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Foreign exchange intervention and expectation in emerging economies[1]

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Abstract

Using monthly data for four selected emerging economies, sterilised central bank foreign exchange intervention is found to have little systematic influence on the near-term nominal exchange rate expectations in the direction intended by the central banks. In other words, central bank dollar purchases to stem exchange rate appreciation or related exchange rate volatility are not associated with an adjustment of the near-term exchange rate forecasts in the direction of depreciation, and vice versa. This suggests intervention may not change the near-term exchange rate expectations. Moreover, intervention may have had unintended effects in the sense that it can lead to undesired volatility in the exchange rate, which is consistent with previous studies.

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[1] This paper is an expanded version of a chapter of a forthcoming BIS Paper, prepared in conjunction with the 18th Annual Meeting of Deputy Governors from major emerging market economies held on 21–22 February 2013. The meeting addressed issues and implications related to foreign exchange intervention by emerging market economies.

[2] Miyajima is Senior Economist at the Bank for International Settlements (BIS). I would like to thank Fernando Avalos, Steve Cecchetti, Jose Luis Escriva, Andy Filardo, Aaron Mehrotra, Madhu Mohanty, Carlos Montoro, Ramon Moreno, Renzo Rossini, Philip Turner, Nick Vause, James Yetman and Fabrizio Zampolli for comments. Tracy Chan, Philippe Staeheli, Diego Urbina and Alan Villegas provided valuable assistance. The views expressed in this article are those of the author alone and do not necessarily those of the BIS.

Contents

1. Introduction

Has sterilised intervention in emerging market economies (EMEs) had an impact on exchange rate expectations? The question arises because "in the era of flexible exchange rates, relative currency prices are clearly expectations driven" (Dominguez (1986)). If expectations remain unchanged, any impact on the spot exchange rate could be short-lived. If interventions are believed to help guide the nominal exchange rate towards values more consistent with fundamentals, such policy actions probably change exchange rate expectations in the direction intended by the central bank. This will be welfare-enhancing to the extent that a persistent deviation of the exchange rate from levels consistent with fundamentals creates welfare losses.

Exchange rate expectations are particularly important for the monetary policy decisions in EMEs. The exchange rate has been a policy tool in EMEs to various degrees due to, for instance, relatively large exchange rate pass-through to domestic inflation or currency mismatches. In this context, BIS (2011) provides a rich discussion as to how external factors can influence monetary policy frameworks and operations in EMEs. The authors follow Ball (1999) and characterise the monetary policy reaction function in EMEs as an exchange rate-augmented Taylor-type rule, and find that the exchange rate is an important policy tool in EMEs.[3]

One important factor dictating exchange rate expectations is macroeconomic fundamentals. A favourable growth outlook or perception of lower macroeconomic vulnerabilities to external shocks can attract foreign capital inflows and strengthen the exchange rate.[4] The red line in Graph 1 shows that the growth rate of real GDP has turned firmly in favour of EMEs relative to that of advanced economies since the turn of the century. The blue bars in Graph 1 show emerging and developing economies have accumulated foreign exchange reserves rapidly over the last decade.

In addition, central bank foreign exchange intervention can potentially influence exchange rate expectations. The authorities in many EMEs have intervened in foreign exchange markets, and often persistently. Since the onset of the global financial crisis in 2008, higher capital flow volatility in the low global interest rate environment has had important implications for their exchange rates, prompting central banks in EMEs to increase their involvement in exchange rate management.[5]

Learning by economic agents appears to be an important element for intervention to be able to have an intended effect on exchange rate expectations. The literature suggests learning is key in characterising exchange rate behaviour. Models with learning by economic agents, rather than rational expectations, can account for key characteristics of exchange rates (Lewis (1989a), Lewis (1989b), Mark

[3] As a special case, Singapore uses exchange rate as a monetary policy tool, with domestic interest rates being determined largely by foreign interest rates and exchange rate expectations.

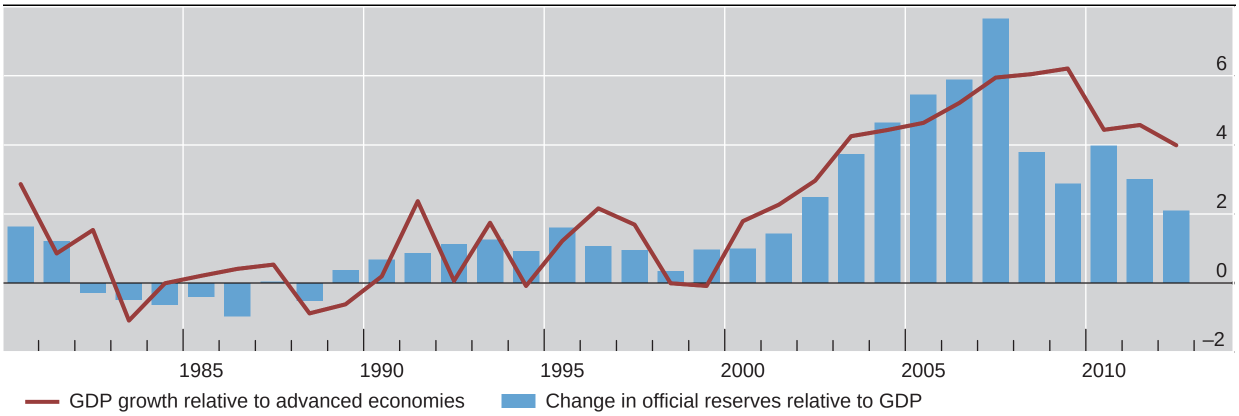
[4] The nominal exchange rate can strengthen through the Balassa-Samuelson effect (Harrod (1933), Balassa (1964), Samuelson (1994)) if the real appreciation associated with faster economic growth stems from nominal appreciation.

[5] Central banks in EMEs have intervened probably for different reasons: to maintain price competitiveness of their exports, safeguard financial stability by reducing the volatility of exchange rates, which can arise, for instance, due to price rigidities (Dornbusch (1976)), or to help achieve monetary policy objectives, such as inflation targeting.

(2009), Kim (2009)), in particular the forward premium puzzle (Chakraborty and Evans (2008)). And market expectation of credible (and marginal) intervention by the central bank can guide the exchange rate as desired by the central bank, such as within the target zone (Krugman (1991)).[6] However, facilitating the formation of the right expectations may not be straightforward, as cautioned by some studies focusing on the Louvre target zone. Klein and Lewis (1993) find that market perceptions of the Louvre target zone, measured as the probability of intervention, were volatile. Findings by Esaka (2000) question the credibility of the Louvre target zone.[7]

GDP growth and change in official reserves of emerging and developing economies[1]

In per cent Graph 1



[1] Real GDP growth of emerging and developing economies minus that of advanced economies. Change in official reserves in dollars divided by GDP in dollars. The correlation coefficient of the red line and blue bars is 0.86, or 0.67 after removing the individual linear time trends.

Sources: IMF, *World Economic Outlook*; BIS staff calculations.

Against this backdrop, we examine how central bank foreign exchange intervention influences exchange rate expectations as follows. First, by extending a model proposed by Bacchetta and Wincoop (2006), we present a basic model that relates exchange rate expectations and central bank intervention, along with other key determinants of exchange rates. In the second stage, we exploit three month ahead exchange rate forecasts reported on a monthly basis to estimate a regression in a static fixed-effect panel framework.

[6] Svensson (1992) introduces intra-marginal intervention and the probability of realignment. Koedijk et al (1995) argue that the instantaneous effectiveness of intervention tends to be larger the more implicit the exchange rate band policy is. In a target zone model with uncertainty, Klein (1992) demonstrates that an infinitesimal unsterilized foreign exchange intervention may cause a very large discrete change in the exchange rate.

[7] Following the Plaza Agreement of September 1985, the dollar depreciated substantially against the other major currencies, with the Japanese yen appreciating from 240 to 155 yen to the dollar. In February 1987, at the meeting of the Group of Five held at the Palais du Louvre, it was agreed that exchange rates should be stabilised at around the prevailing levels. The details of the agreement were never made public, but Funabashi (1989) and others in the press reported that major countries did in fact adopt a target zone at that time.

Our results suggest that sterilised central bank foreign exchange intervention does not seem to systematically influence near-term exchange rate expectations in the direction intended by the central bank. In other words, central bank dollar purchases (sales) to fight currency appreciation (depreciation) or related currency volatility are not associated with an adjustment of near-term exchange rate forecasts in the direction of depreciation (appreciation). Moreover, intervention may have had unintended effects on exchange rate expectations.

In what follows we will review findings in previous studies concerning the influence of central bank foreign exchange intervention on exchange rates. Then, we will present a simple model and econometrically estimate the impact of central bank intervention on 3-month exchange rate forecasts using monthly data from Consensus Economics and for a panel of four EMEs (Brazil and Peru in Latin America, and Malaysia and Korea in Asia) over the period of 2004–12. Finally we discuss the findings and policy implications.

2. Findings in previous studies

A large body of the literature on the effectiveness of central bank interventions focuses on their impact on the spot exchange rate, and evidence in EMEs is mixed. Reviews by Menkhoff (2012) and Ostry et al (2012) suggest that interventions in some cases have a systematic impact on the rate of change in exchange rates, while in other cases they have been able to reduce exchange rate volatility. Intervention appears to be more effective when it is consistent with monetary policy (Amato et al (2005), Kamil (2008)). Thus results vary depending on the intervention episode and instrument. Of course, the effectiveness of central bank intervention needs to be evaluated against its policy goal.

The view taken in the literature is that central bank foreign exchange interventions may have a larger effect in EMEs than in advanced economies. This is because the degree of substitutability between domestic and foreign assets is considered to be lower in EMEs. In addition, central banks in EMEs may have an information advantage over market participants because of their informational and regulatory power (Canales-Kriljenko (2003)). Finally, non-sterilisation of intervention can strengthen the impact of intervention, as discussed by Sarno and Taylor (2001) and Menkhoff (2012). Despite the literature's strong focus on the effectiveness of central bank intervention on spot exchange rates, the response of exchange rate expectations could be of greater importance for policymakers. This is particularly so to the extent that interventions in EMEs have become more persistent, with potential implications for market views about future exchange rates. To have a significant effect on the spot exchange rate, central bank intervention probably needs to alter market expectations about the future path of the exchange rate. Therefore a direct way to measure the effect is to look at the changes in exchange rate forecasts.

A large body of literature exploits data on exchange rate expectations for advanced markets. This literature examines the characteristics of survey-based exchange rate forecasts: formation process, predictive power and heterogeneity across individual forecasters (Dominguez (1986), Frankel and Froot (1987), Ito (1990), Elliott and Ito (1999), Bénassy-Quéré et al (2003), Frenkel et al (2009)).

One interesting question is whether central bank intervention can provide guidance to market participants about the central banks' preference about exchange rate movement. A study by Rülke and Yoshida (2009) for Japan provides tentative evidence about the potential role of learning, whereby interventions, under certain conditions, lead market participants to learn the central bank's reaction function and its preferred exchange rate path. These authors find that, in some cases, dollar purchases by the Bank of Japan can lead to an adjustment of three-month dollar/yen monthly forecasts in the direction of a weaker yen. For this to happen, the intervention needs to be able to influence the spot exchange rate in the same direction. In addition, it needs to be followed by a period of no intervention, which is considered to allow forecasters to evaluate and learn the effect of the intervention.

However, Beine et al (2007) suggest that intervention can unanchor exchange rate expectations. The authors find that interventions can increase the heterogeneity of individual forecasts, measured by the coefficient of variation across the individual forecasts, for the euro/dollar and yen/dollar crosses. In other words, intervention seems to increase uncertainty around the trajectory of exchange rates. This is consistent with the finding in the many studies on advanced economies surveyed by Neely (2008) that central bank intervention can increase the volatility of spot exchange rates.

So far, little work has been done to provide guidance about the impact of central bank intervention on exchange rate expectations in EMEs. Among the few related works, Disyatat and Galati (2007) use market-based option prices as measures of expectations for the Czech Republic and find that intervention had some impact. Thus, our paper attempts to shed light on the impact of central bank intervention on near-term exchange rate expectations.

3. Our approach

This section discusses a theoretical model and an econometric approach to estimate the impact of central bank intervention on exchange rate forecasts.

3.1 Theoretical model

A key determinant of exchange rates is interest rate differentials. The theory of uncovered interest parity predicts that higher domestic interest rates (relative to US interest rates) should weaken exchange rates in EMEs. This is because the gains through earning higher interest rates should be counter-balanced by weaker exchange rates in future once opportunities to make profits have been arbitraged away. Thus we start from uncovered interest rate parity conditions to relate domestic and foreign nominal interest rates, r and r^*, with the expected rate of exchange rate depreciation.

$$(1 + r_t^*)\frac{E_t[e_{t+1}]}{e_t} = (1 + r_t) \qquad (1)$$

$E_t[e_{t+1}]$ is one period ahead exchange rate forecasts made at time t and e_t is spot exchange rate at time t.

Another key determinant of exchange rates in EMEs is perceived country risk. History has shown that exchange rates in EMEs can sometimes depreciate sharply as country risk deteriorates. With high currency mismatches, EMEs were often forced to tighten policies to help stem currency depreciation, adversely affecting domestic activity and country risk. However, the vicious circle has weakened after EMEs have reduced their currency mismatches (Miyajima et al (2012)). Following Bacchetta and van Wincoop (2006), equation (1) is extended with a risk premium Z. After log-linearising,

$$E_t[e_{t+1}] = e_t + r_t - r_t^* + Z_t \tag{2}$$

One important implication of the augmented model is that, despite domestic interest rates being higher, exchange rates in EMEs can appreciate because the risk premium can change. To ensure stationarity, the variables are introduced in first differences.

$$\Delta E_t[e_{t+1}] = \Delta e_t + \Delta(r_t - r_t^*) + \Delta Z_t \tag{3}$$

Given our objective, equation (3) is further extended to include sterilised intervention, measured in terms of central bank net dollar purchases. Sterilised intervention does not change the domestic interest rate, but it can affect exchange rate forecasts by either changing the risk premium (the portfolio channel) or expectations of future interest rates (the signalling channel). When included in the model, intervention I is lagged by one period to account for the endogeneity of movements in exchange rate forecasts and central bank intervention. Using contemporaneous values for both of them can bias the results because exchange rate movements can affect intervention decisions.

$$\Delta E_t[e_{t+1}] = I_{t-1} + \Delta e_t + \Delta(r_t - r_t^*) + \Delta Z_t \tag{4}$$

Therefore our regression model will relate nominal exchange rate forecasts with intervention, the spot exchange rate, domestic and foreign interest rates and country risk. As the intervention variable I_{t-1} appears on the right hand side of the equation, the spot exchange rate Δe_t will need to be instrumented to address potential collinearity.

3.2 Regression model

Based on the theoretical model, we estimate a behavioural equation linking movements in exchange rate forecasts to central bank interventions for a panel of

EMEs. Our specification includes a number of controls while allowing for country-specific effects in some of them.

$$\Delta\log\left(e_{i,t}^{T}\right) = a_i + b * I_{i,t-1} + c * \Delta\log(e_{i,t}) + d * \Delta\left(r_{i,t} - r_{i,t}^{*}\right) + h * \Delta Z_{i,t} + v_{i,t} \qquad (5)$$

where $e_{i,t}^{T}$ is *T* period ahead exchange rate forecasts made for country *i* at time *t* (a higher value signifies a weaker exchange rates in EMEs). $\Delta log\left(e_{i,t}^{T}\right)$ represents $log\left(e_{i,t}^{T}\right) - log\left(e_{i,t-1}^{T}\right)$ and *v* is an error term. We are primarily interested in the sign and statistical significance of the term *c*. The sign will be positive if central bank intervention guides exchange rate expectations to the "right" direction – forecasters expect a weaker exchange rate in EMEs in response to central bank dollar purchases to help weaken the spot exchange rate, and vice versa.

4. Data

Before discussing estimation results, we summarise the data in four categories: country and estimation period, exchange rates, intervention and other determinants. Graph A1 in the Appendix provides a graphical overview of exchange rate forecasts and central bank foreign exchange rate intervention.

4.1 Country and estimation period

We focus on a few EMEs with floating exchange rates that typically conduct discretionary intervention. These EMEs are selected from Asia and Latin America, two regions that have probably been more active in intervention in recent years due to strong foreign capital inflows. In order to add a degree of heterogeneity, we selected economies that are perceived to have different degrees of capital openness—Brazil, Peru, Korea and Malaysia. According to the commonly used Ito-Chinn Index of capital account openness, over the past decade Peru has consistently kept its capital account open during the estimation period, while Brazil's has become more restrictive, likely reflecting measures to cope with the impact of strong capital inflows. Capital account openness has gradually increased in Korea, but has decreased in Malaysia.

Guided partly by data availability, we focus on the period spanning June 2004–August 2012 (for Malaysia mid-2005 onwards to focus on the period of a flexible exchange rate regime). To prevent exceptionally disorderly market conditions around Lehman's bankruptcy from affecting the results, we exclude the observations during July 2008–March 2009 from the estimation.[8]

[8] Several studies focusing on the effectiveness of central bank intervention on spot exchange rate movements exclude times of extreme stress. For instance, Adler and Tovar (2011) exclude September 2008–June 2009, episodes of very large dollar sales.

4.2 Exchange rates

Three-month exchange rate forecasts are taken from Consensus Economics. For many EMEs, a number of market participants report their exchange rate forecasts during the month and the data provider takes the median of the reported figures. As one major drawback, survey data may not necessarily reflect true expectations. Positioning by market participants with their money at stake may reveal market expectations better than what analysts just say. Yet alternative measures of expectations have their own drawbacks. For instance, using the forward discount to proxy the expected change in the exchange rate assumes away the existence of the risk premium that may separate the forward discount from expected depreciation.[9]

The data for both spot exchange rates and three month forecasts summarised in Table 1 have a few distinct characteristics. First, forecasts tend to follow closely the current spot exchange rates, as the average monthly returns are similar across spot and forecasts, but volatility is typically greater for spot exchange rates. This is consistent with the pattern reported in the literature for advanced market exchange rate crosses (Takagi, 1991).

Second, after the onset of the global financial crisis in 2008, the pace of appreciation in both spot and forecast exchange rates moderated somewhat, but volatility of both spot and forecast exchange rates rose markedly.

Third, movements in lagged spot exchange rates often help underpin formation of expectations. The estimated coefficients from the regression of three month forecasts on lagged spot exchange rate, both in terms of changes, are mostly statistically significant and economically meaningful. This is consistent with the literature's finding that near-term forecasts tend to extrapolate spot exchange rate performance. However, other factors also influence exchange rate forecasts, provided that, in many cases, the coefficients are below unity and adjusted R-square is relatively low.

Characteristics of spot exchange rate against US dollar and three-month forecast — Table 1

	Monthly percentage change				Predictive power of lagged spot		Monthly percentage change				Predictive power of lagged spot	
	Average		Standard deviation				Average		Standard deviation			
	Spot	Forecast	Spot	Forecast	Coef	Adj. R^2	Spot	Forecast	Spot	Forecast	Coef	Adj. R^2
	June 2004–June 2008						April 2009–August 2012					
Brazil	–0.53	–0.53	1.49	0.80	0.15**	0.06	–0.12	–0.17	1.73	1.31	0.43***	0.30
Peru	–0.17	–0.21	0.62	0.56	0.46***	0.19	–0.20	–0.22	0.35	0.67	1.27***	0.52
Korea	–0.13	–0.11	0.97	0.72	0.40***	0.30	–0.33	–0.23	1.74	1.04	0.03	–0.02
Malaysia	–0.14	–0.16	0.48	0.33	0.38***	0.28	–0.19	–0.19	0.81	0.66	0.27**	0.09
Average	**–0.24**	**–0.25**	**0.89**	**0.60**	**0.25***	**0.15**	**–0.21**	**–0.20**	**1.16**	**0.92**	**0.23**	**0.11**

Note: ***, ** and * signify statistical significance at the 1%, 5% and 10% levels. Coefficients are based on a monthly regression of the monthly percentage change of the three month exchange rate forecast at time *t* on that of the spot exchange rate at time *t-1*. The coefficient reported in the "average" line is based on a fixed-effect panel regression.

Sources: Consensus forecasts and BIS staff calculations.

[9] See, for instance, Frankel and Froot (1987) for related discussion.

4.3 Intervention

Measuring central bank foreign exchange intervention is a key hurdle for the assessment of its impact. Many EMEs in Latin America make the intervention data publicly available by instrument (ie spot, forward, swaps etc), including Brazil and Peru. For the sake of simplicity, we aggregate intervention data across different instruments, assuming their impact on exchange rates is broadly similar. In Asia, as intervention data are in most cases not made public, we proxy intervention with monthly changes in central bank official reserves, further adjusted for valuation changes stemming from exchange rate movement based on the assumed currency composition guided by the IMF's Currency Composition of Official Foreign Exchange Reserves (COFER) data.

A number of aspects stand out from Table 2, which summarises the main characteristics of foreign exchange market intervention. First, the four EM central banks have leaned more heavily toward dollar purchases than dollar sales and accumulated official reserves. The four EM central banks bought an average of 1.3%–2.5% of official reserves per month, and, in many cases, the largest size of monthly intervention exceeded 10% of official reserves when central banks were net buyers of dollars. There were episodes of outsized intervention, when, for instance, the Central Bank of Brazil was a net buyer of dollars for up to 25 % of official reserves. In contrast, the size of intervention was typically smaller when they were net sellers of dollars.

Second, the four EM central banks have reduced their intervention to stem currency appreciation since the onset of the global financial crisis in 2008. This could be due to lower appreciation pressure, greater tolerance for appreciation or a higher cost of intervention. Table 2 shows that the average size of intervention fell from 2.5% of official reserves during the first sub-period to 1.3% of official reserves during the second sub-period. Similarly, the number of month during which the four EM central banks were net buyers of dollars declined in relative terms, from 83% of the total number of months to 73%.

Characteristics of foreign exchange market intervention — Table 2

	Average	Min	Max	Frequency		Average	Min	Max	Frequency	
				Net sale	Net purchase				Net sale	Net purchase
	(% of official reserves)			(% of total number of months)		(% of official reserves)			(% of total number of months)	
	June 2004–June 2008					April 2009–August 2012				
Brazil	4.6	–1.2	25.4	4.1	91.8	1.5	–1.6	5.5	14.6	82.9
Peru	2.7	–4.7	11.0	12.2	83.7	1.6	–2.7	5.1	12.2	73.2
Korea	0.9	–0.9	7.4	26.5	73.5	1.0	–1.2	5.8	31.7	68.3
Malaysia	1.8	–5.2	8.3	18.4	81.6	1.0	–2.6	14.7	34.1	65.9
Average	**2.5**	**–3.0**	**13.0**	**15.3**	**82.7**	**1.3**	**–2.0**	**7.8**	**23.2**	**72.6**

Note: The relative frequency of net sale and purchase do not sum to 100 as the frequency of months with zero net purchase is not shown.

Sources: Consensus forecasts; Datastream; IMF; national sources and BIS staff calculations.

4.4 Other determinants

Interest rate differentials are calculated using three month ahead forecasts of short-term interest rates taken from Consensus Economics.[10] Even though equation (2) suggests that actual interest rate differential affects exchange rate expectations, we conjecture that expectations about future monetary policy stance can be a better alternative.[11] The effect of credit risk on exchange rates in EMEs is captured by the change in the premium on international sovereign bonds, or credit default swap premia if the former is not available.

5. Baseline Results

In this section we first discuss preliminary correlations between foreign exchange intervention as a share of official reserves and the change in three month exchange rate forecasts. Second, we present the baseline results based on equation (5). To check robustness of the results we extend the baseline model with additional control variables and alternative measures of central bank foreign exchange intervention.

5.1 Preliminary correlation

As a start, Graphs 3 shows monthly net intervention as a percentage of official reserves on the x-axes and the monthly change in three month exchange rate forecast on the y-axes. Intervention data are lagged by one month. The blue and red dots are for the first sub-period (June 2004–June 2008) and the second (April 2009–August 2012), respectively.

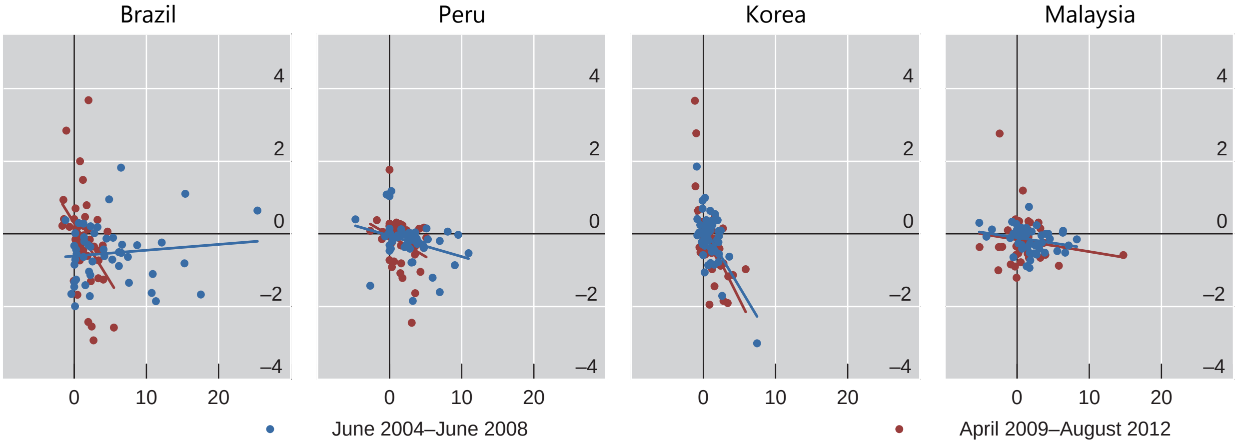
The correlations suggest that dollar purchases in the previous month are often related with an adjustment of three month exchange rate forecasts in the direction of appreciation, rather than depreciation, and vice versa. The trend lines relating the x- and y-axes are in many cases downward sloping, suggesting that, for instance, positive intervention (net dollar purchases) is accompanied by a negative change in three-month exchange rate forecasts (appreciation). Note, however, that other key determinants of exchange rates are omitted from the analysis, so the bivariate correlations are insufficient to provide solid conclusions.

[10] Due to data limitation, the observed 3 month interest rate is used for Peru.

[11] The author is grateful for Renzo Rossini for suggesting this.

Foreign exchange intervention and change in exchange rate forecasts[1]

Graph 3



[1] The x-axis is the monthly central bank foreign exchange intervention in terms of net dollar purchases, as a percentage of the stock of official reserves. The y-axis is the monthly percentage change in three month exchange rate forecasts.

Sources: © Consensus forecasts; Datastream; IMF; national sources and BIS staff calculations.

5.2 Baseline econometric results

When sterilised interventions are successful in moving the exchange rate in the intended direction, net dollar purchases by the central bank should prompt forecasters to adjust their exchange rate expectations in the direction of depreciation. Similarly, net dollar sales should be associated with an adjustment of exchange rate expectations in the direction of appreciation. Hence, the coefficient on the intervention variable should be positive. In contrast, if intervention is followed by forecast revisions in the direction opposite from what is intended by the central bank, the coefficient on intervention should be negative.

An important finding from the estimated results shown in Table 3 is that interventions do not seem to have the intended effects on near-term exchange rate expectations.[12] The first row of the table shows intervention coefficients corresponding to several different specifications (models 1–6). The coefficient on intervention is stable between –0.04 and –0.05, implying that net dollar purchases by the central bank equivalent to 1 percentage point of official reserves tend to be accompanied by a 4–5 basis point appreciation in the three-month exchange rate forecasts. In other words, central bank intervention to weaken (or strengthen) the exchange rate typically leads to an adjustment of exchange rate forecasts in the direction of appreciation (depreciation). However, the results need to be interpreted with caution, as the coefficient is statistically significant only at the 10% level. Moreover, the low r-squared means more than 80% of the model is unable to explain 80% or more of the variations in the dependent variable, suggesting the existence of nonlinearity or key determinants are omitted.

[12] It would be more appropriate to scale intervention by foreign exchange market liquidity, but the denominator was not readily available. The results in Table 3 are broadly unchanged when intervention is scaled by GDP or the sum of exports and imports.

Fixed-effect panel model of impact of lagged intervention on change in exchange rate forecasts[1]

Table 3

Period	June 2004–August 2012					
	1	2	3	4	5	6
Intervention (t-1)	–0.041	–0.044*	–0.041*	–0.044*	–0.047*	–0.049*
	(0.111)	(0.081)	(0.089)	(0.093)	(0.065)	(0.052)
Change in spot FX[2]		0.264*				0.199
		(0.069)				(0.121)
Change interest rate differential			–0.062		–0.221***	–0.217**
(vs US)[3]			(0.658)		0.006	0.017
Change in EMBI spread				0.013**	0.014**	0.013**
				(0.027)	(0.017)	(0.017)
Adjusted R-squared	0.020	0.023	0.017	0.125	0.130	0.125

[1] Dependent variable is monthly difference of the log of 3-month exchange rate forecasts. *, ** and *** signify statistical significance at the 10%, 5% and 1% levels. Intervention (t-1) is lagged actual intervention. The numbers in parentheses are p-values using the sandwich estimator of (Huber (1967), White (1980)). [2] Residual from the regression of change in spot exchange rates on intervention as a percentage of official reserves. [3] Using interest rate forecasts.

Source: BIS staff calculations.

Other than intervention, the interest differential relative to the United States and the international sovereign risk premia are important for exchange rate determination. The estimate coefficients imply that a 100 basis point increase in the domestic interest rate in EMEs relative to that in the United States leads an appreciation of the exchange rate by 0.2%. The result is consistent with the carry trade strategy. As for the international sovereign credit premia of EMEs, a one basis point increase over US Treasury yields is associated with a 1.3 basis point depreciation of exchange rate forecasts. Therefore perception of higher sovereign credit risk leads to a weaker EM exchange rate. The instrumented spot exchange rate (lagged by one month) can also have some effect on three month forecasts to the same direction (see model 2).

6. Robustness

To check the robustness of the above results, we expand the baseline model into several directions. First, we add a few additional key determinants of exchange rate forecasts step by step. Then as a second step, we take the full-fledged model and re-estimate it for two subperiods, which broadly correspond to before and after the onset of the global financial crisis in 2008. Finally, we replace lagged intervention with different measures of intervention calculated from the estimated central bank reaction function.

6.1 Additional control variables

We included a number of additional key variables in the regression as follows. First, international energy prices have been an important factor affecting inflation, monetary policy management and exchange rates. The expected sign of the coefficient is ambiguous: purchasing power parity conditions predict that higher domestic inflation leads to a weaker exchange rate, but, with greater rate hike expectations, it can also lead to currency appreciation.

Second, capital inflows have particularly become an important determinant of exchange rates after the onset of global financial crisis. Portfolio inflows, particularly those into fixed-income products have surged as global investors have reallocated funds into EM assets on structural factors such as the more favourable macroeconomic performance of EMEs, but also as risk taking has been spurred by cyclical factors such as low global interest rates and benign liquidity conditions. In response, some EMEs have taken measures to limit exchange rate appreciation. As a proxy of foreign portfolio inflows, we use monthly net inflows to mutual funds dedicated to EM bonds (all currencies) as a percentage of assets under management.[13]

Third, strong growth performance can lead to nominal exchange rate appreciation in EMEs, if part of the real appreciation stemming from the Balassa-Samuelson effect comes from nominal appreciation. To capture this element, we rely on one year ahead growth expectations relative to the United States calculated based on the current-year and following-year GDP growth forecasts provided by Consensus Economics.[14]

Fourth, data surprises in the United States should also impact exchange rate performance in EMEs, even though the direction is ambiguous. Stronger-than-expected domestic activity in the United States in principle strengthens the US dollar. However, it can also lead to EM currency appreciation if greater activity in the United States is positive for EM activity and/or global risk sentiment. We include data surprise indices, which represent the difference between expectation and outturn, for purchasing managers' index, retail sales, and nonfarm payroll.

Results summarised in Table 4 revel that our baseline results are robust to the inclusion of the additional control variables. When the baseline model is expanded with additional control variables step by step from model 6 to models 7–11, the coefficients on intervention remain around –0.05 and are significant at either the 5% or 10% level.

As for the other control variables in the baseline model, the coefficient on the interest rate forecast differential remains broadly unchanged from the baseline model (model 6 in Table 4), except in the case of model 11, where all control variables are included. The coefficient on the international risk premium remains little changed from the baseline results.

Among the new control variables, foreign bond inflows have a significant impact on exchange rate expectations with the expected sign. The coefficients of around –0.05 in models 7 and 11 imply that an increase in such inflows equivalent to 1 percentage point of assets under management (AUM) leads to a 5 basis point appreciation of exchange rate forecasts. To put this into context, the average

[13] Due to data limitations, inflows to Latin America are used for Brazil and Peru and those into EM Asia for Korea and Malaysia.

[14] Constant horizon forecasts are not available. Therefore we estimate the weighted average of the current- and following-year GDP growth forecasts by changing the weights.

monthly net inflows to Asia ex-Japan bond funds surged from 1% of AUM in 2007 to 5.8% of AUM in 2010, but moderated to 0.6% of AUM in 2012.

Fixed-effect panel model of impact of lagged intervention on change in exchange rate forecasts[1]

Table 4

Period	June 2004–August 2012						Jun 04–Jun 08	Apr 09–Aug 12
	6	7	8	9	10	11	11A	11B
Intervention (t-1)	–0.049*	–0.047*	–0.051**	–0.047*	–0.049**	–0.045*	–0.005	–0.133**
	(0.052)	(0.073)	(0.046)	(0.059)	(0.044)	(0.067)	(0.871)	(0.045)
Change in spot FX[2]	0.199	0.226*	0.124	0.184	0.176	0.111	0.311*	–0.195***
	(0.121)	(0.092)	(0.137)	(0.129)	(0.184)	(0.242)	(0.094)	(0.009)
Change in interest rate	–0.217**	–0.179***	–0.195**	–0.173	–0.229**	–0.099	0.152	–0.326
differential (vs US)[3]	(0.017)	(0.009)	(0.037)	(0.132)	(0.034)	(0.335)	(0.601)	(0.270)
Change in EMBI spread	0.013**	0.012**	0.013**	0.013**	0.013**	0.011**	0.003	0.014*
	(0.017)	(0.021)	(0.018)	(0.017)	(0.015)	(0.016)	(0.348)	(0.074)
Energy price inflation		–0.043				–0.052*	–0.003	–0.094**
		(0.128)				(0.085)	(0.900)	(0.021)
Foreign bond inflows			–0.049***			–0.050***	–0.070**	–0.080*
			(0.005)			(0.010)	(0.023)	(0.050)
Change in growth				–0.314		–0.456	–0.251	–0.463
differential (vs US)[4]				(0.424)		(0.152)	(0.219)	(0.263)
US data surprise A[5]					0.006	–0.000	0.010	0.001
					(0.822)	(0.985)	(0.827)	(0.974)
US data surprise B[6]					–0.056	–0.070**	–0.120	–0.020
					(0.168)	(0.017)	(0.214)	(0.900)
US data surprise C[7]					–0.001	–0.001	–0.000	–0.001
					(0.391)	(0.400)	(0.640)	(0.487)
N	340	340	340	340	340	340	180	160
Adjusted R-squared	0.125	0.140	0.149	0.130	0.127	0.178	0.045	0.354

[1] Dependent variable is monthly difference of the log of 3-month exchange rate forecasts. *, ** and *** signify statistical significance at the 10%, 5% and 1% levels. Intervention (t-1) is lagged actual intervention. The numbers in parentheses are p-values using the Huber-White sandwich estimator of (Huber (1967), White (1980)). [2] Residual from the regression of change in spot exchange rates on intervention as a percentage of official reserves. [3] Using interest rate forecasts. [4] Using GDP growth forecasts. [5] PMI. [6] Retail sales. [7] Nonfarm payroll.

Source: BIS staff calculations.

The coefficients on energy price inflation and US retail sales data surprises turn significant when all control variables are included (model 11). A one percentage point increase in energy price inflation leads to a 5 basis point appreciation of exchange rate forecasts. An increase in US retail sales data surprises (ie. stronger-than-expected activity) by the same magnitude also leads to appreciation of EM exchange rate forecasts (by 7 basis points).

6.2 The global financial crisis

One issue is whether the results are influenced by specific period or development in our sample. The most important event is the global financial crisis that started in 2008, which has been accompanied by significant changes in foreign capital flows and investment behaviour. Therefore, we reestimate the model for two subperiods: June 2004–June 2008 and April 2009–August 2012.

The results show that the intervention coefficient is close to zero and statistically insignificant during the first subperiod, that is, the period preceding the global financial crisis (model 11a in Table 4). This suggests that, during this period, intervention had little effect on three month exchange rate forecasts. The very low adjusted R squared again warns about the possibility that key explanatory variables could be omitted.

In contrast, the intervention coefficient becomes significant and increases in size during the second subperiod (model 11b in Table 4). Moreover, the r-squared rises to 0.35. The impact of intervention has clearly changed following the onset of the global financial crisis. The coefficient of –0.13 and the average size of monthly intervention equivalent to 1.3% of reserves during this period (Table 2) suggest that three month exchange rate forecasts may have been adjusted in the direction of appreciation by 0.17% every month due to foreign exchange intervention. The size of the coefficient appears economically meaningful when compared against the average rate of appreciation of 0.2% per month during the same period (Table 1).

As for the coefficients on the control variables, those on the international sovereign risk premia and energy price inflation are significant and relatively large only during the second subperiod. Higher energy price inflation increase expectations of monetary tightening and exchange rate appreciation. Thus these results suggest that investors have become more sensitive to credit risk and eager to reach for yield after the global financial crisis. These are closely related to the downgrades of advanced sovereign credits previously considered as high quality, and very easy international monetary conditions.

The coefficient on the instrumented spot exchange rate (lagged by one month) warrants an attention. From the first to second subperiods, it changes the sign from positive to negative and increases the significance level from 10% to the 1% level. One interpretation of the negative coefficient is that exchange rate forecasters have a target level. In such a case, a smaller rate of exchange rate appreciation in the spot market should lead to an expectation of greater appreciation three months ahead in order for the exchange rate to reach the target level. Thus exchange rate forecasters started to have a target level in their mind during the second subperiod, rather than extrapolating the performance of the spot exchange rate.

6.3 Instrumenting intervention

With lagged intervention we may lose information that is available only from contemporaneous intervention. For instance, the literature on the impact of intervention on spot exchange rates typically exploits higher-frequency data (daily or intra-day) and uses contemporaneous intervention. In doing so, the endogeneity problem that contemporaneous intervention can be affected by the spot exchange rate is addressed by estimating the central bank reaction function. It is done by instrumenting contemporaneous intervention using historical exchange rate performance and lagged intervention.

In order to use contemporaneous intervention, we follow the literature and estimate the central bank reaction function for the four EMEs. We instrument contemporaneous intervention using two variables capturing historical exchange rate performance. They are (i) the average monthly change of the spot exchange rate during the preceding 6 months and (ii) the percentage deviation of the exchange rate level in the preceding month from its 6 month moving average.

The central bank reaction function is estimated using ordinary least squares, rather than the dynamic Tobit model commonly used in the literature. This is because there are only a few monthly observations with zero net intervention, and we do not restrict the reaction function with respect to net purchases or net sales only. In addition, we do not use lagged dependent variable (ie lagged intervention) as a regressor.

The central bank reaction function was estimated in two different ways:

- First, it was estimated for the two subperiods to allow for time variation in central bank reaction to exchange rate performance. This was, however, done in a panel framework, rather than by country, to ensure the number of observations is sufficiently large.
- Second, it was estimated by country in order to allow for country variation. However, this was done only for the whole sample period, rather than for the two subperiods separately, to maintain a sufficient number of observations.

The estimated central bank reaction functions in Table 5 reveal that the four EM central banks' intervention decision has typically been dictated by historical exchange rate performance. The negative coefficients on the lagged monthly change of the spot exchange rate suggest that, in reaction to appreciation (depreciation) of the domestic currency, the four central banks have typically bought (sold) dollars to help weaken (strengthen) the local currency. Similarly, the negative coefficients on the lagged deviation from the trend suggest that, as the domestic currency strengthen (weaken) relative to the short-term trend level, the four central banks have tended to buy (sell) dollars. However, the explanatory power of the models is relatively low, as the adjusted R squared is around 0.05–0.13.

Central bank intervention reaction function[1] Table 5

Country	Panel		Brazil	Peru	Korea	Malaysia
Period	June 04–June 08	April 09–August 12	June 04–June 08 and April 09–August 12			
Change in spot FX (t-1) 2	–3.906	–0.382*	–2.864**	–5.179**	–0.129	–1.563
	(0.122)	(0.059)	(0.027)	(0.021)	(0.828)	(0.298)
Deviation from trend (t-1) 3	0.584	–0.285**	0.189	0.070	–0.381**	–0.498
	(0.392)	(0.025)	(0.544)	(0.930)	(0.023)	(0.149)
N	163	141	80	80	79	65
Adjusted R-squared	0.053	0.067	0.069	0.127	0.128	0.053

[1] *, ** and *** signify statistical significance at the 10%, 5% and 1% levels. The numbers in parentheses are p-values using the sandwich estimator of (Huber (1967), White (1980)). 2 Average monthly percentage change of the spot exchange rate over six months. 3 Percentage deviation of the exchange rate level from its six month moving average.

Source: BIS staff calculations.

Using these central bank reaction functions, we estimated two sets of predicted central bank intervention. The first one was estimated by using the first and second models in Table 5 to allow for time variation before and after the onset of the global financial crisis in 2008 (no country variation). The second one was estimated by using models for the individual economies in Table 5 (columns three through six) to allow for country variation (no time variation). Finally, using the two predicted intervention measures, we re-estimated the previous regression models and reported the results in Tables A1 and A2.

One important message stemming from the results reported in Tables A1 and A2 is that our main message is broadly unchanged: central bank foreign exchange intervention does not seem to have the intended effect on exchange rate expectations. The coefficients remain negative across different models. Moreover, the size and/or statistical significance of the coefficients increased. For instance, Tables A1 and A2 show that the coefficients on intervention are in the range of –0.1 and –0.2, and, in some cases, statistically significant at the 5% level. Yet, these findings need to be interpreted with caution given that, as discussed earlier, the estimated central bank reaction functions fail to account for the bulk of variation in actual intervention.

The main message stemming from the coefficients on the control variables is broadly unchanged. One exception is that growth differentials are a key determinant of exchange rate expectations, as they are in some cases statistically significant up to the 5% level. It suggests that growth differentials in favour of EMEs are associate with expectations of exchange rate appreciation.

7. Concluding discussion

This paper highlighted that central bank foreign exchange intervention does not seem to systematically influence near-term exchange rate expectations in the direction desired by the central bank. In other words, central bank dollar purchases to fight currency appreciation or related currency volatility are not associated with an adjustment of near-term exchange rate forecasts in the direction of depreciation, and vice versa. This finding was robust to different specifications including interest rate expectations, international country risk premia, international energy prices, foreign capital inflows, growth expectations and US data surprises.

Moreover, central bank foreign exchange intervention may have had unintended effects. For instance, the negative intervention coefficient was statistically significant at the 5% level in some cases, and, in particular, r-squared of the model rose to 0.35 when estimated for the second subperiod starting from early 2009. In other words, central bank intervention to contain directional exchange rate movements or associated volatility prompted exchange rate forecasts to change in the opposite direction to the one intended. This may reflect the fact that global investors have become more sensitive to credit risks since macroeconomic fundamentals of many major advanced economies, once considered as low-risk credits, have deteriorated markedly. Regression models with predicted intervention yielded stronger results, as the negative intervention coefficient became more significant and large in size for the whole sample period.

One interpretation of the result is that intervention does not change the near-term exchange rate expectations. The literature finds that central bank intervention could have a desired impact on the spot exchange rate. However, to the extent that the near-term exchange rate expectations remain little changed, efforts to limit exchange rate movements in the spot markets would merely delay necessary appreciation or depreciation. For instance, dollar purchases to stem appreciation of the EM exchange rate in the spot market leads to expectations of greater appreciation in future.

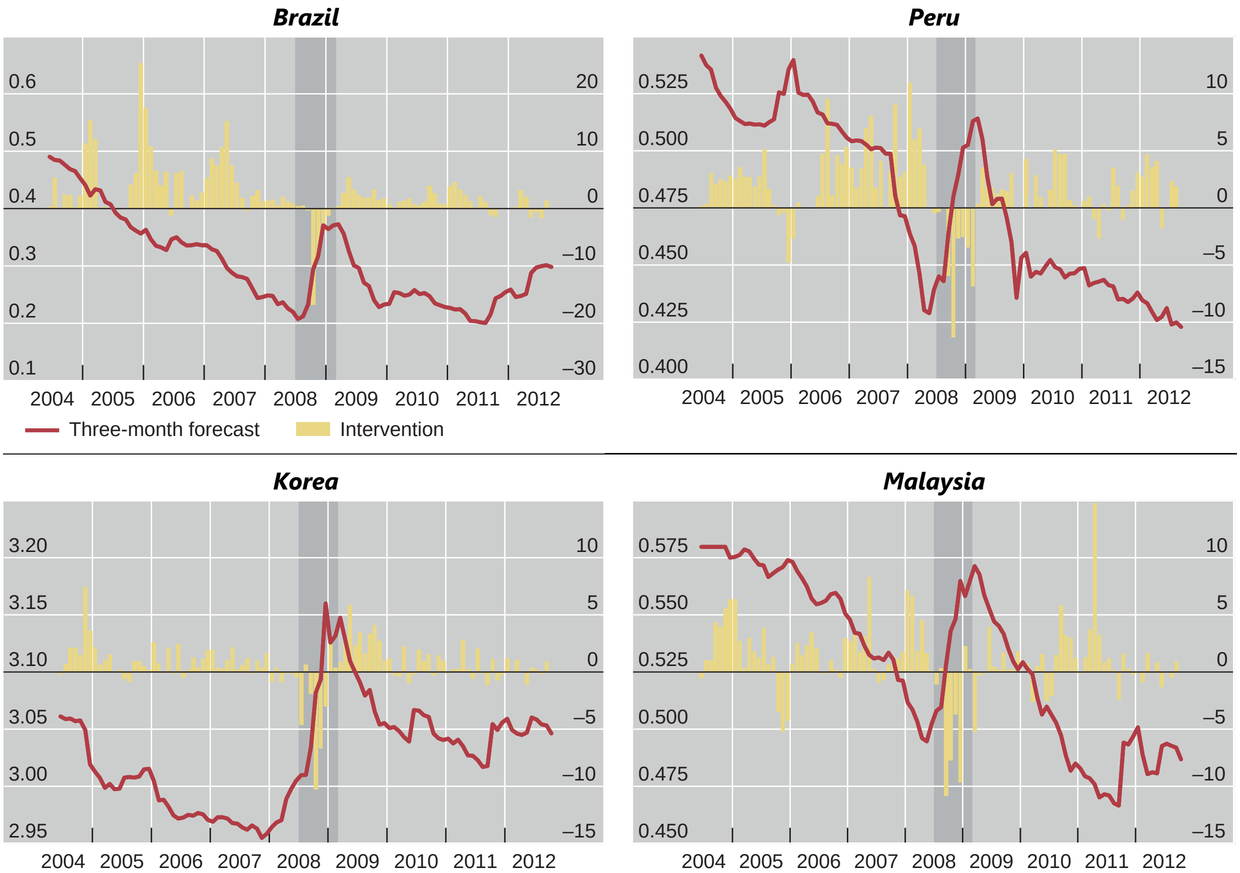
A second interpretation is that dollar purchases by central banks can attract more foreign inflows and lead to expectations of a stronger EM exchange rate in the near term. One reason could be that central bank dollar purchases to lean against the trend can provide an attractive entry point to buy EM currencies. Another reason could be that the new level of fundamentals (ie, a larger stock of official reserves) improves perceived credit quality of the sovereign. In the context of our regression model, central bank intervention and the attendant reserve accumulation capture part of what is represented by EM sovereign credit risk Z.

Finally, our finding suggests that intervention can increase exchange rate volatility to the extent that intervention can amplify investors' exchange rate expectations and capital flows. This is consistent with the views taken in the literature, which suggest that intervention can increase the volatility of both spot exchange rates (Neely (2008)) and exchange rate forecasts (Beine et al (2007)).

Annex Tables

Central bank foreign exchange intervention and three-month exchange rate forecast[1]

Graph A1



[1] Right-hand scale: intervention as a percentage of the stock of official reserves. Left-hand scale: three-month exchange rate forecast in log. Shaded area (July 2008–March 2009) dropped from regression.

Sources: IMF; © Consensus Economist; Datastream; national sources; BIS staff calculations.

Fixed-effect panel model of impact of predicted contemporaneous intervention on change in exchange rate forecasts[1]

Table A1

Period	June 2004–August 2012						Jun 04-Jun 08	Apr 09-Aug 12
	12	13	14	15	16	17	17A	17B
Intervention (predicted)	–0.119*	–0.113*	–0.132*	–0.126*	–0.117*	–0.136**	–0.014	–0.230*
	(0.071)	(0.056)	(0.055)	(0.052)	(0.061)	(0.025)	(0.866)	(0.088)
Change in spot FX[2]	0.622	0.668	0.635	0.598	0.641	0.668	0.578	0.632
	(0.334)	(0.310)	(0.311)	(0.334)	(0.369)	(0.317)	(0.499)	(0.105)
Change in interest rate	–0.381**	–0.317***	–0.356**	–0.290	–0.407**	–0.199	0.072	–0.466
differential (vs US)[3]	(0.022)	(0.009)	(0.031)	(0.125)	(0.033)	(0.226)	(0.825)	(0.423)
Change in EMBI spread	0.017**	0.015**	0.017**	0.018**	0.016**	0.015**	0.005	0.016*
	(0.030)	(0.027)	(0.031)	(0.025)	(0.023)	(0.021)	(0.465)	(0.075)
Energy price inflation		–0.045				–0.044**	–0.005	–0.081**
		(0.162)				(0.040)	(0.828)	(0.012)
Foreign bond inflows			–0.050			–0.067*	–0.038	–0.165**
			(0.184)			(0.054)	(0.562)	(0.011)
Change in growth				–0.713		–0.839**	–0.419	–0.798**
differential (vs US)[4]				(0.133)		(0.041)	(0.369)	(0.027)
US data surprise A[5]					0.016	0.007	–0.014	0.040
					(0.493)	(0.746)	(0.807)	(0.193)
US data surprise B[6]					0.090	0.085	–0.053	0.414
					(0.140)	(0.199)	(0.598)	(0.168)
US data surprise C[7]					–0.001	–0.001	–0.002	0.001
					0.364	0.391	0.297	0.539
N	207	207	207	207	207	207	103	104
Adjusted R-squared	0.197	0.209	0.206	0.230	0.199	0.264	–0.011	0.480

[1] Dependent variable is monthly difference of the log of 3-month exchange rate forecasts. *, ** and *** signify statistical significance at the 10%, 5% and 1% levels. Contemporaneous intervention is predicted from central bank reaction function (panel). The numbers in parentheses are p-values using the Huber-White sandwich estimator of (Huber (1967), White (1980)). [2] Residual from the regression of change in spot exchange rates on intervention as a percentage of official reserves. [3] Using interest rate forecasts. [4] Using GDP growth forecasts. [5] PMI. [6] Retail sales. [7] Nonfarm payroll.

Source: BIS staff calculations.

Fixed-effect panel model of impact of predicted contemporaneous intervention on change in exchange rate forecasts[1]

Table A2

Period	June 2004–August 2012						Jun 04–Jun 08	Apr 09–Aug 12
	18	19	20	21	22	23	23A	23B
Intervention (predicted)	–0.255**	–0.249**	–0.247**	–0.250**	–0.259**	–0.234**	–0.194*	–0.156**
	(0.014)	(0.014)	(0.023)	(0.012)	(0.017)	(0.024)	(0.053)	(0.025)
Change in spot FX[2]	0.022	0.033	–0.010	0.018	0.003	–0.014	0.204	–0.212**
	(0.904)	(0.853)	(0.943)	(0.924)	(0.985)	(0.914)	(0.129)	(0.027)
Change in interest rate	–0.234*	–0.215*	–0.219	–0.210	–0.235*	–0.165	0.073	–0.645***
differential (vs US)[3]	(0.073)	(0.085)	(0.100)	(0.113)	(0.064)	(0.197)	(0.754)	(0.003)
Change in EMBI spread	0.014*	0.013*	0.014*	0.014*	0.013*	0.012*	0.006***	0.012
	(0.066)	(0.068)	(0.066)	(0.066)	(0.073)	(0.076)	(0.008)	(0.149)
Energy price inflation		–0.016*				–0.026**	0.010	–0.083**
		(0.094)				(0.028)	(0.582)	(0.041)
Foreign bond inflows			–0.021			–0.023	–0.047*	–0.057**
			(0.519)			(0.433)	(0.059)	(0.033)
Change in growth				–0.481*		–0.495**	–0.298	–0.452*
differential (vs US)[4]				(0.070)		(0.031)	(0.241)	(0.089)
US data surprise A[5]					0.024	0.015	0.011	0.022
					(0.313)	(0.499)	(0.826)	(0.533)
US data surprise B[6]					–0.095	–0.096	–0.135	–0.064
					(0.302)	(0.249)	(0.103)	(0.763)
US data surprise C[7]					–0.001	–0.000	–0.000	0.000
					0.611	0.630	0.662	0.609
N	303	303	303	303	303	303	163	140
Adjusted R-squared	0.184	0.184	0.186	0.196	0.185	0.200	0.102	0.274

[1] Dependent variable is monthly difference of the log of 3-month exchange rate forecasts. *, ** and *** signify statistical significance at the 10%, 5% and 1% levels. Contemporaneous intervention is predicted from central bank reaction function (by country). The numbers in parentheses are p-values using the Huber-White sandwich estimator of (Huber (1967), White (1980)). [2] Residual from the regression of change in spot exchange rates on intervention as a percentage of official reserves. [3] Using interest rate forecasts. [4] Using GDP growth forecasts. [5] PMI. [6] Retail sales. [7] Nonfarm payroll.

Source: BIS staff calculations.

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