Globalisation, pass-through and the optimal policy response to exchange rates

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Abstract

In this paper we examine how monetary policy should respond to nominal exchange rates in a New Keynesian open economy model. Sterilised intervention can be a potent tool that offers policymakers an additional degree of freedom in maximising global welfare. We show that the gains to sterilised intervention are greater when goods market integration is low and exchange rate pass-through is high. However, increased financial internationalisation reduces the effectiveness of sterilised intervention, as the international policy trilemma implies. Unsterilised intervention may also have a role to play, although the potential welfare gains from this are relatively small.

Most central banks in Asia have actively used sterilised foreign exchange intervention as a policy tool to smooth exchange rate movements. But, over time, declining exchange rate pass-through and the increasing international integration of financial and goods markets will tend to reduce the efficacy of sterilised intervention. Given the limited effectiveness of unsterilised intervention, our model implies that the role of exchange rate movements in the optimal setting of monetary policy is decreasing in Asia.

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1. Introduction

How should central banks respond to exchange rate changes? Historically, economies in Asia have placed a high weight on nominal exchange rate stability. And stabilising the external value of the currency appears to have served as an effective nominal anchor for the domestic economies in the region. But the choice of optimal nominal anchor is likely to evolve with changes in the underlying structure of the economy. In this paper, we assess the underlying nature of those changes and discuss their implications for the role of the nominal exchange rate in monetary policy.

In the past, the degree of exchange rate pass-through to domestic prices tended to be high in the region. Any change in the exchange rate was likely to quickly show up as a corresponding change in domestic price levels. One explanation for this is that imports tended to be invoiced and priced in foreign currencies. Under such conditions, there is a high degree of complementarity between exchange rate stability and inflation stability.

Another key characteristic of previous decades was relatively low levels of financial internationalisation. Banking systems tended to be less integrated across borders than they are today. Domestic financial markets were relatively underdeveloped, so that external investors had little choice of domestic assets that they could purchase, and effective capital controls further restricted the scope for international risk sharing.

But, as we document below, both of these characteristics have changed. By most metrics, the degree of exchange rate pass-through has fallen in Asia, in a similar way to that seen in many advanced economies in an earlier decade, and is now at low levels. As average inflation rates have come down, prices have tended to become stickier, slowing the rate at which exchange rate shocks are passed on to domestic price levels.

Also, financial markets are now more integrated globally. Clearly there are still large deviations from complete international risk sharing, but the combination of developing domestic financial markets in emerging and emerged economies, and declining barriers to international capital flows, have seen increased financial globalisation.

In addition, goods markets have become more integrated, and consumer preferences across different countries have moved closer together, as trade costs have fallen and international brands have become more established.

We model these characteristics in a New Keynesian model in the following way. To capture variation in the degree of underlying exchange rate pass-though, our model assumes that some portion of imports is priced in local currency, with the remainder priced in the producers' currency. To model increasing financial internationalisation, our model assumes a linear combination (in log terms) of the conditions for balanced trade and complete international risk sharing. And we model increases in the degree of goods market integration by a reduction in the degree of home bias in the consumer's utility function.

This paper argues that these trends in characteristics of exchange rate pass-through and financial market and goods market integration may have important effects for the conduct of monetary policy. In particular, we argue that the effect of these developments is to reduce the gains to using sterilised intervention to influence exchange rates. In the limit, as financial internationalisation increases, sterilised intervention will become completely incapable of influencing exchange rates.[2]

But we find that this does not leave policymakers completely without effective tools for influencing exchange rates. In response to productivity shocks, there remains a small role for unsterilized intervention to improve global welfare.

Our paper adds to the existing literature on the desirability of stabilising exchange rates.[3] For example, Taylor (2001) reviews the literature on including the exchange rate in monetary policy reaction

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[2]   There are some signs that this is already being reflected in policy settings in the region, as central banks are allowing more de facto exchange rate flexibility than in the past.

[3]   See Mussa et al (2000) for a summary of the various factors that may influence the optimal choice of exchange rate regime.

functions and finds that this can result in only modest improvements (or even a deterioration) in terms of output and inflation outcomes in standard small open economy macro models.

Garcia et al (2011) argue that a central bank response to exchange rates may be desirable, especially in financially vulnerable economies. They define financially vulnerable economies as those where agents have limited access to the means of saving and borrowing so that a portion of consumption is based on current income, rather than inter-temporal optimisation.[4] Sutherland (2005) shows that the optimal variance of exchange rates depends on a variety of factors, including the degree of pass-through, the size and openness of the economy, the elasticity of labour supply and the volatility of foreign producer prices.

Engel (2011) argues that, in a model with currency misalignments, monetary policy should respond to those misalignments. Currency misalignments cause inefficient outcomes because home and foreign households pay different prices for the same goods. Responding to exchange rates can then play a role in reducing the cost of that distortion. Corsetti and Pesenti (2005) argue that using monetary policy to reduce exchange rate volatility may be welfare enhancing, even if it leads to increased output gap volatility. This is because risk-averse foreign exporters are likely to reduce average mark-ups in response to decreased exchange rate volatility.

Devereux (2004) demonstrates that, in a world with nominal rigidities, perhaps due to incomplete international financial markets, then, even if a flexible nominal exchange rate would serve as a perfect shock absorber, fixed exchange rates may be preferable. Effectively, flexible exchange rates can lead to inefficient output responses to demand shocks in that output may be too stable. In this paper, we obtain similar results in the case of financial autarky. However, we find that this argument is weakened as financial markets become more internationalised.

In the next section, we discuss the recent evolution of Asian economies, focusing on changes that might warrant a reconsideration of the role of the exchange rate in monetary policy. Section 3 discusses the range of possible policy responses to exchange rate developments. In section 4 we outline an open economy model that can be used to analyse the effect of on-going changes in Asian economies, and their implications for the use of both sterilised and unsterilized intervention in foreign exchange markets. We discuss the results from our model in section 5. Finally, section 6 concludes.

2. The evolution of emerging Asian economies

Recent decades have witnessed a wide range of changes in the structure of Asian economies. Four factors however are of particular relevance to the traditional desire by central banks in the region to stabilise nominal exchange rates.

First, exchange rate pass-through to inflation appears to now be low. We provide evidence for this in graph 1. We estimate a simple vector autoregression, economy-by-economy, on quarterly data, consisting of real GDP growth, inflation, the change in the policy rate and the change in the nominal effective change rate, in that order.[5] We also include four seasonal dummies and three lags. The model is identified by orthogonalising the reduced-form errors by means of a Choleski decomposition of the variance-covariance matrix. We then compute the impulse response of inflation, in per cent, to a 10% depreciation shock to the nominal effective exchange rate. We use monte carlo methods and plot, in the graph, the median projection along with the 10th and 90th percentiles (as confidence bands), for the longest period for which all our data are available.[6]

[4] See also Cespedes et al (2004) and Moron and Winkelried (2005).

[5] Our variables are defined as the quarter-on-quarter change in the log of the level for real GDP, the CPI and the nominal effective exchange rate, and the change in the level for the policy rate.

[6] Sample periods vary between 1994Q1-2012Q4 (Australia, China, Hong Kong, Japan, Korea, Malaysia, Philippines, Thailand), 1994Q1-2012Q3 (New Zealand, Singapore), 1996Q1-2012Q4 (Indonesia) and 1996Q2-2012Q3 (India).

Impulse response of CPI inflation to NEER shock

10% depreciation

Graph 1

Australia

China

Hong Kong SAR

India

Indonesia

Japan

Korea

Malaysia

New Zealand

Philippines


Singapore

Thailand
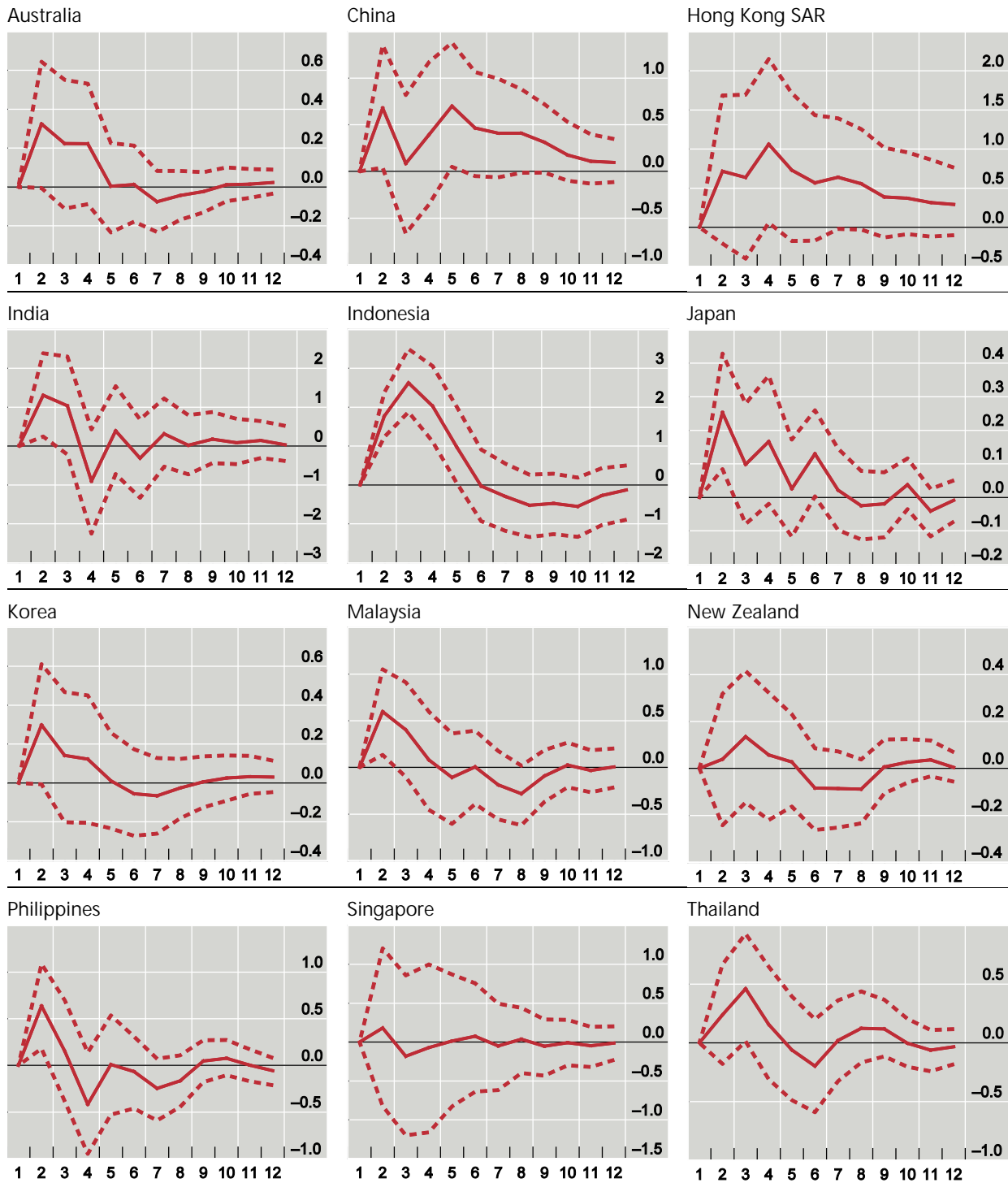
Vertical axis in per cent. Dashed lines display 80 per cent confidence bands.

Source: authors' estimates.

The results suggest that exchange rate pass-through for many economies in Asia-Pacific has been low for some time. The point-estimate of the peak increase in inflation following a 10% depreciation in the nominal effective exchange rate is 0.7% or lower for most economies. The only exceptions are Hong Kong (1.1%), China (1.3%) and Indonesia (2.6%). However, the relatively high rate of pass-through in Indonesia is driven entirely by observations around the time of the Asian Financial Crisis. If we instead start the data sample in 2001, the peak increase in inflation drops to 1.0% (Graph 2).

Exchange rate pass-through to Indonesia

Response of CPI inflation to a 10% depreciation shock to the NEER; different sample periods   Graph 2

— 1996 Q1–2012 Q4   — 2001 Q1–2012 Q4
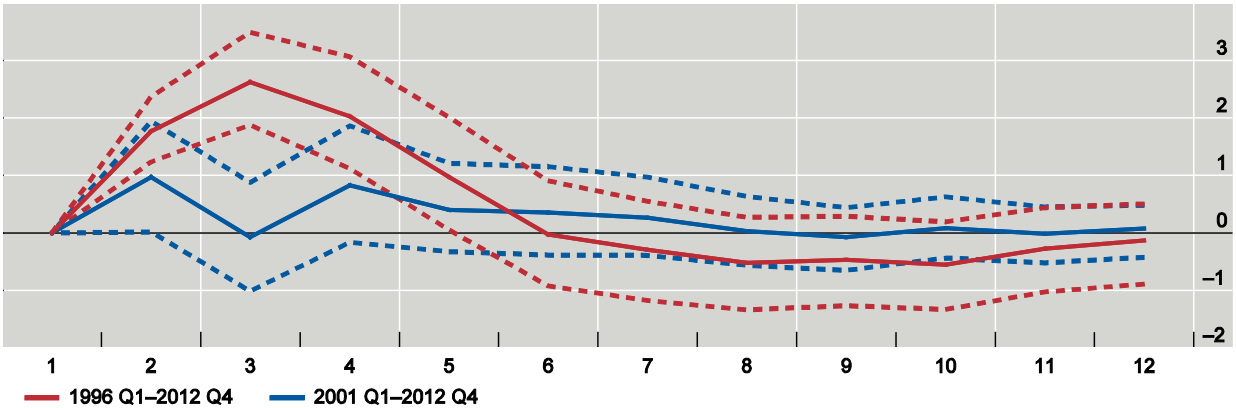
Source: authors' estimates.

We are not the first to question the received wisdom that exchange rate pass-through remains high in emerging market economies, especially compared to advanced economies. Brun-Aguerre et al (2012), for example, find that short-run pass-through in emerging market economies is low and close to that for advanced economies.[7]

The literature offers a number of possible explanations for declining exchange rate pass-through that are likely to apply in the Asian context. For example, improved inflation control, leading to declines in both the level and volatility of inflation, is associated empirically with lower levels of exchange rate pass-through, as prices become more sticky (Devereux and Yetman 2010; Choudry and Hakura, 2006; Gagnon and Ihrig, 2004).[8] For Asian economies with a history of high inflation, the improvement in inflation outturns has been substantial. Average inflation in China and Indonesia, for instance, declined by almost one half from 1993–2002 to 2003–2012. Hong Kong SAR, Korea, Malaysia, the Philippines and Thailand have also seen substantial, although smaller, declines in inflation between these same two periods.[9]

Additional plausible explanations for declining exchange rate pass-through in Asia relate to changes in the supply chain and the composition of imports. Increasingly internationalised supply chains, with the

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[7] See, also, Ca'Zorzi (2007) and Mihaljek and Klau (2008).

[8] Care should be taken in giving a decline in pass-through a structural interpretation, however. Improved inflation outcomes are likely to present as evidence of declining pass-through regardless of any underlying structural changes. This is because, the more stable inflation is, the less correlated inflation will tend to be with any potential explanatory variables, including exchange rates, as Parsley and Popper (1998) argue. Similarly, Reyes (2007) argues that successful currency intervention to smooth exchange rate changes may result in the appearance of reduced pass-through, even if pricing behaviour is unchanged.

[9] A related potential cause of declining pass-through is less volatile exchange rates. Brun-Aguerre et al (2012) find that pass-through is higher in response to large exchange rate shocks than small ones.

production process involving multiple firms in multiple countries, are likely to result in the largest exporters also being the largest importers. As Amiti, Itskhoki and Konings (2012) argue, then the effects of exchange rate changes on firm profitability are muted, as reduced (increased) import costs are offset by diminished (increased) export revenues, so that firms are less likely to adjust prices in response to exchange rate changes. Further, changes in the composition of import bundles are also likely to play an important role, with the elasticities of pass-through for manufactured goods and food products generally lower than commodities and energy, as Campa and Goldberg (2005) argue. More generally, changing import patterns associated with wealth increases are likely to contribute to declining exchange rate pass-through.

The up-shot of declining pass-through is that the effectiveness of exchange rate control as a policy lever may be declining, for three reasons. First, declining pass-through implies a weakening link between exchange rate stability and inflation stability. To the extent that exchange rate movements are a source of macroeconomic volatility, then, less exchange rate pass-through decreases the domestic macroeconomic benefits from stabilising the exchange rate. Second, if exchange rate movements act as a shock absorber to help to insulate the economy from external shocks, low pass-through implies that nominal exchange rate changes are more likely to translate into shock-absorbing real exchange rate changes, as Edwards (2006) argues.[10] And third, where exchange rates are actively used as a tool for domestic business cycle management to offset other shocks, if domestic prices fail to adjust, there will be little expenditure-switching in response to exchange rate changes. Adjusting the exchange rate in response to shocks in a low pass-through environment will have smaller effects on the demand for domestically produced goods than in a high-pass-through environment.

A second changing dynamic that may influence the role of the exchange rate is the ongoing integration of goods markets. Graph 3 illustrates the growth in trade volumes over time. One consequence of this is that consumption bundles are becoming increasingly similar across economies over time. As we will see, the mechanics of international risk sharing depend in part on the degree to which consumption bundles overlap between economies.

Trade integration

Imports and exports of goods and services as a percentage of GDP   Graph 3

Simple average across economies   Aggregated ratio

— ACC[1]   — All economies[2]
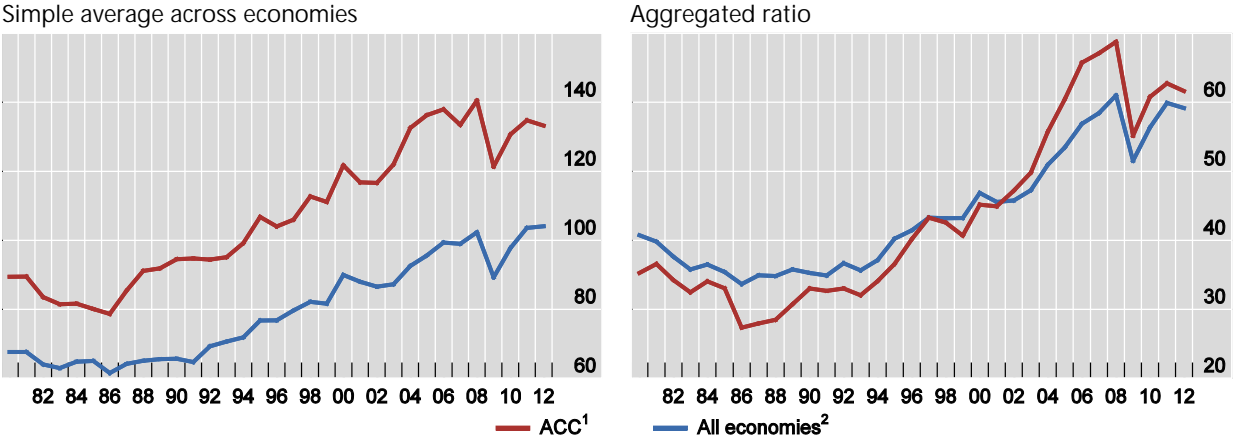
[1] BIS Asian Consultative Council: Australia, China, Hong Kong SAR, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore and Thailand.   [2] Aggregation of 50 major economies.
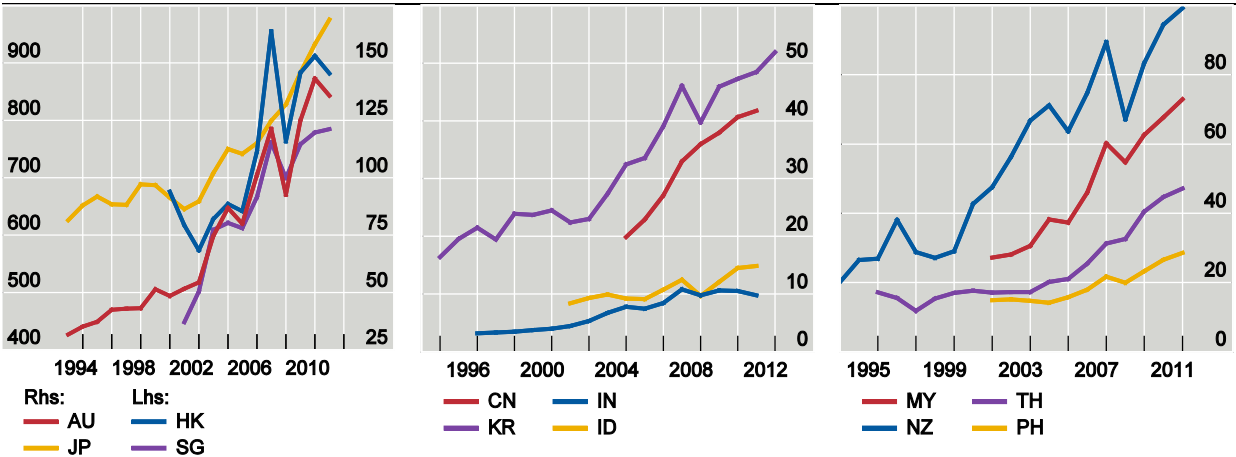
Source: IMF *World Economic Outlook*, April 2013.

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[10] On the other hand, Devereux and Engel (2003) argue that the case for exchange rate flexibility rests in part on prices responding to exchange rates so as to stimulate expenditure switching. For a more general discussion of pass-through, see Burstein and Gopinath (2013).

A third characteristic that may be important for the policy trade-offs than central banks face between exchange rate stability and inflation control is the increasing degree of financial internationalisation. One simple metric of this is gross investment positions as a share of GDP, given in Graphs 4A and 4B. Without question, these have grown dramatically in recent years, in spite of a noticeable correction at the time of the International Financial Crisis. Further, in the latest available data, gross international positions as a share of GDP are at all-time highs for most regional economies.

International investment positions
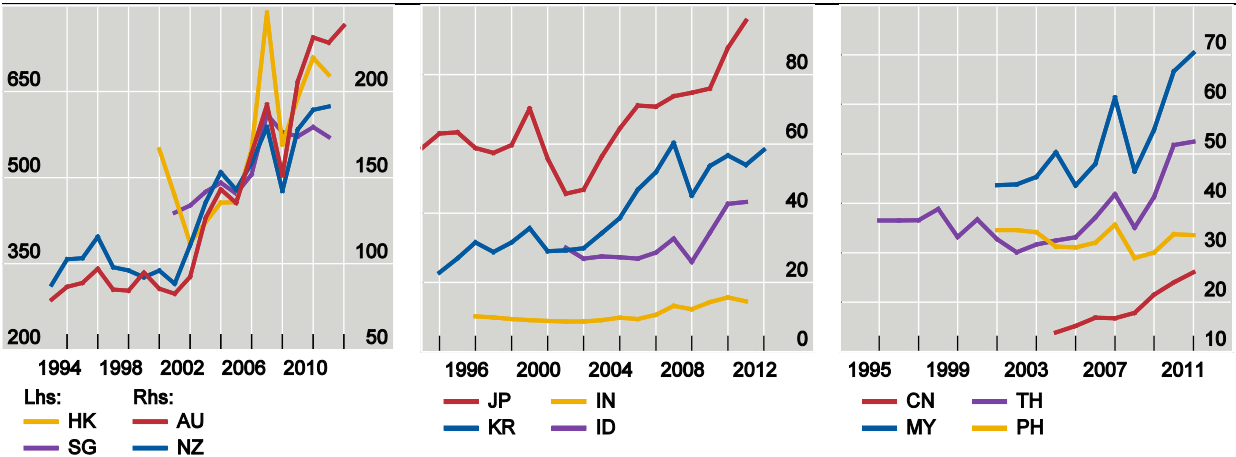
Gross assets as a percentage of GDP at PPP exchange rate   Graph 4A

Source: IMF *International Financial Statistics*; IMF *World Economic Outlook*; CEIC.

International investment positions
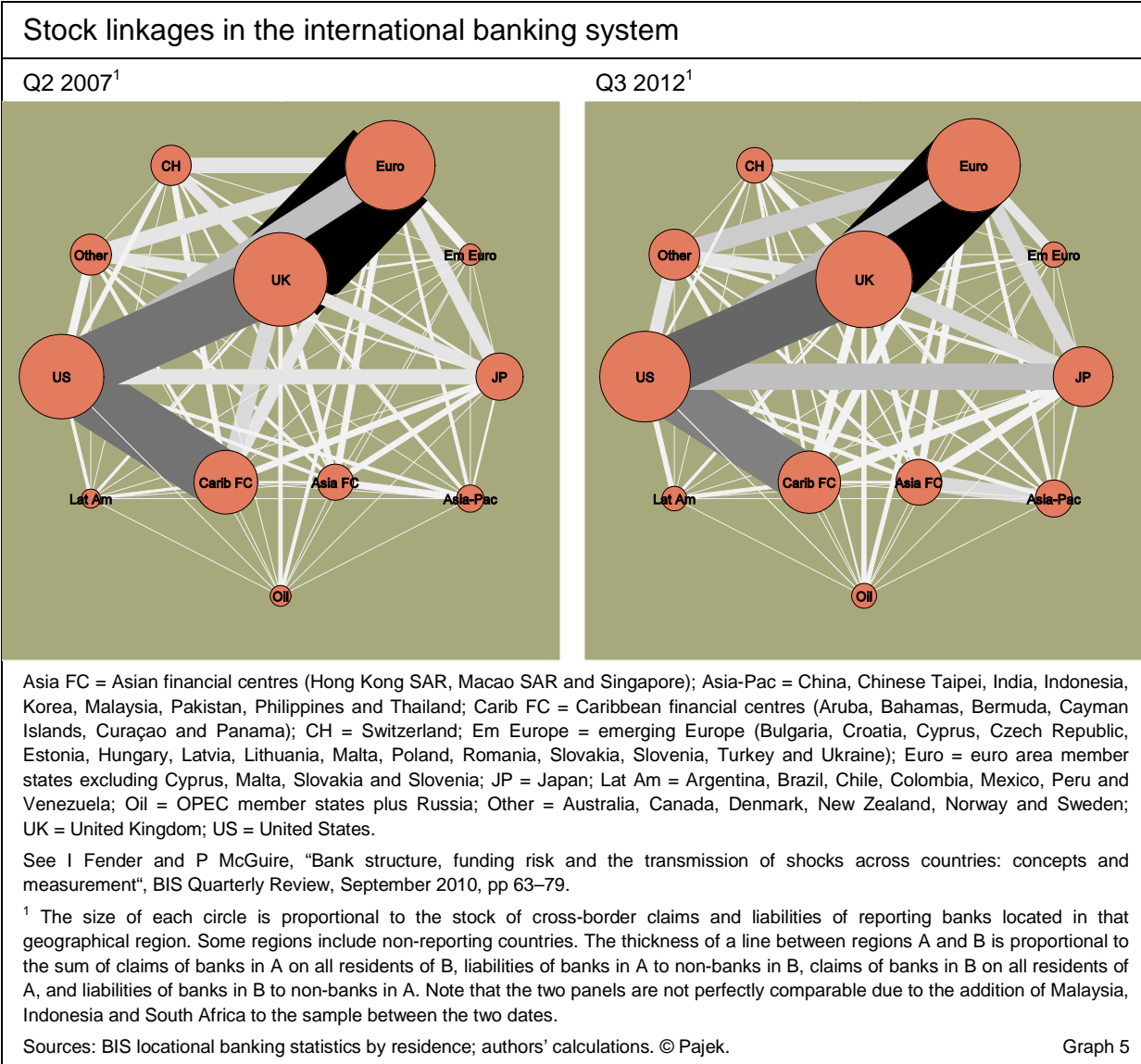
Gross liabilities as a percentage of GDP at PPP exchange rate   Graph 4B

Source: IMF *International Financial Statistics*; IMF *World Economic Outlook*; CEIC.

The international links between banking systems globally, based on BIS data and illustrated in Graph 5, tell a similar story. The size of the circles is proportional to total cross-border positions of banks in a given geographical area, and the thickness of the lines proportional to the cross-border positions

between regions where at least one of the counterparties is a bank. "Asia-Pac" refers to China, Chinese Taipei, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines and Thailand. "Asia FC" consists of Hong Kong SAR, Macau SAR and Singapore.

Stock linkages in the international banking system

Q2 2007[1]   Q3 2012[1]

Asia FC = Asian financial centres (Hong Kong SAR, Macao SAR and Singapore); Asia-Pac = China, Chinese Taipei, India, Indonesia, Korea, Malaysia, Pakistan, Philippines and Thailand; Carib FC = Caribbean financial centres (Aruba, Bahamas, Bermuda, Cayman Islands, Curaçao and Panama); CH = Switzerland; Em Europe = emerging Europe (Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey and Ukraine); Euro = euro area member states excluding Cyprus, Malta, Slovakia and Slovenia; JP = Japan; Lat Am = Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela; Oil = OPEC member states plus Russia; Other = Australia, Canada, Denmark, New Zealand, Norway and Sweden; UK = United Kingdom; US = United States.

See I Fender and P McGuire, "Bank structure, funding risk and the transmission of shocks across countries: concepts and measurement", BIS Quarterly Review, September 2010, pp 63–79.

[1] The size of each circle is proportional to the stock of cross-border claims and liabilities of reporting banks located in that geographical region. Some regions include non-reporting countries. The thickness of a line between regions A and B is proportional to the sum of claims of banks in A on all residents of B, liabilities of banks in A to non-banks in B, claims of banks in B on all residents of A, and liabilities of banks in B to non-banks in A. Note that the two panels are not perfectly comparable due to the addition of Malaysia, Indonesia and South Africa to the sample between the two dates.

Sources: BIS locational banking statistics by residence; authors' calculations. © Pajek.   Graph 5

The Asia-Pacific region has seen a substantial increase in the size of cross-border positions over time. And while, as with gross investment positions, there was a pull-back in the aftermath of the international financial crisis, the strength of current links involving banks are at, or near, all-time highs.

Overall, this graphical evidence is suggestive that the economies in emerging Asia are increasingly internationalised and integrated into global financial markets. One practical implication of this is that the scope for policymakers to use foreign exchange intervention to stabilise exchange rate movements may be becoming more limited. Indeed, in the limit, if financial markets are fully integrated and asset markets are complete, then the implications of the policy trilemma becomes stark. It is possible for central banks to influence exchange rates, but only by using unsterilized intervention. Then any policy response to exchange rates may come at the expense of optimally responding to other macroeconomic variables.

While such a stylised model of efficient markets and full risk sharing is unlikely to match reality, the underlying principle of reduced effectiveness of foreign exchange intervention as financial internationalisation increases is likely to be a practical constraint on policymakers' actions. Effectively,

central bankers may still be able to influence exchange rates as financial internationalisation increases, but not without having to sacrifice some degree of domestic monetary control. In practical terms, as we will later model, increased financial openness reduces the possibility of sterilised intervention – where the exchange rate can be controlled without changing domestic interest rates – while leaving open the possibility of unsterilised intervention.[11]
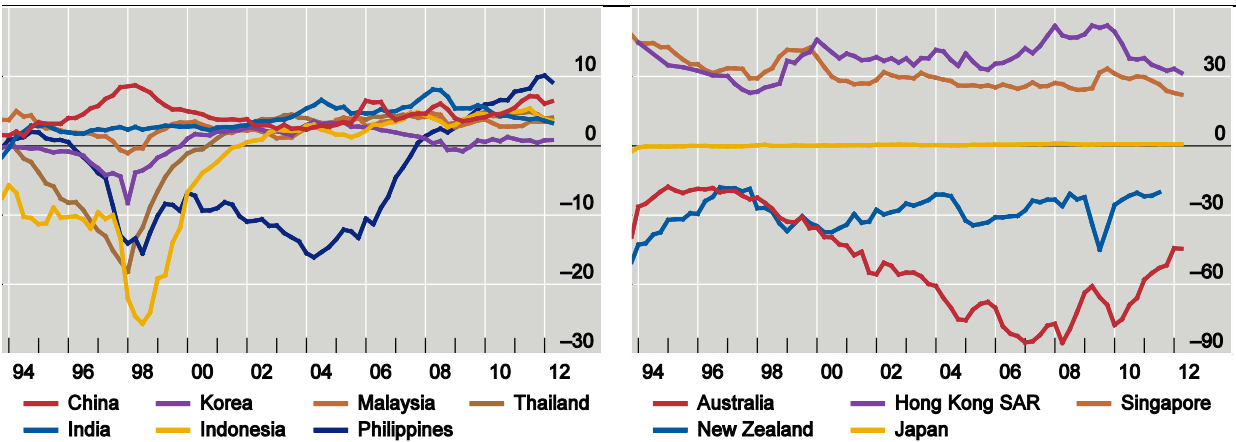
Devereux and Sutherland (2008) examined whether increased international asset positions in themselves influence optimal monetary policy. After all, when international positions are large, exchange rate movements may have considerable wealth effects. However, they show that when large asset positions are the result of efficient portfolio choices, so that the increase in asset positions represents an increase in international risk sharing, movements in the exchange rates are an important ingredient in ensuring the optimal sharing of risk. Then large international positions per se do not support the need for exchange rate stability.

A final important factor that is likely to weigh heavily on the minds of policymakers in emerging Asia when considering the need to stabilise exchange rates is the interaction between exchange rate stability and financial stability. Central to this concern is the degree of mis-match on private sector balance sheets. Suppose that the growing gross international financial positions displayed in Graph 4A represent banks and corporations borrowing heavily in foreign currencies to finance domestic spending, for example. Then any significant depreciation of the domestic currency may threaten the solvency of firms and banks and, ultimately, the entire financial system. This currency mis-match was a central element explaining the propagation and severity of the Asian financial crisis of 1997-99.[12]

There are a variety of possible measures of currency mis-match. We present one specific measure in Graph 6, based on Goldstein and Turner (2004). It is constructed from two variables: the foreign currency share of total debt and net foreign currency assets vis-à-vis non-residents.

Aggregate effective currency mismatch (AECM)[1]   Graph 6

China   Korea   Malaysia   Thailand   Australia   Hong Kong SAR   Singapore
India   Indonesia   Philippines   New Zealand   Japan

[1] The AECM is the product of the economy's net foreign currency asset position (as a percentage of GDP) and the "mismatch ratio", i.e. the foreign currency share of aggregate debt relative to export (or imports)/GDP ratio. Hence an economy with a net foreign currency liability position has a negative AECM; the larger this is in absolute magnitude, the greater the effective currency mismatch.

Sources: IMF *International Financial Statistics*; Datastream; national data; BIS locational banking statistics; BIS international debt securities statistics; BIS domestic debt securities statistics; Goldstein and Turner (2004).

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[11] As with declining exchange rate pass-through, improved inflation performance may encourage increased financial internationalisation. Devereux et al (2013, JMCB forthcoming) show that a monetary policy rule which reduces inflation variability leads to an increase in the size of gross external positions, both in equity and bond portfolios, consistent with increased financial globalisation.

[12] For related discussion, see Calvo (2002).

From the graph, there is a strong correlation between the degree to which economies were affected by the Asian Financial Crisis and the size of the AECM measure in 1997. More recently, the degree of currency mis-match has changed dramatically. With the exceptions of Australia and New Zealand, all regional economies represented here have had positive measures of currency mis-match for at least the last two years, indicating that exchange rate depreciation would increase the overall net-worth of these economies in domestic currency terms, while an appreciation would decrease it, in sharp contrast to earlier periods.

Graphs 7 and 8 represent the main components of the AECM, the net foreign currency asset position and the foreign currency share of aggregate debt, separately. These tell a consistent story. Whereas many economies had considerable net negative asset positions in 1997, they are generally positive and trending up today (Graph 7). Thus the implications of exchange rate movements for financial stability are likely to be less severe than in the past. Given the large (gross and net) stock of foreign assets owned by domestic interests, any sudden rush for the exits from assets denominated in domestic currencies are more likely to be met with inflows as domestic residents repatriate their wealth. This offsetting dynamic was generally not present in the past, and may reduce the macroeconomic fallout from a sudden stop, as well as the need to increase policy rates during a crisis in order to support the domestic currency. Meanwhile, the foreign currency share of debt has been steady or declining in most economies (Graph 8).

Net foreign currency assets

As a percentage of GDP at PPP exchange rate   Graph 7
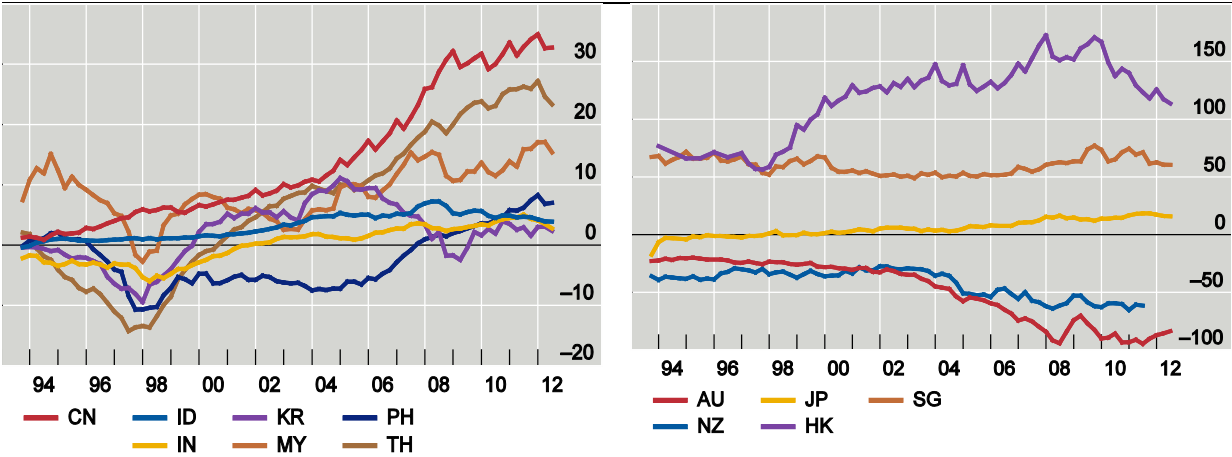
Sources: IMF *International Financial Statistics*; BIS locational banking statistics; BIS international debt securities statistics; BIS domestic debt securities statistics.

One contributing factor to this decline in currency mis-match is the continued development of domestic financial markets. For example, local currency bond markets have grown consistently in emerging Asian economies in recent years, though in some cases from a low base. Domestic borrowers can increasingly find sources of funding without taking on currency risk.[13]

Taking all our arguments together, there is increasing evidence that most of the historical motivations for what have lain at the heart of the so-called "fear of floating" (Calvo and Reinhart, 2002), or reluctance of policymakers to allow nominal exchange rate flexibility, have declined. Improved inflation performance, indicating increased policy credibility, declining currency mismatch and decreased

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[13]   Aghion et al (2009) report empirical evidence that exchange rate volatility results in negative growth outcomes in economies with low levels of financial development. In contrast, for financially advanced economies, they find no relationship.

exchange rate pass-through may now allow for a reassessment of the importance of exchange rate stability in achieving monetary policy goals.

Foreign currency share of total debt outstanding

In percentage   Graph 8
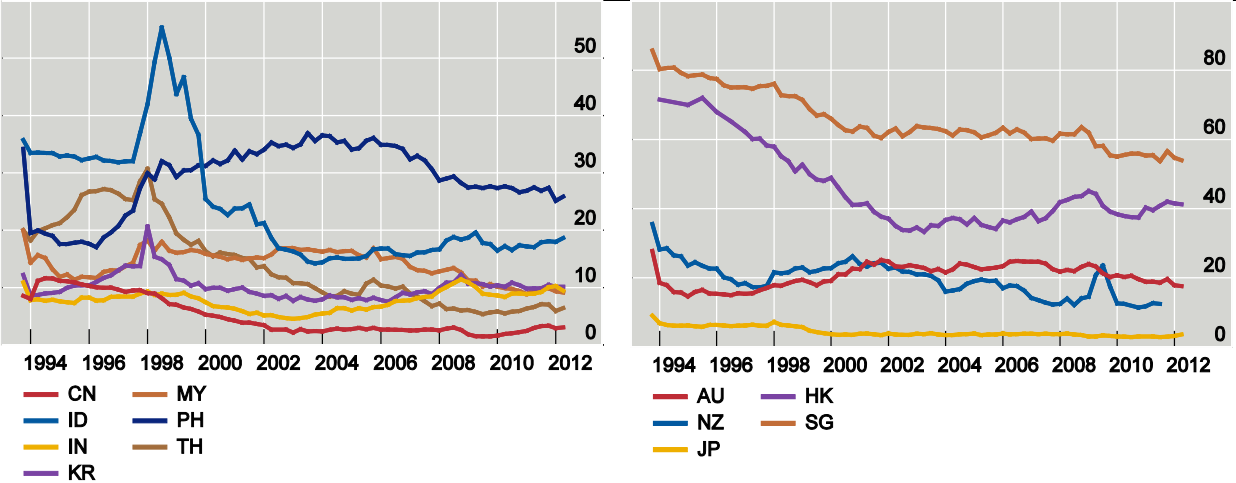
Sources: IMF *International Financial Statistics*; BIS locational banking statistics; BIS international debt securities statistics; BIS domestic debt securities statistics.

In Section 4, we will develop an analytical model to address the effects of two of the three factors discussed above on the optimal central bank response to exchange rates: changes in the degree of exchange rate pass-through and increased financial internationalisation. But first, we discuss the range of central bank responses to exchange rate movements.

3. Policy responses to exchange rates

In many Asian economies, a common response to exchange rate fluctuations has been foreign exchange intervention, intended to smooth the path of exchange rates. Mohanty and Klau (2004) found that some emerging market economies respond more strongly to exchange rate movements than to either inflation or the output gap. More recently, Filardo et al (2011) provided a summary of how emerging market economy central banks respond to exchange rates and reported that central banks managed the value of their currencies more actively in the aftermath of the international financial crisis than before.

One consequence of attempts to manage exchange rates has been the massive expansion of foreign exchange reserves on central bank balance sheets in the region. The overall size of the central bank balance sheet has increased dramatically over the past decade, and lies at around 100% of GDP in the case of Hong Kong and Singapore, and more than 30% of GDP in China, Korea, Malaysia, the Philippines and Thailand. Changes in foreign exchange reserves account for nearly all of the change in the size of the overall central bank balance sheet for these economies (Graph 9).

Turning to the liabilities side of the balance sheet, only a small portion of the increase in foreign exchange reserves has been financed via an increase in the amount of currency in circulation (Graph 10). Instead, increased required reserves and the issuance of sterilisation instruments has been used

to effectively sterilise the effects of the increase in foreign exchange reserves, allowing policymakers to maintain domestic monetary control.[14]

Change in composition of central bank assets in emerging Asia, 2002–12

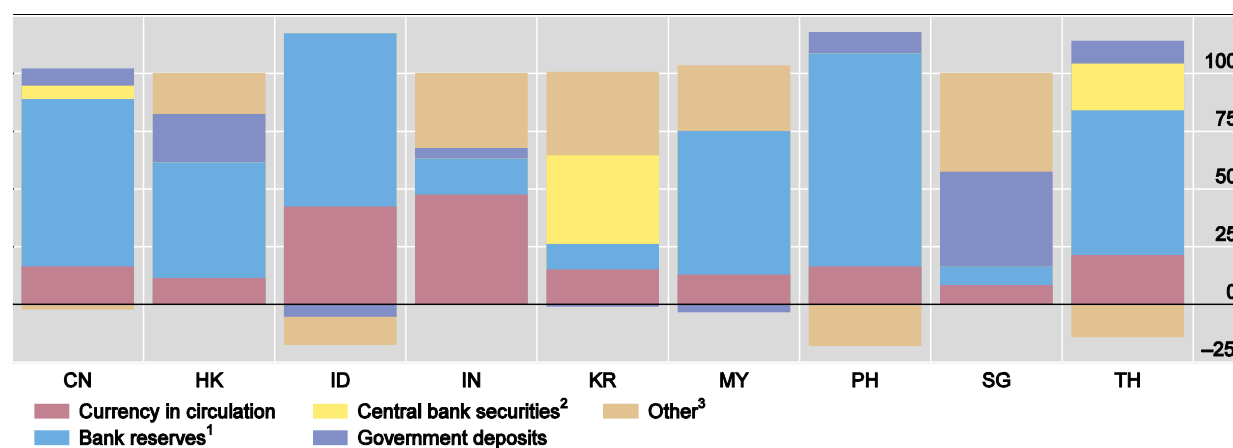As a percentage of change in total assets   Graph 9
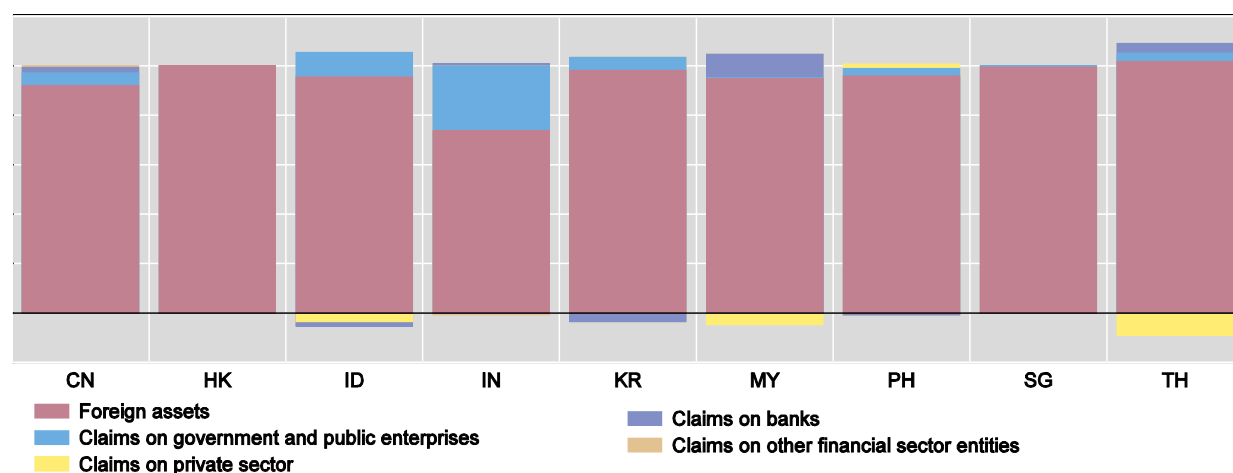
CN = China; HK = Hong Kong SAR; GB = United Kingdom; ID = Indonesia; IN = India; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand.

Source: IMF *International Financial Statistics*.

Change in composition of central bank liabilities in emerging Asia, 2002–12

As a percentage of change in total liabilities   Graph 10

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

[1] Reserves and deposits of banks.   [2] Central bank bonds and securities.   [3] Including other liabilities (foreign liabilities, loans and other net items) and equity capital.

Source: IMF *International Financial Statistics*.

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[14]   See the discussion in Filardo and Yetman (2012).

Going forward, one possibility would be for policymakers to continue with past practice, and offset any on-going exchange rate pressures with intervention. However, there are two reasons why this is becoming a less attractive policy option. First, as we have argued above, Asia is becoming more financially internationalised. Thus, it may be increasingly likely that attempts to intervene in foreign exchange markets will simply be offset by other market participants, so that policy measures fail to have their desired effect on exchange rates. Second, the already large holdings of foreign exchange reserves are very costly to the central banks in the region, and are only likely to become more so as they grow larger, especially if appreciation pressures remain dominant.

Table 1 offers a simple illustration of the possible costs of large reserves, under the simplifying assumption that all reserves are held in short term US treasury bills and are financed (or, equivalently, sterilised) via the sale of short term sterilisation bills with an interest cost equal to the domestic deposit rate.[15]

Estimates of sterilisation costs and valuation losses from domestic currency appreciation

As of December 2012 Table 1

	FX reserves (USD billions)	Short-term rate (%)	Central bank equity[1,2]	100% sterilisation cost[1,3]	Valuation loss for a 10% appreciation of domestic currency (%)[1]
AU	44.94	3.17	0.13	0.10	0.29
CN	3331.12	3.78	0.04	1.11	4.04
HK	317.23	0.40	31.17	–0.31	12.30
IN	270.59	8.74	0.07	0.73	1.39
ID	106.04[4]	4.92	2.02	0.64[4]	1.18[4]
JP	1227.15	0.28	0.00	0.05	2.05
KR	323.21	2.89	0.88	0.90[4]	2.81
MY	137.75	3.21	0.01	1.22	4.48
NZ	17.58	2.64	1.30	0.39	1.05
PH	73.48	0.83	0.55	0.89	3.05
SG	259.09	0.31	20.49	–0.12	9.67
TH	173.33	2.93	2.61	0.98	4.60

[1] As a percentage of nominal GDP. [2] Capital and reserves for AU and NZ; provisions and other liabilities for SG; net worth or own capital for others. [3] Assumes entire FX reserve is invested in 1–3 year US government bonds and the funding rate is the domestic deposit rate. [4] As of September 2012.

Sources: IMF *IFS*; Bloomberg; Datastream; BIS calculations.

One component of this is carrying (or sterilisation) costs. Typically, domestic interest rates in Asia are higher than the yields central banks earn on their reserves. The difference between these two is a loss to the central bank, and may be as much as 1.2% of GDP per year for some economies. Another, potentially much larger, cost could result from an appreciation in the domestic currencies. For illustrative purposes, the table considers a 10% appreciation against the US dollar under the simplifying assumption that all foreign exchange reserves are held in US dollar denominated instruments, and indicates that the mark-to-market losses as a per cent of GDP for the central banks

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[15] See also the discussion in Cook and Yetman (2012).

in the region would be considerable. As a comparison, the table also displays central bank equity, which is available to absorb central bank losses, again as a per cent of GDP, and illustrates that this is low relative to potential losses. While a central bank can in principle continue to operate with low, or even negative, capital, this is unlikely to be desirable in the long run.

4. An open economy model

We now outline a simple model consisting of two economies, home and foreign. The model is largely a standard New Keynesian framework, with a mixture of producer currency pricing and local currency pricing.[16] We add one new twist, based on Devereux and Yetman (2013). First, consider an economy that is perfectly integrated into global financial markets, such that there is perfect international risk sharing, with complete markets. Then, in standard open-economy models, the following condition will be satisfied:

$$\left(\frac{C_t^{-\sigma}}{C_t^{*-\sigma}}\right)\left(\frac{P_t}{S_t P_t^*}\right)=1, \tag{1}$$

where C is consumption, P is the price level, S is the nominal exchange rate (defined as number of units of domestic currency per unit of foreign currency, so that an increase is a domestic currency depreciation), σ is the inverse of the elasticity of inter-temporal substitution and an asterisk (*) indicates a variable for the foreign economy. Under complete risk sharing, this condition should always be satisfied, irrespective of the behaviour of policymakers, as a result of optimizing behaviour by consumers.

Now, consider an alternative extreme case where, due to high transactions costs or capital controls, there is financial autarky (with one exception), but trade is fully open. Suppose that the only form of international financial transactions, other than to pay for trade, is changes in the official foreign reserves of the central bank. Then we would expect the following condition to hold:

$$\frac{\overline{P}_t Y_t - \Delta(FR_t)}{P_t C_t}=1, \tag{2}$$

where Y is total domestic production, $\overline{P}$ is the average price, in domestic currency, received by domestic producers, and FR is the total stock of foreign exchange reserves, measured in domestic currency. Excluding the role of foreign exchange reserves, we have balanced trade in our autarkic economy: the total value of production must equal the total value of consumption. But a change in the stock of foreign exchange reserves drives a wedge between production and consumption. An increase in foreign exchange reserves implies a trade surplus, and a decrease a trade deficit.

Clearly conditions (1) and (2) represent polar extremes of perfectly open and integrated international financial markets, and perfectly closed. We also consider intermediate cases, by combining these two conditions in the following way:

$$\left[\left(\frac{C_t^{-\sigma}}{C_t^{*-\sigma}}\right)\left(\frac{P_t}{S_t P_t^*}\right)\right]^{\lambda}\left[\frac{\overline{P}_t Y_t - \Delta(FR_t)}{P_t C_t}\right]^{1-\lambda}=1. \tag{3}$$

By varying the value of λ, we can approximate any intermediate case between complete financial autarky and complete international risk sharing.[17]

Note that it is immediately clear that, by construction, the effectiveness of foreign exchange reserves as a policy tool that policymakers can use will depend critically on the level of financial

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[16] The model is similar to Engel (2011, 2013).

[17] Devereux and Yetman (2013) show that this condition can be derived based on a tax on the financial returns from investing in foreign assets.

internationalisation. In particular, in the limit, as $\lambda \to 1$, a change in foreign exchange reserves will have no effect on exchange rates.

We combine this condition with a largely standard New Keynesian open-economy model with the following distinguishing features. We allow for a portion δ of imported goods to be priced in the consumers' currency and the remainder in the producers' currency, as in Berka, Devereux and Engel (2012). As we outlined in the previous section, short-run exchange rate pass-through appears to have declined in many economies in recent years, so that the link between exchange rate changes and inflation has weakened. We can model this analytically by assuming that a greater portion of imported goods are now priced in the consumers' currency (commonly referred to as local currency pricing), rather than the producers' currency (producer currency pricing).

We also allow the policymaker to respond to exchange rate changes in two ways. First, we assume that interest rates, which are assumed to be a policy instrument, respond not just to CPI inflation, but also to the change in the nominal exchange rate in the home country. One may think of this as being a form of unsterilised foreign exchange intervention, since interest rates are affected by policy actions intended to influence exchange rates.

Second, we allow policymakers to intervene directly in foreign exchange markets by allowing foreign exchange reserves to respond to changes in the nominal exchange rate. This will directly affect the solution to equation (3) above. We assume that:

$$\Delta(FR)_t = \left(\frac{S_{t-1}}{S_t}\right)^{\nu},$$ (4)

where lower case letters indicate per cent deviations from steady-state values. One may think of foreign exchange intervention of this nature as a form of sterilised intervention, as interest rates are not directly affected by such policy actions that influence the exchange rate.

There are few existing papers that model sterilised intervention in a comparable manner. Prasad (2013) shows that capital controls and sterilised intervention, used together, can be welfare-improving by offering the central bank an additional policy tool. The combination of these two tools allows authorities to effectively choose the level of foreign bond holdings. Since households do not take account of the effect of their foreign bond-buying decisions on prices, and central banks can, the ability to control holdings of foreign bonds can be welfare enhancing. In contrast, we take the degree of financial internationalisation as given and compare the effectiveness of sterilised intervention versus unsterilised intervention in pursuit of policy goals.

Another paper that is similar to the approach considered here is Benes et al (2013).[18] They also allow for two different monetary policy responses to exchange rates, including both interest rate responses and sterilized foreign exchange intervention. But their modeling of the latter differs from ours. They assume that foreign exchange intervention works through a portfolio balance effect to influence endogenous interest rate spreads, and hence exchange rates. In their model, the central bank adjusts the stock of foreign exchange reserves according to:

$$\log(F/L) = \log(\overline{F}/L) - \omega \log(S^T/S) - \vartheta \log(S_{-1}/S),$$ (5)

where $\overline{F}/L$ is the steady state ratio of foreign exchange reserves to the stock of credit and S^T is the exchange rate target. ω is a policy parameter between 0 and ∞ that captures how strongly foreign exchange intervention is used to stabilise exchange rates.

One way of interpreting our model is that we endogenise ω and treat it as a function of the degree of financial internationalisation. In this way, our model fully captures the idea of the trilemma: policymakers can choose any two of exchange rate fixity, domestic interest rate control and capital account openness.

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[18] See, also, Ostry et al (2012), who construct a reduced-form linear model where sterilised intervention and interest rates are used to minimise a quadratic loss function in the output gap, inflation, the exchange rate and the stock of reserves.

The full model, together with its log-linearisation, are outlined in the appendix. A full set of variable and parameter names, descriptions and parameter values in our model is given in Table 2.

Variables and parameters

Table 2

Names	Description	Name	Description	Value
c	Consumption	σ	Inverse of elasticity of inter-temporal substitution	2.0
p	Price level	υ	Home bias in consumption	1-2
s	Exchange rate	ξ	Elasticity of substitution between different varieties of home (foreign) goods	11.0
y	Output	δ	Share of imports that are LCP (remainder PCP)	0-1
τ	Terms of trade	λ	Degree of financial internationalisation	0-1
Δ	Deviation from law of one price	v	Response of foreign reserves to nominal exchange rate changes	0-∞
fr	Foreign exchange reserves	β	Discount rate	0.99
u	Cost-push shock	κ	Degree of price stickiness	0.075
a	Productivity shock	ϕ	Elasticity of labour supply	1.0
V	Welfare	ζ	Interest rate response to inflation	0-∞
		γ	Home interest rate response to the change in exchange rates	0-∞

5. Results

We now examine the results of our model, focusing on how a central bank can utilise sterilised or unsterilised foreign exchange intervention to improve welfare. We compute the maximum achievable level of global welfare under four different assumptions about how monetary policy is set. First, monetary policy is characterised by a simple Taylor-type rule, where interest rates in both countries respond linearly to domestic CPI inflation (labelled "Taylor" in the graphs that follow). Second, monetary policy is characterised by a Taylor-type rule, but where interest rates in the home country also respond linearly to the change in the nominal exchange rate ("Taylor + unsterilised"). Third, monetary policy is characterised by a Taylor-type rule in both countries, but the home country monetary authority can also make use of sterilised intervention in foreign exchange markets, where the change in foreign exchange reserves is a linear function of the change in the nominal exchange rate ("Taylor + sterilised"). Finally, we also compute the optimal Ramsey outcome, where the responses of interest rates in both countries, and the change in foreign exchange reserves in the home country, are chosen optimally so as to maximise global welfare ("Ramsey").[19]

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[19] The first three of these are solved using the "optimal simple rules" routine in Dynare, and the final one using the "Ramsey policy" routine.

We consider two different shocks: a productivity shock and a cost-push shock. In each case, both countries are subject to independent shocks that have AR(1) persistence coefficients of 0.5. We then examine the relative performance of the different monetary policy regimes across three different dimensions:

- Varying the degree of financial internationalisation. $\lambda = 0$ corresponds to financial autarky, where trade must be balanced except for any change in foreign exchange reserves. $\lambda = 1$ corresponds to complete international financial markets, and complete international risk sharing. In such an economy, sterilised foreign exchange intervention is ineffective by construction. We can think of this as a world in which Ricardian equivalence holds, so any change in foreign exchange reserves will be perfectly offset by the actions of other economic actors and have no effect on prices, exchange rates or real variables.

- Varying the degree of exchange rate pass-through. δ measures the proportion of imported goods that is priced in the local currency; $(1-\delta)$ is priced in the producer's currency. Low δ implies that any change in the exchange rate will quickly translate into inflation. This heightened sensitivity means that the exchange rate is a key driver of domestic inflation, but also that exchange rate control may be an effective way to target the inflation rate.

- Varying the degree of goods market integration. υ is a measure of home bias in consumption. For $\upsilon = 2$ there is no international goods trade, and our model reduces to two closed economies. For $\upsilon = 1$, there is no home bias in consumption, and consumers in each country share identical preferences over home and foreign goods.

Graph 11 illustrates the effectiveness of different policy rules at achieving optimal welfare in response to productivity shocks. The horizontal axis is the proportion of imports that are priced in the local currency, δ. The top panel is under financial autarky ($\lambda = 0$), and the bottom panel with complete financial internationalisation ($\lambda = 1$). In-between levels of financial internationalisation are qualitatively similar to the autarky case. In this exercise, there is some home-bias in consumption ($\upsilon = 1.5$).

Welfare effects of productivity shocks

Home bias (υ=1.5)   Graph 11

Financially closed (λ=0.0)   Financially open (λ=1.0)
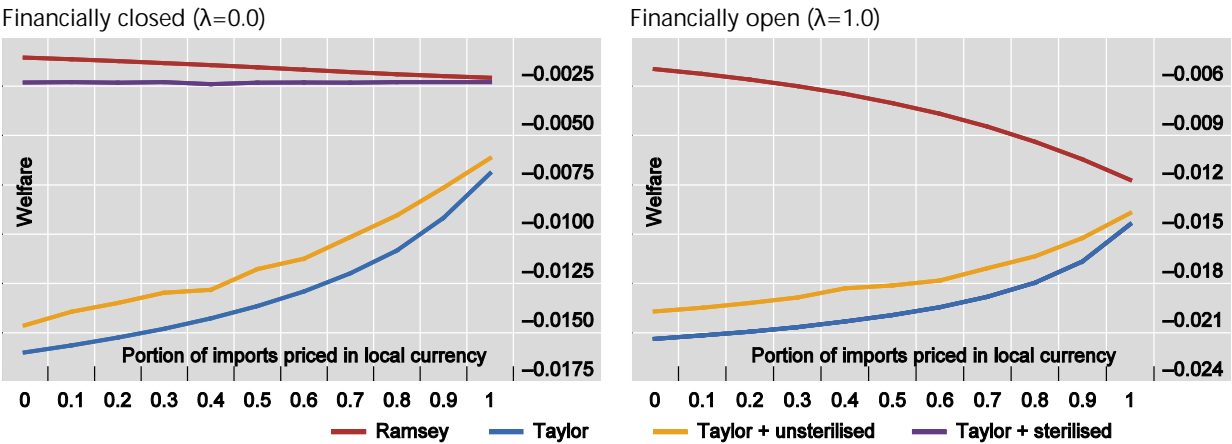
Source: Authors' calculations.

In both panels, welfare under the optimal Ramsey policy is deteriorating in the degree of local currency pricing. This is because a high level of short-run exchange-rate pass-through implies that

policymakers can use the exchange rate, in addition to interest rates, to influence the consumption level of consumers and to thereby achieve optimal levels of expenditure switching. But as the level of local currency pricing increases, and short-run pass-through correspondingly decreases, the potency of this additional lever declines. Note, however, that when we restrict monetary policy to follow simple linear rules, the negative association between the degree of local currency pricing and welfare is eliminated.

Perhaps the most important result here is that, with less-than-complete financial internationalisation, a combination of sterilised intervention and following a simple Taylor rule where the coefficient is chosen optimally comes close to achieving the optimal Ramsey outcome. However, there is little substitutability between sterilised and unsterilised intervention. This is because, with unsterilised intervention, any improvement in outcomes is the result of a trade-off: a single policy instrument (interest rates) is being used to respond to an additional variable. In welfare terms, that trade-off is barely worth making: the paths of all nominal and real variables are little changed whether the central bank responds only to inflation or to both inflation and exchange rate changes optimally. In contrast, unsterilised intervention represents an additional policy tool that does not compromise the effectiveness of interest rates in responding to other variables.
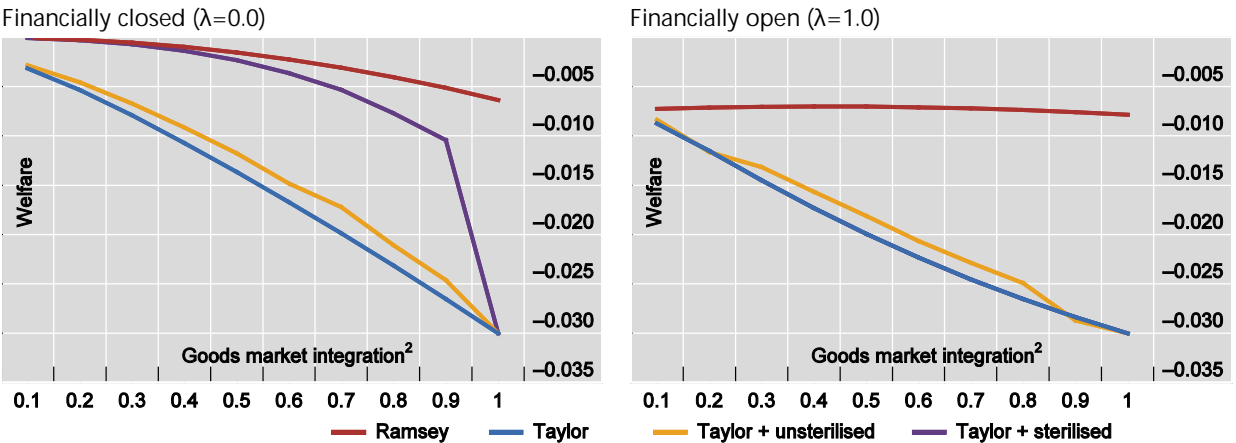
In a world of complete financial internationalisation, sterilised intervention is no longer effective. Instead, the only avenue for policymakers to influence the exchange rate is through unsterilised intervention. And when the policymaker cannot use sterilised intervention as a secondary policy tool, they cannot get as close to Ramsey outcome, *conditional* on the level of financial internationalisation.

Graph 12 repeats the same exercise but with the degree of short-run exchange rate pass-through fixed such that half of imports are priced in the producer currency, and half in the local currency ($\delta = 0.5$). Instead, the degree of goods market integration is varied between $\upsilon = 1.9$ (the economies are almost closed) and $\upsilon = 1.0$ (no home bias in consumption). The horizontal axis- goods market integration- is defined as $(2 - \upsilon)$, so that a higher number corresponds with greater integration. Note that the levels of welfare across different values of goods market integration are not directly comparable, since υ is a preference parameter. Instead, the purpose of the exercise is to focus on the relative performance of the different policy measures at given levels of goods market integration.

Welfare effects of productivity shocks

Mixture of local and producer currency pricing (δ=0.5)[1]   Graph 12

Financially closed (λ=0.0)   Financially open (λ=1.0)

Legend: Ramsey — Taylor — Taylor + unsterilised — Taylor + sterilised

[1] Half of all import varieties are assumed to be priced in the local currency and half in the producer currency.   [2] Goods market integration is defined as 2-υ.

Source: Authors' calculations.

With high levels of home bias, sterilised intervention, if feasible, is an especially potent tool for achieving close to the first-best outcome. Without sterilised intervention, a positive domestic

productivity shock would cause the domestic currency and terms of trade to depreciate, distorting consumption decisions. The appropriate use of sterilised intervention can be used to prevent this.

But the effectiveness of sterilised (and unsterilised) intervention in response to productivity shocks relies on some degree of home bias. In the limit of no home bias in consumption, provided the monetary policy response to inflation is optimal, there are no gains to intervening in foreign exchange markets in response to productivity shocks. (This is true independent of the degree of exchange rate pass-through and financial internationalisation). This is because the optimal response to inflation via the Taylor rule is sufficient to fully stabilise inflation and, when consumers in both countries have identical preferences over both home and foreign goods, this also fully stabilises the nominal exchange rate. Given that the exchange rate is fully stabilised, there are no gains to a monetary policy rule that entails a response to the exchange rate over one that simply responds to inflation.

More generally, if goods markets are not fully integrated, then even if inflation in both countries is stabilised, the price of imported goods will tend to behave differently from the price of domestically produced goods, and the exchange rate will vary in response to productivity shocks. In that case, sterilised intervention can be effective. This is because the efficacy of sterilised intervention depends on its ability to reduce trade frictions, independent of the degree of financial integration. In the no-home-bias case, there are effectively no trade frictions to overcome, and so sterilised intervention is ineffective.

One way to understand the results of our model is to note that the quadratic approximation to the welfare function (laid out in the appendix) includes terms in output gaps, inflation rates and deviations from the law of one price. When monetary policy is constrained to follow a simple response to CPI inflation, the best that it can achieve in response to a productivity shock is to stabilise inflation. This also eliminates much (but not all) of the output gaps in our model. In the case of no home bias, coincidentally, this also eliminates deviations from the law of one price. More generally, however, there is an inconsistency between the interest rate that removes inflation volatility and that which eliminates volatility in deviations from the law of one price. Then adding an additional policy tool – sterilised intervention – is a potent tool that can be used to adjust exchange rates so as to eliminate deviations from the law of one price, and so maximise global welfare.

In the following two graphs we repeat the analysis for a cost-push shock, across the same dimensions as above. The results are broadly similar, with the following exceptions. Whereas unsterilised intervention could play a (small) role in improving welfare in response to productivity shocks, they have virtually no role to play in response to cost-push shocks. And whereas sterilised intervention could come close to achieving the optimal outcome in response to productivity shocks, the gap is larger with cost-push shocks. The intuition behind these results is that, given an optimal response to inflation, remaining movement in the exchange rate acts as a shock-absorber in response to cost-push shocks; reducing the volatility of the exchange rate further moves output and consumption further from the optimal Ramsey path relative to simply following a Taylor rule. In contrast, in response to a productivity shock, stabilising the exchange rate moves the real variables in the model closer to their optimal Ramsey path. The nominal exchange rate in the case of a productivity shock is not acting as an effective shock absorber.

One interesting outcome across all our results is the relative unimportance of the degree of financial internationalisation. Visually, for all levels of $\lambda < 1$, the graphs look similar to the financially closed ($\lambda = 0$) case presented above. As λ increases, provided it remains below 1.0, there is little impact on the achievable level of welfare. But once we move to a world of perfect financial internationalisation then, by construction, sterilised intervention no longer plays a role.

One limitation in this interpretation of our results is that we do not capture the potential costs of volatile reserves in our model. As the level of financial internationalisation increases, but remains incomplete, central banks are able to achieve exactly the same outcome with ever increasing foreign exchange intervention. But this implies that the volatility of foreign exchange reserves is increasing in the level of financial internationalisation.

Welfare effects of cost-push shocks

Home bias ($\upsilon=1.5$) Graph 13

Financially closed (λ=0.0)   Financially open (λ=1.0)
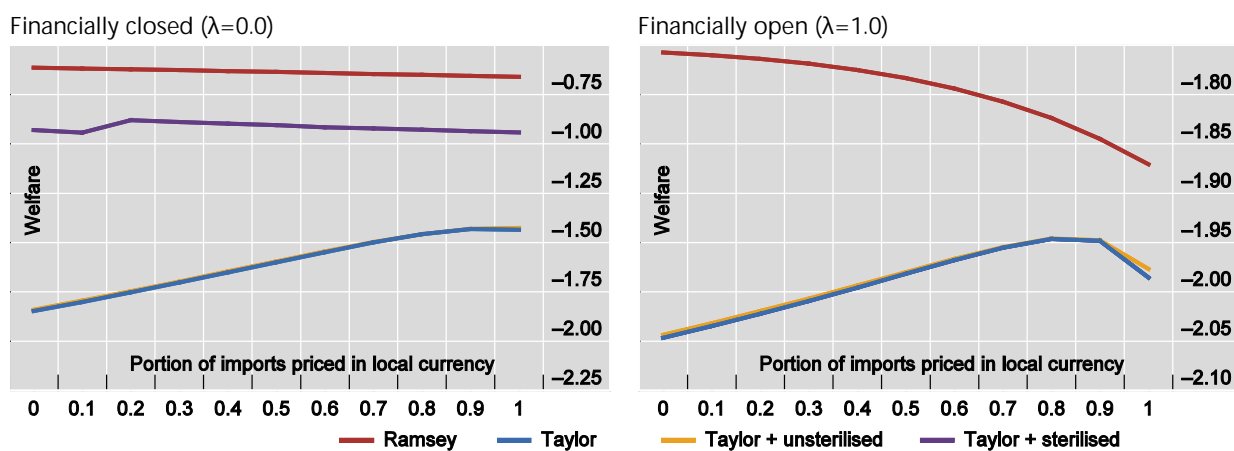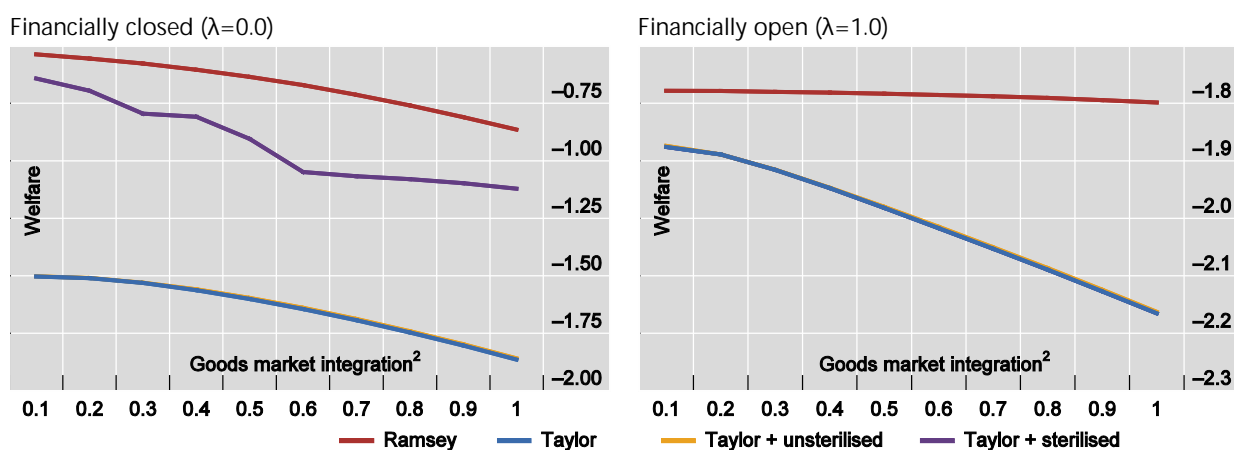

Source: Authors' calculations.

Welfare effects of cost-push shocks

Mixture of local and producer currency pricing ($\delta=0.5$)[1] Graph 14

Financially closed (λ=0.0)   Financially open (λ=1.0)

[1] Half of all import varieties are assumed to be priced in the local currency and half in the producer currency. [2] Goods market integration is defined as 2-υ.
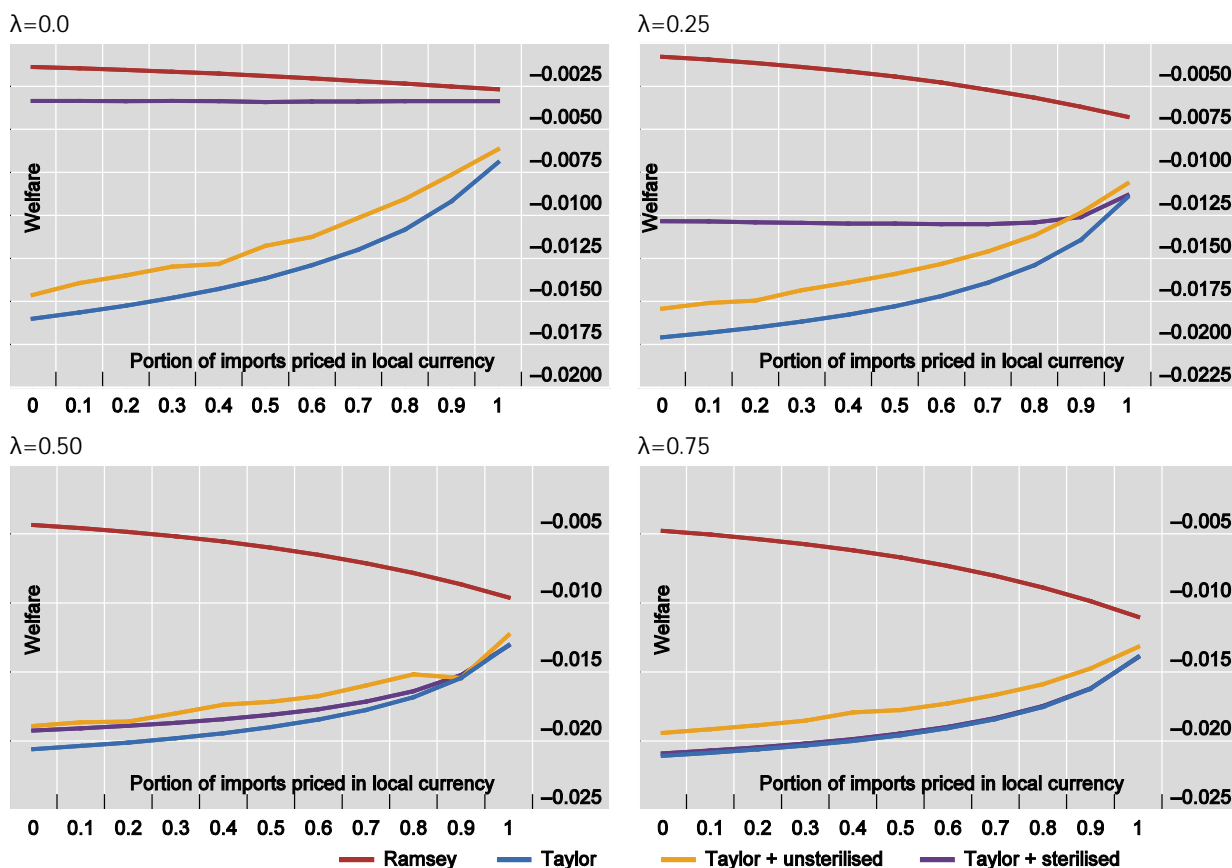
Source: Authors' calculations.

Clearly policymakers would ascribe a negative welfare impact to highly volatile foreign exchange reserves. While explicitly modelling the cost of volatile reserves is beyond the scope of the current paper, we address this issue by adding an additional term to the welfare function of $(fr_t - fr_{t-1})^2$, with a weight of negative one. In Graph 15 we present analogous results to those presented previously in Graph 11 for a range of levels of financial internationalisation, but incorporating this negative welfare effect of foreign reserves volatility. This has the intuitive effect of lowering the gains available from

pursuing sterilised intervention, such that unsterilised intervention dominates sterilised intervention long before the economies are fully financially internationalised.[20]

Welfare effects of productivity shocks with costly reserves volatility

Home bias (υ=1.5)   Graph 15

λ=0.0

λ=0.25

λ=0.50

λ=0.75

Ramsey — Taylor — Taylor + unsterilised — Taylor + sterilised

Source: Authors' calculations.

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6. Conclusions

In this paper, we have examined how monetary policy should respond to nominal exchange rate changes. We have shown how the optimal response to exchange rates depends on the degree of financial internationalisation, goods market integration and exchange rate pass-through. Sterilised intervention can be a potent tool that offers policymakers an additional degree of freedom in maximising global welfare. The potential welfare benefits from sterilised intervention are largest when exchange rate pass-through is high, when international goods markets are poorly integrated and in response to real productivity shocks (less so with nominal cost-push shocks).

However, as the international policy trilemma implies, there are limitations to the use of sterilised intervention. As financial internationalisation increases, achieving a given degree of exchange rate stability requires ever increasing changes in foreign exchange reserves. Taking into account the costs

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[20] For analogous graphs to Graphs 12, 13 and 14 where foreign exchange reserves volatility are costly, please see the appendix.

of volatile reserves, increased financial internationalisation reduces the role for sterilised intervention. And in the case of fully integrated international financial markets, sterilised intervention has no influence on exchange rates at all.

Where sterilised intervention is no longer a desirable policy tool, unsterilised intervention may have a small role to play. However, the potential welfare gains from the optimal use of unsterilised intervention in our model are between relatively small (in the case of productivity shocks) and negligible (cost-push shocks). With unsterilised intervention, a single policy instrument (interest rates) is being used to respond to an additional variable (exchange rates). In contrast, unsterilised intervention represents an additional policy tool that does not compromise the optimal response of interest rates to other variables.

Most central banks in Asia have actively used sterilised foreign exchange intervention as a policy tool to smooth exchange rate movements over time. In our model, the use of sterilised intervention represents optimal policy when goods markets and financial markets are not well integrated internationally and exchange rate pass-through is high. But these characteristics are changing in the region. By most metrics, the degree of exchange rate pass-through has fallen. The combination of developing domestic financial markets, and declining barriers to international capital flows, has seen increased financial internationalisation. And goods markets have become more integrated as consumer preferences across countries have moved closer together.

The effect of these changes is to reduce the benefits of stabilising exchange rates with sterilised foreign exchange intervention in our model. And, given the limited effectiveness of unsterilised intervention, our model results imply that the role of exchange rate movements in the optimal setting of monetary policy is decreasing across the region.

Appendix

Take a model of two countries, where in each country households consume and choose how much to work given wages and prices. The countries are referred to as 'home' and 'foreign'. The countries are of equal size (with population normalized to unity). Consumption takes place across a range of differentiated goods. Asset markets are complete within countries, but between countries we construct a mechanism which allows for asset market completeness to vary between financial autarky and a full set of security markets. Firms produce goods, but product prices are sticky. We allow for prices of exported goods to be set either in the currency of the producer (PCP) or the buyer (LCP). In addition, we allow for home bias in consumption preferences, so that we can vary the degree of trade integration.

Households

Let the utility of a representative home household evaluated from date zero be defined as:

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t (U(C_t) - V(N_t)), \tag{6}$$

where U and V represent the utility of the composite home consumption bundle C_t and disutility of labour supply N_t, respectively. U is differentiable and concave in C, while V is differentiable and convex in N.

Consumption is defined as:

$$C_t = \Phi C_{Ht}^{\upsilon/2} C_{Ft}^{1-\upsilon/2}, \upsilon \geq 1, \tag{7}$$

where $\Phi = (\upsilon/2)^{\upsilon/2}(1-\upsilon/2)^{1-\upsilon/2}$, C_{Ht} is consumption of the home country composite good, and C_{Ft} is consumption of the foreign composite. The parameter $\upsilon \geq 1$ allows for home bias in preferences. In addition, C_{Ht} and C_{Ft} are defined over the range of home and foreign differentiated goods with elasticity of substitution $\theta > 1$ between goods, so that:

$$C_H = \left[\int_0^1 C_H(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \quad C_F = \left[\int_0^1 C_F(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}. \tag{8}$$

Price indices for home and foreign consumption may be written as:

$$P_H = \left[\int_0^1 P_H(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}, \quad P_F = \left[\int_0^1 P_F(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}. \tag{9}$$

while the aggregate (CPI) price index for the home country is $P = P_H^{\upsilon/2} P_{Ft}^{1-\upsilon/2}$. In addition to this decomposition, we assume that foreign goods consumption can be further differentiated between PCP goods and LCP goods, with shares of $(1-\delta)$ and δ respectively. This allows us to vary the measure of export prices which are set in home and foreign currency, but has no effect on the flexible price equilibrium of the model.

Demand for the individual differentiated goods and home and foreign composite goods can be derived from these functions in the usual way. Individual firms choose prices given a demand elasticity of θ.

The representative home household sells labour services to each of a continuum of home country firms, and receives a nominal wage W_t in return. The household's implicit labour supply is determined by the condition:

$$U_c(C_t)W_t = P_t V'(N_t). \tag{10}$$

We assume that there is a full set of state-contingent securities traded between home and foreign residents. However, there is a state-contingent wedge in the security returns across countries that prevents the equalization of marginal utilities of asset returns between households in the two countries. Denote this wedge as Ω_t. Then we have the risk-sharing relationship given by:

$$U_c(C_t) = U_c(C_t^*) \frac{S_t P_t^*}{P_t} \Omega_t, \tag{11}$$

where S_t is the nominal exchange rate (home price of foreign currency). The real exchange rate $S_t P_t^* / P_t$ will be driven by two factors: a) deviations from the law of one price in home and foreign goods, due to local currency pricing, and b) movements in the terms of trade (price of foreign to home goods) which, in the presence of home bias in consumption, will drive movements in the relative CPI's over time.

Now we assume that the wedge in risk-sharing is governed by the functional relationship:

$$\Omega_t = \left(\frac{P_t C_t}{\overline{P}_t Y_t - \Delta(FR_t)} \right)^{\frac{1-\lambda}{\lambda}}, \tag{12}$$

where Y_t represents home country GDP, an average of the output of all home firms, $\overline{P}_t$ is the average selling price of all goods produced by home firms and $\Delta(FR_t)$ is the change in the stock of foreign exchange reserves. This form can be rationalized by the presence of lump-sum financed taxes that are conditioned on the ratio of consumption to domestic GDP. The specific usefulness of (12) is that it allows us to vary the effective degree of asset market completeness between that of un-restricted cross country risk-sharing (when $\lambda = 1$) to financial autarky (when $\lambda = 0$).[21]

We assume also that households hold domestic nominal government bonds, which pay an interest rate of R_t in all states of the world. Then the Euler equation for nominal bond pricing is given by:

$$\frac{U_c(C_t)}{P_t} = \beta R_{t+1} E_t \frac{U_c(C_{t+1})}{P_{t+1}}. \tag{13}$$

Foreign household's actions can be defined exactly analogously. As we see from the definition of P_t^* given above, the foreign representative household has weight $\upsilon/2$ on the foreign ($1 - \upsilon/2$ on the home) composite good.

Firms

Firms use labour to produce individual differentiated goods. Firm i in the home country has the production function:

$$Y_t(i) = A_t N_t(i), \tag{14}$$

where A_t is productivity. The home firm's profits are defined by:

$$\Pi_t(i) = P_t(i) Y_t(i) - (1 - s_t) W_t N_t(i), \tag{15}$$

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[21] The form of this risk-sharing wedge is used in Devereux and Yetman (2013). The appeal of (12) is that it allows for intermediate degrees of asset market completeness without adding on additional state variables into the model, as would be the case, for instance, if we limited asset trade across countries to that of non-state contingent bonds.

where s_t is a wage subsidy given to all home firms by the home government, financed with lump-sum taxation. This facilitates approximation of the model around an undistorted steady state.

We assume that each home firm re-sets its price according to Calvo pricing, where the probability of re-adjusting its price is $(1-\kappa)$ in each period. Under PCP the home firm sells its product to home and foreign consumers, and the home government, at a common price (adjusted for the exchange rate in the case of exported goods), facing an elasticity of demand of θ. When the firm can adjust its price, it sets the new price, denoted $\hat{P}_{Ht}(i)$, so as to maximize the present value of profits evaluated using the stochastic discount factor:

$$m_{t+j} = \frac{P_t}{U_c(C_t)} \frac{U_c(C_{t+j})}{P_{t+j}}. \tag{16}$$

This leads to the optimal price setting condition as follows:

$$\hat{P}_{Ht}(i) = \frac{\theta}{\theta-1}(1-s_t) \frac{E_t \sum_{j=0}^{\infty} m_{t+j} \kappa^j W_{t+j} Y_{t+j}(i)^{pcp} / A_{t+j}}{E_t \sum_{j=0}^{\infty} m_{t+j} \kappa^j Y_{t+j}(i)^{pcp}}, \tag{17}$$

where $Y_t(i)^{pcp}$ indicates the demand for goods produced by home firms engaged in PCP pricing, coming from both home and foreign consumers. All PCP home firms that can adjust their price choose the same price. In the aggregate, the PCP price index for the home good then follows the process given by:

$$P_{Ht} = [(1-\kappa)\hat{P}_{Ht}^{1-\theta} + \kappa P_{Ht-1}^{1-\theta}]^{\frac{1}{1-\theta}}. \tag{18}$$

For domestic firms who price their goods abroad using LCP, the pricing of goods sold to home consumers parallels the above. The pricing for foreign consumers is in foreign currency, and is defined as:

$$\hat{P}_{Ht}^*(i) = \frac{\theta}{\theta-1}(1-s_t) \frac{E_t \sum_{j=0}^{\infty} m_{t+j} \kappa^j W_{t+j} Y_{t+j}(i)^{lcp,f} / A_{t+j}}{E_t \sum_{j=0}^{\infty} m_{t+j} \kappa^j S_{t+j} Y_{t+j}(i)^{lcp,f}}, \tag{19}$$

where S_{t+j} is the nominal exchange rate at time $t+j$, and $Y_{t+j}(i)^{lcp,f}$ denotes the foreign demand for the LCP-priced home good of firm i. Again, all LCP home firms that can adjust their price choose the same price. In the aggregate, the LCP price index for the home good then follows the process given by:

$$P_{Ht}^* = [(1-\kappa)\hat{P}_{Ht}^{*(1-\theta)} + \kappa P_{Ht-1}^{*(1-\theta)}]^{\frac{1}{1-\theta}}. \tag{20}$$

The behaviour of foreign firms and the foreign good price index may be described analogously.

Monetary Policy

We assume that monetary policy is governed by an augmented Taylor rule given by:

$$R_t^r = (1+\rho)(1+\hat{\pi})(1+\hat{s})\left(\frac{P_t}{P_{t-1}}\frac{1}{1+\hat{\pi}}\right)^{\zeta}\left(\frac{S_t}{S_{t-1}}\frac{1}{1+\hat{s}}\right)^{\gamma}, \tag{21}$$

where ρ represents a desired equilibrium real interest rate and $\hat{\pi}$ and $\hat{s}$ represent a desired path for the home country inflation rate and the rate of change of the nominal exchange rate, respectively. We assume that $\zeta > 1$. This rule does not allow for interest rate 'smoothing'. This simplification allows for

simple analytical solutions to the model governed by the Taylor rule, and is not critical for the results. The monetary policy rule for the foreign country is characterized in an analogous manner.

We also allow for a foreign exchange rate policy which, when $\lambda < 1$, is equivalent to sterilized intervention. In particular, assume that the change in foreign exchange purchases is set proportional to the change in the nominal exchange rate, so that:

$$\Delta(FR)_t = \left(\frac{S_{t-1}}{S_t} \right)^\nu . \tag{22}$$

Market Clearing

Each home country firm i faces demand for its good from home consumers, foreign consumers and its home government. Take first the PCP pricing home firm. It sets the same price in the home and foreign market, in home currency. We can define equilibrium in the market for good i as:

$$Y_t(i)^{pcp} = \left(\frac{P_{Ht}(i)}{P_{Ht}} \right)^{-\theta} \left[\frac{\upsilon}{2} \frac{P_t}{P_{Ht}} C_t + \left(1 - \frac{\upsilon}{2} \right)(1-\delta) \frac{S_t P_t^*}{P_{Ht}} C_t^* \right], \tag{23}$$

where $(1-\delta)$ comes from the fact that a share δ of home goods sold abroad are sold by LCP pricing home firms. Now, aggregating across all home firms, market clearing in the PCP pricing home good is defined as:

$$Y_t^{pcp} = \frac{\upsilon}{2} \frac{P_t}{P_{Ht}} C_t + \left(1 - \frac{\upsilon}{2} \right)(1-\delta) \frac{S_t P_t^*}{P_{Ht}} C_t^* . \tag{24}$$

Here $Y_t^{pcp} = V_t^{-1} \int_0^1 Y_t(i)^{pcp} di$ is aggregate home country PCP output, where we have defined $V_t = \int_0^1 (P_{Ht}(i)/P_{Ht})^{-\theta} di$. It follows that home country PCP employment (employment for the representative home household) is given by $N_t^{pcp} = \int_0^1 N_t(i)^{pcp} di = A^{-1} Y_t^{pcp} V_t$.[22]

For the LCP pricing firm, output is divided between selling to home consumers in home currency and foreign consumers in foreign currency. We define equilibrium in the market for its good as:

$$Y_t(i)^{lcp,h} = \left(\frac{P_{Ht}(i)}{P_{Ht}} \right)^{-\theta} \left[\frac{\upsilon}{2} \frac{P_t}{P_{Ht}} C_t \right], \tag{25}$$

$$Y_t(i)^{lcp,f} = \left(\frac{P_{Ht}^*(i)}{P_{Ht}^*} \right)^{-\theta} \left[\left(1 - \frac{\upsilon}{2} \right) \delta \frac{P_t^*}{P_{Ht}^*} C_t^* \right]. \tag{26}$$

We may aggregate over each of these terms separately and define aggregate output for the LCP firm as:

$$Y_t^{lcp} = Y_t^{lcp,h} + Y_t^{lcp,f} . \tag{27}$$

Total home GDP in the linear approximation of the model ends up simply being a weighted sum of Y_t^{pcp}, $Y_t^{lcp,h}$ and $Y_t^{lcp,f}$.

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[22] Note that these V_t terms disappear in the linear approximation of the model.

We can follow an analogous approach for foreign firms under both PCP and LCP pricing.

Shocks

Our model incorporates two kinds of shocks: productivity shocks (a_t, a_t^*) and cost-push shocks (u_t, u_t^*).We assume that these are independent and each follow AR(1) processes with autoregressive parameter 0.5.

Linear approximation

We linearise our model around the flexible-price, zero foreign reserves, steady-state. Our model reduces to a 12-equation log-linearised system, as follows:

Home goods market equilibrium:

$$y_t = \frac{\upsilon}{2}c_t + \left(1 - \frac{\upsilon}{2}\right)c_t^* + \upsilon\left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t). \tag{28}$$

Foreign goods market equilibrium:

$$y_t^* = \frac{\upsilon}{2}c_t^* + \left(1 - \frac{\upsilon}{2}\right)c_t - \upsilon\left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t). \tag{29}$$

Risk-sharing / international financial market equilibrium:

$$\lambda\left[\sigma(c_t - c_t^*) - \delta\Delta_t - (\upsilon-1)(\tau_t + (1-\delta)\Delta_t)\right]$$
$$+(1-\lambda)\left[c_t + \left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-2\delta)\Delta_t) - y_t - (fr_t - fr_{t-1})\right] = 0. \tag{30}$$

Inflation equation for home goods sold at home:

$$\pi_{Ht} = \kappa\left[\sigma c_t + \phi(y_t - a_t) - a_t + \left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t)\right] + u_t + \beta E_t \pi_{Ht+1}. \tag{31}$$

Inflation equation for home goods sold in the foreign market with local currency pricing:

$$\pi_{Ht}^* = \kappa\left[\sigma c_t + \phi(y_t - a_t) - a_t + \left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t) - \Delta_t\right] + u_t + \beta E_t \pi_{Ht+1}^*. \tag{32}$$

Inflation equation for foreign goods sold in the foreign market:

$$\pi_{Ft}^* = \kappa\left[\sigma c_t^* + \phi(y_t^* - a_t^*) - a_t^* - \left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t)\right] + u_t^* + \beta E_t \pi_{Ft+1}^*. \tag{33}$$

Inflation equation for foreign goods sold in the home market with local currency pricing:

$$\pi_{Ft} = \kappa\left[\sigma c_t^* + \phi(y_t^* - a_t^*) - a_t^* - \left(1 - \frac{\upsilon}{2}\right)(\tau_t + (1-\delta)\Delta_t) + \Delta_t\right] + u_t^* + \beta E_t \pi_{Ft+1}. \tag{34}$$

Inflation equation for foreign goods sold in the home market with both local currency pricing and producer currency pricing:

$$\pi_{Ft} = \pi_{Ht} + (\tau_t - \tau_{t-1} + (1-\delta)(\Delta_t - \Delta_{t-1})). \tag{35}$$

Inflation equation for home goods sold in the foreign market with both local currency pricing and producer currency pricing:

$$w^*_{Ht} = \pi^*_{Ft} - \left(\tau_t - \tau_{t-1} + (1-\delta)(\Delta_t - \Delta_{t-1})\right). \tag{36}$$

Home investment-savings equation (from the monetary policy rule, including an interest rate response to the change in the nominal exchange rate and home CPI inflation, and the Euler equation):

$$\gamma\left[\Delta_t - \Delta_{t-1} - (\pi^*_{Ft} - \pi_{Ft})\right] + \zeta\left[\frac{\upsilon}{2}\pi_{Ht} + \left(1-\frac{\upsilon}{2}\right)w_{Ft}\right]$$
$$= E_t\left[\frac{\upsilon}{2}\pi_{Ht+1} + \left(1-\frac{\upsilon}{2}\right)w_{Ft+1}\right] + \sigma E_t(c_{t+1} - c_t). \tag{37}$$

Note that the change in the nominal exchange rate in this model is given by:

$$s_t - s_{t-1} = \Delta_t - \Delta_{t-1} - (\pi^*_{Ft} - \pi_{Ft}). \tag{38}$$

Foreign investment-savings equation (from the monetary policy rule, incorporating an interest rate response to foreign CPI inflation, and the Euler equation):

$$\zeta\left[\frac{\upsilon}{2}\pi^*_{Ft} + \left(1-\frac{\upsilon}{2}\right)w^*_{Ht}\right] = E_t\left[\frac{\upsilon}{2}\pi^*_{Ft+1} + \left(1-\frac{\upsilon}{2}\right)w^*_{Ht+1}\right] + \sigma E_t(c^*_{t+1} - c^*_t). \tag{39}$$

Terms of trade equation:

$$\tau_t - \tau_{t-1} = \kappa\left(\phi(y^*_t - y_t) + \sigma(c^*_t - c_t) + (\upsilon-1)(\tau_t + (1-\delta)\Delta_t) + \delta\Delta_t - \tau_t + (1+\phi)(a_t - a^*_t)\right)$$
$$+ \beta E_t(\tau_{t+1} - \tau_t). \tag{40}$$

Welfare in this model depends in part on output levels relative to their flexible-price equilibrium values. Solving for flexible prices ($\kappa = 0$) yields the following five-equation system:

$$\tilde{y}_t = \frac{\upsilon}{2}\tilde{c}_t + \left(1-\frac{\upsilon}{2}\right)\tilde{c}^*_t + \upsilon\left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t, \tag{41}$$

$$\tilde{y}^*_t = \frac{\upsilon}{2}\tilde{c}^*_t + \left(1-\frac{\upsilon}{2}\right)\tilde{c}_t - \upsilon\left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t, \tag{42}$$

$$\lambda\left[\sigma(\tilde{c}_t - \tilde{c}^*_t) - (\upsilon-1)\tilde{\tau}_t\right] + (1-\lambda)\left[\tilde{c}_t + \left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t - \tilde{y}_t\right] = 0, \tag{43}$$

$$\sigma\tilde{c}_t + \phi(\tilde{y}_t - a_t) - a_t + \left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t = 0, \tag{44}$$

$$\sigma\tilde{c}^*_t + \phi(\tilde{y}^*_t - a^*_t) - a^*_t - \left(1-\frac{\upsilon}{2}\right)\tilde{\tau}_t = 0, \tag{45}$$

where ~ indicates flexible-price allocation. Then, up to a second-order approximation, the welfare function for a given λ is given by:

$$V_t = -\frac{1}{4}\frac{D_1 D_3}{D_2^{\,2}}\left(2-\upsilon(1-\lambda)\right)^2 \delta^2 \Delta_t^{\,2} - (\sigma+\phi)\,y_{tw}^{\,2} - (1+\phi)\,y_{tr}^{\,2}$$

$$-\frac{(\sigma-1)(\upsilon-1)^2}{D_2^{\,2}}\left(2-\upsilon(1-\lambda)\right)^2 y_{tr}^{\,2} - 4D_3\left(\frac{\lambda(\sigma-1)(\upsilon-1)}{D_2}\right)^2 y_{tr}^{\,2}$$

$$-\frac{D_3(2-\upsilon)(\sigma-1)(1-\lambda)(\upsilon-1)\delta}{D_2^{\,2}}\left(2-\upsilon(1-\lambda)\right)y_{tr}\Delta_t$$

$$-\frac{\xi}{2\kappa}\left((\frac{\upsilon}{2}+(1-\delta)(1-\frac{\upsilon}{2}))\pi_{Ht}^{\,2} + \frac{2-\upsilon}{2}\delta\pi_{Ft}^{\,2} + (\frac{\upsilon}{2}+(1-\delta)(1-\frac{\upsilon}{2}))\pi_{Ft}^{*\,2} + \frac{2-\upsilon}{2}\delta\pi_{Ht}^{*\,2}\right),$$

(46)

where $\quad D_1 = \sigma\upsilon(2-\upsilon)+(1-\upsilon)^2$, $\qquad D_2 = 2D_1\lambda+(1-\lambda)(2-\upsilon)$, $\qquad D_3 = \upsilon(2-\upsilon)$,

$y_{tr} = \frac{1}{2}\left[(y_t - \cancel{y}_t) - (y_t^* - \cancel{y}_t^*)\right]$ and $y_{tw} = \frac{1}{2}\left[(y_t - \cancel{y}_t) + (y_t^* - \cancel{y}_t^*)\right]$.

Welfare effects of productivity shocks with costly reserves volatility

Mixture of local and producer currency pricing (δ=0.5)[1]

λ=0.0

λ=0.25

λ=0.50

λ=0.75

Legend: Ramsey — Taylor — Taylor + unsterilised — Taylor + sterilised

Y-axis (top two panels): Welfare; −0.005, −0.010, −0.015, −0.020, −0.025, −0.030, −0.035

Y-axis (bottom two panels): Welfare; −0.010, −0.015, −0.020, −0.025, −0.030, −0.035

X-axis: Goods market integration[2]; 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9

[1] Half of all import varieties are assumed to be priced in the local currency and half in the producer currency.   [2] Goods market integration is defined as 2-υ.

Source: Authors' calculations.

Welfare effects of cost-push shocks with costly reserves volatility

Home bias (υ=1.5)

λ=0.0

λ=0.25
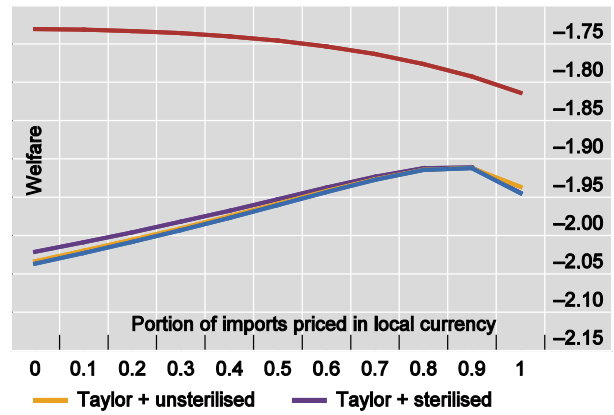

λ=0.50

λ=0.75

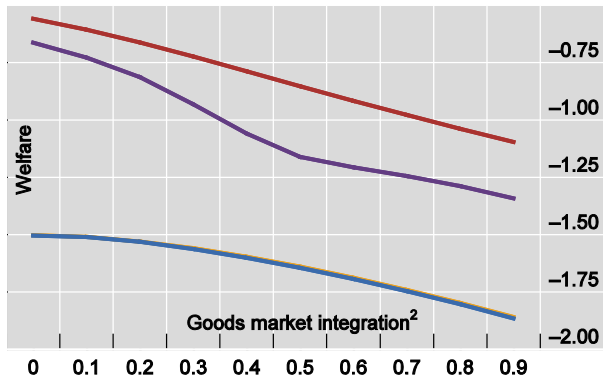Legend: Ramsey — Taylor — Taylor + unsterilised — Taylor + sterilised

Source: Authors' calculations.

Welfare effects of cost-push shocks with costly reserves volatility

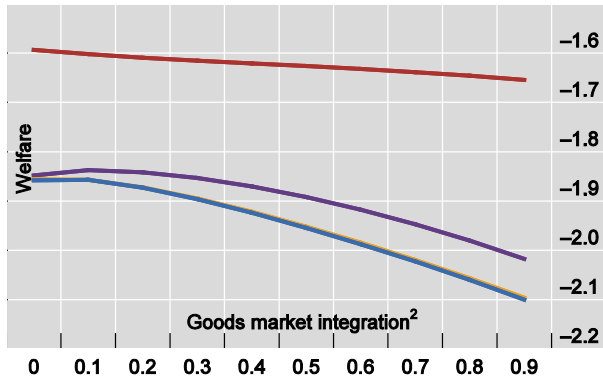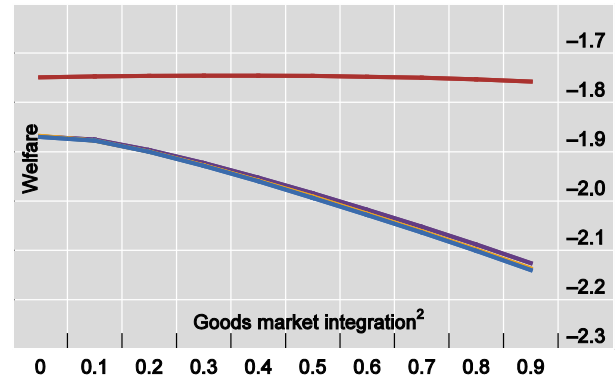Mixture of local and producer currency pricing (δ=0.5)[1]

λ=0.0

λ=0.25

λ=0.50

λ=0.75

Legend: Ramsey — Taylor — Taylor + unsterilised — Taylor + sterilised

[1] Half of all import varieties are assumed to be priced in the local currency and half in the producer currency. [2] Goods market integration is defined as 2-υ.

Source: Authors' calculations.

References

Aghion, Philippe, Philippe Bacchetta, Romain Ranciere and Kenneth Rogoff (2009): "Exchange rate volatility and productivity growth: the role of financial development," Journal of Monetary Economies 56(4), 494-513.

Amiti, Mary, Oleg Itskhoki and Jozef Konings (2012): "Importers, Exporters, and Exchange Rate Disconnect," NBER Working Paper no 18615.

Benes, Jaromir, Andrew Berg, Rafael A Portillo and David Vavra (2013): "Modeling sterilised interventions and balance sheet effects of monetary policy in a New-Keynesian framework", IMF Working Paper 13/11.

Berka, Martin, Michael B. Devereux and Charles Engel (2012): "Real exchange rate adjustment in and out of the Eurozone", American Economic Review 102(3), 179-85.

Brun-Aguerre, Raphael, Ana-Maria Fuertes and Kate Phylaktis (2012): "Exchange rate pass-through into import prices revisited: what drives it?" Journal of International Money and Finance 31(4), 818-844.

Burstein, Arial and Gita Gopinath (2013): "International prices and exchange rates", NBER Working Paper 18829.

Calvo, Guillermo A. (2002): "On dollarization", Economics of Transition 10(2), 393-403.

Calvo, Guillermo A. and Carmen M. Reinhart (2002): "Fear of floating", Quarterly Journal of Economics 117(2), 379-408.

Campa, Jose Manuel and Linda S Goldberg (2005): "Exchange rate pass-through into import prices," Review of Economics and Statistics 87(4), 679-690.

Ca'Zorzi, Michele Elke Hahn and Marcelo Sánchez (2007): "Exchange rate pass-through in emerging markets," ECB Working Paper 739.

Cespedes, Luis Felipe, Roberto Chang and Andres Velasco (2004): "Balance sheets and exchange rate policy," American Economic Review 94(4), 1183-1193.

Choudry, Ehsan U and Dalia S and Hakura (2006): "Exchange rate pass-through to domestic prices: does the inflationary environment matter?" Journal of International Money and Finance 25(4), 614-639.

Corsetti, Giancarlo and Paolo Pesenti (2005): "International dimensions of optimal monetary policy", Journal of Monetary Economics 52(2), 281-305.

Devereux, Michael B (2004): "Should the exchange rate be a shock absorber?" Journal of International Economics 62(2), 359-377.

Devereux, Michael B and Charles Engel (2003): "Monetary policy in the open economy revisited: price setting and exchange-rate flexibility", Review of Economic Studies 70(4), 765-783.

Devereux, Michael B, Ozge Senay and Alan Sutherland (2013): "Inflation and financial globalization," Journal of Money, Credit and Banking, forthcoming.

Devereux, Michael B and Alan Sutherland (2008): "Financial globalization and monetary policy," Journal of Monetary Economics 55(8), 1363-1375.

Devereux, Michael B and James Yetman (2013): "Capital controls, global liquidity traps and the international policy trilemma," Scandinavian Journal of Economics, forthcoming.

Devereux, Michael B and James Yetman (2010): "Price adjustment and exchange rate pass-through," Journal of International Money and Finance 29(1), 181-200.

Edwards, Sebastian (2006): "The relationship between exchange rates and inflation targeting revisited," NBER Working Paper 12163.

Engel, Charles (2013): "Inflation and globalisation: a modeling perspective", BIS Papers no 70, 99-108.

Engel, Charles (2011): "Currency misalignments and optimal monetary policy: a reexamination", American Economic Review 101(6), 2796-2822.

Filardo, Andrew and James Yetman (2012): "The expansion of central bank balance sheets in emerging Asia: what are the risks?" BIS Quarterly Review, June, 47-63.

Filardo, Andrew, Guonan Ma and Dubravko Mihaljek (2011): "Exchange rates and monetary policy frameworks in EMEs," BIS Papers no 57, 37-63.

Gagnon, Joseph and Jane Ihrig (2004): "Monetary policy and exchange rate pass-through," International Journal of Finance and Economics 9(4), 315-338.

Garcia, Carlos J, Jorge E Restrepo and Scott Roger (2011): "How much should inflation targeters care about the exchange rate?" Journal of International Money and Finance 30(7), 1590-1617.

Goldstein, Morris and Philip Turner (2004): "Controlling currency mismatches in emerging markets," Institute for International Economics, Washington DC.

Mihaljek, Dubravko and Marc Klau (2008): "Exchange rate pass-through in emerging market economies: what has changed and why?" BIS Papers no 35, 103-130.

Mohanty, M S and Marc Klau (2004): "Monetary policy rules in emerging market economies: issues and evidence", BIS Working Papers no 149.

Moron, Eduardo and Diego Winkelried (2005): "Monetary policy rules for financially vulnerable economies," Journal of Development Economics 76(1), 23-51.

Mussa, Michael, Paul Masson, Alexander Swoboda, Esteban Jadresic, Paolo Mauro and Andy Berg (2000): "Exchange rate arrangements of developing and transition countries", IMF Occasional Paper 193, 13-35.

Ostry, Jonathan D, Atish R Ghosh and Marcos Chamon (2012): "Two targets, two instruments: monetary and exchange rate policies in emerging market economies", IMF Staff Discussion Note 12/01.

Parsley, David C and Helen A Popper (1998): "Exchange rates, domestic prices, and central bank actions: recent US experience," Southern Economic Journal 64(4), 957-972.

Prasad, Nalini (2013): "Sterilised interventions and capital controls," manuscript.

Reyes, Javier A (2007): "Exchange rate passthrough effects and inflation targeting in emerging economies: what is the relationship?" Review of International Economics 15(3), 538-559.

Rose, Andrew K (2011): "Exchange rate regimes in the modern era: fixed, floating, and flaky," Journal of Economic Literature 49(3), 652-672.

Sutherland, Alan (2005): "Incomplete pass-through and the welfare effects of exchange rate variability", Journal of International Economics 65(2), 375-399.

Taylor, John B (2001): "The role of the exchange rate in monetary policy rules", American Economic Review 91(2), 263-267.