Capital flow dynamics and FX intervention

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Abstract

Many emerging markets have intervened in FX markets during and after the global financial crisis to dampen movements in exchange rates and smooth volatile capital flows. Firstly, we show that the joint dynamics of capital flows, FX changes and asset returns in emerging markets are largely consistent with portfolio rebalancing of international investors. This suggests that large and volatile capital flows are here to stay and policy makers will have to devise effective frameworks to deal with them. Secondly, we analyse the differences between FX interveners and non-interveners. We show that intervening economies, on average, have exhibited dynamics that are less destabilising. In particular since 2009, non-intervening economies tend to experience additional capital inflows in response to an exchange rate appreciation – and these capital inflows then create additional appreciation pressures on the exchange rate (ie a momentum effect). In contrast, intervening economies have been able to break the destabilising feedback loop of this momentum effect.

Keywords: FX intervention, portfolio rebalancing, capital flow dynamics

JEL classification: F31, G11, G15

Introduction

After the financial crisis, large and volatile capital flows to emerging markets (EMs) have put strong pressures on exchange rates. To dampen these pressures and the associated exchange rate volatility, many central banks have intervened in the FX market. This raises two main questions for policymakers: what triggers large and volatile capital flows? And can FX intervention influence the dynamics of capital flows and their impact on exchange rates?

We answer these questions by examining the joint dynamics of capital flows and exchange rates in EMs represented at the 2013 Meeting of Deputy Governors in Basel. We demonstrate that the portfolio rebalancing theory provides a robust empirical description of these joint dynamics. We also show that intervening economies, on average, have exhibited dynamics that are less destabilising than those of economies which do not intervene to counter capital flows or exchange rate pressures.

According to the portfolio rebalancing theory, shocks to EM equity prices or FX rates prompt international investors to rebalance their portfolios by changing their portfolio risk-return profiles. Following Hau and Rey (2004), we use a structural VAR model to show that the empirical dynamics are consistent with the predictions of the portfolio rebalancing model for various time periods and regions. In other words, the volatile market reactions seem to be consistent with the behaviour of international investors adjusting to economic shocks or news. Even though the resulting capital flows and pressures on exchange rates and asset prices could be large enough to raise financial stability concerns, these effects should be temporary as portfolio rebalancing will ultimately help to restore a sustainable equilibrium of flows and prices.

We analyse the differences between intervening and non-intervening economies by using central banks' responses to the BIS questionnaire to identify the two groups. This analysis reveals that, during the post-crisis period, the short-term dynamics for the group of non-intervening economies are no longer consistent with portfolio rebalancing, but have taken on a more destabilising character. Non-intervening economies tend to experience additional capital inflows in response to an exchange rate appreciation – and these capital inflows then create additional appreciation pressures on the exchange rate (ie a momentum effect). In contrast, intervening economies have been able to break the destabilising feedback loop of this momentum effect: an exchange rate appreciation did not lead to capital inflows, thus eliminating second-round effects.

The results suggest that capital flow reversals are an integral part of international portfolio adjustment. Furthermore, they also hint at another possible channel for the impact of FX intervention: namely by influencing the interaction between exchange rates and capital flows. In particular, interventions might break the positive feedback loop between capital flows and exchange rates. Importantly, our analysis focusses on short-term dynamics driven by portfolio rebalancing. Beyond the very short term, FX intervention may be less successful in moving the exchange rate in the desired direction as described in the Miyajima and Montoro paper volume.
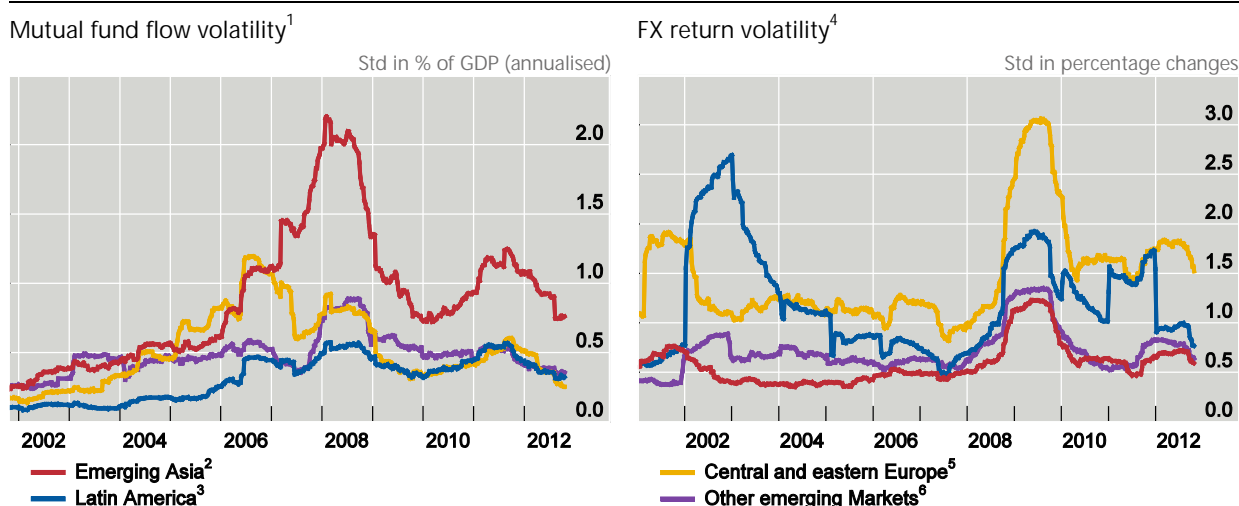
1. Capital flows, exchange rates and financial stability

The volatility of gross capital flows to emerging markets has increased substantially since the financial crisis. Although bond flows are increasingly important, equity flows constitute the dominant share of gross portfolio flows. Below we present flows into emerging markets from US- and Europe-based mutual funds. Equity fund flow volatility quadrupled in emerging Asia and doubled in other emerging market regions at the beginning of 2008 (left-hand panel of Graph 1). Equity flow volatility increased again in 2011 as the euro area crisis intensified and remained generally higher than before the financial crisis. Naturally, the relative shallowness of FX markets in EMs implies that higher capital flow volatility generally translates into higher exchange rate volatility (right-hand panel of Graph 1).

Volatility of mutual fund flows and exchange rates

52-week rolling window standard deviation   Graph 1

Mutual fund flow volatility[1]

Std in % of GDP (annualised)

FX return volatility[4]

Std in percentage changes

Emerging Asia[2]
Latin America[3]
Central and eastern Europe[5]
Other emerging Markets[6]

[1] Simple average across economies. Weekly flows in percent of GDP (annualised). Standard deviation of annualised weekly flows over a 52-week rolling window.   [2] Emerging Asia = China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore, Thailand.   [3] Latin America = Argentina, Brazil, Chile, Colombia, Mexico, Peru.   [4] Standard deviation of weekly percentage changes over a 52-week rolling window.   [5] Central and eastern Europe = Czech Republic, Hungary, Poland, Russia, Turkey   [6] Other emerging markets are Arab Emirates, Israel, Saudi Arabia, and South Africa.
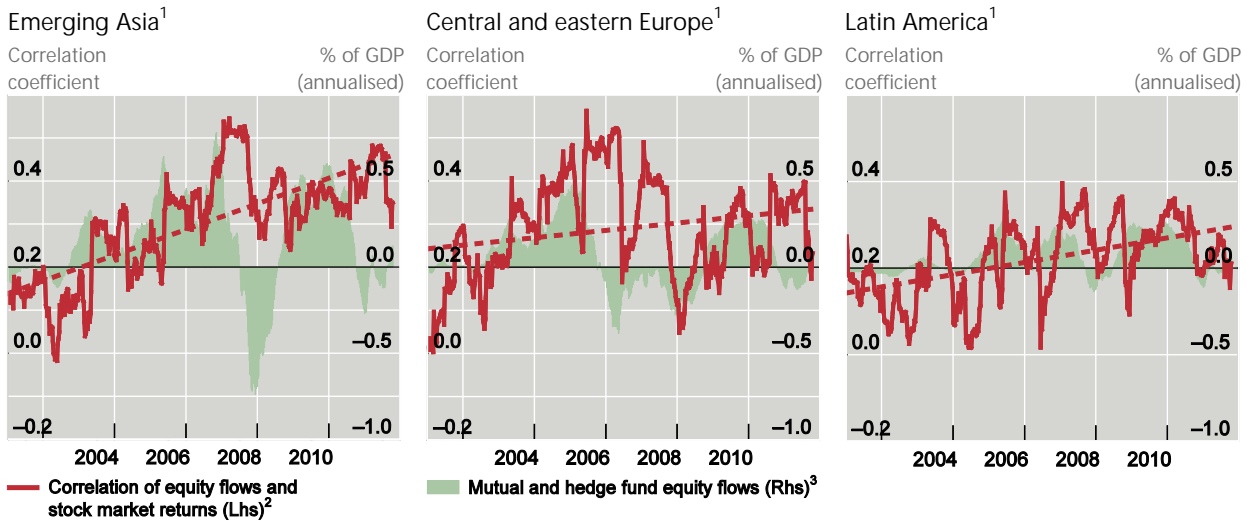
Sources: EPFR; Bloomberg.

As the participation of international investors in EM equity markets is rapidly increasing, their portfolio allocation decisions have become significant drivers of overall capital flows. The impact of international investors' order flows on prices is widely documented in the literature. Froot and Ramadorai (2005) found a strong and persistent link between FX order flows and FX returns. Dunne, Hau and Moore (2010), among many others, present evidence for the impact of international equity order flows on equity returns and exchange rates. In addition, trading volumes on EM FX and equity markets can be relatively limited. Thus, large order flows from US and European mutual funds and other institutional investors can have a strong and persistent effect on prices.

Furthermore, correlations (red lines in Graph 2) between mutual fund equity flows (green bars) and asset market returns in EMs are high and increasing. Although the 2008–09 financial crisis marks a natural peak, the upward trend is

visible. The relationship is particularly strong in regions that attract higher inflows relative to the size of their economies such as emerging Asia (left-hand panel).

Correlation of equity flows and local equity market returns

Graph 2

Emerging Asia[1]

Correlation coefficient   % of GDP (annualised)

Central and eastern Europe[1]

Correlation coefficient   % of GDP (annualised)

Latin America[1]

Correlation coefficient   % of GDP (annualised)

— Correlation of equity flows and stock market returns (Lhs)[2]

▇ Mutual and hedge fund equity flows (Rhs)[3]

[1] Unweighted averages. For regional economies see footnotes below Graph 1.   [2] Correlation coefficient between weekly equity flows and weekly local stock market returns in USD (52-week moving window); simple average across economies.   [3] Mutual and hedge fund equity flows are the cumulative flows over the last 52 weeks; sum over all economies; in percent of annual GDP.

Sources: Morgan Stanley; EPFR; BIS calculations.

Large and volatile exchange rates and capital flows can greatly affect monetary and financial stability. Therefore, it is not surprising that central banks intervene on foreign exchange markets with the aim of curbing excessive exchange market speculation and FX volatility, as highlighted by the responses to the BIS questionnaire.[2] However, it remains unclear whether these interventions are capable of changing the basic dynamics of capital flows and exchange rates. In order to answer this question, we apply a structural VAR model in the next section to analyse the joint dynamics of capital flows, exchange rates and equity market returns.

2. The portfolio rebalancing model

According to the portfolio rebalancing model, international investors allocate their assets by trading off the expected return and variance of assets in different markets across the globe. This holds true even in the presence of substantial market imperfections (ie high trading costs, imperfect information) or capital controls. As long as it is possible to trade, investors can simply adjust the expected return and variance of assets accordingly. If investors are fully insured against FX risks, however, *random shocks* to equity prices or exchange rates do not alter the optimal portfolio allocation. In contrast, as is widely documented in the literature,[3] international

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[2]   See the background note for this meeting by Mohanty and Berger.

[3]   The lack of hedging by institutional investors is well documented, for instance, in Bank of New York Mellon (2010) and Levich et al (1999). Furthermore, FX hedging instruments are bound to be

investors typically do not fully insure against FX risks on the grounds of cost and complexity. Thus, even though risk management practices have improved after the financial crisis, currency hedging is far from perfect. Therefore random shocks do affect the FX risk exposure of international investors; although by definition, they do not alter investors' expectations about the future returns or risks of their asset holdings. But, to retain a portfolio with an optimal trade-off between risk and return, investors need to rebalance their portfolio.

As an example, consider a positive random shock to equity prices in an emerging market economy. The representative international investor, who we assume is based in the United States, sees the emerging market share of his portfolio rising. This share is denominated in EM currency. Thus, with incomplete FX hedging, the FX risk exposure inherent in the investment portfolio increases. The risk of the investment portfolio is now too high, given that expected returns are unchanged by a random asset return shock. To restore an optimal portfolio allocation, the international investor sells equities from the respective emerging market until the risk-return ratio of the portfolio returns to its optimal level. The asset sales trigger capital outflows and, given the relative shallowness of EM FX markets, depreciates the emerging market's exchange rate vis-à-vis the US dollar.

Implied dynamics of the model

Based on the theoretical mechanism described above, the empirical implications of the portfolio rebalancing model for the joint dynamics of asset prices, capital flows and FX rates can be summarised as follows:

(i) A positive shock in EM equity prices triggers capital outflows and a currency depreciation, as investors reduce their FX risk exposure by repatriating a share of their assets.

(ii) By the same logic, an exchange rate appreciation shock in EMs leads to capital outflows and lower equity prices.

(iii) A capital inflow shock to EMs leads – via higher demand – to higher equity prices and exchange rate appreciation. If the respective EM equity and FX markets are relatively illiquid, then this effect is even stronger.

FX intervention, momentum effect and structural shifts

Three scenarios could alter the portfolio rebalancing dynamics:

(i) *FX intervention*: FX intervention can potentially influence the expectations of international investors about short-run exchange rate movements. Effective intervention can mitigate exchange rate volatility and counter the impact of capital flows. The central bank can also influence the demand and supply of foreign exchange relative to domestic currency on the FX market. All the above would affect the joint dynamics of exchange rates and capital flows.

(ii) *Momentum effect*: many international investors adopt a positive feedback strategy – also known as momentum strategy – in which they buy when prices

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incomplete: in many EMs FX derivative contracts are still not widely available; and even when they are used, hedging against currency risks is highly complex and often not very effective as documented in Dale (1981) and Jong et al (1997) among many others.

rise and sell when prices fall (Kaminsky et al (2004)). Such a positive (ie destabilising) feedback loop is very different from the negative (ie stabilising) feedback implied by the portfolio rebalancing theory. Under the momentum effect, a positive exchange rate shock would lead to additional capital inflows and thereby second-round exchange rate appreciation.

(iii) *Structural shifts in portfolio allocation*: if international investors consistently shift their portfolios towards emerging market assets, then the resulting flows could potentially dominate the effects of portfolio rebalancing; even in the higher frequency data we use here. To account for this possibility, we will look separately at periods of prolonged inflows (2002–07, 2009–12) and a period of persistent outflows (2007–08).

The three scenarios are not independent of each other. A structural shift of the optimal portfolio allocation towards additional EM assets, as observed in recent years, can reinforce the momentum effect. If higher EM equity returns (relative to advanced economies) signal a structural shift towards additional EM asset holdings, then this would rationally imply greater capital inflows. The resulting exchange rate and asset price appreciations would ex post justify the reallocation of capital – and this justification might motivate even higher EM allocations. Furthermore, FX intervention might weaken or completely break the momentum effect, if the intervention is able to limit the second round of exchange rate appreciation.

Econometric model

Following Hau and Rey (2004), we formulate a structural vector auto-regression model in three variables:[4]

(i) EM equity price returns relative to the US equity market index;

(ii) Equity portfolio flows into EM dedicated mutual funds (relative to GDP);

(iii) EM exchange rate returns.

To capture the dynamics implied by portfolio rebalancing, we employ weekly data. The higher frequency of this data is well suited to capturing the movements caused by active international investors.

As the three variables in the system move contemporaneously, a simple identification based on a causal ordering is not permissible. Instead, we utilise the theoretical predictions of the portfolio rebalancing model to achieve identification. By imposing sign restrictions on the correlation between impulse responses of the three shocks (Uhlig (2001) and Canova and De Nicolo (2002)), we identify the variance-covariance matrix decomposition that is most consistent with the theoretical priors (see Appendix for details). Note that the sign restrictions do not pre-impose our results. A restriction on the correlation between impulse responses does not predetermine whether the individual responses are positive or negative.

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[4] See the Appendix for a detailed technical description of the model and the shock identification strategy. We employ data for 16 of the 20 participating economies: Argentina, Brazil, China, Colombia, the Czech Republic, Hong Kong SAR, Hungary, India, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, the Philippines, Russia, Saudi Arabia, Singapore, South Africa, Thailand, and Turkey. Due to incomplete data, Chile, India, Russia, and Saudi Arabia could not be included in the sample.

3. Results

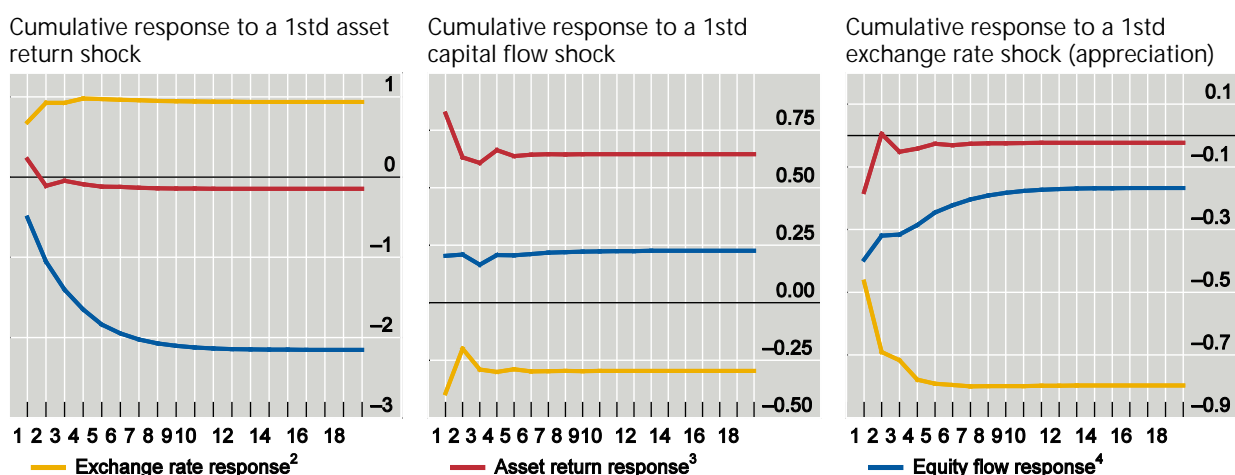## The relevance of portfolio rebalancing

The joint short-run dynamics of equity returns, equity flows and exchange rates in emerging markets are fully consistent with the portfolio rebalancing model (Graph 3). The signs of all impulse responses are as predicted by the model.

On average, a positive shock to EM equity prices (as shown in the left-hand panel) triggers capital outflows (blue line) and currency depreciation, ie a positive exchange rate response (yellow line). As expected, capital inflow shocks to EMs do lead to higher equity prices and exchange rate appreciation (centre panel). Finally, an unexpected exchange rate appreciation in EMs leads to capital outflows and lower equity prices, as investors reduce their FX risk exposure (right-hand panel).

Cumulative impulse responses from SVAR[1]

Weeks ahead, based on weekly data from 2009–12   Graph 3

Cumulative response to a 1std asset return shock

Cumulative response to a 1std capital flow shock

Cumulative response to a 1std exchange rate shock (appreciation)

— Exchange rate response[2]   — Asset return response[3]   — Equity flow response[4]

[1] Impulse responses represent a GDP-weighted average over the 16 emerging economies for which data is available (see footnote 6 in the main text). Based on weekly data from the beginning of 2009 to November 2012.   [2] FX returns response; weekly percentage changes in FX rates measured as local currency per USD.   [3] Weekly percentage changes of broad based equity market index.   [4] Weekly annualised flows in % of GDP; mutual and hedge fund flows from advanced economies into EM equities.

Sources: EPFR; Morgan Stanley; Bloomberg; Datastream; national data; BIS calculations.

The estimated short-term responses are also very significant in economic terms. A one-standard-deviation asset return shock (0.2% in a given week) triggers capital outflows of 2.1% of GDP (annualised) in the long run, as well as a currency depreciation of almost 1% (Graph 3, left-hand panel). Likewise, a one-standard-deviation capital flow shock (additional inflows of around 0.2% of GDP), leads to an FX appreciation of roughly 0.3%, and a rise in EM equity prices of about 0.6% in the long run (middle panel). In response to a one-standard-deviation currency appreciation (typically 0.45% in a given week), EMs, on average, exhibit annualised capital outflows of roughly 0.2% of GDP in the long run, although with only minor effects on asset prices after four weeks or more (right-hand panel).The robustness of this result is remarkable. While the presented impulse responses are based on weekly data from 2009 until November 2012 and are averaged across economies, the shock responses are qualitatively and quantitatively stable over time and across

regions. In particular, the results hold across both the full 2002–12 period and for the 2002–07 pre-crisis period. Consequently, they are not an artefact of recent crisis related capital movements. Furthermore, the results also hold for the three major EM regions separately.

FX intervention and portfolio rebalancing

In order to investigate the impact of intervention, we use the responses by central banks to the BIS questionnaire for this meeting to classify economies according to the motives for intervention. In particular, we identify two groups of economies that intervene actively in the FX market to influence portfolio rebalancing dynamics, namely (i) economies that intervene to dampen FX volatility and (ii) those that intervene to ease the pressure on FX rates caused by international speculators (see Table 1 for short summary). These two motives for intervention are not necessarily different from each other, but the economies which have responded to intervene on the grounds of the two different motives are not the same in the BIS questionnaire. Hence this can be seen as a robustness check for our identification.

Economies intervening in the FX market

Grouping according to the motives for intervention based on the responses to the BIS questionnaire   Table 1

Reporting economies	Brazil, Hong Kong SAR, Korea, Malaysia, Peru, the Philippines, Singapore, Thailand, Turkey, South Africa	
Motives for intervention	Curb upward or downward pressure caused by international investors	Dampen exchange rate volatility
Number of economies intervening with this aim	7	7
Number of economies NOT intervening with this aim	3	3

Classifying economies in this way reveals a systematic effect of FX intervention in the post-2008 period, when international investor interest in EMs was particularly high. The non-intervening economies exhibit a momentum effect: FX appreciation leads to capital inflows and higher asset prices, which in turn leads to even more FX appreciation (red lines in both panels of Graph 3). In contrast, the intervening economies seem to have been able to break this momentum effect (blue lines in both panels of Graph 4).

A closer look at the motives for intervention provides additional insights. Economies that intervened to limit FX volatility have seen significant long-run capital outflows and small negative asset returns after currency appreciations (blue lines in left-hand panel of Graph 4). In contrast, economies that intervened to limit upward or downward pressures caused by international investors did not experience any long-run impact on capital flows or asset returns after an exchange rate appreciation (blue lines in the right-hand panel).
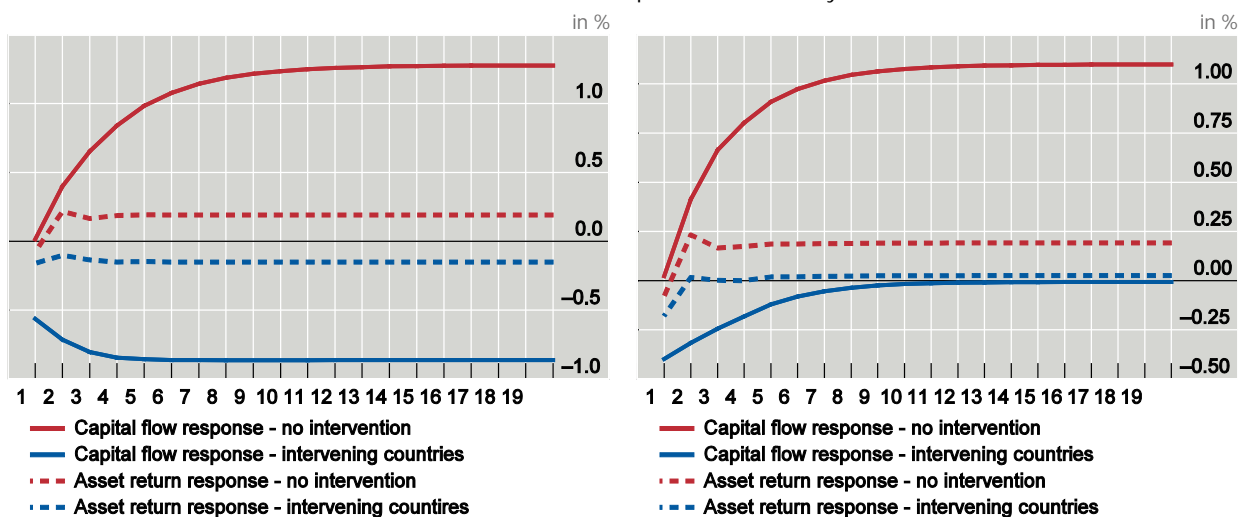
Cumulative impulse responses from the SVAR

Cumulative responses (weeks ahead) to a **_1std FX return shock_** (appreciation of currency)[1]   Graph 4

Economies intervening to limit exchange rate volatility

Economies intervening to limit upward or downward pressure caused by international investors

- Capital flow response - no intervention
- Capital flow response - intervening countries
- Asset return response - no intervention
- Asset return response - intervening countires

[1] Impulse responses are weighted averages over economies which responded with yes or no. Based on responses from the BIS questionnaire on questions regarding immediate objectives of intervention. Equity flows are mutual and hedge fund flows from advanced economies into EM equities. FX returns are the weekly percentage changes in FX rates measured as local currency per USD. Based on weekly data from beginning of 2009 to November 2012.

Sources: EPFR; Morgan Stanley; Bloomberg; BIS calculations.

However, if shocks other than innovations in FX returns are considered, both intervening and non-intervening economy dynamics are again consistent with the portfolio rebalancing theory (Graph A1 in the Appendix). The impulse responses all have the right sign. The signs of all impulse responses to asset return (upper row) and capital flow shocks (lower row) are as predicted by the model. This suggests that portfolio rebalancing remains a key driver of exchange rate and capital flow dynamics also for intervening economies.

Overall, it seems that FX intervention may work through a channel which is often overlooked in the literature. It can mitigate the most destabilising effects on emerging markets by breaking the reinforcing feedback between FX appreciation and capital inflows. However, it cannot systematically insulate against the effects of portfolio rebalancing by international investors.

4. Caveats

Our results should be read with appropriate caveats. Most importantly, we identified systemic differences between intervening and non-intervening economies and did not analyse the effectiveness of exchange rate interventions. Hence, our results provide indirect, as opposed to direct, evidence of the effects of such interventions. For instance, it is theoretically possible that the momentum effect was broken by common factors other than FX interventions, such as capital control measures or large FX reserves. Hence, careful examination of policies that accompanied FX interventions might provide additional insights for policymakers. Nevertheless,

our results suggest a theoretically sound, but so far overlooked, channel through which intervention can be effective: to dampen potentially destabilising higher frequency *interactions* between exchange rate shocks and capital inflows.

A further caveat is that we base our identification of the motives for intervention on the questionnaire responses for the most recent time period (2011–12). While this ensures consistency across the empirical results for different time periods, it also implies that the identification of intervening and non-intervening economies becomes weaker as we consider older samples. For instance, if we repeat the analysis for the period preceding the financial crisis (2002–07), the difference between intervening and non-intervening economies disappears. This might be due to the fact that the set of interveners has changed during this time period.

While the applied methodology allows a structural identification of shocks, it has some important limitations. First, it treats capital inflows and outflows symmetrically. This may be appropriate most of the time, but capital outflows can differ in many important aspects from inflows, especially during times of market stress, as deputy governors highlighted during the discussions. As we have focussed our analysis on relatively high frequency data, a structural shift towards EME assets should not fundamentally influence our results. Nevertheless, it is unclear whether the news of improving or worsening economic fundamentals could drive asset prices and capital flows, rather than portfolio rebalancing motives. As deputy governors highlighted, exchange rate intervention policies might be able to curb speculative momentum, but it is unlikely to affect more fundamental reallocation.

Finally, our results concern groups, typically large groups of EMs. Consequently, the experiences of some individual economies, especially over shorter time periods, might differ significantly from the aggregated picture presented here.

5. Conclusion

The paper has demonstrated that portfolio rebalancing by international investors provides a robust model for describing the joint dynamics of exchange rates, capital flows and asset prices in EMs. Furthermore, FX intervention seems to have been effective in breaking the momentum effect of FX appreciation and capital inflows in the post-crisis period.

These results are relevant to policymakers for three main reasons. First, the portfolio rebalancing theory's success in describing capital flow dynamics so robustly throughout the past decade suggests that large and volatile capital flows are here to stay. In fact, as gross cross-border EM asset positions in advanced economies increase, economic shocks might well trigger a greater absolute amount of portfolio purchases and sales, and hence larger capital flows and reversals in the coming years. Consequently, policymakers in EMs might want to devise frameworks and strategies to cope with them.

Second, our results also propose a potential role for FX intervention in curbing some of the destabilising short-run effects of capital flow and exchange rate shocks. In particular, intervening economies seem to have succeeded in breaking the momentum effect of exchange rate appreciation and capital inflows in the post-crisis period. To some extent, this result may reflect that only central banks which are confident in the effectiveness of intervention do take action. However, the

relatively large number of interveners in our sample (7 out of 10) suggests that, on average, our results bear economic significance.

Finally, the overall picture emerging from our research suggests that portfolio rebalancing effects are strongly present in both intervening and non-intervening economies. Consequently, policymakers might also want to consider instruments other than FX interventions, such as macroprudential tools or capital account measures, when addressing potential financial stability issues that arise from portfolio rebalancing by international investors.

Appendix:
Model description

Specification and variables

Following Hau and Rey (2004), we set up a three-dimensional linear VAR

$$
\begin{bmatrix} r_t^c \\ fl_t^c \\ fx_t^c \end{bmatrix} = \mu^c + \sum_{l=1}^{L} A_l \begin{bmatrix} r_{t-l}^c \\ fl_{t-l}^c \\ fx_{t-l}^c \end{bmatrix} + \varepsilon_t^c
$$

where c denotes the economy (or region) and l the lag length. The model is estimated with weekly data and thus t denotes the time period in weeks. Based on the Akaike and Bayesian information criteria, the most appropriate common number of lags for all economies is $L = 2$.

The three endogenous variables are asset returns (r), equity flows (fl) and FX returns (fx). Asset returns are defined as weekly percentage changes in the broad-based MSCI equity market index for a given economy c. Capital flows are in percent relative to GDP (annualised). The measure is based on the weekly net inflows into emerging market dedicated mutual funds reported by EPFR. The funds reporting their net inflows are based primarily in the United States and Europe, as well as in some offshore centres. These inflows can be broken down into individual recipient economies. We divide the net inflows for individual economies by the respective annual nominal GDP in USD (as reported by the IMF) and then annualise (multiply by 52) to obtain the net inflows relative to GDP. Finally, FX returns are the weekly percentage changes of the daily end-of-business USD exchange rate in local currency as reported by Bloomberg.

To generate the impulse response functions for regional data, or the whole sample of economies, we construct GDP weighted averages of the endogenous variables.

Structural identification of shocks

The question of how structural economic shocks are identified is crucial in this setup. A standard causal ordering is not valid, since the variables in the VAR are moving at high frequencies. Hence a shock to one variable will most likely have an effect on other variables in the system within the same time period. To disentangle the effects of the three shocks in our system, we have to impose an additional structure on the VAR model. In effect, this means deriving implications from the underlying economic theory which help to pin down the set of plausible impulse response functions. From the implications of the portfolio rebalancing model (Section III), one can directly derive a set of time series correlation restrictions among impulse responses:

$$corr\big(IRF_{r^c}(r^c), IRF_{r^c}(fl^c)\big) < 0; \ \ corr\big(IRF_{r^c}(r^c), IRF_{r^c}(fx^c)\big) > 0;$$

$$corr\left(IRF_{fl^c}(r^c), IRF_{fl^c}(fl^c)\right) > 0; \ \ corr\left(IRF_{fl^c}(fl^c), IRF_{fl^c}(fx^c)\right) < 0;$$

$$corr\left(IRF_{fx^c}(r^c), IRF_{fx^c}(fx^c)\right) > 0; \ \ corr\left(IRF_{fx^c}(fl^c), IRF_{fx^c}(fx^c)\right) > 0;$$

where $IRF_{r^c}(fl^c)$, for instance, denotes the impulse response function of capital flows (fl) in response to an asset return shock (r). Note that these restrictions are

based on the sign of a time series correlation and do not pre-impose whether the impulse response is negative or positive at any given point in time.

The identification is then achieved by a grid-search over the possible three-dimensional rotations of the covariance matrix of shocks, such that the resulting impulse responses are most consistent with the restrictions above. Consistency is measured by a high value of the objective function

$$\sum_s (1 - \exp(-(corr_s)^2)) \times I\big(sign(corr_s)\big)$$

where $I\big(sign(corr_s)\big)$ is an indicator function which takes a value of 1 if the measured correlation fulfils the corresponding sign-restriction above, and is set to -1 if the restriction s is not fulfilled. This deviates slightly from Hau and Rey (2004) to give more weight to the sign of the observed correlation rather than its absolute value.
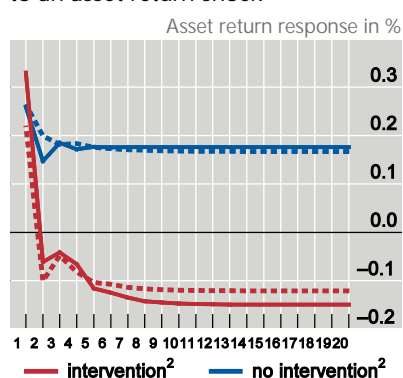
Appendix graph
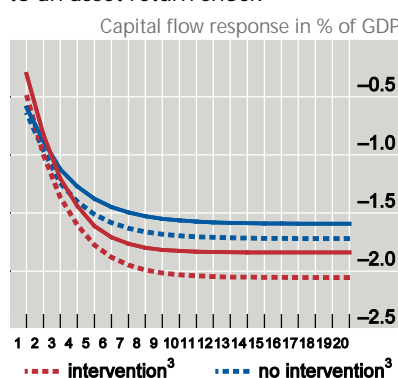
Cumulative impulse responses to 1 std shocks[1]

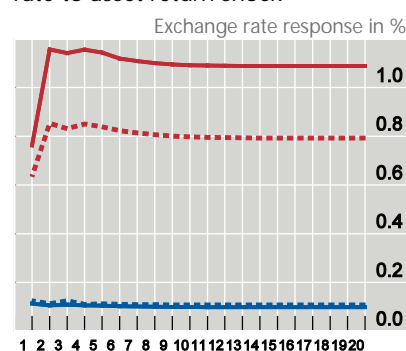Weeks ahead, based on weekly data from 2009–12   Graph A1

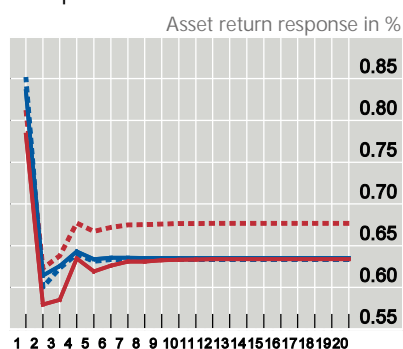Cumulative response of asset returns to an asset return shock

Asset return response in %

Cumulative response of capital flows to an asset return shock

Capital flow response in % of GDP

Cumulative response of exchange rate to asset return shock

Exchange rate response in %

— intervention[2]   — no intervention[2]   ···· intervention[3]   ···· no intervention[3]

Cumulative response of asset return to capital flow shock

Asset return response in %

Cumulative response of capital flows to capital flow shock

Capital flow response in % of GDP
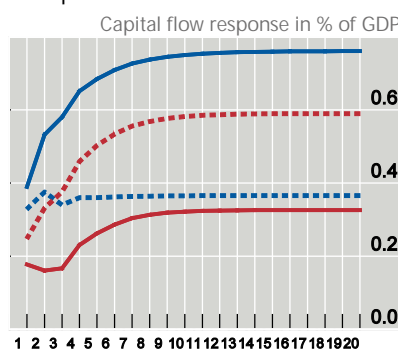
Cumulative response of exchange rate to capital flow shock

Exchange rate response in %
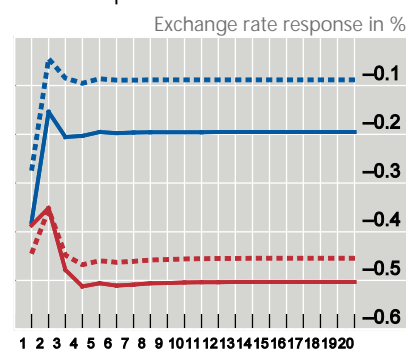
[1] Impulse responses are GDP-weighted averages over economies which responded with yes or no. Based on responses from the BIS questionnaire regarding the immediate objectives of intervention. Capital flows are mutual and hedge fund flows from advanced economies into EM equities. FX returns are the weekly percentage changes in FX rates measured as local currency per USD. Based on weekly data from beginning of 2009 to November 2012.   [2] Economies that intervened to dampen exchange rate volatility.   [3] Economies that intervened to limit upward and downward pressure caused by international investors.

Sources: EPFR; Morgan Stanley; Bloomberg; Datastream; national data; BIS calculations.

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