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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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,

[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).

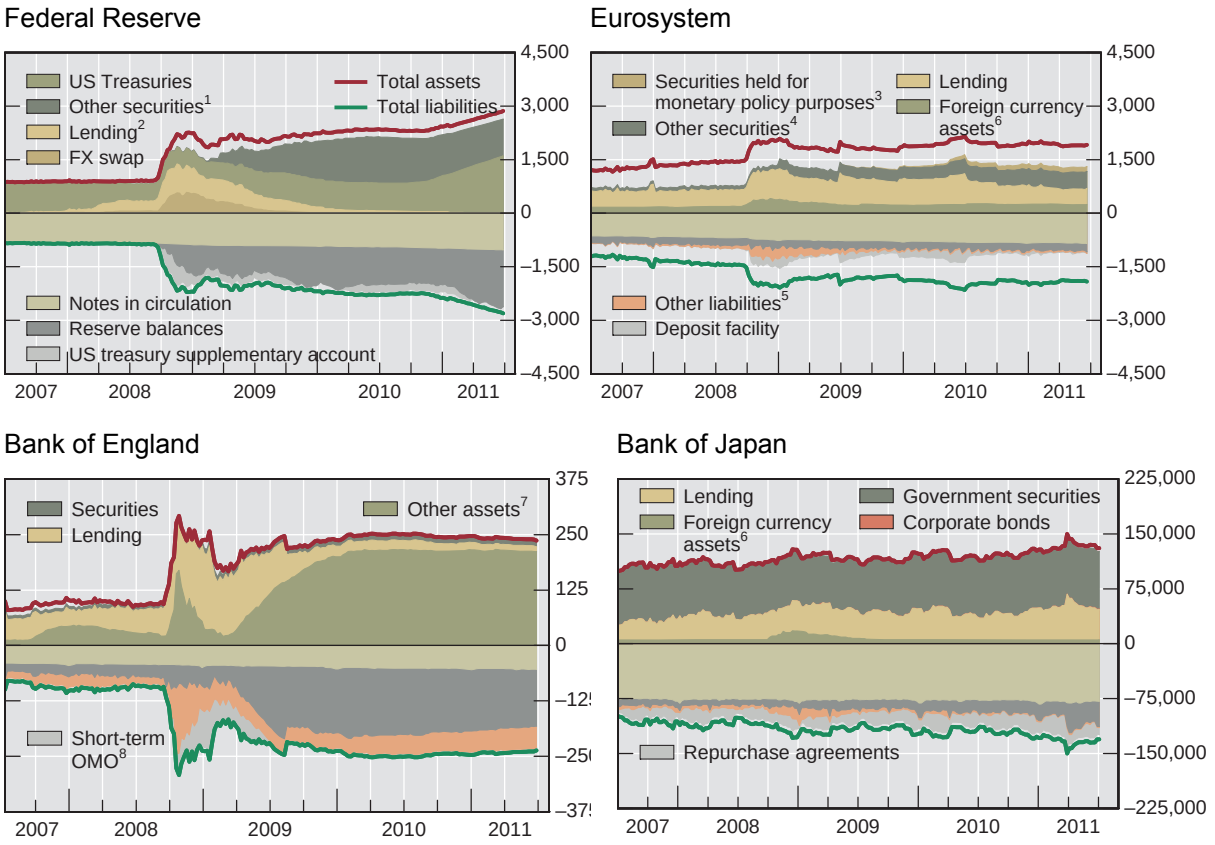
its balance sheet on the liability side by setting targets for current account balances held by financial institutions with the Bank. Eventually the BOJ purchased almost JPY 30 trillion of domestic government bonds.

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.

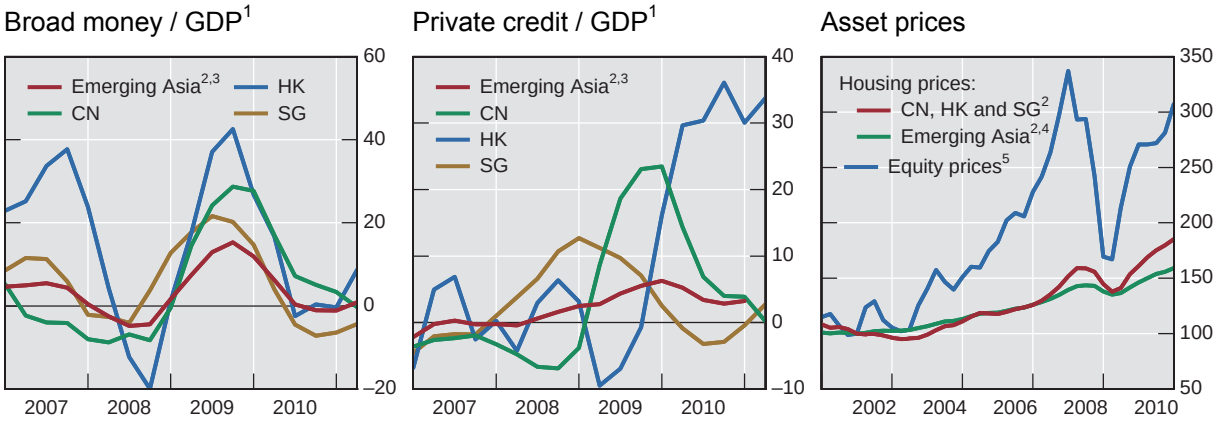
Moreover, real effects of quantitative easing in the advanced economies could spread directly through an external demand or trade channel. Quantitative easing could boost demand for emerging economy goods and services through easier trade credit and increased spending in the advanced economies. However, 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

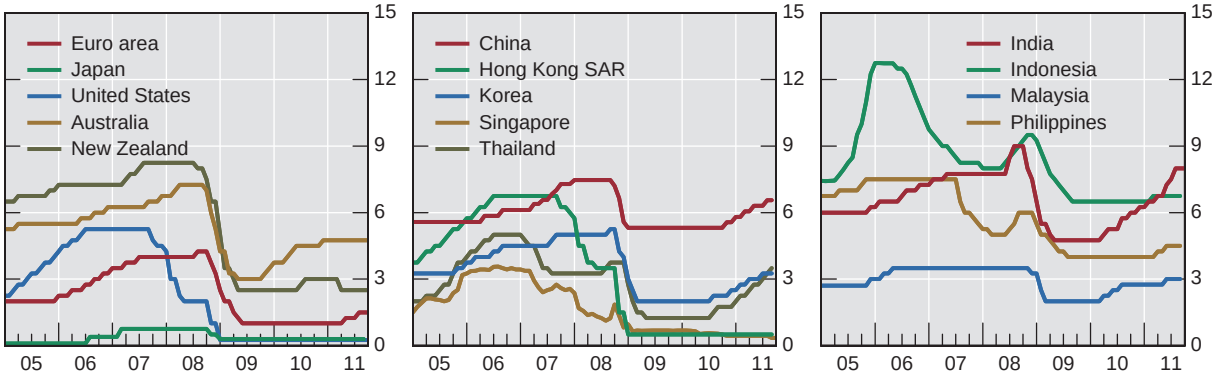
major reserve currencies; in a world of integrated finance and trade, a large-scale and sustained monetary easing is bound to have significant impact on emerging economies.

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.

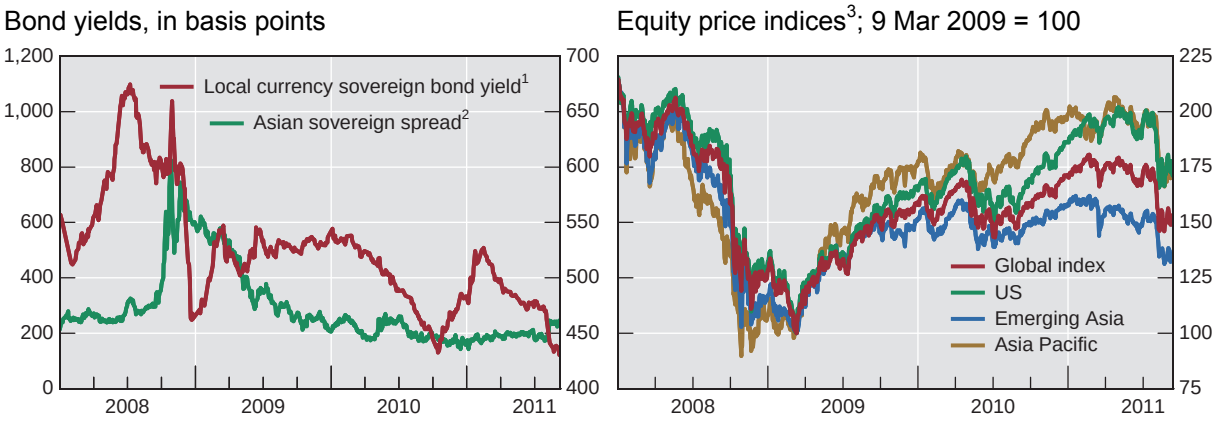
Sources: Bloomberg, Datastream.

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



[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.

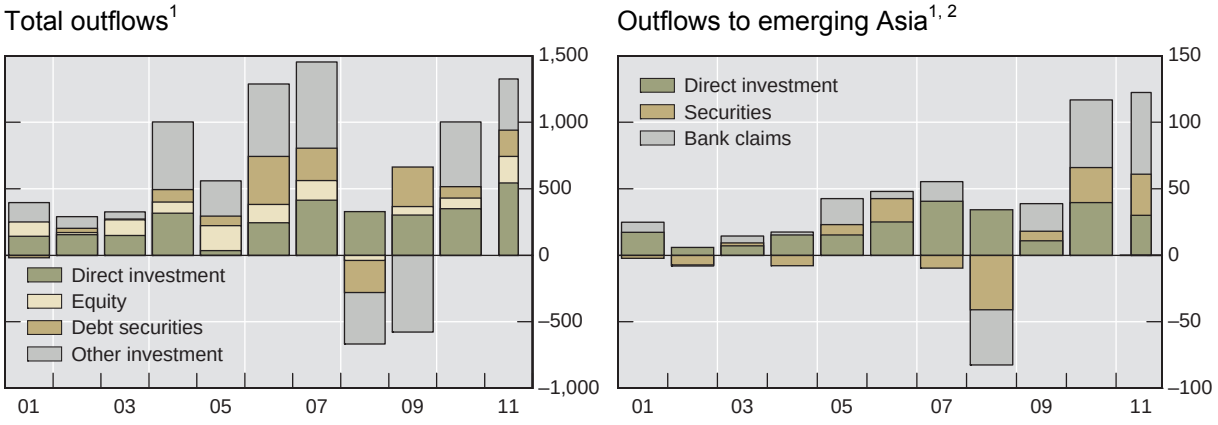
Sources: Bloomberg.

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



[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

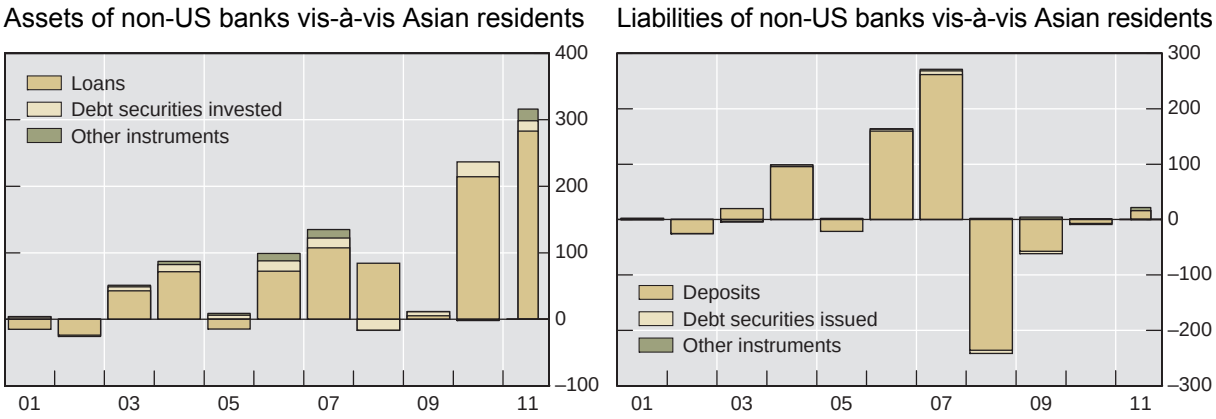
is ample, this could lead to lending booms in the region. Indeed, Graph IV.4 shows a marked increase in US dollar credit to Asia emanating from non-US banks. Bank loans make up the lion's share of the increase. However, this surge in assets is not matched by a similarly sized increase in US liabilities (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.

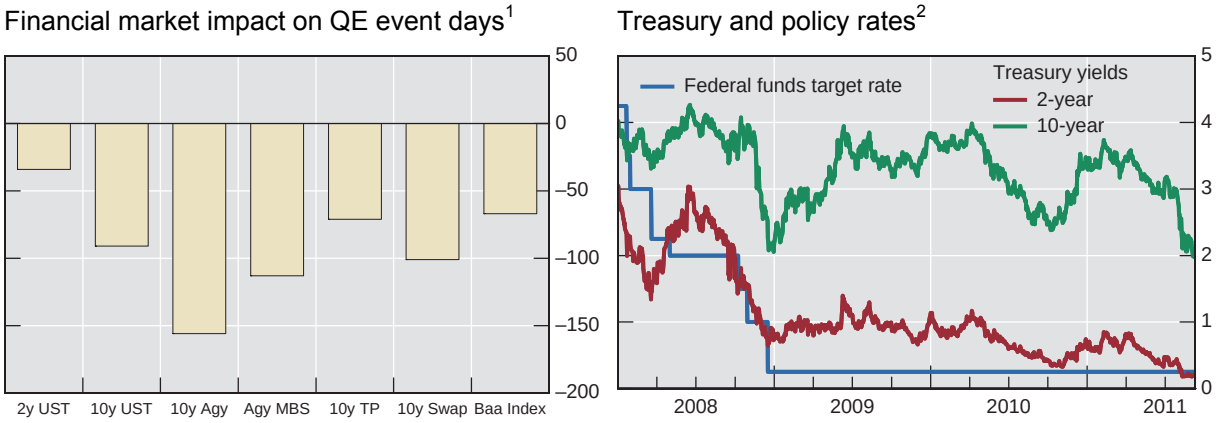
We find significant spillovers from US monetary policy actions to a wide range of emerging financial markets. Averaging across countries, US QE1 had a much larger cumulative effect than US QE2. By way of comparison, Japan's quantitative easing programme earlier in the decade had a somewhat greater impact 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]

	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	–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]

[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.

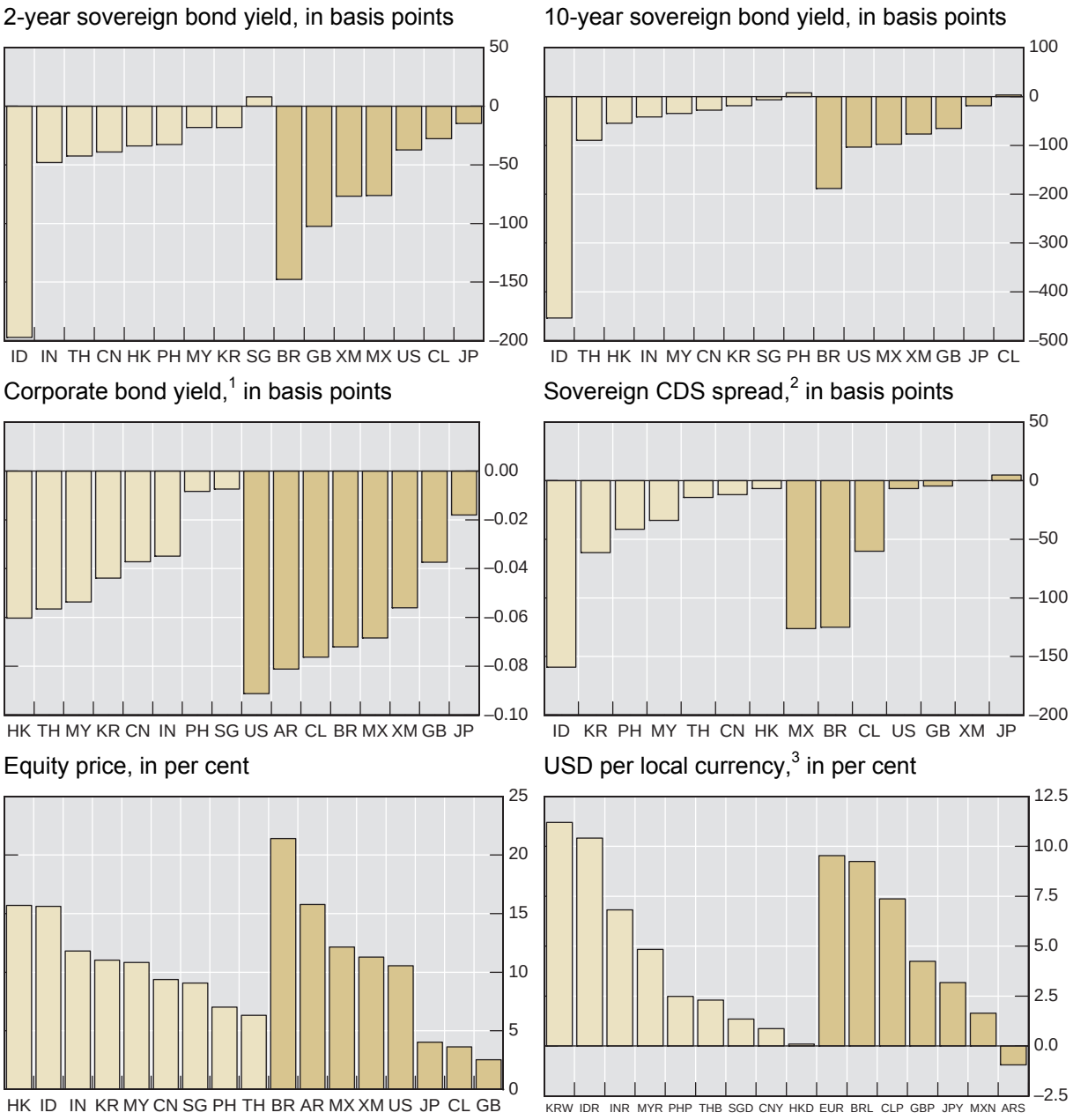
For the US QE2 announcements, the results are rather mixed. Sovereign CDS spreads declined in almost all the emerging economies under analysis, while the Philippines saw its yields drop much more than the others. China, Thailand, Hong Kong SAR and Argentina experienced a significant rally in their equity markets. One factor that might account for this was the pace of foreign reserve accumulation. In some of these economies, foreign reserve

[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

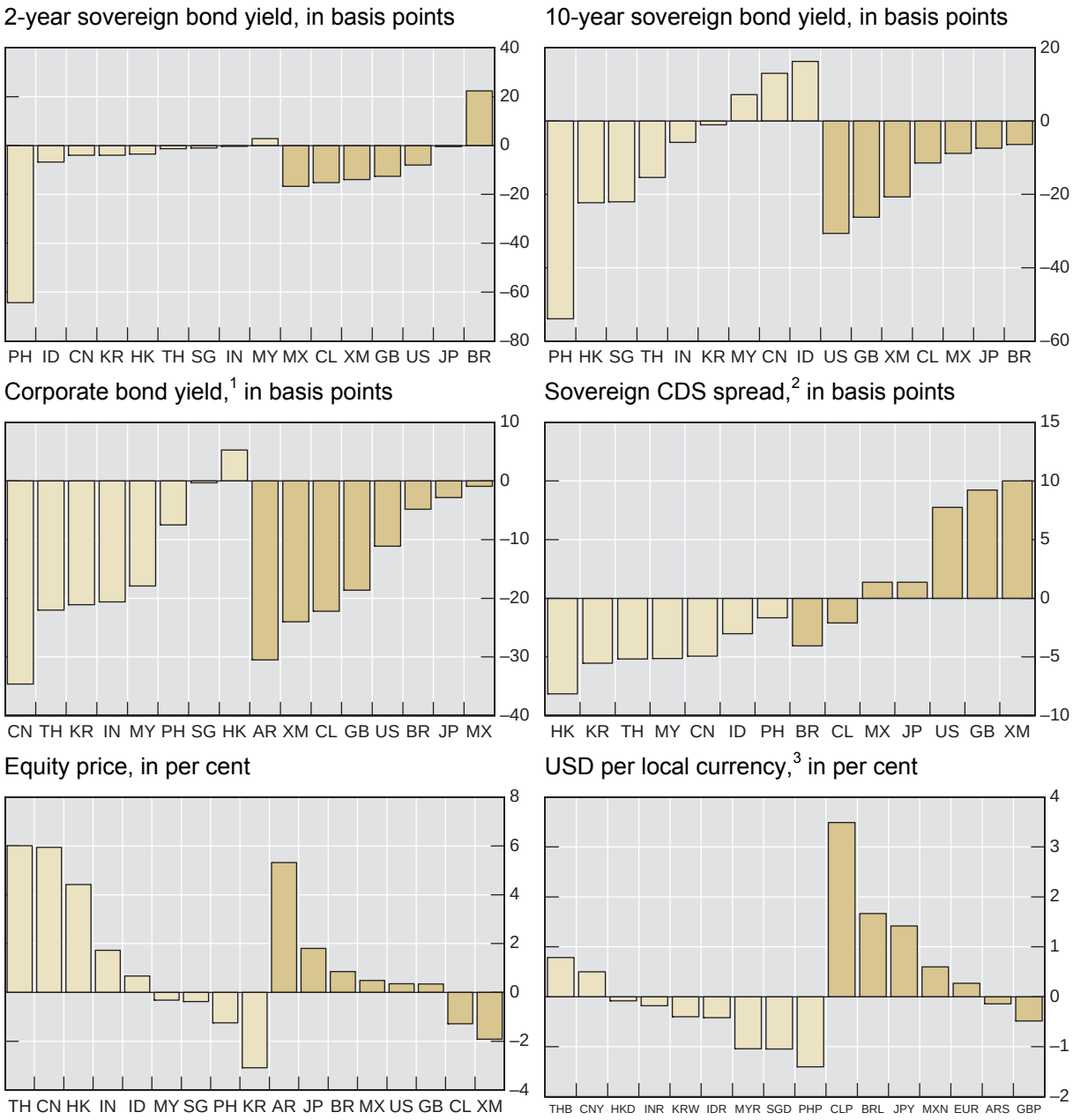


[1] Merrill Lynch AAA-bond yields for GB, JP, US and XM; JPMorgan Corporate Emerging Markets Bond Index (Broad) yield for others. [2] Senior 5-year CDS spreads. [3] A positive change indicates appreciation against the US dollar.

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

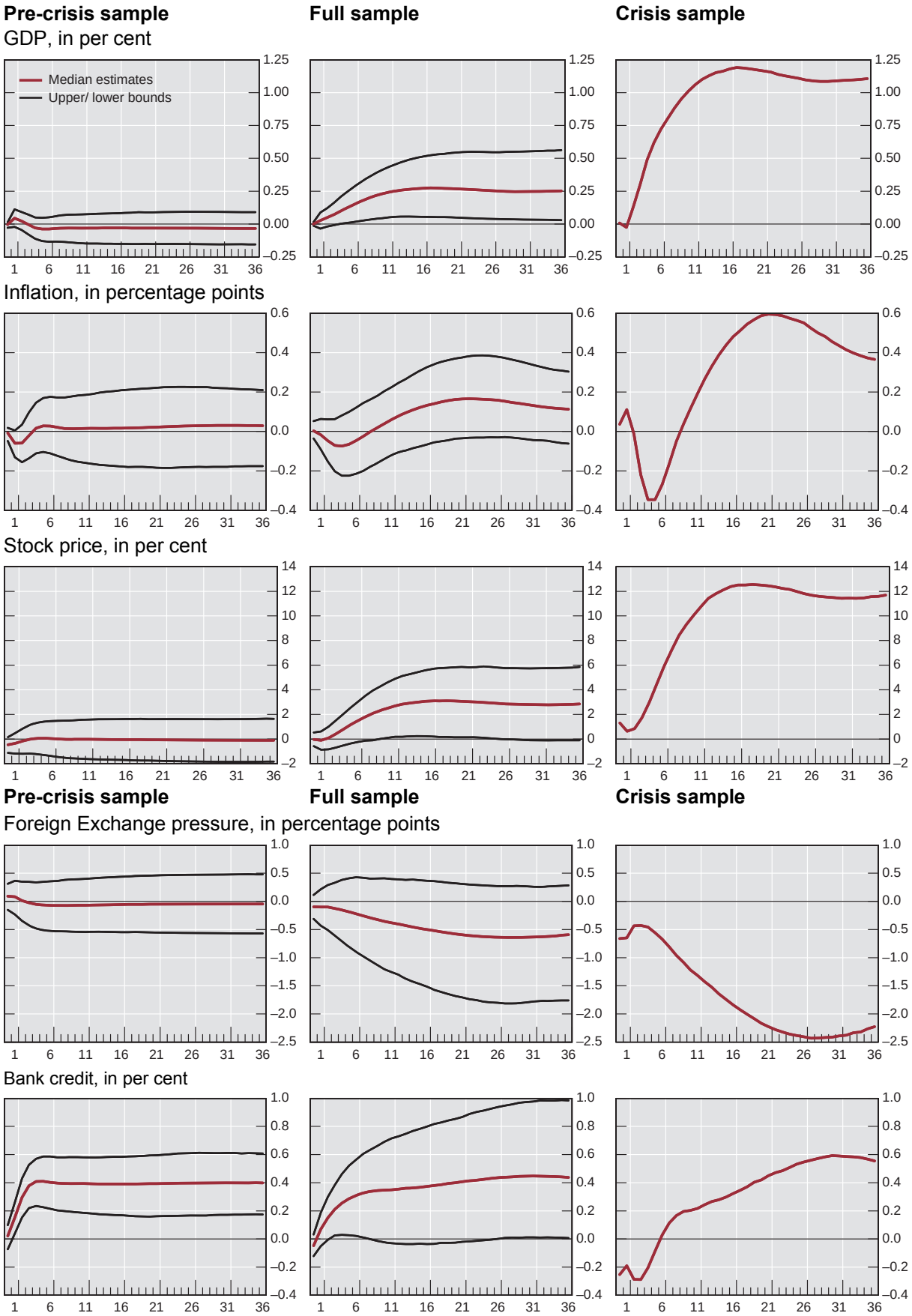
We present in Graph IV.8 the impulse responses to a negative US term spread shock of about 20 basis points (one standard deviation from the shock) over 36 months, estimated on the basis of the pre-crisis sample (February 1995 to December 2006), the full sample (February 1995 to December 2010) and the 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.

[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

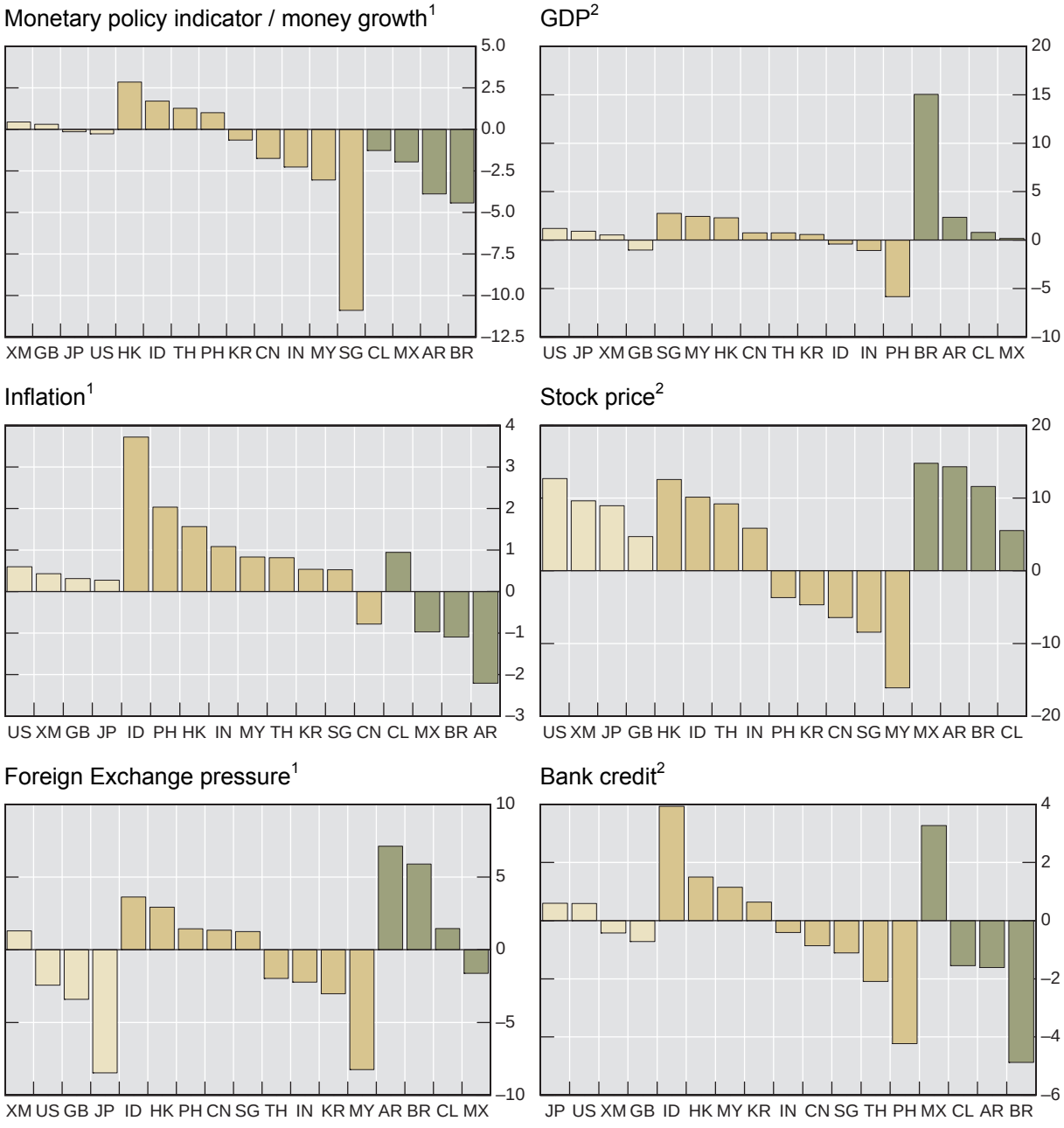
[15] The weights are determined by the lengths of the two sub-samples relative to the full sample.

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



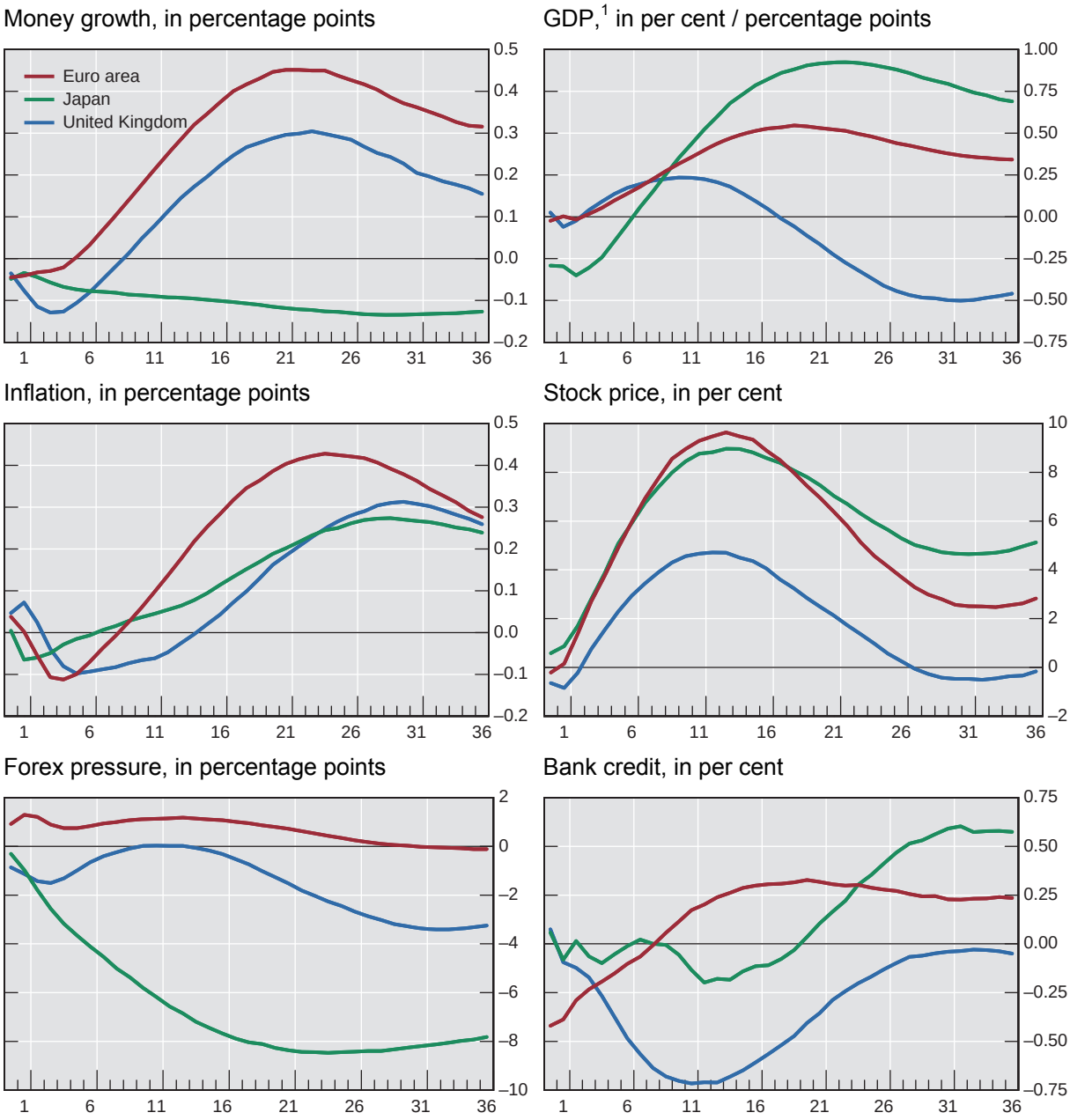
[1] In percentage points. [2] In per cent.

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.

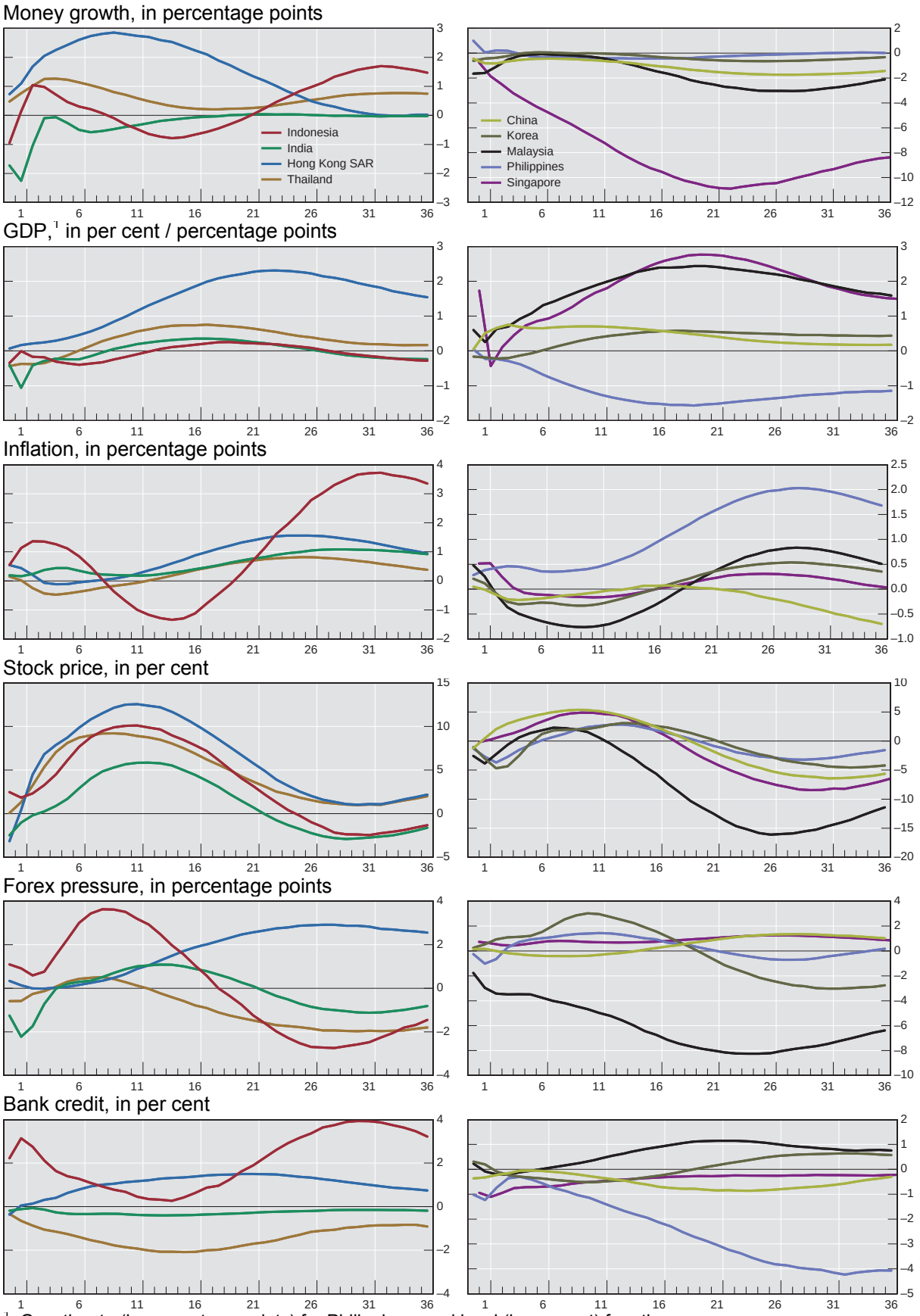
Third, the impulse responses in the form of foreign exchange pressure, money growth and bank credit in the emerging Asian economies do not seem to have uniform patterns. This probably reflects differences in the transmission channels and in the adjustment mechanisms each economy chooses to rely on. Unsurprisingly, 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



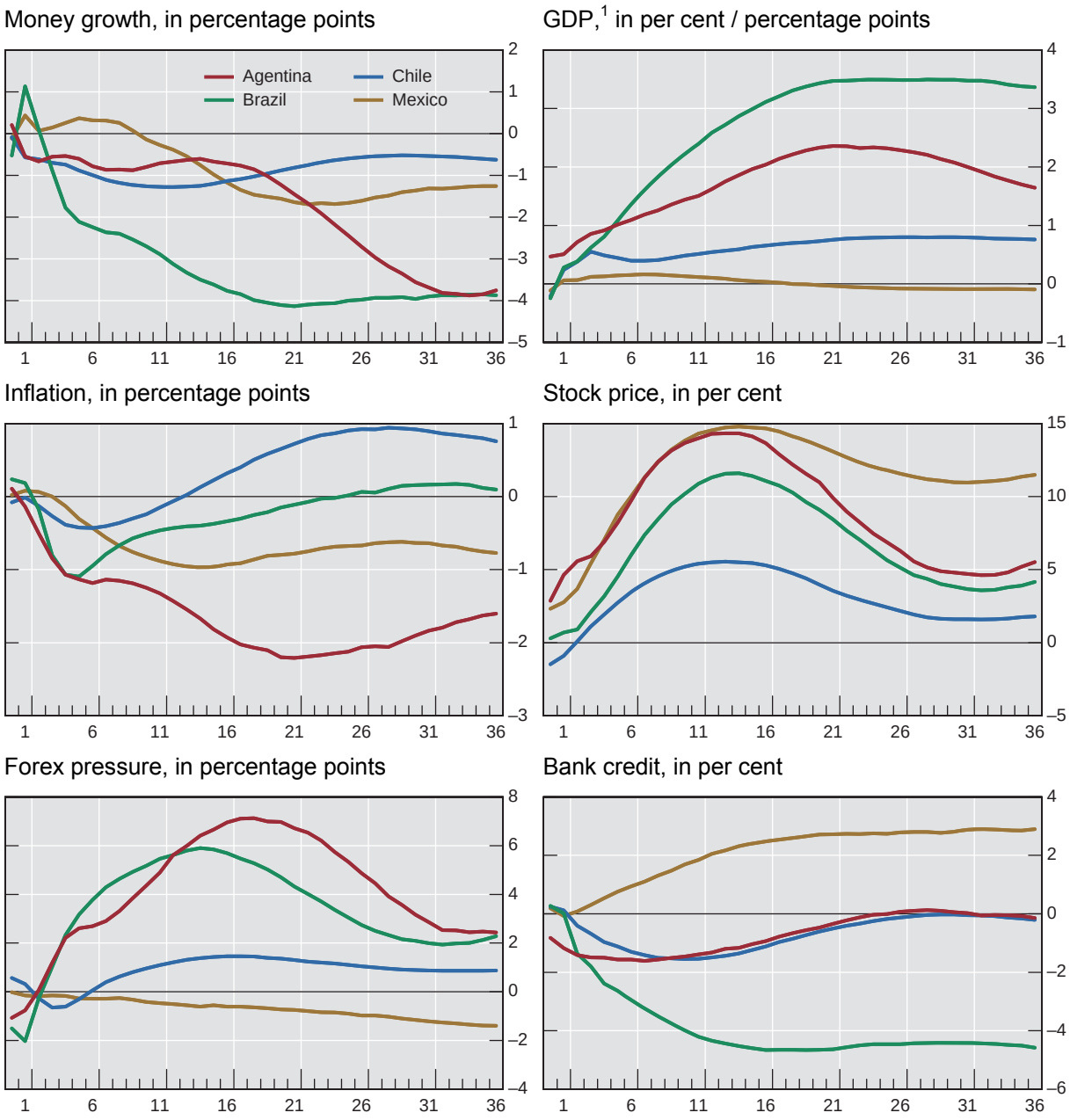
[1] Growth rate (in percentage points) for Philippines, and level (in per cent) for others.

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

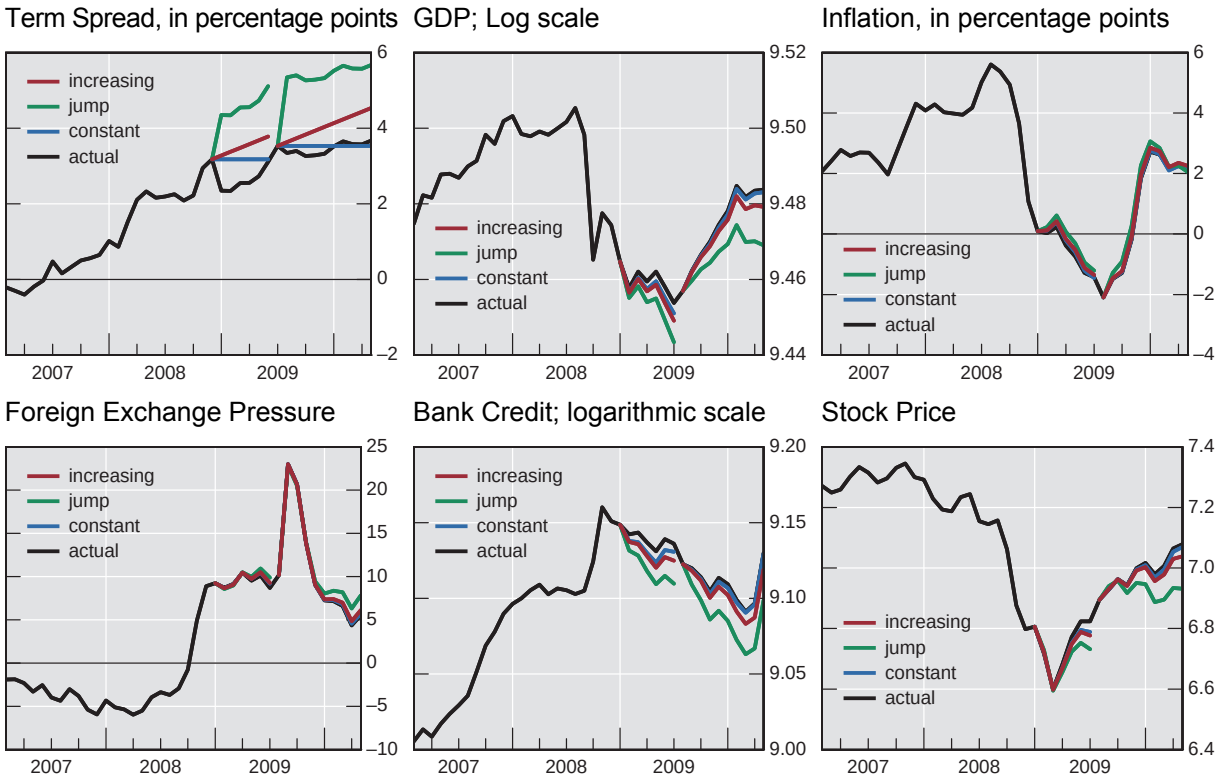
spreads below the levels that obtained when quantitative easing began. There are two possibilities: first, there were economic factors such as adverse supply shocks which counteracted the effects of asset purchases and pushed US term spreads higher than they would have been; second, the effect of US 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

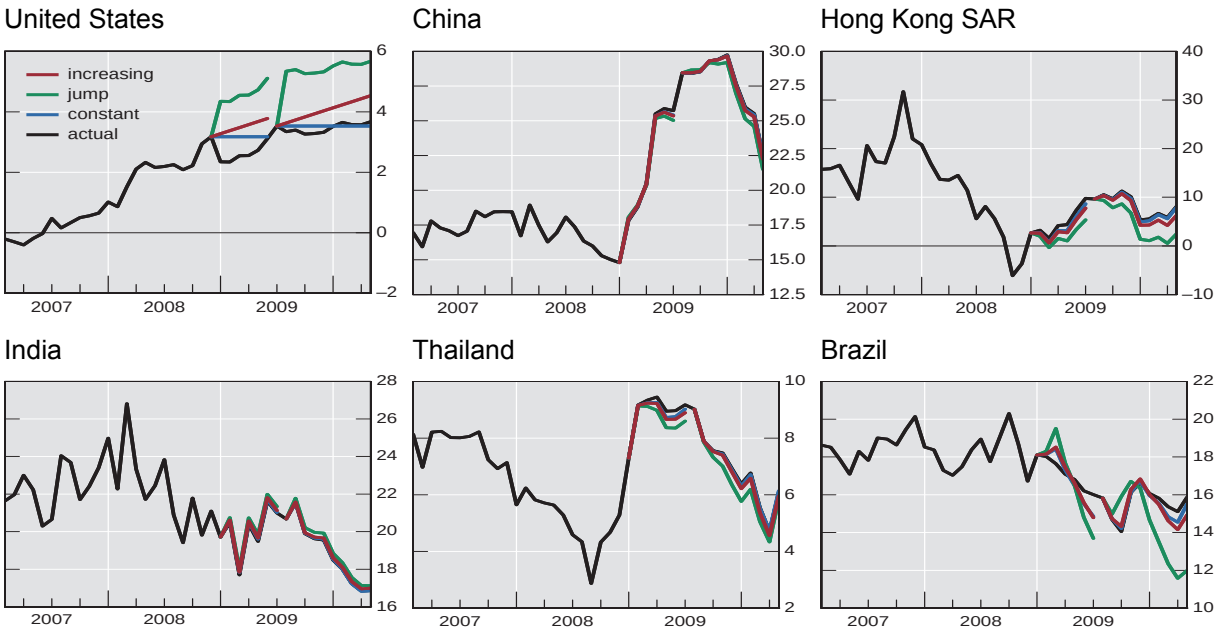
Counterfactual analysis in this section shows that US quantitative easing, through a reduction in the long-term bond yields or term spreads, indeed has had a significant impact on the emerging economies. Moreover, as we discussed in the previous section on the estimated impulse responses, the impact 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.

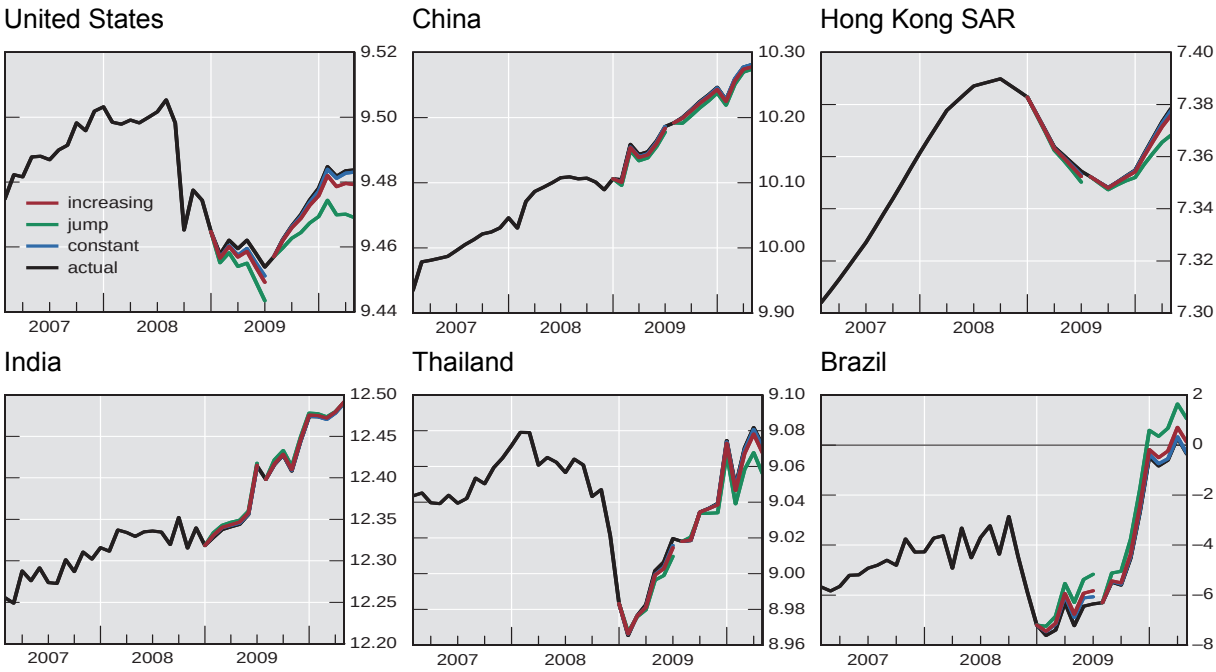
Source: Authors' estimation based on Global Error Correction Model.

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.

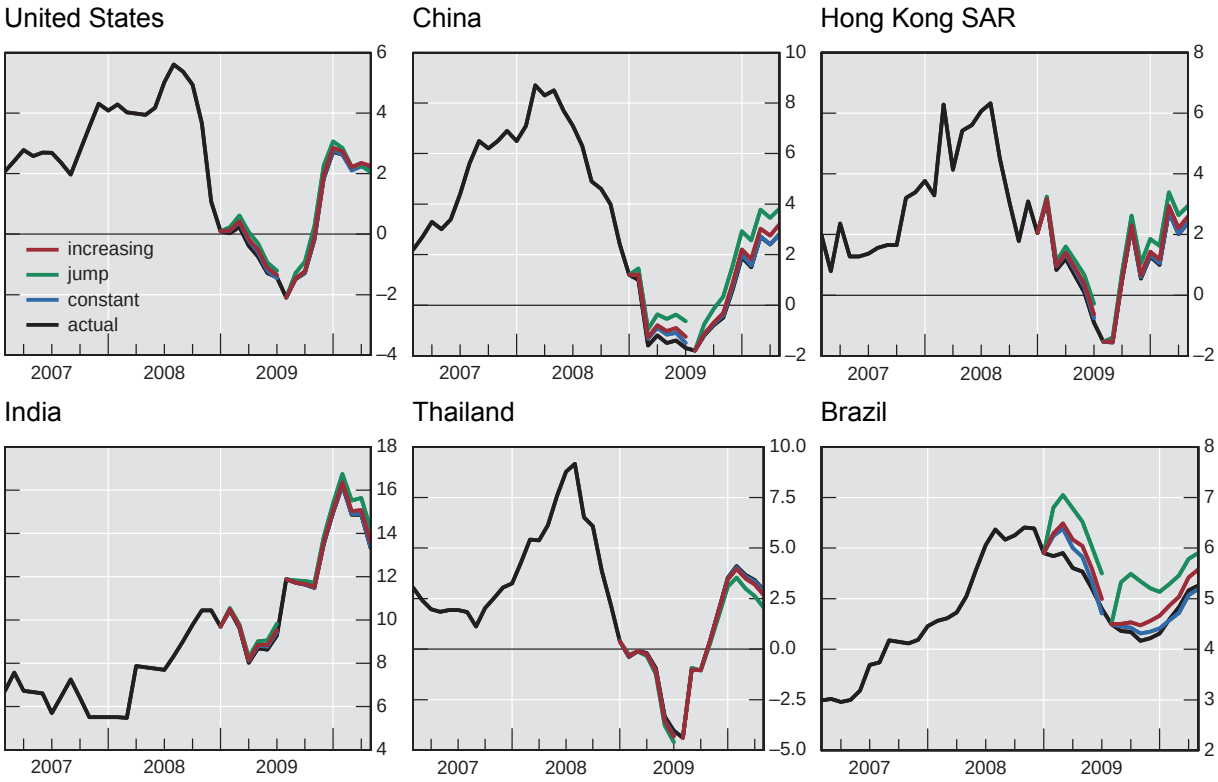
While US quantitative easing had little impact on US domestic inflation, its cross-border impact is diverse (Graph IV.15). The inflation impact in the first phase of asset purchases turned out to be smaller than in the second phase in Hong Kong, India and Thailand. More interestingly, while lowering 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

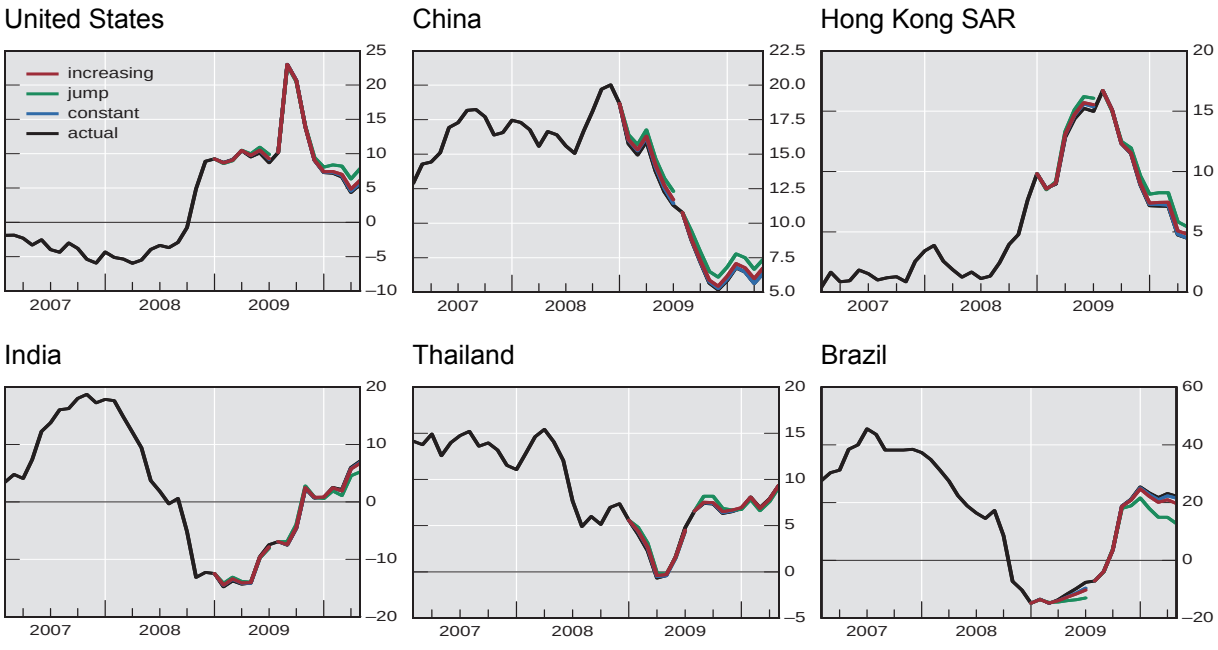


Source: Authors' estimation based on Global Error Correction Model.

Graph IV.16

Counterfactual analysis–foreign exchange pressure

In per cent

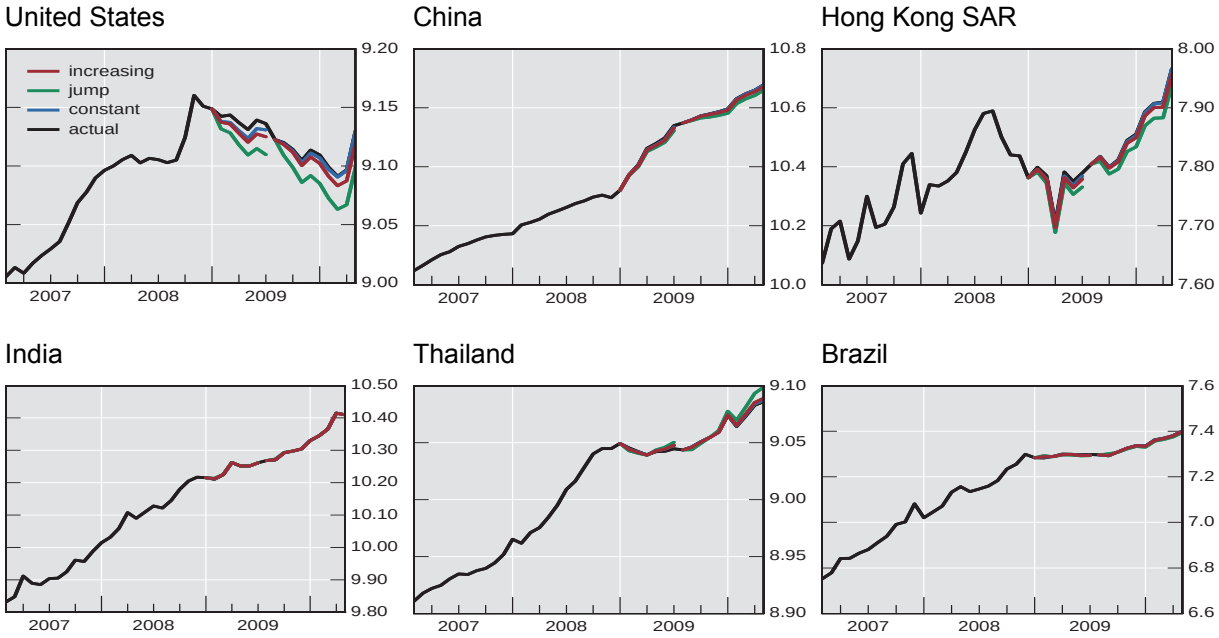


Our analysis suggests that the cross-border spillover effect of US easing on bank credit was very small, except probably for Hong Kong and Thailand (Graph IV.17). Bank credit would have been lower in Hong Kong without a cut in the US term spread in both phases of US asset purchases, but would have been 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



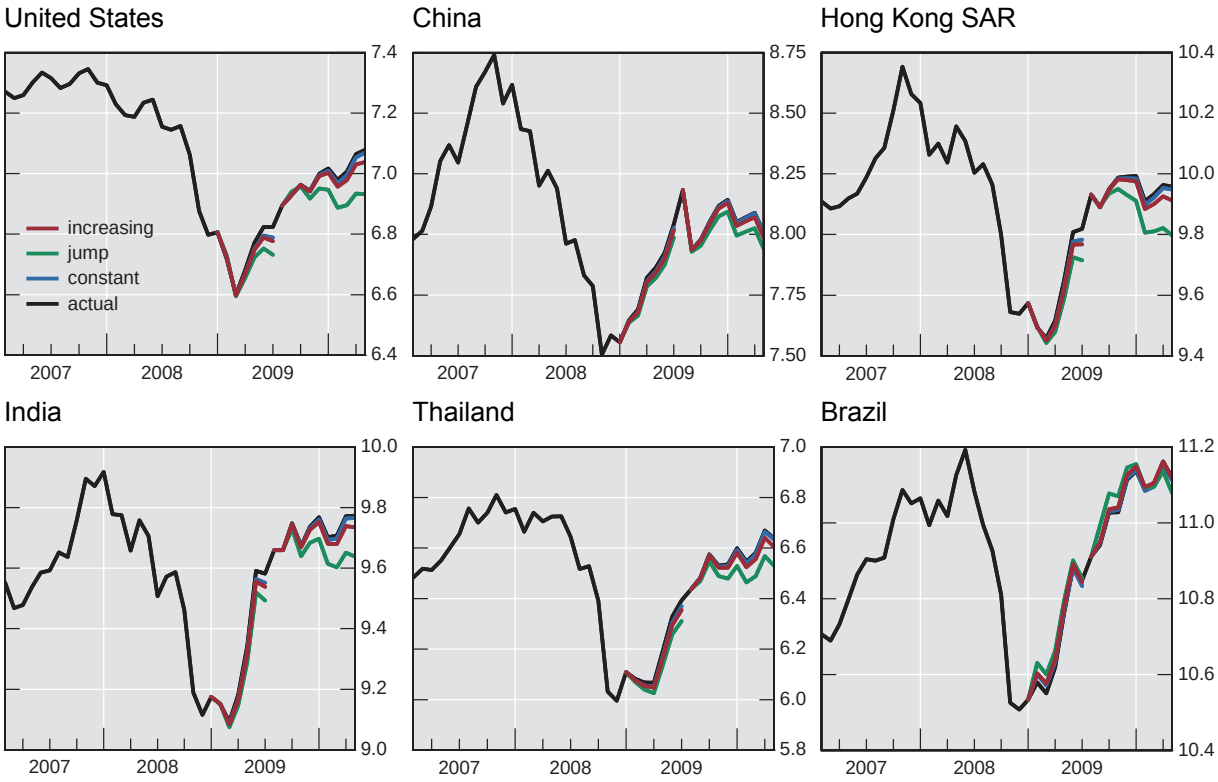
Source: Authors' estimation based on Global Error Correction Model.

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 $u_{it} \overset{iid}{\sim} (0, \sum_i)$,

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 $i \neq j$, *I 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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