possibility that sometime in the future haircuts would be imposed on other countries. As a result, a large number of the euro area member states are now considered much less trustworthy than before the PSI decisions and face higher financing costs.

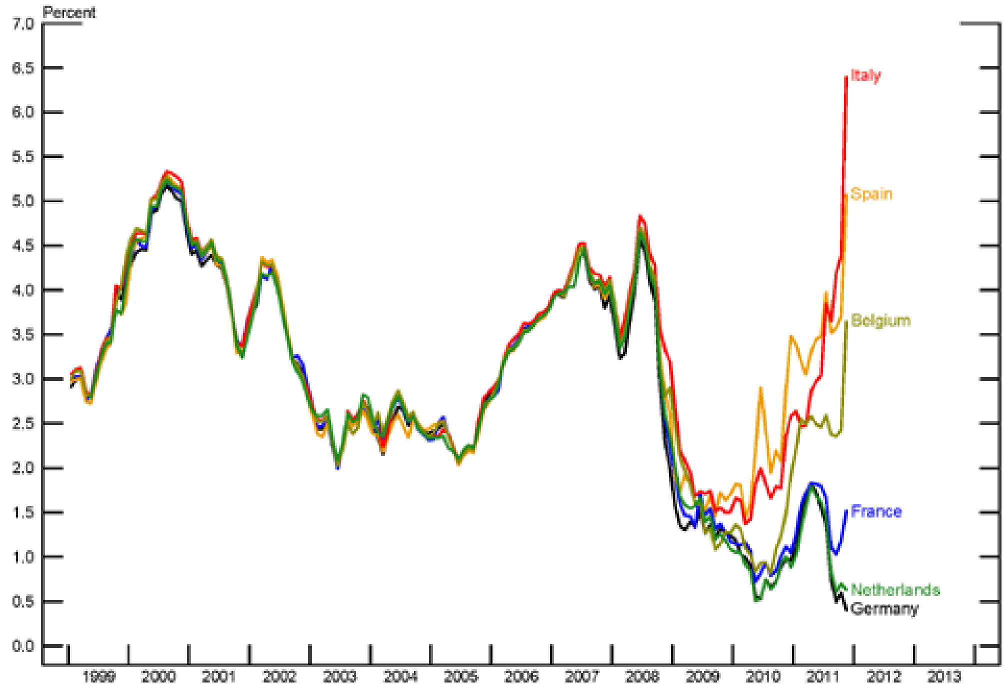
So where do we go from here? First, a positive note. The damage created by the PSI decisions seems to have been understood. A major U-turn was observed in last week's meeting of the European heads of state. The notion that private sector involvement should be expected with higher frequency for those who purchased euro area debt is now recognized as damaging, and there is an effort to remove it from the framework that is being built for the future. There is essentially an effort to go back to the alternative choice I mentioned earlier, which was not made in 2010.

Instead of raising the costs of solving a liquidity crisis when that occurs, this backpedaling is taking us to the other alternative, that of prevention and credible enforcement. A very important step that was agreed last week is the agreement that, going forward, all euro area governments will impose stricter rules on themselves by adopting balanced budget amendments in their constitutions. And there is discussion on limiting sovereignty as an enforcement device. We are going to see in the coming weeks how this will be implemented.

With this in place, if this indeed develops as projected in the coming weeks, then the second element could be discussed, perhaps by the next meeting of the heads of state. And that element would consist of finding more reasonable ways to provide liquidity, helping a country that is under market threat. This is something that we haven't touched upon yet. Here I want to note that although the EFSF was created last year, and a permanent stabilization fund is planned, in limiting the amount of resources that can be made available during a crisis we have failed to convince the markets that sufficient resources would be available in case countries such as Italy or Spain face difficulties. Now that decisions improving the governance framework and protecting against moral hazard have been taken, we need to improve the crisis management framework so that potentially unlimited backing is available from governments to other governments if needed.

I leave you with a question. A lot of analysts around the world are looking at the EFSF and saying to the ECB, isn't that your job? And the answer is no, the ECB is the lender of last resort to the banking system; it cannot serve as a lender of last resort to governments. What we have here is a fiscal governance issue that our governments need to solve. Once the political solutions are provided, once we have the appropriate framework at the political level, then and only then can we solve this problem convincingly.

Yields on 2-year government bonds



Wrap-up panel discussion

Randall Kroszner[1]

I am delighted to be able to take part in this final panel. Jaime introduced four issues for us to consider: in a nutshell, what are the policy risks associated with the expansion of central bank balance sheets with respect to (i) inflation, (ii) financial stability, (iii) financial market distortions, and (iv) debt management.

I don't want to try to address all four but would like to focus on two overarching themes. First, where is the line between monetary policy and fiscal policy? This touches on the financial stability and market distortion issues, some of which we had a taste of in Governor Orphanides' discussion. The second theme I'd like to address came up particularly in the last session and was also raised in the initial session of this conference: what is the role of central banks in foreign exchange markets, and what are the implications of their growing foreign exchange exposures? This second theme brings up some sovereign debt issues – which you will see are very closely related to the inflation risks.

Let me first talk about the fiscal versus monetary issues. These are very difficult ones. What should and shouldn't be on the central banks' balance sheets? One example that came up in the United States when I was at the Federal Reserve was the case of AIG. Here was a large non-bank entity that had enormous exposures in the credit default swap market. In fact, they were a major counterparty for all the other major institutions. If AIG had failed, there would have been no one to step in and replace those contracts. Suddenly, everyone's net exposures might have turned into their gross exposures, and there would not have been enough capital to deal with these exposures.

Is this a case where the Treasury or the central bank should have intervened? At the Fed, we considered this question. While we had some difference of views in the discussion, we unanimously decided to have the central bank intervene (partially) because there was no alternative fiscal element available at the time. Crisis management and resolution inevitably require some fiscal elements, regardless of whether the failure is in individual financial institutions or government institutions.

Of course, central bank resources are ultimately taxpayers' money. If a central bank's balance sheet sustains losses, the central bank would return less seigniorage revenue to the fiscal authority, and hence the fiscal authority's balance sheet would reflect that. So in the end, there is a connection between the two balance sheets.

In Europe, for example, it is clear that the central bank is being increasingly called upon to deal with severe fiscal problems in many individual countries. In principle, the central bank *could* act. It could continue to buy, or go much further in buying, government debt. However, this, as we know from past Latin American experiences, can be a recipe for disaster. If the central bank simply becomes the off-balance sheet fiscal arm of the State, and provides the financing for the government, then the situation ends in tears – it can result in high inflation and the destruction of the currency.

This actually happened in the United States during the 18th century. A number of people here have mentioned the blog I posted on the Freakonomics website a few weeks ago.[2]

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[1] Norman R Bobins Professor of Economics, University of Chicago Booth School of Business.

[2] This blog can be found at http://www.freakonomics.com/2011/11/30/circling-the-drain-can-the-euro-be-saved-or-is-it-doomed-to-die-a-freakonomics-quorum/.

There I argued that Europe is struggling with exactly the same challenges that the United States did after the War of Independence. The United States initially was a very loose confederation of states, based on the Articles of Confederation. But this arrangement did not work very well, in terms of both security and economics. The central government did not have the power to tax, but it did have a central bank. The central bank wound up issuing lots of so-called "Continentals" to pay the army. You may have heard the phrase "not worth a Continental" – well, that comes from the central authority issuing lots and lots of Continentals because they had no ability to tax or to force the states to share tax revenue with them. As it happens, the states in the confederation were very independent – maybe too independent – and eventually this system melted down. The economic result was very high inflation in the United States. Clearly, this approach was seen as not the right way to go – the United States recognised the need for a much more solid fiscal union and, in the end, a new US Constitution was penned in the late 1780s. In the end, the United States had to endure almost a decade of struggling with the problems of a loose confederation of states before resolving them.

Are there lessons for policymakers today? European officials appear to be taking their time in addressing the underlying issues of their union, perhaps thinking Europe has the luxury of a decade or so to work out the problems. I think if the policymakers try to use a decade-long timetable to deal with this, there is a distinct possibility that the euro area, as we know it today, won't be there by the end of that decade. Europe has to move much more swiftly. So far, it has taken two years, during which European policymakers have only slowly started to grope with exactly the core issue, that is, the need for a stronger fiscal union.

In the case of Europe, it is clear that one important part of any resolution is the need for effective fiscal monitoring across the EU. In a sense, that is what the United States achieved by the end of the 18th century. These are challenging issues, both economically and politically.

I now turn to my second theme, related to foreign exchange and foreign exchange exposures. Andy Filardo and James Yetman earlier presented interesting charts that showed that the expansions in central bank balance sheets in Asia are due primarily to increases in foreign exchange assets. This is very different from what happened in the United States. The Federal Reserve had a very large increase in its balance sheet; but it was not in foreign assets but in domestic assets. My guess is that most of those foreign assets on Asian central banks' balance sheets are US dollar-denominated assets. So it's been very interesting to see that this expansion of central bank balance sheets has largely been a dollar phenomenon worldwide, and I don't think that's gotten enough attention.

In the previous session, we had presentations on Korea and Thailand that underscored the important challenges going forward. A lot of what's happening in Asia, as well as in other emerging markets, cannot be separated from the fact that the United States has continued to maintain a very accommodative monetary policy stance. This has raised concerns about exchange rate appreciation in a lot of emerging market countries. In particular, many emerging market central banks, rather than tightening as rapidly as they might otherwise have done, have faced a lot of pressure from export-related interests, especially in economies where exports are a much higher percentage of total activity than in the United States. I think this has helped to explain why emerging market central banks have tried to avoid raising interest rates and have taken action to alleviate exchange rate appreciation pressures under the rubric of "macroprudential policies". In the old days, we called many of these measures capital controls; now we call them macroprudential policies, even though they are often targeted to offset pressures on the exchange rate. So, being less aggressive on interest rate increases resulted in adopting a variety of policies that slowed the rise of the exchange rate.

One question that needs to be asked in this respect is: do these measures actually help to reduce exchange rate volatility? These measures are usually undertaken in the name of that purpose. However, if you were providing markets with a guarantee, or something close to a guarantee, that the exchange rate movement is a one-way bet, the appearance of short-term stability can be misleading. That is because the market pressures that appear to be contained are continuing to build under the surface, leading to sharp currency movements when the pressures can no longer be contained. History shows that it is very difficult for central bank foreign exchange rate intervention to succeed in the long run – whether it's going back to George Soros breaking the Bank of England, or many other currency crises in the past. In other words, central banks may be able to postpone the inevitable but that can come at a large cost in the intermediate to longer run.

Of course, central bank interventions can actually generate more hot money inflows by undertaking what seem to be reasonable macroprudential policies to try to offset those initial capital inflows. This helps to explain in part why some emerging markets' central bank balance sheets have been growing so large; central banks are trying to fight strong market forces, manifesting themselves in the very large expansion of foreign assets on central bank balance sheets. In some cases, the willingness to use their balance sheets in this way, creating market expectations of "one way currency bets", may be driving more flows into some of these countries.

Now, I have some sympathy with the concern that it is very difficult to deal with very volatile exchange rates for exporters. And if exports dominate a country's economic activity, it's foolhardy to ignore that. One possible way to frame the issue is to ask, why doesn't the private sector just hedge? This is an important question because exporters, of course, want to reduce volatility and may be wary of undertaking long-term investments when they see strong secular exchange rate appreciation pressures. However, hedging markets are still fairly limited in most emerging market economies. While private hedging markets often operate fairly well in the short term, it's much harder to go out for a few years, which is the horizon relevant for longer-term investment.

In this situation, it seems reasonable to ask, why shouldn't the central bank be doing this for the private sector? By heavily managing the exchange rate, central banks in the region have been able to stabilise the exchange rate in recent years. However, there are risks. One good reason not to do this is that over-reliance on central bank "hedging" can end in tears. Obviously, this was something that happened in Thailand and much of Asia in the late 1990s, when a lot of the currencies collapsed and the central banks were effectively, but ultimately unsuccessfully, providing the hedge for the private sector. In the end, the private sector was able to borrow at lower rates than was sustainable. This history raises important questions. Are we currently seeing a replay of history? Will this end in disorderly changes in exchange rates? Will this end in tears?

Hopefully we've learned some lessons from the past on this front, but I am worried about growing fragilities in emerging market financial markets. I should note that this worrisome dynamic is not unique to Asian markets. We also have related concerns in the United States – the concerns about contagion from US dollar financing in Europe to the United States. For example, we have a lot of branches of foreign banks in the United States that are financing themselves in US dollars but do not have any stable sources of US dollar funding; they don't rely on retail deposits. And, we just heard about the example of Korea, which is facing a similar challenge, given the strong demand for US dollars. Foreign branches are operating in these markets but are not generating US dollar deposits. Instead, they're using short-term external financing vehicles, including commercial paper, repos etc. Managing these currency mismatches and foreign exchange exposures of central banks will continue to be important challenges going forward.

In sum, I think Jaime focused on the right questions in terms of the range of policy risks. And, when we start considering these questions, we see a wide range of vulnerabilities policymakers need to focus on. On the inflation side, are we trying to force the European central banks to finance the fiscal deficits, which ultimately could lead to high inflation? On the financial stability side, are macroprudential policies having unintended consequences in generating financial market distortions that could lead to more fragility down the line, especially when we consider the cross-border US dollar flows and currency mismatches? And lastly, sovereign debt management is a very important issue at the forefront of the policy agenda in Europe. Obviously, this is an issue the United States will also have to deal with down the line. Given the US dollar exposures of central banks in Asia and throughout the world, this is going to be an issue we will all have to deal with over the next few years.

Thank you.