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Foreign Exchange Inflows in Emerging Markets: How Much Are They Sterilised?

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Abstract

As some emerging market economies have amassed large quantities of foreign exchange reserves, concern has arisen over the sterilisation of the domestic money stock from these flows. Existing studies focus mostly on narrow (reserve) money, and estimate a high degree of sterilisation. Empirical work on the long-run relationship between money and prices emphasises broad money, yet the long-run effect of foreign exchange inflows on broad money has been almost entirely ignored. Using a sample of quarterly data from 28 countries over the period 1990-2010, it is shown that broad money is sterilised to a significantly smaller degree than reserve money. This pattern is not confined to any particular group of countries and is unrelated to the nature of the flows (e.g. current account versus capital account surpluses). Sterilisation rates have increased in Asia during the recent period of persistent accumulation of foreign exchange reserves.

Keywords: foreign exchange intervention, money, sterilisation, emerging markets

JEL No.: E51, E52, F31, F33

[#]This paper draws on two chapters of Sharmila Devadas' PhD thesis at the University of Nottingham. The views expressed in this paper, unless otherwise indicated, are those of the authors, and do not in any manner reflect the position of the Central Bank of Malaysia.

1. Introduction

In the absence of full sterilisation of domestic money from inflows and outflows across the exchanges, foreign exchange intervention has consequences for domestic monetary conditions. Unless the domestic currency paid out by the central bank in buying up foreign exchange is mopped up by sales of other assets, the money supply will increase. These issues have become topical in recent years as emerging market countries, which typically manage their exchange rates to a considerable degree, have accumulated foreign exchange reserves (Aizenman and Glick, 2009). In the absence of full sterilisation, there is a danger that any advantages in export competitiveness gained by managing the nominal exchange rate could be eroded through higher inflation. Previous empirical estimates such as those of Aizenman and Glick (2009) and Lavigne (2008) have suggested a high degree of sterilisation, which would imply that this is not a problem in practice. There is, however, an important *caveat* here: these studies have focused almost exclusively on reserve money.

This focus on reserve money stands in sharp contrast to the recent empirical literature emphasising the role of money in the macroeconomy, which stresses broad rather than narrow money (Assenmacher-Wesche and Gerlach, 2007; Bridges and Thomas, 2012; Gerlach, 2004; Ireland, 2004; Leeper and Roush, 2003). These papers demonstrate a long-run relationship between broad money and prices. The theoretical importance of money is discussed by Nelson (2008). This work suggests that it is important to investigate whether foreign exchange inflows affect broader measures of the money stock, and this is the main contribution of our paper. We find that, unlike reserve money, broad money is to a significant degree *not* sterilised against foreign exchange intervention, particularly in the longer run. The failure to sterilise broad money in the longer run may explain why Cardarelli *et al*. (2009, pp. 30-1), in their cross-country study of large net private capital inflows,

conclude that "a policy of resistance to nominal appreciation has not generally been successful in preventing real appreciation, and has often been followed by a sharper reversal of capital inflows, especially when these inflows have persisted for a longer time." Our estimates of sterilisation derive from a regression-based approach that includes controls for demand factors. Some part of monetary growth is demand-driven, reflecting factors such as the growth in personal incomes, and it is important to control for these effects.

We find that the accumulation of foreign exchange reserves feeds through significantly to broad money in the long run. This pattern is fairly consistent across countries, and is not confined to those with particular balance-of-payments positions or other characteristics. In Asia, the effect of reserve accumulation on broad money growth has fallen since the 1990s.

The rest of this paper is organised as follows. Previous research is surveyed in Section Two. Section Three discusses the theoretical framework and choice of econometric methodology. Empirical results are presented in Section Four, and Section Five concludes.

2. Literature Review

There have been various single-country studies of the effects of intervention on reserve money in emerging market economies either as the focal point or as a subcomponent of issues related to capital flows and reserve accumulation (e.g. Ouyang and Rajan, 2011; Ouyang *et al*., 2010). However, there exist only a few recent studies that cover a group of countries that cut across regions, as in Aizenman and Glick (2009), Cardarelli *et al*. (2009) and Lavigne (2008). The first covers nine countries, of which six are Asian economies and three are Latin American economies, while the second and third encompass 52 and 35

countries respectively. Methods differ across the three with the latter two adopting comparatively simple approaches to analysis.

Aizenman and Glick (2009) adopt a static multivariate regression specification based on a simple version of the monetary approach to the balance of payments, and allow for real GDP and inflation as control variables. They estimate rolling 40-quarter regressions over the period 1994-2006. They estimate current-quarter sterilisation rates of close to 100%, particularly in the later years. Cardarelli *et al*. (2009) estimate sterilisation rates separately for each country in each calendar year, by a simple bivariate regression on the twelve monthly observations. They do this for both reserve money and broad money, but focus on the former. The cross-country averages in their Figure 8 indicate current-month sterilisation rates of base money of about 0.6 in the average country, with no particular time trend since 1991. Neither study considers how differences in countries' monetary policy frameworks and choice of instruments, namely reserve requirements, may have affected their estimation results. Lavigne (2008) focuses on periods of sizeable accumulation of foreign exchange reserves in East Asia from 1990 to 1996 and from 2000 to 2006. He takes into account the effect of reserve requirements, but uses straightforward ratios, essentially dividing the cumulative change in currency in circulation over the relevant years by the cumulative change in net foreign assets (ΔNFA). The estimated sterilisation ratios exceed 0.8 in most cases.

In contrast, there is a dearth of econometric analysis of the effects of foreign exchange intervention on broad money growth, which is potentially more important than reserve money; arguably the effects on reserve money are of significance mainly because they may feed through to broad money. Another limitation of existing research is that sometimes only current-quarter or even current-month effects are investigated. When countries persistently

accumulate foreign exchange reserves, it is necessary to consider longer-run effects extending beyond the current month or quarter.

Our contribution is to provide a detailed analysis for a reasonably large and diverse group of 28 countries, with particular attention to intervention effects on broad money growth. Our approach allows us to disentangle short-run and long-run effects of intervention. We also investigate differences in monetary policy frameworks across countries and conduct tests of possible country characteristics that may account for variations in individual country results.

3. Theoretical Framework and Econometric Methodology

The conceptual framework for analysing the effects of intervention begins with the following identities for the determinants of reserve money (RM) and broad money (BM).

$$\Delta RM_t = \Delta NDA_t + \Delta NFA_t \quad (1)$$

where

ΔNDA_t = the change in net domestic assets of the central bank during time t

ΔNFA_t = the change in net foreign assets of the central bank during time t

Sterilisation involves insulating reserve money from changes in NFA, for instance by open market operations. For broad money, the effect of changes in net foreign assets depends also on what is happening to the money multiplier (m = BM/RM).

$$\Delta BM_t = m_t(\Delta NDA_t + \Delta NFA_t) + \Delta m_t(RM_t) \quad (2)$$

The money multiplier can change through policy actions (e.g. alteration of banks' reserve requirements) or because of exogenous factors. Some portion of the growth of the money supply is demand-driven, by growth in nominal incomes, for example. To make sure that our estimates of sterilisation are not distorted by this effect, we add controls for demand factors, as in Aizenman and Glick (2009). Thus the equation that we estimate for each country is of the form

$$\Delta BM_t = a + b\Delta NFA_t + \underline{c}.\underline{Z}_t + u_t \qquad (3)$$

where the vector $\underline{Z}$ consists of a set of control variables that are discussed in detail later; *a*, *b* and the vector $\underline{c}$ are parameters to be estimated; and *u* is a random error. The sterilization coefficient for country *j* is estimated as $(1 - b_j)$. At the second stage we investigate whether the set of country estimates $(1 - b_j)$ is correlated with country characteristics such as the current account balance.

Net foreign assets are equal to gross foreign assets minus gross foreign liabilities. Gross foreign assets consist of foreign exchange reserves plus non-currency items such as gold stocks and Special Drawing Rights (SDRs). The gross assets and liabilities series are not always complete and may have been subject to changes in definition, for example with the shift to Standardised Reporting Forms. Moreover, recorded gross assets are occasionally smaller than foreign exchange reserves, which implies that non-currency assets are implausibly negative. In this paper we proxy changes in net foreign assets by changes in foreign exchange reserves, which we believe to be a more reliable series. Dominguez (2012) uses data on a component of the balance of payments statistics – the change in the US dollar value of reserve assets – as a measure of intervention. These figures are less complete than foreign exchange reserve data, but closely correlated with them (the median correlation coefficient across the 28 countries in our data set is 0.93).

Foreign currency reserves consist mostly of securities denominated in foreign currencies. The domestic-currency value of net foreign assets can therefore vary because of valuation effects of a given stock; these valuation effects do not correspond to any actual flow across the exchanges. Accurate estimation of the valuation effects requires full information on the composition of each country's foreign exchange reserves, which is very much lacking. The IMF's COFER database[1] indicates that, aggregated over the whole world, US dollar (USD) assets dominate reserves, but to a decreasing extent – USD assets represented approximately 60% of reserves in 2010 compared with 75% over 1995-1998. However, the currency composition is only known for a portion of reserves belonging to a segment of countries, and this portion, known as allocated reserves in the database, has dwindled over time.

In the absence of further information, we assume that foreign exchange reserves of each country consist 100% of US dollar assets. Since the data source gives reserves valued in US dollars, any change in this amount (ΔFXR_t^{USD}) is assumed to represent a genuine flow. This ignores the component arising from interest payments on foreign securities, which Dominguez (2012) estimates to be about 4% p.a. globally. Since interest payments are a very smooth series, this should make little difference to our results. This flow is translated into national currency at the average exchange rate prevailing during that period ($E_t^{avg.}$: national currency units per US dollar).

$$\Delta FXR_t = \Delta FXR_t^{USD} . E_t^{avg.} \quad (4)$$

Column (1) of Table 1 shows that the correlation between this measure of ΔNFA and an unadjusted measure that is simply based on the change in the domestic-currency value of

[1] Source: http://www.imf.org/external/np/sta/cofer/eng/index.htm

reserves over the period is sometimes quite low, particularly for countries that have had substantial exchange rate movements against the US dollar.

Column (2) of Table 1 contains the correlation coefficients between the change in the national currency value of foreign exchange reserves and the change in the national currency value of net foreign assets, both adjusted for exchange rate revaluation effects (Adjusted ΔFXR_t and Adjusted ΔNFA_t respectively). Low correlations would primarily reflect the difference in components between the two measures, with additional foreign assets and the netting off of foreign liabilities in the latter. The correlations are, however, fairly high across countries, with 20 countries exhibiting a correlation of more than 0.75. There are notably low correlations for Japan and Canada, which we attribute to possible misclassification or reporting errors in the NFA series, since in the case of both countries FXR exceeds the gross foreign asset component of NFA several times over.

Table 1. Correlation between Different Measures of Foreign Exchange Intervention

Country	Correlation Coefficient		
	(1)	(2)	(3)
	Adjusted ΔFXR_t and Unadjusted ΔFXR_t	Adjusted ΔFXR_t and Adjusted ΔNFA_t	ΔFXR_t^{USD} and $\Delta RA(BOP)_t^{USD}$
	1990m1-2010m6		1990q1-2010q2
Argentina	0.81	0.79[(a)]	0.93
Australia	0.93	0.58	0.98
Brazil	0.49	0.69	0.98
Canada	0.82	0.00	0.86
Chile	0.67	0.97	0.95[(b)]
China	0.98	0.71	0.99[(c)]
Colombia	0.33	0.81	0.92[(d)]
Czech Rep	0.37[(e)]	0.91[(e)]	0.78[(f)]
Denmark	0.90	0.81	0.91
Hong Kong	1.00[(h)]	0.71[(h)]	0.95[(i)]
Hungary	0.66	0.76[(j)]	0.87
India	0.72	0.87	0.83
Indonesia	0.37	0.84	0.92
Israel	0.75	1.00[(k)]	0.96
Japan	0.29	0.16	0.94
Korea	0.12	0.69	0.96
Malaysia	0.88	0.76	0.95[(l)]
Mexico	0.63	0.94	0.79
New Zealand	0.85	0.93	0.98
Norway	0.88	0.80[(m)]	0.64
Peru	0.84	0.89	0.96
Philippines	0.74	0.74	0.92
Poland	0.48	0.85	0.93[(n)]
Russia	0.58[(o)]	0.99[(o)]	0.98[(p)]
Singapore	0.57	0.99	0.70[(q)]
South Africa	0.02	0.78	0.89
Thailand	0.68	0.93	0.95
Turkey	0.36	0.81	0.92

(1) The adjusted change in the national currency value of foreign exchange reserves which excludes exchange rate revaluation changes (Adjusted ΔFXR_t) is equal to $\Delta FXR_t^{USD} . E_t^{avg.}$.
The unadjusted change in the national currency value of foreign exchange reserves which includes exchange rate revaluation changes (Unadjusted ΔFXR_t) is equal to $FXR_t^{USD} . E_t$ - $FXR_{t-1}^{USD} . E_{t-1}$.

(2) The adjusted change in the national currency value of net foreign assets which excludes exchange rate revaluation changes (Adjusted ΔNFA_t) is equal to $NFA_t - NFA_{t-1}\left(1 + \frac{\Delta E_t}{E_{t-1}}\right)$.

(3) $\Delta RA(BOP)_t^{USD}$ is the change in reserve assets in USD taken from the balance of payments account and excludes exchange rate revaluation effects.

Unless otherwise indicated below, the correlation coefficients in (1) and (2) are based on monthly data over 1990m1-2010m6, and those in (3) are based on quarterly data over 1990q1-2010q2:
(a)1990m2-2010m6, (b)1991q1-2010q2, (c)Annual data, 1990-2009, (d)1996q1-2010q2, (e)1993m2-2010m6, (f)1993q2-2010q2, (g)Annual data, 1990-2009, (h)1997m1-2010m6, (i)1999q1-2010q2, (j)2000m1-2010m6, (k)1990m1-2010m5, (l)1999q1-2010q2, (m)1990m1-2010m4, (n)2000q1-2010q2, (o)1996m1-2010m6, (p)1996q1-2010q2, (q)1995q1-2010q2.

In column (3) of Table 1, we present the correlation coefficients between the change in the USD value of foreign exchange reserves and the USD value of reserve assets flow from the balance of payments used by Dominguez (2012) ($\Delta \mathrm{FXR}_t^{\mathrm{USD}}$ and $\Delta \mathrm{RA(BOP)}_t^{\mathrm{USD}}$ respectively). The latter includes the change in the stock of non-currency reserves, namely monetary gold, Special Drawing Rights (SDRs) and the reserve position with the IMF. The correlation coefficients serve as a check on the accuracy of the proxy for intervention that we have used. Low correlations can arise from differences in components, and importantly, if a substantial portion of reserves are held in assets denominated in foreign currency other than the USD, from the exchange rate revaluation effects for which we have not made an adjustment. We find, however, that the correlation coefficients are relatively high across the countries, with 26 countries displaying a coefficient of more than 0.75. The two exceptions are Norway and Singapore.

Baseline Model Specification

Individual country estimations are based on quarterly observations over the sample period 1990q1 to 2010q2. The sample is shorter for some countries because of the lack of availability of long time series data for certain variables. The following is the basic model for quarterly broad money growth:

$$
\begin{aligned}
\Delta \mathrm{BM}_t / \mathrm{BM}_{t-1} &= \alpha_0 \\
&+ \sum_{i=1}^{4} \alpha_{1i} \Delta \mathrm{BM}_{t-i} / \mathrm{BM}_{t-i-1} + \sum_{i=0}^{4} \alpha_{2i} \Delta \mathrm{FXR}_{t-i} / \mathrm{BM}_{t-i-1} + \sum_{i=0}^{4} \alpha_{3i} \Delta \mathrm{Y}_{t-i} \\
&+ \sum_{i=0}^{4} \alpha_{4i} \Delta \mathrm{i}_{\mathrm{M}_{t-i}} - \sum_{i=0}^{4} \alpha_{5i} \Delta \mathrm{i}_{\mathrm{B},t-i} - \sum_{i=0}^{4} \alpha_{6i} \Delta \mathrm{i}_{\mathrm{US},t-i} + \sum_{i=0}^{4} \alpha_{7i} \Delta \ln (\mathrm{REER})_{t-i} - \sum_{i=0}^{4} \alpha_{8i} \Delta \mathrm{Inf}_{t-i} \\
&+ \text{seasonal dummies} + \varepsilon_t
\end{aligned}
$$

(5)

where *BM* is real broad money; Δ*FXR* is the adjusted measure of foreign exchange inflows, in real terms; *Y* is the log of real GDP; i_M, i_B and i_{US} are respectively the interest rates on money, bonds and US Treasury Bills; *REER* is the real effective exchange rate and *Inf* is the consumer price inflation rate. Four lags of each variable, including the dependent variable, are included. A similar equation is estimated for reserve money except that i_B is omitted. The control variables reflect standard money demand specifications: income, relative interest rates, inflation and the return on holding foreign securities. The precise definition of variables is given in Appendix Table A1.

Because of the lags in equation (5), the procedure generates both a short-run (current-quarter) and a long-run estimate of the sterilisation coefficient for each country ($1 - b_j$). The short-run sterilisation coefficient is α_{20}, and the long-run coefficient is:

$$\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$$

(6)

Equation (5) contains a large number of regressors, some of which are inevitably insignificant. To obtain a more parsimonious regression for each country, a general-to-specific modelling procedure was adopted. At each step the least significant variable was removed, and the equation re-estimated, until all the remaining regresssors were statistically significant at the 10% level. Only the contemporaneous effect of the change in foreign

exchange reserves was retained even if insignificant. Although the initial unrestricted model is identical, these parsimonious specifications differ across countries. A comparison of results from the parsimonious and the unrestricted regressions shows that the main effect of eliminating insignificant regressors was to reduce the standard errors of the sterilisation coefficients rather than to change the point estimate.

Reserve money is defined as the narrowest measure in each country, consisting of currency in circulation and banking institutions' reserve balances. Broad money is not defined identically across countries. In general, for each country, the broad money variable used here reflects the broadest national definition of money that is available, which excludes the central government and non-residents from the money-holding sectors[2]. Non-transferable deposits and securities other than shares account for the predominant portion of broad money components other than currency and demand deposits (IMF, 2000). National definitions of broad money may include repurchase agreements, negotiable certificates of deposits, commercial paper issued by depository corporations, bankers' acceptances, and depending on their liquidity, shares in money market funds. There will, therefore be, differences across countries in the range of financial assets considered as part of broad money.

None of the variables have been seasonally adjusted. This is to avoid the risk that seasonal adjustment affects the dynamics of the equations being estimated, resulting in a loss of information (Davidson and MacKinnon (1993) highlight the problem of biased coefficients arising from the use of linear filters when specifications have lags of the dependent variable). To account for seasonality, a set of seasonal dummy variables is included in the estimating equations.

[2] The principal money-holding sectors are the same in almost all countries (IMF, 2000). Nevertheless, there may be some exceptions with regard to the classification of government units other than the central government, and non-residents.

In instances where serial correlation and/or heteroscedasticity had been detected either in the unrestricted model or in the final parsimonious model, robust standard errors were used from the beginning of estimation. The robust standard errors were derived according to either the Newey-West HAC or White Consistent Covariances method. Serial correlation was tested for at lags 2, 4 and 8 using the F-test for joint significance of lagged residuals and the Breusch-Godfrey LM test. The effects of outliers, primarily in the context of non-normality in the residuals, and also in regard to other diagnostic test results, have been removed for some countries with the use of impulse dummy variables.

The sample consists of 22 emerging market economies[3] that are listed in the Appendix. The focus is on these countries because of their tendency to intervene more in the foreign exchange market than the typical advanced countries. The requirement for quarterly data restricts the sample in some cases. To these we have added a number of smaller advanced countries for comparison purposes: Australia, Canada, Denmark, New Zealand and Norway. We have also included Japan because, like many other East Asian countries, it has accumulated a large stock of foreign exchange reserves in recent years.

4. Empirical Results

4.1 Sterilisation of Reserve Money

We start by estimating the parsimonious versions of equation (5) for reserve money. Table 2 shows the average short-run and long-run estimated coefficients of the change in foreign exchange reserves for emerging market economies by region, and for developed economies.

[3] The IMF's World Economic Outlook (WEO) database classifies the Czech Republic, Israel, Hong Kong, Korea, Singapore and Taiwan as advanced economies although some of the IMF's research studies classify these economies as emerging markets. In our empirical analysis, we group these countries with the emerging market economies.

The full array of country-by-country sterilisation coefficients is shown in Appendix Table A2.

There are two columns of results in Table 2. Column (i) consists of the short-run coefficient on $\Delta\,\mathrm{FXR_t}/\mathrm{RM_{t-1}}$, while column (ii) lists the corresponding long-run coefficient. For the short-run coefficients, t-statistics are reported, while for the long-run coefficients, F-statistics are reported – both statistics are in brackets.

The results indicate that the effect of foreign exchange intervention on reserve money growth is on average low. The average coefficients for the sample of 28 countries are 0.069 in the short-run and 0.095 in the long-run respectively. In effect, a one unit increase in foreign exchange reserves only leads to a 0.069 unit increase in the change in reserve money in the short run and a 0.095 unit increase in the long run. Thus, foreign exchange flows are more than 90% sterilised, even in the long run. However, the corresponding standard deviations across the sample group are 0.133 and 0.185 respectively, which suggests substantial dispersion across countries. On closer inspection, the short-run and long-run coefficients are in the range of 0.000 – 0.200 for about half of the countries (15 and 16 respectively), and negative in value for eight countries. Nevertheless, the negative coefficients tend to be of small economic significance, even if they are statistically significant. Since these results are fairly similar to those of Aizenman and Glick (2009), we now turn our attention to broad money.

Table 2. The Effects of a Change in Foreign Reserves on Reserve Money Growth - Group Averages

Group	The group average effect of $\Delta FXR_t/RM_{t-1}$ on $\Delta RM_t/RM_{t-1}$	
	(i)	(ii)
	Contemporaneous β_{20}	Long-run multiplier $\beta_{2,LR} = \sum_{i=0}^{4} \beta_{2i} \Big/ (1 - \sum_{i=1}^{4} \beta_{1i})$
Asia	0.067 (1.251)	0.039*** (9.170)
Latin America	0.050 (1.113)	0.111*** (55.249)
Other Emerging Markets	0.104*** (3.349)	0.144*** (20.947)
Developed Economies	0.048 (0.466)	0.106 (1.900)
TOTAL	**0.069** **(1.578)**	**0.095***** **(20.430)**
Sample standard deviation	*0.133*	*0.185*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average *t*-statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic, with the F-statistics taking the sign of the coefficient. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest *t*-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta FXR_t/RM_{t-1}$ which is not removed in the general to specific modelling process.
- Excluding Peru, for which the standard errors are particularly small, the average long-run effects are 0.107*** (14.180) for the Latin America sub-group and 0.088*** (11.536) for the whole sample.

4.2 Sterilisation of Broad Money

In Table 3, we present the group averages of the short-run and long-run intervention effects on broad money growth, using equation (5). Individual country results are detailed in Appendix Table A3. As in the case of reserve money, the results refer to a parsimonious version of equation (5) that was the outcome of a general-to-specific modelling approach. As in Table 2, column (i) consists of the short-run coefficient on foreign exchange flows, while column (ii) lists the corresponding long-run coefficient.

The results shown in Table 3 indicate that the effect of intervention on broad money growth is, on average, relatively low in the short run, but noticeably higher in the long run. The average coefficients for the sample of 28 countries are 0.079 in the short run and 0.396 in the long run respectively. The short-run effects are not significant in the typical country, as shown by the average *t*-statistic, and are rather higher than the average of 0.079 only for Latin America. For countries with persistent inflows, the longer-run effects should be of more concern, and here the results are markedly different. A foreign exchange inflow that represents 1% of the broad money stock is estimated to increase broad money after four quarters by 0.47% in Asia, 0.34% in Latin America, 0.27% in other emerging markets, and 0.50% in developed economies. Thus there is a consistent pattern across all countries, and these numbers average out at 0.40% for the typical country, indicating only 60% sterilisation of broad money in the long run, compared with the 90% for reserve money shown in Table 2.

Table 3. The Effects of a Change in Foreign Reserves on Broad Money Growth - Group Averages

Group	The group average effect of $\Delta FXR_t / BM_{t-1}$ on $\Delta BM_t / BM_{t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Asia	0.096 (1.077)	0.466** (4.187)
Latin America	0.239*** (3.374)	0.337*** (17.855)
Other Emerging Markets	-0.069 (-0.668)	0.265** (4.984)
Developed Economies	0.065 (0.829)	0.503** (7.107)
TOTAL	**0.079** **(1.080)**	**0.396***** **(7.715)**
Sample standard deviation	*0.249*	*0.669*

- Column (i) reports the simple average of the contemporaneous effect and the corresponding average *t*-statistic.
- Column (ii) reports the simple average of the long-run multiplier and the corresponding average F-statistic, with the F-statistics taking the sign of the coefficient. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest *t*-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta FXR_t / BM_{t-1}$ which is not removed in the general to specific modelling process.

The corresponding standard deviations across the sample group of 28 countries are 0.249 and 0.669 respectively, which suggests substantial dispersion, particularly with regard to the long-run coefficients. The degree of dispersion is larger than for reserve money growth. On closer inspection, the short-run coefficients are in the range of 0.000 – 0.250 for fourteen countries and negative in value for 10 countries. With regard to the long-run coefficients, seventeen countries fall in the range 0.200-0.750, whilst five countries display negative values.

It is difficult to make comparisons with the results of previous empirical work, not least because of the limited amount of existing research that has quantified the effects of intervention on broad money growth. Furthermore, where there has been work done, comparisons are complicated by differences in country coverage, methodology and sample period. Nevertheless, we have compared the long-run coefficients for a subset of countries[4] analysed by Takagi (1999). Takagi's estimated coefficients are based on static multivariate regressions using quarterly data over the period 1987q1-1997q2. At an average of 0.428 for these countries, our result is markedly in contrast to that of Takagi's at -0.009. Furthermore, on an individual-country basis, in Takagi's case, there is hardly any statistical significance of the coefficients, except in the case of the Philippines. One obvious difference between our study and Takagi's is the sample period under consideration, suggesting the importance of variations in the coefficients over time. However, it would appear that the methodology and data used also matter. With regard to the former, our dynamic model specification allows for both the contemporaneous and indirect effects of intervention to be taken into account.

Cardarelli *et al*. (2009) do not report the results for the effects of a change in foreign assets on changes in broad money, but they claim to find a high degree of sterilisation, as for

[4] The countries are Indonesia, Korea, Malaysia, Philippines and Thailand.

reserve money. Since they estimate only a short-run coefficient, based on monthly data, their results are consistent with our findings.

4.3 Estimated Sterilisation Coefficients and Country Characteristics

Can the pattern of estimated sterilisation coefficients of broad money shown in Appendix Table A3 be explained? This is the issue that we address in this sub-section. Initially, we test for differences among the countries in our sample by splitting them into clearly delineated groups based on regions, current account and capital account balances (surpluses versus deficits), income levels (high income versus middle income) and monetary policy frameworks (inflation-targeting versus non-inflation-targeting). Table 4 shows that, based on the results of ANOVA F-tests for differences in means[5], none of these features are close to statistical significance.

In Table 5, we assess if there exist linear relationships between intervention effects on broad money growth and specific country characteristics. We treat the estimated coefficients for long-run intervention effects in the equation for each country, shown in Appendix Table A3, as the dependent variable, and use a series of bivariate regressions to investigate whether these coefficients vary systematically with (1) income levels; (2) the nature of intervention (volatility, the number of surplus periods, and reserve accumulation); (3) exchange rate flexibility; and (4) the nature of the current and capital accounts in terms of openness and net balances. As in Table 4, the results in Table 5 are resoundingly negative: in every case the *t*-statistic is very low and the adjusted R-squared negative. Thus we are left with the conclusion that no obvious features explain the degree to which broad money growth is sterilised.

[5] The distributions for the short-run and long-run coefficients were pre-tested for non-normality and heterogeneous variances across subgroups based on the subgroup classifications. We did not find any evidence of non-normality.

Table 4. Mean Equality Tests for Intervention Effects on Broad Money Growth

Groups	Effect of ΔFXR on ΔBM			
	Short-run Coefficient		Long-run Coefficient	
	Group Mean	Mean Equality F-test (p-value)	Group Mean	Mean Equality F-test (p-value)
1. **Region**				
Asia	0.096	0.1681	0.466**	0.9143
Latin America	0.239***		0.337***	
Other EMEs	-0.069		0.265**	
Developed Economies	0.065		0.503**	
2. **Current Account (CA) Balance**				
CA surplus	0.114**	0.4929	0.500***	0.4783
CA deficit	0.048		0.306**	
3. **Capital Account (KA) Balance**				
KA surplus	0.078	0.9693	0.432***	0.6640
KA deficit	0.082*		0.307***	
4. **Income Level**				
High income	0.031	0.3510	0.297**	0.4777
Middle income	0.120*		0.481***	
5. **Monetary Policy Framework**				
Inflation-targeting	0.064	0.6645	0.429**	0.6519
Non-inflation-targeting	0.109**		0.327***	

CA and KA surpluses are measured based on the number of surplus years as a proportion of the total number of years corresponding to the regression sample period for each country. A country is recorded as a surplus country if the proportion exceeds 0.5.
Income level is measured by the average of GDP per capita based on purchasing power parity over the regression sample period for each country. Countries are classified as either high or middle income based on the World Bank income classification scheme.
Inflation-targeting countries are countries that have adopted the inflation-targeting framework at some point during our sample period.
Short-run and long-run average statistical significance of the coefficients for subgroups in the "Group Mean" columns are based on the corresponding simple average of *t*- and F-statistics, with the F-statistics taking the sign of the coefficient. These do not indicate statistically significant differences across the subgroups.
The mean equality test is the single-factor ANOVA F-test or Welch F-test for unequal variances.
***significant at the 1% level, **significant at the 5% level, *significant at the 10% level.

Table 5. Bivariate Regressions between Long-run Coefficients of Intervention Effects and Country Characteristics

Country Characteristic (Regressor in bivariate regression)		Dependent Variable: Long-run Effect of ΔFXR on ΔBM		
		Coefficient	t-statistic	Adjusted R^2
1.	GDP per capita (Y/c)	-2.526	-0.209	-0.04
2.	Intervention volatility (FXIV)	0.085	0.417	-0.03
3.	Surplus periods (FXIS)	-0.601	-0.502	-0.03
4.	Reserve accumulation (RA)	0.141	0.428	-0.03
5.	Exchange rate flexibility (ERF)	-0.043	-0.897	-0.01
6.	Current account openness (CAO)	0.081	0.612	-0.02
7.	Capital account openness (KAO)	0.281	0.599	-0.02
8.	Current account balance (CAB)	0.364	0.153	-0.04
9.	Current account surplus years (CAS)	0.089	0.246	-0.04
10.	Capital account balance (KAB)	0.051	0.015	-0.04
11.	Capital account surplus years (KAS)	-0.098	-0.223	-0.04
12.	Net direct and portfolio investment balance (DIPIB)	-0.577	-0.161	-0.04
13.	Net direct and portfolio investment balance surplus years (DIPIS)	0.076	0.158	-0.04
14.	Net other investment balance (OIB)	-0.135	-0.042	-0.04
15.	Net other investment balance surplus years (OIS)	-0.477	-0.799	-0.01

The dependent variable is the set of estimated long-run multipliers for each country listed in Appendix Table A3. All regressions include a constant which is not shown for brevity.
For t-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.

4.4 Comparing the 1990s and the 2000s

The 40-quarter rolling regressions shown in Aizenman and Glick (2009, Fig. 2) suggest that the degree of sterilisation of reserve money has increased over time in a number of Asian countries (China, Korea, Malaysia, Thailand), reaching close to 100% by the end of their sample period (2006). Lavigne's estimates (2008, Appendix B), comparing 2000-06 with 1990-96, suggest a marked increase in the sterilisation coefficient from low levels in China and India, but little change in Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand, where the estimated sterilisation coefficient was already high in the earlier period. On the other hand, the average estimate in Cardarelli *et al*. (2009, Fig. 8) is fairly stable over time at around 0.6. Arguably persistent foreign exchange reserve accumulation since 2000 has made sterilisation a much more important issue in recent years.

To estimate whether the degree of sterilisation of broad money has changed between the 1990s and the 2000s, we split the sample into two periods: up to 1999q4, and from 2000q1 to 2010q2. The seasonal factors, all lagged $\Delta BM_{t-i}/BM_{t-i-1}$ variables, all $\Delta FXR_{t-i}/BM_{t-i-1}$ variables (contemporaneous and lagged values) and the intercept term are individually interacted with a dummy variable, d(00q1-10q2), that takes the value of 1 from 2000q1-2010q2 and 0 otherwise, but to preserve degrees of freedom the coefficients of the other variables are constrained to be unchanged over the two sub-samples. The new estimating equation, in its general form, is as follows (but, rather than repeat the whole general-to-specific procedure, we just added the new variables into the chosen parsimonious regression for each country):

$$
\begin{aligned}
{}^{\Delta BM_t}/_{BM_{t-1}} = {} & \alpha_0 + d(00q1 - 10q2) \\
& + \sum_{i=1}^{4} \alpha_{1i} {}^{\Delta BM_{t-i}}/_{BM_{t-i-1}} + \sum_{i=1}^{4} \alpha_{2i} {}^{\Delta BM_{t-i}}/_{BM_{t-i-1}} * d(00q1 - 10q2) \\
& + \sum_{i=0}^{4} \alpha_{3i} {}^{\Delta FXR_{t-i}}/_{BM_{t-i-1}} + \sum_{i=0}^{4} \alpha_{4i} {}^{\Delta FXR_{t-i}}/_{BM_{t-i-1}} * d(00q1 - 10q2) + \sum_{i=0}^{4} \alpha_{5i} \Delta Y_{t-i} \\
& + \sum_{i=0}^{4} \alpha_6 \Delta i_{M..\,t-i} - \sum_{i=0}^{4} \alpha_{7i} \Delta i_{B,t-i} - \sum_{i=0}^{4} \alpha_{8i} \Delta i_{US,t-i} + \sum_{i=0}^{4} \alpha_{9i} \Delta \ln (REER)_{t-i} - \sum_{i=0}^{4} \alpha_{10i} \Delta Inf_{t-i} \\
& + \text{seasonal dummies} + \text{seasonal dummies} * d(00q1 - 10q2) + \varepsilon_t
\end{aligned}
\tag{8}
$$

The short-run coefficients on intervention effects are now α_{30} for the period from the beginning of the sample to 1999q4 and $(\alpha_{30} + \alpha_{40})$ for the period 2000q1-2000q2. The long-run coefficients are now:

$$\alpha_{3,LR} = \sum_{i=0}^{4} \alpha_{3i} / (1 - \sum_{i=1}^{4} \alpha_{1i}) : \text{sample start} - 1999q4 \tag{9}$$

$$\alpha_{(3+4),LR} = (\sum_{i=0}^{4} \alpha_{3i} + \alpha_{4i}) / (1 - \sum_{i=1}^{4} \alpha_{1i} + \alpha_{2i}) : 2000q1\text{-}2010q2 \tag{10}$$

Table 6 summarizes the results by region (the results for individual countries are shown in Appendix Table A4). The results indicate that, for Asian countries in particular, the intervention effects are lower in the 2000q1-2010q2 period, indicating a significantly higher degree of sterilisation. For the average Asian country the long-run intervention coefficient for broad money has fallen from 0.89 to 0.28; for Latin America the figures are 0.28 for the 1990s and 0.24 for the 2000s; and for the other emerging markets -0.03 for the 1990s and 0.14 for the 2000s. For the whole sample the average has fallen from 0.43 to 0.22.

Table 6. The Effects of a Change in Foreign Reserves on Broad Money Growth – Group Averages for Sub-periods

Country	The estimated effect of $\Delta FXR_t/BM_{t-1}$ on $\Delta BM_t/BM_{t-1}$			
	Contemporaneous		Long-run Multiplier	
	α_{30}	$\alpha_{30} + \alpha_{40}$	$\alpha_{3,LR}$	$\alpha_{(3+4),LR}$
	Sample start-1999q4	2000q1-2010q2	Sample start-1999q4	2000q1-2010q2
Asia	0.319 (1.247)	0.018 (0.903)	0.894* (2.963)	0.276 (1.086)
Latin America	0.247 (1.054)	0.218** (3.855)	0.284* (2.995)	0.238** (3.942)
Other Emerging Market Economies	0.356 (-0.282)	0.019 (0.120)	-0.029 (0.220)	0.140 (0.542)
All Emerging Market Economies	**0.311** **(0.708)**	**0.073** **(1.459)**	**0.434** **(2.099)**	**0.222** **(1.692)**

- To split the periods, the constant, seasonal factors, all lagged $\Delta BM_{t-i}/BM_{t-i-1}$ variables, and all $\Delta FXR_{t-i}/BM_{t-i-1}$ variables (contemporaneous and lagged values) are individually interacted with a dummy variable that takes the value of 1 from 2000q1-2010q2 and 0 otherwise. See equation (8).
- Columns one and two report the respective group average contemporaneous effect for the two periods and the corresponding average *t*- and F-statistics in brackets, with the F-statistics taking the sign of the coefficient. Columns three and four report the average long-run effects and corresponding average F-statistics.
- For both *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%.

5. Conclusions

In this paper, we set out to investigate the effects of real intervention on the growth of reserve money and broad money over the period 1990q1-2010q2. Empirical work in this regard has been relatively scarce, with emphasis mainly on reserve money sterilisation.

Our empirical analysis was carried out using multivariate dynamic regressions for a sample of 28 countries. This allowed us to consider the short-run and long-run effects of intervention on money growth separately, and also to recognise heterogeneity across countries. For reserve money our results confirmed those of others: there is a high degree of sterilisation in both the short and the long run. For broad money our results were rather different: in the long run it is only about 60% sterilised, compared with over 90% in the short run. We investigated in some detail whether the estimated degree of long-run sterilisation of broad money varied systematically with country characteristics, including the structure of current and capital account balances, with negative results. Our findings imply that countries are substantially less successful at sterilising foreign exchange inflows than previous research has suggested. Although Asian countries seem to have insulated broad money from the effects of foreign exchange intervention more effectively since 2000 than previously, our point estimate for this period is that over 20% of foreign exchange reserve accumulation finds its way into the broad money stock, which still represents a substantial contribution to monetary growth, given the quantity of reserves accumulated.

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Appendix Table A1: General Explanatory Notes on Variables

Variable	Description
BM_t	Real broad money valued in national currency (NC) and deflated by the CPI.
RM_t	Real base money valued in NC and deflated by the CPI.
FXR_t	The central bank's real foreign exchange reserves valued in NC. The raw foreign exchange reserves (FXR) series is in USD (IFS code: .1D.DZF). The real monthly change is derived as follows: $\Delta FXR\ (NC) = \{(\Delta FXR(USD) \times E^{avg.})/CPI\} \times 100$ ($E^{avg.}$ = NC/USD, monthly average exchange rate).
Y_t	Logarithm of gross domestic product (GDP) valued at constant prices (base years vary across countries). Where only current-price data were available, the CPI was used as a deflator.
IntRate(M)_t	Interest rate on money, typically a time deposit rate which is expressed in percent per annum.
IntRate(B)_t	Interest rate on domestic government/corporate bill/bond rate expressed in percent per annum.
IntRate(US)_t	US 3-month Treasury Bill rate expressed in percent per annum.
$\ln(\text{REER})_t$	Logarithm of the real effective exchange rate.
Inflation_t	The annual inflation rate is calculated as the four-quarter change in the logarithm of the CPI: $\ln \text{CPI}_t - \ln \text{CPI}_{t-4}$.

Data Source:
IMF International Financial Statistics (IFS) (downloaded via ESDS International, University of Manchester, http://www.esds.ac.uk/international/doipages/imfifs.asp), national agencies, Datastream, and Abeysinghe and Gulasekaran (2004).

Appendix Table A2: The Estimated Effects of a Change in Foreign Reserves (ΔFXR) on Reserve Money Growth (ΔRM) - Individual Country Results

Country	The effect of $\Delta FXR_t/RM_{t-1}$ on $\Delta RM_{,t}/RM_{,t-1}$	
	(i)	(ii)
	Contemporaneous a_{20}	Long-run multiplier $_{2,LR} = \sum_{i=0}^{4} a_{2i} \Big/ (1 - \sum_{i=1}^{4} a_{1i})$
Asia		
China	0.213**	0.000
	[2.645]	[0.000]
	1991q2-2010q2	
Hong Kong	0.266***	0.151**
	(4.595)	(4.221)
	1999q1-2010q2	
India	0.209***	0.242***
	(4.088)	(44.074)
	1998q1-2010q2	
Indonesia	-0.009	0.070*
	[-0.391]	[2.086]
	1996q2-2010q2	
Korea	-0.088**	-0.058*
	(-2.447)	(3.008)
	1991q1-2010q2	
Malaysia	0.039**	-0.003
	(2.071)	(0.013)
	1991q1-2010q2	
Philippines	-0.073*	-0.073*
	[-1.848]	[3.414]
	1990q2-2010q2	
Singapore	0.018*	0.038***
	[1.777]	[38.928]
	1990q3-2010q2	
Thailand	0.030	-0.019
	[0.770]	[0.345]
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding t statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \beta_{2i}/(1 - \sum_{i=1}^{4} \beta_{1i}) = 0$.
- For both the *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest *t*-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta FXR_t/\ RM_{t-1}$which is not removed in the general to specific modelling process.

Continued

Country	The effect of $\Delta FXR_t/RM_{t-1}$ on $\Delta RM_{,t}/RM_{,t-1}$	
	(i)	(ii)
	Contemporaneous a_{20}	Long-run multiplier $_{2,LR} = \sum_{i=0}^{4} a_{2i} \Big/ (1 - \sum_{i=1}^{4} a_{1i})$
Latin America		
Argentina	0.095* (1.685)	-0.080 (0.800)
	1994q4-2010q2	
Brazil	0.066 [1.286]	0.079 [1.651]
	1997q1-2010q2	
Chile	0.035* [1.876]	0.088*** [16.237]
	1991q1-2010q2	
Colombia	0.137* [2.033]	0.486*** [61.187]
	1995q2-2010q2	
Mexico	-0.056*** [-2.739]	-0.040*** [7.463]
	1991q2-2010q2	
Peru	0.021** [2.537]	0.130*** [260.589]
	1995q2-2010q2	

Continued

Country	The effect of $\Delta FXR_t / RM_{t-1}$ on $\Delta RM_t / RM_{t-1}$	
	(i)	(ii)
	Contemporaneous a_{20}	Long-run multiplier $a_{2,LR} = \sum_{i=0}^{4} a_{2i} \Big/ (1 - \sum_{i=1}^{4} a_{1i})$
Other Emerging Market Economies		
Czech Republic	0.037 (1.198)	0.088*** (8.027)
	1997q2-2010q2	
Hungary	0.056 [1.730]	0.162*** [15.004]
	1996q1-2010q2	
Israel	0.533*** (7.176)	0.780*** (56.117)
	1990q4-2010q2	
Poland	-0.091 (-1.209)	-0.065 (0.063)
	1997q3-2010q2	
Russia	0.239*** [16.089]	0.154*** [80.707]
	1996q3-2010q2	
South Africa	0.038 (0.743)	0.055 (1.277)
	1991q2-2010q2	
Turkey	-0.086** [-2.287]	-0.164*** [14.437]
	1995q2-2010q2	
Developed Economies		
Australia	0.055 [0.582]	0.040 [0.356]
	1990q4-2010q2	
Canada	-0.002 [-0.056]	-0.079 [0.897]
	1990q4-2010q2	
Denmark	-0.028 [-1.351]	0.008 [0.246]
	1991q1-2010q2	
Japan	0.140 [0.870]	0.199 [0.761]
	1990q2-2010q2	
New Zealand	0.054 [1.431]	0.204** [5.146]
	1991q1-2010q2	
Norway	0.071 [1.322]	0.107** [5.787]
	1991q1-2010q2	

Appendix Table A3: The Effects of a Change in Foreign Reserves (ΔFXR) on Broad Money Growth (ΔBM) - Individual Country Results

Country	The effect of $\Delta FXR_t/BM_{t-1}$ on $\Delta BM_t/BM_{t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Asia		
China	-0.141 [-0.810]	0.661** [5.748]
	1991q2-2010q2	
Hong Kong	0.312 (1.497)	0.826** (13.062)
	1998q1-2010q2	
India	0.236 (1.550)	0.205 (0.405)
	1997q3-2010q2	
Indonesia	0..093 [0.607]	0.328** [7.115]
	1995q2-2010q2	
Korea	-0.148 [-1.081]	-1.285** [9.170]
	1990q4-2010q2	
Malaysia	0.197*** (3.824)	0.029 (0.086)
	1991q1-2010q2	
Philippines	-0.038 (-0.263)	0.912** (5.812)
	1991q1-2010q2	
Singapore	0.166*** (2.612)	0.363** (5.387)
	1990q2-2010q2	
Thailand	0.187* (1.754)	2.156*** (9.239)
	1991q2-2010q2	

- Column (i) reports the contemporaneous effect and the corresponding *t*-statistic.
- Column (ii) reports the long-run multiplier and the corresponding F-statistic. The F-statistic is for the test, $\sum_{i=0}^{4} \alpha_{2i}/(1 - \sum_{i=1}^{4} \alpha_{1i}) = 0$.
- For both the *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.
- The results are based on restricted regressions, which include only statistically significant variables at the minimum 10% significance level. Regressors are removed one at a time in a unidirectional backwards manner based on the lowest *t*-statistic each time. This applies to all regressors except the contemporaneous effect of $\Delta FXR_t/\ BM_{t-1}$ which is not removed in the general to specific modelling process.

Continued

Country	The effect of $\Delta FXR_t/BM_{t-1}$ on $\Delta BM_t/BM_{t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Latin America		
Argentina	0.567*** [10.656]	0.653*** [75.334]
	1994q4-2010q2	
Brazil	0.205*** [3.048]	0.120 [0.230]
	1997q4-2010q2	
Chile	0.136 (1.542)	0.136 (2.378)
	1990q3-2010q2	
Colombia	0.523*** [3.737]	0.910** [11.493]
	1995q2-2010q2	
Mexico	-0.187* (-1.769)	-0.162 (0.904)
	1991q2-2010q2	
Peru	0.192*** (3.032)	0.362*** (18.597)
	1995q2-2010q2	
Other Emerging Market Economies		
Czech Republic	-0.233*** [-3.538]	0.149 [1.388]
	1997q2-2010q2	
Hungary	0.069 (1.108)	0.206** (3.979)
	1996q2-2010q2	
Israel	-0.091 [-0.770]	-0.406*** [8.508]
	1991q2-2010q2	
Poland	-0.064 [-0.934]	0.992 [1.709]
	1998q1-2010q2	
Russia	0.187*** (3.107)	0.323*** (15.744)
	1996q3-2010q2	
South Africa	-0.081 (-0.302)	0.735** (4.285)
	1990q2-2010q2	
Turkey	-0.271*** [-3.346]	-0.146 [0.723]
	1995q1-2010q2	

Continued

Country	The effect of $\Delta FXR_t / BM_{t-1}$ on $\Delta BM_t / BM_{t-1}$	
	(i)	(ii)
	Contemporaneous α_{20}	Long-run multiplier $\alpha_{2,LR} = \sum_{i=0}^{4} \alpha_{2i} \Big/ (1 - \sum_{i=1}^{4} \alpha_{1i})$
Developed Economies		
Australia	0.081 (0.110)	0.172 (0.004)
	1991q1-2010q2	
Canada	0.366 (1.222)	1.862* (2.951)
	1991q2-2010q2	
Denmark	0.062 (0.639)	0.425*** (7.940)
	1990q4-2010q2	
Japan	-0.604* [-1.795]	-0.545* [3.169]
	1991q2-2010q2	
New Zealand	0.242 [1.423]	0.399*** [7.735]
	1991q2-2010q2	
Norway	0.240*** [3.376]	0.704*** [20.845]
	1990q2-2010q2	

Appendix Table A4. The Effects of a Change in Foreign Reserves on Broad Money Growth – Individual Country Results for Sub-periods

Country	The effect of $\Delta FXR_t/BM_{t-1}$ on $\Delta BM_t/BM_{t-1}$			
	Contemporaneous		Long-run Multiplier	
	α_{30}	$\alpha_{30} + \alpha_{40}$	$\alpha_{3,LR}$	$\alpha_{(3+4),LR}$
	Sample start-1999q4	2000q1-2010q2	Sample start-1999q4	2000q1-2010q2
Asia				
China	0.190 [1.251]	-0.684 [2.716]	0.982** [4.834]	-0.114 [0.095]
Hong Kong	0.179 (0.118)	0.417 (1.052)	0.137 (0.011)	0.987** (5.351)
India	0.604 (0.567)	0.290 (2.693)	2.410 (0.381)	0.141 (0.202)
Indonesia	0.983 [1.567]	0.202 [1.423]	1.157*** [8.385]	0.255 [1.557]
Korea	0.062 [0.280]	-0.269 [2.275]	-1.259 [0.720]	-0.991** [4.369]
Malaysia	0.234*** (3.492)	0.129* (2.858)	0.111 (1.036)	-0.095 (0.237)
Philippines	0.072 (0.441)	-0.199 (0.302)	1.179** (5.793)	-0.167 (0.137)
Singapore	0.138 (1.556)	0.206** (5.106)	0.165 (2.156)	0.416** (4.041)
Thailand	0.412* (1.947)	0.074 (0.288)	3.162** (4.794)	2.051* (3.463)
Latin America				
Argentina	0.830*** [3.356]	0.399** [5.354]	1.060*** [10.584]	0.464** [4.194]
Brazil	0.041 [0.102]	0.231 [1.741]	-0.891 [0.051]	0.073 [0.096]
Chile	0.131 (1.283)	0.110 (0.331)	0.131 (1.647)	0.110 (0.331)
Colombia	0.510** [2.033]	0.532*** [10.797]	1.052 [2.659]	0.877*** [7.423]
Mexico	-0.242** (-2.042)	-0.155 (0.477)	0.046 (0.047)	-0.443 (1.575)
Peru	0.213 (1.594)	0.190** (5.383)	0.307* (3.085)	0.348*** (13.185)

- To split the periods, the constant, seasonal factors, all lagged $\Delta BM_{t-i}/BM_{t-i-1}$ variables, and all $\Delta FXR_{t-i}/BM_{t-i-1}$ variables (contemporaneous and lagged values) are individually interacted with a dummy variable that takes the value of 1 from 2000q1-2010q2 and 0 otherwise. See equation (8).
- Columns one and two report the respective contemporaneous effect for the two periods and the corresponding *t*- and F-statistics in brackets. Columns three and four report the long-run effects and corresponding F-statistics.
- For both *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.

Continued

Country	The effect of $\Delta FXR_t/BM_{t-1}$ on $\Delta BM_t/BM_{t-1}$			
	Contemporaneous		Long-run Multiplier	
	α_{30}	$\alpha_{30} + \alpha_{40}$	$\alpha_{3,LR}$	$\alpha_{(3+4),LR}$
	Sample start-1999q4	2000q1-2010q2	Sample start-1999q4	2000q1-2010q2
Other Emerging Market Economies				
Czech Republic	2.577** [2.349]	-0.318** [6.976]	1.109*** [14.376]	-0.063 [0.147]
Hungary	-0.012 (-0.089)	0.087 (1.259)	-0.017 (0.008)	0.239 (2.581)
Israel	-0.157 [-1.004]	-0.015 [0.011]	-0.427** [4.402]	-0.541*** [12.420]
Poland	1.142* [1.920]	-0.110 [0.891]	-0.924** [6.757]	1.063 [0.759]
Russia	-0.429 (-1.637)	0.165** (7.281)	-0.584* (3.965)	0.335*** (16.229)
South Africa	-0.435 (-1.321)	0.689 (1.592)	0.708 (2.418)	0.682 (1.044)
Turkey	-0.191** [-2.190]	-0.365 [1.415]	-0.066 [0.122]	-0.737** [4.253]

- To split the periods, the constant, seasonal factors, all lagged $\Delta BM_{t-i}/BM_{t-i-1}$ variables, and all $\Delta FXR_{t-i}/BM_{t-i-1}$ variables (contemporaneous and lagged values) are individually interacted with a dummy variable that takes the value of 1 from 2000q1-2010q2 and 0 otherwise. See equation (8).
- Columns one and two report the respective contemporaneous effect for the two periods and the corresponding *t*- and F-statistics in brackets. Columns three and four report the long-run effects and corresponding F-statistics.
- For both *t*- and F-statistics, ***: significant at 1%; **: significant at 5%; *: significant at 10%, using (Default), [Newey West], {White} standard errors.

Appendix 5: Definitions of Country Characteristics

1. Current account/Capital account openness (CAO/KAO):
   Average of the sum of the absolute value of annual inflows and outflows for each account respectively, taken as a ratio to average annual GDP.

2. Current account/Capital account surplus years (CAS/KAS):
   Number of years with net inflows into the account as a proportion of the total number of years that corresponds to the regression sample period. A country is recorded as a surplus country in the respective account if CAS/KAS > 0.5. Net direct and portfolio investment/other investment balance surplus years (DIPIS/OIS) are calculated in a similar manner.

3. Current account/Capital account balance (CAB/KAB):
   Average of the annual net position in the account scaled by the average annual nominal GDP for the years that corresponds to the regression sample period, multiplied by 100. Net direct and portfolio investment/other investment balance (DIPIB/OIB) are calculated in a similar manner.

4. Intervention volatility (FXIV) is measured by the standard deviation of the monthly changes in foreign exchange reserves scaled by the average annual nominal GDP.

5. Reserve accumulation (RA) is the sum of change in foreign exchange reserves, scaled by the average annual nominal GDP.

6. The total surplus quarters (FXIS) refers to the number of quarters with a positive increase in reserves as a proportion of the total number of quarters.

7. GDP per capita (Y/c) based on purchasing power parity (millions of current international dollar), is taken as an annual average over the regression sample period. Source: WEO. Countries are classified into high or middle income countries based on the World Bank income group classifications.
   (http://data.worldbank.org/about/country-classifications)

8. Exchange rate flexibility (ERF) is identified based on the historical de facto fine classification provided by Ilzetzki et al. (2011). Each year's regime is assigned a number between 1 and 14, with larger numbers reflecting increased flexibility. We use the average over the years corresponding to the regression sample period as an indicator of each country's exchange rate regime flexibility.
   (http://personal.lse.ac.uk/ilzetzki/IRRBack.htm)