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EXCHANGE-RATE SWINGS AND FOREIGN CURRENCY INTERVENTION

Abstract

This paper develops a new approach for exploring the effectiveness of foreign currency intervention, focusing on real exchange cycles. Using band spectrum regression methods, it examines the role of macroeconomic fundamentals in determining the equilibrium real exchange rate at short-, medium-, and low frequencies. Next, it assesses the effectiveness of FX intervention depending on the degree of cycle-specific misalignments for 26 advanced- and emerging market economies, covering the period 1990–2018, and using different techniques to mitigate endogeneity concerns. Evidence supports the hypothesis that central banks can lean effectively against short-run cyclical misalignments of the real exchange rate. The effects are present in quarterly data—i.e., at policy-relevant horizons. The effectiveness of intervention rises with the size of the misalignment, and with the duration of one-sided interventions. FX sales appear to be somewhat more effective than FX purchases, and intervention is less effective in more liquid FX markets.

JEL Classification: E32, E58, F31, F37

Keywords: Central banking, Equilibrium exchange rates, Foreign exchange intervention, band spectrum regression

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I. INTRODUCTION

Over the last decade, the role of exchange rate intervention has taken on greater prominence in policy discussions. Key questions have centered on the effectiveness of exchange rate intervention as a policy instrument in a central bank's arsenal—that is for smoothing macroeconomic volatility, preventing the buildup of financial vulnerabilities, and helping attain inflation targets at times when the effectiveness of conventional monetary policy instruments reaches limits.[1]

In this context, several studies have explored the question of the optimal policy mix for small open economies in response to external shocks. The key insight is that, in the presence of key real and financial frictions, the use of additional policy instruments—such as foreign exchange interventions and capital flow measures—can, in specific settings, improve policy tradeoffs that arise in more standard models of international finance and monetary policy (see Basu et al., 2020, and Adrian et al., 2020, 2021).

The debate has also been informed by country experiences deploying this instrument. Exchange rate intervention remains popular among many emerging market- and small, open advanced economies, whereas the major advanced economies have not intervened much over the past decade. Surveys by the BIS (2004, 2015, 2019b) and World Bank (2013) of EM central bank motives and objectives for exchange rate intervention show consistent patterns. Most central banks profess to assign high importance to stem volatility, rather than to achieve a particular exchange rate. However, some also name smoothing the impact of commodity price fluctuations and enhancing competitiveness as objectives. These latter objectives remain particularly controversial, both in terms of their desirability and feasibility in practice.[2]

However, the effectiveness of FX interventions remains subject to debate. Few questions in international finance are as studied as the policy effectiveness of sterilized foreign exchange intervention. Yet, the research debate is far from resolved. Survey articles by Edison (1993), Sarno and Taylor (2001), Menkhoff (2013) and Villamizar-Villegas and Perez-Reyna (2017) summarize the results from a wide range of empirical studies of interventions. These academic surveys offer a much less favorable assessment of the effectiveness of exchange rate interventions, suggesting that there remains a considerable gap between the policy and academic views about effectiveness.

Several key empirical challenges have continued to hold back progress in assessing accurately the policy effectiveness of exchange rate intervention. The first challenge is a difficulty in identifying reliable econometric 'instruments' with which to isolate the independent effect of exchange rate intervention on exchange rate developments. Estimates of effectiveness are known to be plagued by an endogeneity bias. Such biases for at least two reasons. First, authorities may purchase (sell) foreign exchange as the currency appreciates (depreciates) in an attempt to prevent movements in the exchange rate. If such operations are ineffective, central bank foreign asset purchases (sales) aimed at offsetting appreciations (depreciations) would be positively correlated because of other cyclical factors driving the exchange rate. Second, the authorities may purchase (sell) foreign exchange simply to take advantage of the capital inflows (outflows). Once again, such operations would result in a positively (wrongly) signed coefficient in a regression analysis. The academic response to this challenge has been to focus on very short-run intervention impacts, e.g., event studies and the use of high-frequency data (Menkhoff 2010; Fatum and Hutchison, 2003; Fratzscher et al., 2019; Dominguez, 2003) which enable better identification. However, the studies are of limited value policy-wise because they are

[1] See Adrian et al. (2020, 2021) and Basu et al. (2020).

[2] Chamon et al. (2019) review the Latin American experience with intervention and conclude that the countries have achieve a "considerable degree of success."

not able to address the question of whether interventions have a longer-lasting effect that shapes the path of exchange rates over relevant policy horizons.

The second challenge arises from data limitations. The availability of high-quality data on exchange rate intervention has traditionally been very limited, constraining accurate statistical testing. More recently, this constraint has been loosened somewhat as data availability has improved in terms of quality and cross-country coverage.[3]

The third challenge is the size and variation of exchange rate interventions in the past. The size of exchange rate interventions decades ago pales in comparison to the size of potential interventions today. Foreign reserve buffers have generally grown over time, with levels now often exceeding commonly used foreign exchange reserve adequacy benchmarks that were established in the 1990s. Indeed, the lack of statistical significance of effectiveness in past studies may in part simply reflect the small variations of the interventions rather than an inherent lack of effectiveness. The increased use of foreign currency reserve buffers by a wider range of central banks in the past two decades offers a better environment in which to test the effectiveness hypothesis.[4]

Despite these challenges, recent empirical research has made further strides in our understanding of intervention effectiveness. Several studies using new cross-country databases have found evidence supporting the effectiveness of exchange rate interventions in reducing exchange rate misalignments. Daude et al. (2016), using quarterly data from 2003-2011, find that interventions are on average effective in influencing the real exchange rate, with a higher effectiveness associated with greater exchange rate misalignment; their measure of misalignment is estimated from an error correction model and captures the tendency of exchange rates to converge over time to long run trends. Adler et al. (2019) document persistent impacts of exchange rate intervention with a half-life of 12-23 months for a broad international set of country experiences. Blanchard et al. (2015) take a different approach focusing on cross country differences in quarterly exchange rate behavior between those countries that intervene heavily and those that do not. They conclude that those countries heavily reliant on intervention experience less exchange rate volatility than non-intervening countries. Consistent with this evidence, Adler and Tovar (2014) report similar results for Latin American countries using weekly data, Hofmann et al. (2019) report persistent intervention impacts over two quarters in the case of Colombia using high-frequency data, and Menkhoff et al. (2020) document a multi-month impact in the case of Japan.

At the same time, new theoretical work casts new light the drivers of exchange rate misalignments and the mechanism through which intervention may be effective. Gabaix and Maggiori (2015) and Maggiori (2022), for example, argue that misalignments (with respect to the exchange rate consistent with macroeconomic fundamentals) stem in large part from imperfect financial intermediation; their research emphasizes the risk-bearing capacity of global financial institutions and its implications on the demand for foreign assets, gross capital flows, and other drivers of persistent disconnects of exchange rates from macroeconomic fundamentals. Relatedly, in earlier work, Bacchetta and van Wincoop (2006), building on the empirical results of Evans and Lyons (2002), find that private information-based order flows drive short-term exchange rate dynamics.

[3] Availability of cross-country data on financial factors emphasized in new theories of exchange rate intervention remains limited and incomplete, especially comparable balance sheet data and risk-taking capacity of global financial institutions (Gabaix and Maggiori 2015). This limits the ability to distinguish between financial factors and macroeconomic fundamentals as drivers of exchange rate swings movements.

[4] At the same time, the size (in terms of daily activity) of the exchange rate market has also increased. The relative importance vis-à-vis the effectiveness of exchange rate intervention is ultimately an empirical question.

While these financial frictions seem to be important in the short run, the evidence so far suggests that macroeconomic determinants matter more at longer horizons (Mark 1995). The notion that the drivers of nominal exchange-rate movements likely differ across different horizons is the so-called exchange determination puzzle (see, e.g., Lyons (2001), Engel et al. (2008)). On the one hand, the weak explanatory power of macro fundamentals over the short run may mean that interventions to counter financial forces may help guide exchange rates toward their fundamental equilibrium levels. On the other hand, exchange rate intervention is likely to be much less effective when leaning against fundamental-driven, longer-term exchange rate movements. However, empirical evidence differentiating intervention effectiveness on these issues is still missing.

In this paper, we build on recent empirical and theoretical insights and offer a novel approach for measuring the effectiveness of exchange rate intervention at policy-relevant horizons. In addition to using an expanded cross-country dataset, our approach is based on cycle-specific exchange rate misalignments.[5] The intuition behind this strategy is that the relation between exchange rates and fundamentals may be different at different cycle lengths—longer-term swings in exchange rates may be driven by longer-term swings in fundamentals in different ways than short-term exchange rates swings are by shorter-term movements in fundamentals.[6] If this is the case, the effectiveness of exchange rate intervention may naturally vary by the nature of the cyclical forces at any point in time driving the cyclical misalignments.

Econometrically, our approach entails a multi-step estimation procedure. After specifying cycle lengths, we use spectral regression methods to estimate the equilibrium real exchange rate at short-, medium-, and long-run cycles for 30 advanced- and emerging market economies.[7] We then use these estimates to derive exchange-rate misalignments, cycle by cycle. Third, we examine the effectiveness of exchange rate intervention for each cycle-specific misalignment using a quarterly unbalanced panel estimation. To address endogeneity concerns, we employ FXI "surprises" as deviations from estimated policy rules (Brandao-Marques et al., 2020). In a robustness exercise, we also use capital flows to other countries as an instrument, following Blanchard et al. (2015). We use quarterly data.

Our empirical findings strengthen the case for the effectiveness of exchange rate intervention. However, we find intervention is effective only when leaning against misalignments with respect to short-cycle misalignments, but not with respect to medium-cycle misalignments and long-cycle misalignments. For a short-cycle misalignment of 10 percent, a tenth-percentage-point-of-GDP exchange rate intervention is associated with a statistically significant percent change in the exchange rate ranging from 1.5 to 4.5 percent. Our evidence also provides support for the view that persistent, one-sided interventions increase the effectiveness relative to one-off interventions as do relatively large interventions. We also find that FX sales are generally more effective than purchases. In terms of cross-sectional differences in our sample of economies, effectiveness varies across regions (with intervention in Asian economies generally more effective) and across exchange rate regimes (with intervention by regular interveners more effective than by floaters). Finally, we present some initial evidence that FX intervention is more effective when market depth is low.

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[5] Our perspective is related to the extensive literature on long-term swings in real exchange rates (e.g., Engel and Hamilton (1990), Evans and Lewis (1995), Klaassen (2005), and Chen and Lee (2006)). These swings in part were seen as persistent changes in macroeconomic fundamentals and global financial conditions.

[6] The cyclical nature of the misalignments—i.e., mean reverting—is consistent with the literature that exchange rates and long-run fundamentals are cointegrated (Mark and Sul, 2001) and that PPP holds in the long run (Canzoneri, et al., 1999).

[7] Long time series are available for real and nominal exchange rates. However, in the main analysis of the paper, we are constrained to 1990-2018 due to availability of data on macroeconomic fundamentals.

That said, we do not rule out the possibility that the estimated intervention effects are even larger than we report because, despite our attempts, we may have not been able to fully overcome the inherent endogeneity bias challenge. As in the case of Daude et al. (2016), our estimates should therefore be seen as a lower bound for the true intervention effects given that the endogeneity bias tends to work against finding intervention effectiveness.[8]

The rest of the paper is organized as follows. The next section describes our dataset and its sources. Section III outlines our new approach to measuring equilibrium exchange rates. Section IV describes our econometric model and presents the results on the effectiveness of exchange rate intervention. Section VI concludes and draws policy implications.

II. Data Description

Our sample consists of 30 advanced and emerging market economies covering the period 1990-2018. The sample size is constrained by the availability of exchange rate intervention data, which starts only in 1990:Q1, and the availability of data on regressors in our empirical analysis, which reduces the sample size to 26 countries. The full country list and data details can be found in the Appendix A.

Exchange rate data: The real effective exchange rate (REER) index[9] and nominal bilateral exchange rate with the US dollar (USNER) data are available at a monthly frequency from the IMF's International Financial Statistics (IFS) database. In the analysis, we focus on both the trade-weighted real effective exchange rate—which more accurately reflects trade flow relationships—and the real bilateral exchange rate relative to the US dollar—which may be more important from a financial perspective.

Macroeconomic fundamentals: real GDP growth rates, general government fiscal deficit, monetary policy rates, and CPI inflation all come from the IMF's IFS database and are available at a quarterly frequency for most advanced and emerging market economies. Commodity terms of trade data are available at a monthly frequency from the IFS database. In addition, we use data on GDP per capital in real USD terms from the IFS database to proxy for productivity levels.

Exchange rate interventions (FXI): The exchange rate intervention proxy is defined as the quarterly change in central banks' Net Foreign Assets (NFA), adjusted for valuation effects due to movements in exchange rates. Appendix B describes the construction of this FXI proxy measure. Considerable variation is evident in Figure 1.[10]

Global and policy variables: Net foreign assets (NFA), exports (X) and imports (M), and gross and net capital inflows (GKI and NKI) are taken from the IMF's Balance of Payments and International Investment Position (BoPIIP) database. Official reserves come from the IMFs Composition of Official Foreign Exchange Reserves (COFER) database. We proxy for global financial volatility using the S&P 100 Volatility Index (VXO)

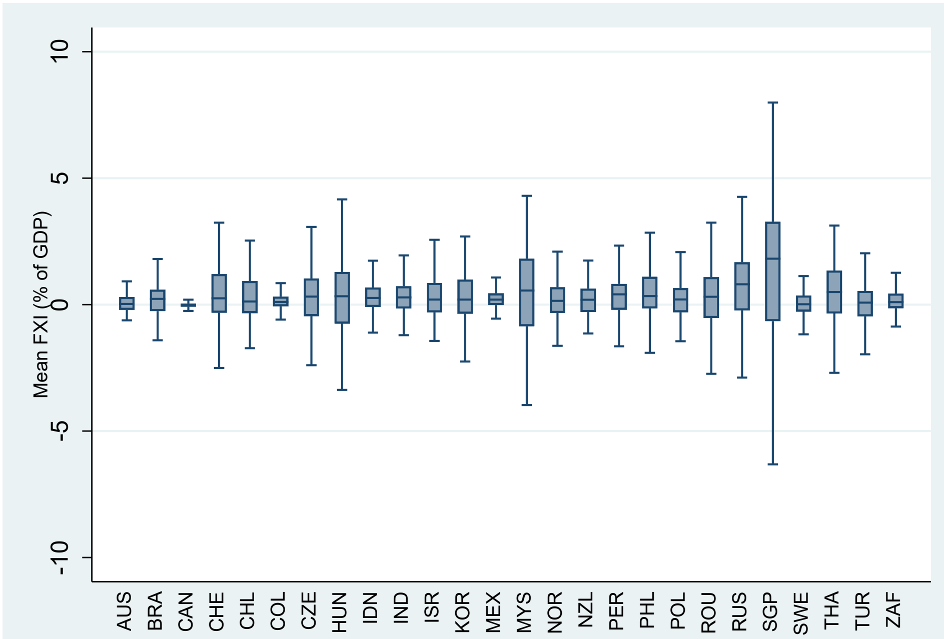
[8] Note that our findings are consistent with the two dominant theoretical mechanisms linking intervention to exchange rate dynamics: the portfolio balance and signaling channels. The portfolio balance channel assumes imperfect substitutability between domestic and foreign assets. The signaling channel emphasizes the information that interventions provide about changes to future policy; interventions are also seen to reflect changes in central bank intentions about the exchange rate and willingness to intervene (e.g., Cavallino and Patel (2019)). Assessing the contributions of these mechanisms is left for future research.

[9] We use the REER as constructed by the IMF IFS using consumer price indices for all countries except Hong Kong SAR, where we use the REER constructed using unit labor cost indices.

[10] Note, our data do not distinguish between exchange rate interventions that are sterilized and those that are not. However, during most of period covered by our regression analysis, central banks in our sample pursued interest rate operating frameworks which allow us to treat the interventions as effectively being sterilized.

from the St. Louis Federal Reserve FRED database and for capital account openness using the overall restrictions index from Fernández et al. (2016).

Figure 1. Exchange Rate Intervention (FXI), by Country From 1990–2018



III. A New Approach to Measuring Exchange Rate Misalignments

This section describes a new approach to measuring exchange rate misalignments. The conventional approach is to estimate an "equilibrium" exchange rate and define the misalignment as the deviation of this estimate from the exchange rate. Our approach emphasizes cycle-specific misalignments, i.e., misalignments of short-, medium-, and long-cycles in the exchange rate. To do this, we first decompose the equilibrium exchange rate into short-, medium-, and long-cycles and then use spectral regression methods to derive real exchange-rate deviations from their equilibrium levels at short-, medium-, and long-run cycles. This section describes the multi-step procedure.

A. Exchange Rates and Their Macroeconomic Fundamentals at Different Cyclical Frequencies

As is conventional in the literature, we are interested in estimating the relationship between the real exchange rate and macroeconomic fundamentals of the form:

$$er^{\mathrm{f}}_{i,t} = \beta X^{\mathrm{f}}_{i,t} + \theta^{f}_{i} + \varepsilon^{f}_{i,t}, \tag{1}$$

where $er^{\mathrm{f}}_{i,t}$ is the real effective exchange rate index for country i at time t; $X^{f}_{i,t}$ is a vector of macroeconomic fundamentals consisting of: log per capita income, net foreign assets (as percent of GDP), log openness (sum of exports and imports as percent of GDP), government consumption (as percent of GDP), and the log of the commodity terms of trade index; and θ_i^f are country fixed effects. This choice of the macroeconomic fundamental variables reflects findings in the literature.[11]

One key difference between our approach and that in the literature is our emphasis on cycle-specific misalignments. Namely, $f \in \{s, m, l\}$ indexes the three frequency bands that corresponding to the short-, medium-, and long-cycles. Operationally, after specifying the frequency bands, Equation 1 can be estimated with band spectrum regression methods (following Engle 1974, Granger and Engle 1983, Phillips 1991, and Corbae, Ouliaris, and Phillips 2002, among others). First, all variables are transformed to the frequency domain using a Fourier transformation.[12] The transformed dependent variables can then simply be regressed on the transformed explanatory variables for each selected frequency band. In our case, we transform the exchange rate and our macro fundamentals into their cyclical components at different frequencies, before proceeding with a standard linear regression.

B. Identifying Short-, Medium-, and Long-Cycles

We choose the frequency bands corresponding to the short-, medium-, and long-cycles following the tradition of Burns and Mitchell (1946). In particular, we use a statistical algorithm that identifies peaks and troughs in the real bilateral exchange rate (against the US dollar) as in Bry and Boschan (1971) and Albuquerque et al. (2015).[13] Figure C.1 in Appendix C plots the real effective exchange rate for the 22 advanced and emerging market economies for which we have monthly data, along with the identified peaks and troughs.

The cyclical nature of real exchange rates is visually striking for our sample of countries, with clear peaks and troughs. From peak-to-peak, the average length of the estimated cycles is around 10 years. With the duration estimate for exchange rate cycles, we calibrate the decomposition of the exchange rate series into different sub-cycles. The long-run cycle is estimated by filtering out frequencies associated with cycles of duration of 10 years or more; the medium-run cycle is defined as filtering out frequencies associated with cycles of duration greater than 4 years and less than 10-years. The remaining frequencies of interest are associated with short (including business) cycles of 1 to 4 years.[14] For less than a year, we treat the relationship between macroeconomic fundamentals and the real exchange rate as being statistically unpredictable.[15]

[11] For example, see Daude et al. (2016), Ricci et al. (2013), and Cubeddu et al. (2019).

[12] In practice this is achieved using a Butterworth high-pass filter without a trend. We filter out stochastic frequencies above a pre-specified frequency corresponding to the short-, medium-, and long-run frequencies. The benefit of such a filter is that it is "maximally flat" in that the gain function is as close as possible to a flat line at 0 for the unwanted periods and 1 after.

[13] Essentially, we calculate a 3-year moving average, identify turning points within a window of ±2 years, find the nearest max/min of the actual exchange rate that corresponds to this turning point.

[14] The filtering results, using a Butterworth spectral filter, are presented in Appendix C, Figure C.2.

[15] In our empirical implementation, we abstract from high frequency movements in the exchange rate, which can be driven by a whole host of factors including arbitrage, market sentiment, and liquidity.

C. Relationship of Cycle-Specific Exchange Rates and Macroeconomic Fundamentals

Given these calibrated cycle lengths of interest, Equation 1 can be estimated as a set of cycle-specific regressions. Table 1 presents the results. For each cycle-specific regression, the coefficients on the fundamental variables are highly significant and generally have the expected signs. The coefficients on NFA and trade openness are both quite negative, as expected, and consistent across cycles, while the coefficient on income is positive, as expected. The coefficient on government consumption differs across cycles. The commodity terms of trade are measured such that a decrease is an improvement in the terms of trade (and tends to be associated with an appreciation in the domestic currency).

The results—and in particular the size of the coefficients—confirm that the macroeconomic fundamentals are more powerful in explaining movements in the exchange rate over longer cycles compared to short cycles, with the exception of trade flows—smaller coefficient at longer cycles—which are more important for the short and medium cycles.[16]

Table 1. First-Stage Regression Model of Exchange Rate Macro Fundamentals

	(2) Short	(3) Medium	(4) Long
Income	0.217***	0.222***	0.212***
Net foreign assets (NFA)	-0.0130***	-0.0169***	-0.0161***
Trade openness	-0.163***	-0.168***	-0.125***
Government consumption	0.0000860	-0.0000962	-0.00272***
Commodity terms of trade	-0.0912***	-0.0964***	-0.112***
Observations	2552	2552	2260
Country fixed effects	yes	yes	yes
Countries	30	30	30
R-squared	0.52	0.52	0.55

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Dependent variable is the log of the real effective exchange rate (REER). Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 4 quarter lags.

D. Defining Cycle-Specific Exchange Rate Misalignments

Armed with the estimates from Equation 1, we define the cycle-specific *equilibrium real exchange rate* $eer_{i,t}^{f}$ at each frequency $f \in \{\mathrm{s}, \mathrm{m}, \mathrm{l}\}$ in the following way (where the *hat* notation denotes the OLS estimate):

$$eer_{i,t}^{f} = \hat{\alpha} + \hat{\beta} X_{i,t}^{f} + \hat{\theta}_{i}^{f}. \qquad (2)$$

Accordingly, the *cycle-specific misalignments* mis_{it}^{f} at each frequency are defined as,

[16] Busetti and Caivano (2017) follow a similar approach for real interest rate determinants.

$$mis_{i,t}^{f} = er_{i,t}^{f} - eer_{i,t}^{f}, \quad (3)$$

where $er_{i,t}^{f}$ is the real exchange rate for each country at frequency $f \in \{\mathrm{s, m, l}\}$.

These measures of misalignments—shown in Figure 2—differ from those found in the literature in two ways.[17] First, these misalignments indicate the extent to which the exchange rate deviates from its fundamental value at different cyclical frequencies. Second, the frequency-domain method estimates are theoretically unbiased (Engle, 1974)) as long as all variables are transformed using the same frequency band in each regression. This unbiasedness property of the estimators is generally not present when misalignments are constructed as the difference between the actual exchange rate and some equilibrium level, as in Daude et al. (2016).

IV. Estimates of FXI Effectiveness Using Cycle-Specific Misalignments

This section begins by describing the baseline FXI effectiveness model and results. It then addresses various robustness issues and extensions of the baseline to include large and persistent interventions, sales versus purchases of foreign assets, and cross-sectional comparisons among the sample population.

A. Baseline Panel Regression Model

Our baseline regression model to assess the effectiveness of FXI is as follows:

$$\begin{aligned} er_{it} = \rho er_{i,t-1} + \mu X_{i,t} + \varphi Z_{i,t} + \textstyle\sum_f \beta^f mis_{i,t-1}^{f} \\ \delta FXI_{i,t} + \textstyle\sum_f \mu^f \left(FXI_{i,t} \times mis_{i,t}^{f}\right) + \theta_i + \varepsilon_{i,t} \end{aligned} \quad (4)$$

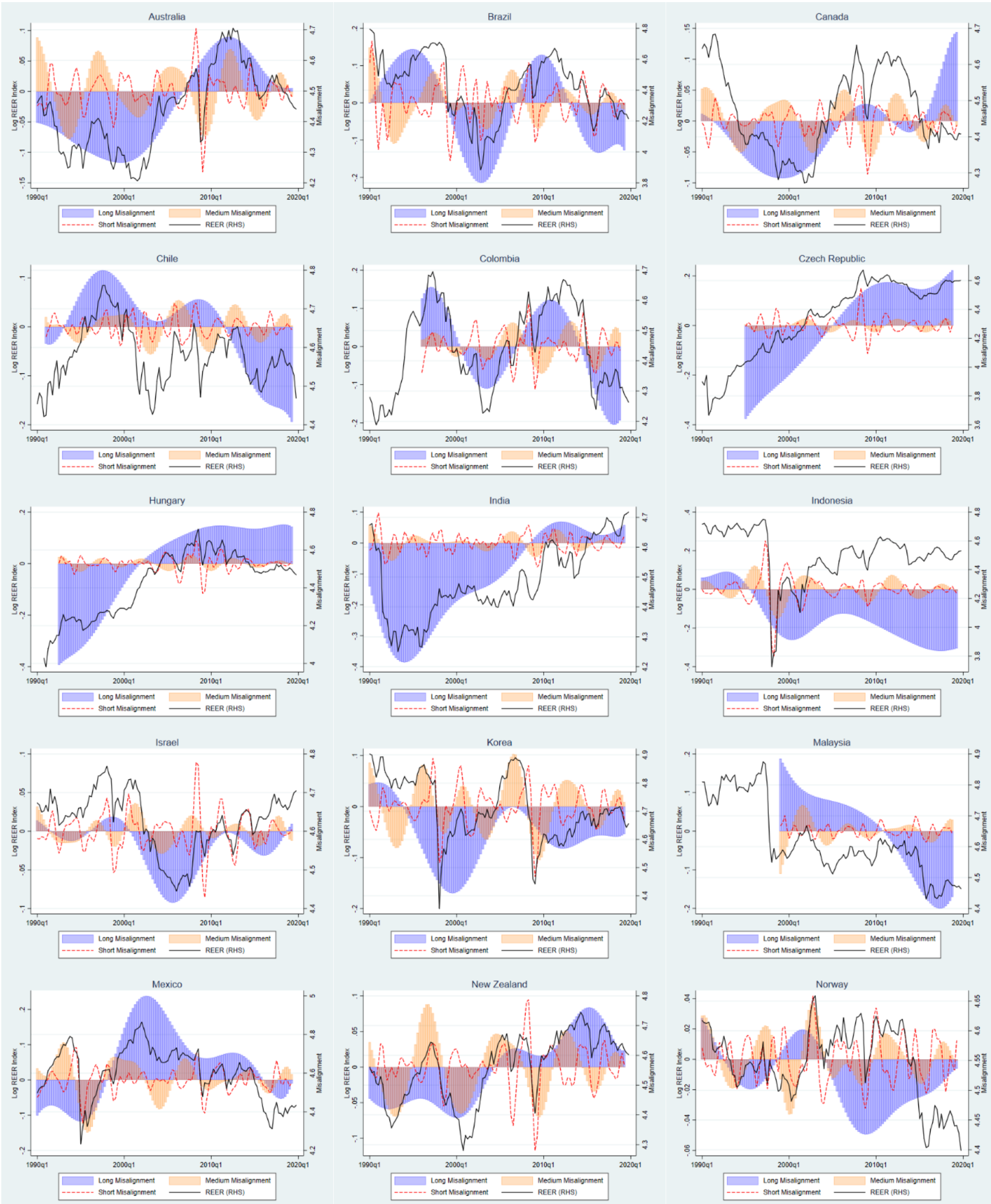
where $er_{i,t}$ is the log of the real effective exchange rate for country i and time t; $X_{i,t}$ are the usual exchange rate fundamentals; $Z_{i,t}$ are the a set of policy variables and global factors[18]; $FXI_{i,t}$ is our interventions proxy; the $mis_{i,t}^{f}$ variables are the measures of short-, medium-, and long-run misalignments; and θ_i are country fixed effects. The coefficients μ^f measure the extent of the correlation between FXI and cycle-specific misalignments.[19] All models are estimated using fixed effects with heteroskedasticity and serial correlation corrected Newey-West standard errors.

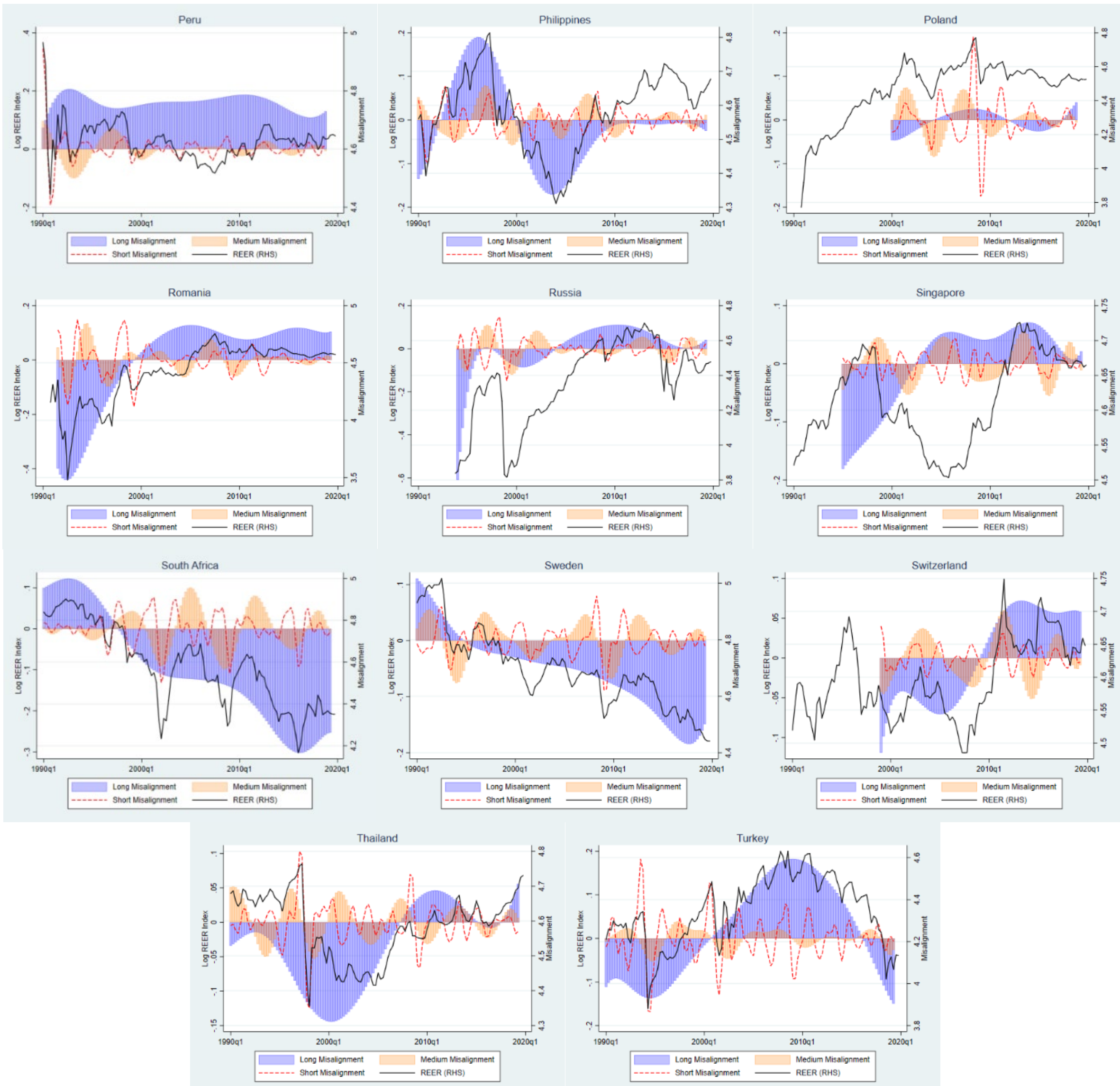
[17] Note that the sample size is reduced from 30 to 26 countries due to data availability.

[18] Policy variables comprise the real policy rate (nominal policy crate deflated using the current inflation rate), the reserve-to-imports ratio, and the Chin-Ito index for capital account openness; the global variables comprise of interactions between the VXO index and capital account openness, and between the real policy rate and capital account openness.

[19] Note that the use of contemporaneous control variables attributes variation in the real exchange rate to them rather than FXI. In this sense, the specification may underestimate the contribution of FXI to exchange rate variation and hence yield more conservative estimates of the FXI impact.

Figure 2. Cyclic-Specific Exchange Rate (REER) Misalignments





Peru
Philippines
Poland
Romania
Russia
Singapore
South Africa
Sweden
Switzerland
Thailand
Turkey
Log REER Index
Misalignment
1990q1
2000q1
2010q1
2020q1
Long Misalignment
Medium Misalignment
Short Misalignment
REER (RHS)

B. Baseline Results

The results support the hypothesis that central banks are effective at leaning against short-run misalignments in the real exchange rate. Table 2 Column 1 presents the baseline specification in Equation (4). The sample is restricted to 26 countries for whom we have data on policy variables for. The evidence of cycle-specific FXI effectiveness can be read off the cross terms FXI*mis S, FXI*mis M, and FXI*mis L. Theory suggests that these coefficients should be negative, i.e. effective exchange rate intervention is counter-cyclical—FX purchases (positive) lead to a deprecation (negative) of the exchange rate.

In terms of magnitude, the estimates indicate that for a short-run misalignment of 10 percent, a tenth-percentage-point-of-GDP of exchange rate intervention (FXI), in this case purchases of foreign exchange, is associated with a statistically significant 1.5 percent depreciation in the exchange rate.[20]

Table 2. Effectiveness of Leaning Against the Wind

	(1)	(2)
Lag REER	-0.164***	-0.195***
Lag mis S	0.468***	0.564***
Lag mis M	0.643**	0.759***
Lag mis L	0.810***	1.010***
FXI	0.000522**	-0.00226***
FXI * mis S	-0.0146*	-0.0446**
FXI * mis M	0.0056	-0.0259
FXI * mis L	-0.0049*	-0.0081
Fundamentals	Yes	Yes
Policy	Yes	Yes
Global	Yes	Yes
Model	**Baseline**	**FXI surprise**
Observations	1198	1101
Countries	26	26
R-squared	0.92	0.90

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Estimated with country fixed effects. Dependent variable is the log of the real effective exchange rate (REER). FXI is foreign exchange intervention as a share of GDP. Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index; Policy variables: real policy rate, reserve-to-trade ratio (both in percent), Chin-Ito index for capital account openness; Global variables: interactions between the VXO index and capital account openness and between the real policy rate and capital account openness. Short-, medium-, and long-cycle misalignments are relative to their respective cyclical equilibrium real exchange rate based on Equation 1. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 4 quarter lags.

[20] The dependent variable is the natural logarithm of the real exchange rate index while the FXI variable is measured in levels of foreign exchange purchases as a percent of GDP, so a value of 1 is equivalent to an exchange rate intervention of 1 percent of GDP. The misalignments are defined in terms of the difference of natural logarithms and are mean zero by construction. The coefficients when multiplied by 100 give an approximate relationship as the percent change in the exchange rate.

The coefficients on the medium-cycle and long-cycle misalignments (FXI*mis M and FXI*mis L) are relatively modest.[21] Moreover, the medium-cycle misalignment coefficient is not of the correct sign and not statistically different from zero. This is evidence that exchange rate intervention is ineffective in leaning against the forces associated with the medium-cycle misalignments. In contrast, the long-cycle misalignment coefficient appears to be statistically significant but small. Our subsequent robustness checks suggest that this finding is statistically fragile and may be spurious. One explanation for this finding could be that short-run misalignments are often generated by external shocks in the context of shallow or illiquid markets, a setting in which FX intervention may be particularly effective, especially in the presence of financial frictions. Such financial frictions may be less binding over the long-run, perhaps explaining why we find FX interventions less effective at longer horizons. We explore this further in section IV.G.

C. Addressing the Endogeneity Bias Challenge

We address the endogeneity by using policy "surprises" as deviations from estimated policy rules. Specifically, we follow Brandao et al. (2020) in estimating the FXI "surprises" as the residual from the following linear intervention rule:

$$FXI_{i,t} = \beta X_{i,t} + \delta \sigma_{i,t}^{reer} + \theta_i + \varepsilon_{i,t}^{fxi} \,, \tag{5}$$

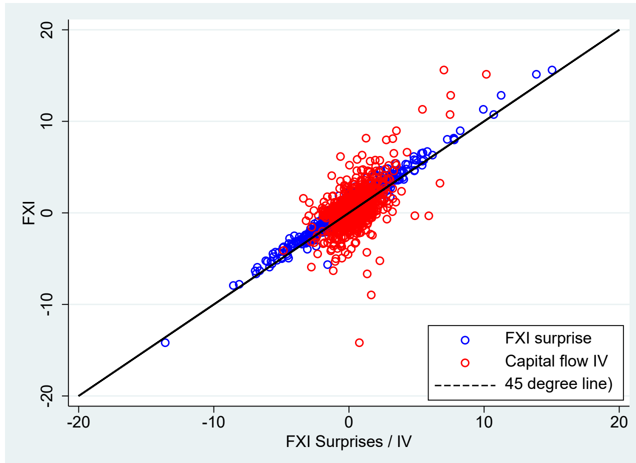
where the vector X denotes the fundamentals; $\sigma_{i,t}^{reer}$ is the monthly variance of the real effective exchange rate index within the quarter; θ_i are country fixed effects, and $\varepsilon_{i,t}^{fxi}$ is the residual and our measure of the FXI IV policy shock. Figure 3 plots the FXI surprises against FXI.

The results from re-running Equation 4 and replacing FXI with FXI surprises are shown in Column 2 of Table 2.[22] Several key findings stand out. First, the coefficients on FXI and the FXI cross terms have the expected negative sign. Second, the coefficient on FXI*mis S is threefold larger than in Column 1 and is statistically more significant. Third, the FXI*mis M and FXI*mis L coefficients are of the expected sign, albeit statistically insignificant. All this suggests that use of the FXI surprises helped to attenuate the endogeneity problem and reinforces our baseline finding that exchange interventions are effective in influencing short-cycle misalignments; these results even suggest that exchange rate intervention may have a modest impact on medium- and long-cycle misalignments.

[21] The contemporaneous FXI coefficient is very small (.0005) despite its statistical significance; it is also of unexpected sign. This suggests FXI on its own is not quantitatively important if controls for the cycle-specific misalignments are included in the estimation. The "wrong" sign also suggests that the endogeneity bias may be present.

[22] An alternative approach would have been to strip these FXI policy surprises out of the construction of exchange rate misalignment, by including them in the fundamentals model in eq 1. The challenge here is that doing so would restrict the sample size of the fundamentals model. We see a benefit in estimating cycles over as long a horizon as possible.

Figure 3. FXI Surprise and Capital Flow IVs



Notes: Figures plots FXI (as % of GDP) on the vertical axis against the FXI policy surprise variable (blue circles) and the fitted FXI instrument using capital flows (red circles) on the horizontal axis respectively; black line is the 45 degree line.

D. Robustness

We report three statistical checks that confirm the robustness of our conclusions.[23] Column 1 of Table 3 shows estimates from Equation 4 but replaces the fixed effects baseline specification with a specification in first differences. Column 2 reports the results when replacing the fundamentals with the equilibrium REER—that is the simple fitted REER obtained from eq. 1 without filtering the regressors. Column 3 considers the usefulness of global capital flows as an instrument, as proposed by Blanchard et al. (2015).[24]

The main result is that central banks are effective at leaning against short-cycle misalignments, as indicated by the negative and statistically significant coefficients on FXI*mis S in all three columns. The other coefficients are fairly robust, even though the signs on the cross terms with mis M and mis L are economically small, statistically insignificant, and tend to be positive.

[23] In addition to the robustness checks discussed here, we perform two additional exercises which are not discussed in detail in the interest of conciseness. We replace the FXI variables in our baseline model with a randomly generated FXI variables, with the same mean and standard deviation of actual interventions for each country. In this case, all coefficients are insignificant, suggesting that our results are not due to spuriously correlation between FXI and the misalignment measures. We also explore the possibility that the US bilateral exchange rate may be more sensitive to FXI owing to the prominent role USD reserves play at central banks. We re-estimate the model with the bilateral USD real exchange rate as the dependent variable. The results confirm that our conclusions from the REER baseline results continue to hold but provide weaker evidence on FXI effectiveness when leaning against USRER misalignments.

[24] Blanchard et al. (2015) argue that global capital inflows in the rest of the world, i.e., excluding those to the home country, can be used as a valid instrument to orthogonalize exchange rate interventions with respect to domestic fundamentals. See Figure 3 for a comparison of this instrument relative to the FXI surprise instrument. The capital flow instrument implicitly assumes that global capital flows are largely independent of individual country domestic fundamentals. In this case, we regress FXI on a gross and net global capital inflows and use the fitted values as the FXI instrument. The effectiveness estimate is small and of the correct size. In many respects, the measure of global capital flows as a proxy for important global financial intermediation imperfections may be far from perfect but nonetheless points to the need for better financial proxies that capture global financial frictions.

E. Effectiveness of Persistent, Large, and One-Sided Interventions

The results in the previous section suggest that FX intervention can smooth out misaligned exchange rates by one-off interventions. We now shift our attention to the impacts of large and persistent interventions. Are persistent interventions more effective?[25] We investigate this possibility using the following model:

$$\begin{aligned} er_{i,t} = {} & \rho er_{i,t-1} + \mu X_{i,t} + \varphi Z_{i,t} + \textstyle\sum_f \beta^f mis_{i,t-1}^f + \\ & \delta_1 FXI_{i,t} + \textstyle\sum_f \delta_{fxi}^f \left(FXI_{i,t} \times mis_{i,t}^f\right) + \\ & \beta CFXI_{i,t} + \varphi_1\left(FXI_{i,t} \times CFXI_{i,t}\right) + \textstyle\sum_f \varphi_{cfxi}^f\left(FXI_{i,t} \times CFXI_{i,t-1} \times mis_{i,t}^f\right) + \\ & \theta_i + \varepsilon_{i,t}, \end{aligned} \tag{6}$$

where $CFXI_{i,t-1} = \sum_{j=1}^{4} FXI_{i,t-j}$ is the 4-quarter cumulative sum of our FX intervention variable. $X_{i,t}$ are the usual exchange rate fundamentals; $Z_{i,t}$ are the policy variables and global factors. The φ_{cfxi} coefficients measure the effect of FXI conditional on the previous quarters' cumulative FXI and on the cyclical misalignment. We use the FXI policy surprises instrument as our FXI variable.

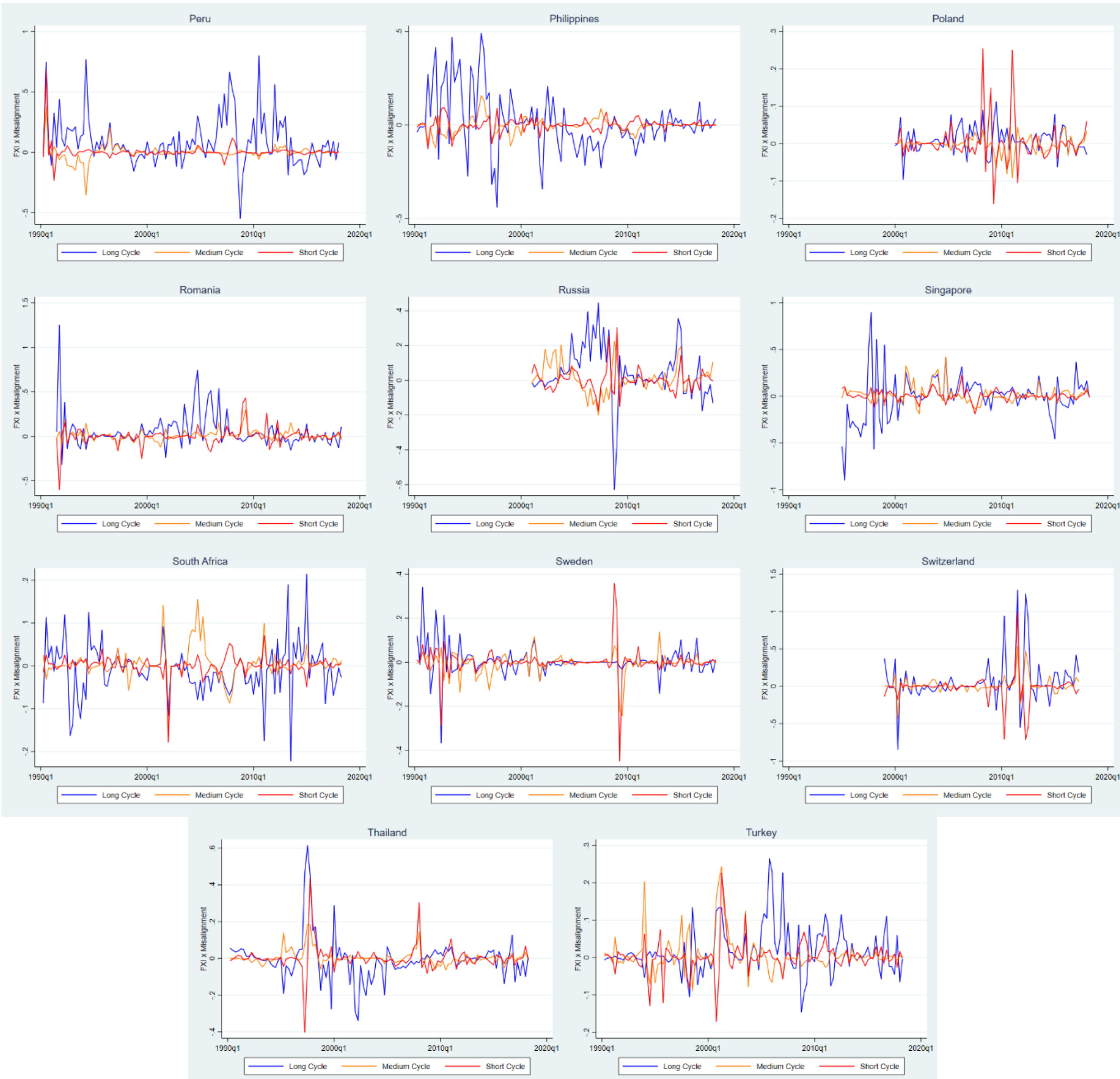
Table 3. Robustness Checks

	(1)	(2)	(3)
Lag REER	0.295***	0.182***	0.175***
Lag S mis	0.509***	0.426***	0.546***
Lag M mis	0.873***	0.701*	0.679**
Lag L mis	0.971***	0.935***	1.206***
FXI	0.000768*	-0.000253	-0.00231***
FXI * mis S	-0.0362***	-0.0160*	-0.00794*
FXI * mis M	0.00150	0.00773	0.00631
FXI * mis L	0.00180	-0.00436	0.00747
Fundamentals	Yes	No	Yes
Policy	Yes	Yes	Yes
Global	Yes	Yes	Yes
Model	**First Difference**	**Effective REER**	**Global K Flow**
Observations	1181	1198	1227
Countries	26	26	26
R-squared	0.39	0.91	0.89

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Estimated with country fixed effects. Dependent variable is the log of the real effective exchange rate (REER). FXI is foreign exchange intervention as a share of GDP. Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index; Policy variables: real policy rate, reserve-to-trade ratio (both in percent), Chin-Ito index for capital account openness; Global variables: interactions between the VXO index and capital account openness and between the real policy rate and capital account openness. Short, medium, and long run misalignments are computed relative to their respective cyclical equilibrium real exchange rate level based on the macroeconomic fundamentals model. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 4 quarter lags.

[25] For example, persistent or large interventions may have a stronger signaling effect than isolated, smaller ones. Large interventions are more likely to alter financial conditions associated with financial frictions.

Figure 4. Exchange Rate (REER) Misalignments, by Cycle Type


Peru
Philippines
Poland
Romania
Russia
Singapore
South Africa
Sweden
Switzerland
Thailand
Turkey
FXI x Misalignment
1990q1
2000q1
2010q1
2020q1
Long Cycle
Medium Cycle
Short Cycle

We find evidence that persistent interventions increase intervention effectiveness. The results are presented in Table 4. Cumulative interventions are found to be effective at leaning against short-run misalignments. For every additional percent of CFXI, the exchange depreciates by a further .26 percent. This suggests that policy makers face an additional "bang for their buck" if they intervene systematically against misalignments over consecutive quarters. Note that these results are for persistent interventions but do not distinguish between persistent purchases or sales; it is important to note that sales may be more effective because markets understand that there is an absolute lower bound at zero reserves and that there may be an implicit lower bound above zero at which rating agencies may downgrade sovereign debt. If a central bank were to sell reserves during a period of stress, it could signal a strong commitment to offset non-fundamental pressures.

Next, to investigate the impact of particularly large interventions, we adjust the above equation as follows:

$$
\begin{aligned}
er_{i,t} = \rho er_{i,t-1} + \mu X_{i,t} + \varphi Z_{i,t} + \textstyle\sum_f \beta^f mis_{i,t-1}^f \\
\delta_1 FXI_{i,t} + \textstyle\sum_f \delta_{fxi}^f \left(FXI_{i,t} \times mis_{i,t}^f\right) + \\
\beta P/S_{i,t} + \mu_1\left(FXI_{i,t} \times P/S_{i,}\right) + \textstyle\sum_f \mu_{P/S}^f\left(FXI_{i,t} \times P/S_{i,t} \times mis_{i,t}^f\right) + \\
\theta_i + \varepsilon_{i,t} \qquad (7)
\end{aligned}
$$

where P/S denotes either large FX purchases (P) or sales (S), defined as FX interventions in either direction that are greater than 1 percent of GDP. The $\mu_{P/S}$ coefficients capture the differential effect of FXI conditional on the size of the interventions and the cyclical misalignments. We continue to use our FX policy surprises as our FXI measure. Figure 6 summarizes the data on sales and purchases.

The evidence is consistent with the perspective that policy makers generally lean against the wind, either purchasing foreign assets during periods of capital inflow pressures and exchange rate appreciation. or selling foreign assets during periods of capital outflow pressures and currency depreciation. Table 5 documents that both large FX purchases and sales tend to strengthen the countercyclical effect of intervention with respect to short-cycle misalignments. FXI sales appear to be somewhat more effective in terms of economic size (3.6 percent vs 3.0 percent).

Figure 6. FX Sales vs. Purchases

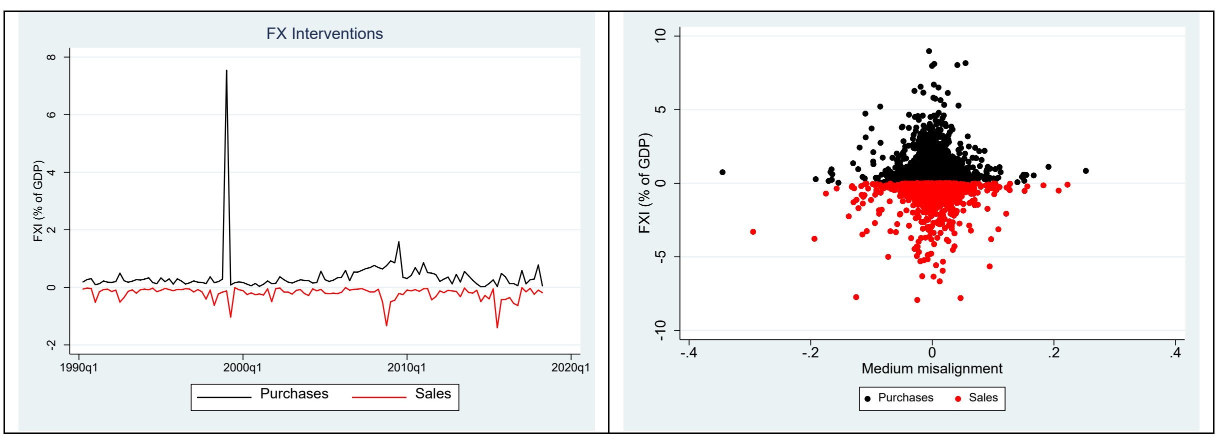


Table 4. Persistent and One-Sided Interventions

	(1)
Lag REER	0.188***
Lag S mis	0.474***
Lag M mis	0.751***
Lag L mis	0.815***
FXI	0.00294***
FXI * mis S	-0.0304**
FXI * mis M	-0.0177
FXI * mis L	-0.0126
CFXI	0.000589**
FXI * CFXI	-0.00260**
FXI * CFXI * mis S	0.00651
FXI * CFXI * mis M	0.00374
FXI * CFXI * mis L	0.00145
Fundamentals	Yes
Policy	Yes
Global	Yes
Observations	1207
Countries	26
R-squared	0.90

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Estimated with country fixed effects. Dependent variable is the log of the real effective exchange rate (REER). FXI is foreign exchange intervention as a share of GDP. CFXI are cumulative FX interventions for the last 4 quarters. Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index; Policy variables: real policy rate, reserve-to-trade ratio (both in percent), Chin-Ito index for capital account openness; Global variables: interactions between the VXO index and capital account openness and between the real policy rate and capital account openness. Short, medium, and long run misalignments are computed relative to their respective cyclical equilibrium real exchange rate level based on the macroeconomic fundamentals model. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 5 quarter lags. Column (5) uses a randomly generated FXI variables drawn from a normal distribution.

Table 5. Large Interventions (Sales vs Purchases)

	(2)	(3)
Lag REER	0.187***	0.201***
Lag S mis	0.440***	0.430***
Lag M mis	0.757***	0.752***
Lag L mis	0.819***	0.800***
FXI	0.00378***	0.00301***
FXI * mis S	-0.221***	-0.0739***
FXI * mis M	-0.0485	-0.0165
FXI * mis L	-0.0211*	-0.00407
Large purchases	-0.000984*	
FXI * L Purch	-0.00212	
FXI * L Purch * mis S	-0.0296***	
FXI * L Purch * mis M	-0.0441	
FXI * L Purch * mis L	-0.0156	
Large sales		-0.00587*
FXI * L Sales		-0.000364
FXI * L Sales * mis S		-0.0356***
FXI * L Sales * mis M		0.00140
FXI * L Sales * mis L		-0.0310*
Model	Purchases	Sales
Fundamentals	Yes	Yes
Policy	Yes	Yes
Global	Yes	Yes
Observations	1207	1207
Countries	26	26
R-squared	0.93	0.91

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Estimated with country fixed effects. Dependent variable is the log of the real effective exchange rate (REER). FXI is foreign exchange intervention as a share of GDP. Large purchases and sales are dummy variables for FX purchases or sales greater than 1 percent of GDP . Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index; Policy variables: real policy rate, reserve-to-trade ratio (both in percent), Chin-Ito index for capital account openness; Global variables: interactions between the VXO index and capital account openness and between the real policy rate and capital account openness. Short, medium, and long run misalignments are computed relative to their respective cyclical equilibrium real exchange rate level based on the macroeconomic fundamentals model. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 5 quarter lags. Column (5) uses a randomly generated FXI variables drawn from a normal distribution.

F. Delving Into the Cross Section

While the baseline results captured in Table 2 highlights the importance of accounting for cyclical misalignments when gauging the effectiveness of exchange rate intervention for the full sample of economies, this section digs into the cross-sectional differences across our sample of countries. Table 6 reports the results for (i) Latin American and Asian economies, and (ii) managed floaters and interveners.

Differences between Asia and Latin America. Columns (1) and (2) highlight the regional differences in the impact of FXI on the misalignments. Nearly all the coefficients have the expected signs. There is some evidence that Asian interventions are more impactful. For Asia, which relies heavily on the dollar in both trade and finance, the results for both the short- and medium-cycle misalignment measures are statistically significant.

Differences between countries which are managed floaters versus interveners. The distinction between the managed floaters and the interveners is the degree to which a country relies on exchange rate intervention in its respective policy framework. In general, the FXI*mis S coefficients for interveners and floaters are both negative, but the coefficient is statistically significant and more negative for interveners. The other coefficients in the table are statistically insignificant and may reflect low explanatory power of the limited regional datasets. The results do suggest that a credible intervener may be able use its interventions to signal its intentions, and expect markets to react accordingly. This does not suggest that there are not more nuanced differences among the groups of floaters and interveners. Delving into the details of how policy makers can effectively signal its intervention intentions is left for future research.

Table 6. Country Differences, by Regions and FXI Intensity

	(1)	(2)	(3)	(4)
Lag REER	-0.0222	0.0115	-0.0295	0.00486
FXI	0.00297**	0.000185	0.000176	0.000157
FXI * mis S	-0.0544***	-0.0880***	-0.0116	-0.0839***
FXI * mis M	-0.118	0.0179	-0.00514	0.0165
FXI * mis L	-0.00839	0.000884	-0.00368	-0.00284
Fundamentals	Yes	Yes	Yes	Yes
Policy	Yes	Yes	Yes	Yes
Global	Yes	Yes	Yes	Yes
Sample	**LATAM**	**SE Asia**	**Float**	**Interveners**
Observations	211	159	873	228
Countries	5	9	17	13
R-squared	0.93	0.96	0.93	0.92

See notes to Table 2. The classification of interveners and floaters is based on the IMF's 2020 https://www.elibrary-areaer.imf.org/Pages/Home.aspx Database.

G. Market depth and liquidity

FX intervention is likely to be more effective in countries where market depth is shallow and is subject to bouts of illiquidity. To investigate this issue, we construct a measure of the liquidity of FX markets as follows:

$$spread_{i,t} = \frac{bid_{i,t} - offer_{i,t}}{er_{i,t}} \times 100 \quad (8)$$

where market liquidity is measured as the difference between the average spread between the bid- and offer-rate within the quarter, normalized by the nominal exchange rate, and measured in percent. More shallow, less liquid FX markets should exhibit a larger spread. We add this variable to our baseline specification as a triple interaction with FXI and our different misalignment terms, controlling for the spread on its own, as well as its interaction with the misalignments.

The results, presented in Table 7 based on our baseline specification, suggest that less liquidity FX markets (as captured by a larger bid-offer spread) are indeed associated with a more effective leaning-against-the wind effect of FX interventions. For a 1-percentage point increase in the bid-offer spread[26], a tenth-percentage-point-of-GDP FX purchase is associated with a statistically significant 4-percent *larger* depreciation in the exchange rate, when starting from a 10 short-run misalignment. The impact associated with medium- and long-run misalignments is not statically significant. When we use our FX policy surprise measure, the differential impact increases to 7 percent.

One explanation for this result is that short-run misalignments are typically generated by external financial shocks in the presence of financial frictions and shallow FX markets. In such a setting, FX intervention is likely to be particularly effective at serving as a liquidity buffer which helps prevent adverse, self-reinforcing liquidity spirals. Misalignments over longer horizons may be driven more by the divergence of exchange rates from macroeconomic fundamentals, which would explain the result that FX interventions are less effective with respect to longer cycle misalignments.

[26] The average spread in our dataset is 10bps (0.1 percent) with a standard deviation of 20bps.

Table 7. Market depth and liquidity

	(1)	(2)
Lag REER	-0.173***	-0.210***
Lag mis S	0.517***	0.498***
Lag mis M	0.824***	0.831***
Lag mis L	0.997***	1.003***
FXI	0.00110**	0.00122**
FXI * mis S	0.0277	-0.104***
FXI * mis M	-0.0486	0.0401
FXI * mis L	0.00875	0.00502
Bid-offer spread	-0.0462***	-0.0288**
Spread * mis S	-1.825***	-2.069***
Spread * mis M	-1.709**	-1.519**
Spread * mis L	-0.0440	-0.00561
Spread * FXI * mis S	-0.400**	-0.710***
Spread * FXI * mis M	0.382	0.631
Spread * FXI * mis L	0.168	0.0729
Fundamentals	Yes	Yes
Policy	Yes	Yes
Global	Yes	Yes
Model	**Baseline**	**FXI surprise**
Observations	1187	1187
Countries	26	26
R-squared	0.91	0.94

Notes: Significance levels: 1 percent (***), 5 percent (**), 10 percent (*). Estimated with country fixed effects. Dependent variable is the log of the real effective exchange rate (REER). FXI is foreign exchange intervention as a share of GDP. Fundamentals: log per capita income, net foreign assets (as percent of GDP), log openness (as percent of GDP), log government consumption (as percent of GDP), log of the commodity terms of trade index; Policy variables: real policy rate, reserve-to-trade ratio (both in percent), Chin-Ito index for capital account openness; Global variables: interactions between the VXO index and capital account openness and between the real policy rate and capital account openness. Short-, medium-, and long-cycle misalignments are relative to their respective cyclical equilibrium real exchange rate based on Equation 1. Newey-West corrected standard errors for heteroskedastic autocorrelation up to 4 quarter lags.

V. Conclusions

The policy debate on the usefulness and effectiveness of exchange rate intervention has been reinvigorated in recent years. One challenge to forging a consensus have been the huge gaps in our understanding of when intervention is likely to work and when it is not.

It is in this context that the findings of our analysis are helpful. Leaning against short-cycle misalignments is found to be effective, both in terms of the economic size and statistical significance; but not for leaning against medium- and long-cycle misalignments. Persistent, one-sided interventions appear to offer additional benefits compared to one-off interventions. The effects are measurable at policy-relevant horizons. That said, there are considerable differences—across regions, and between those economies which actively intervene and those which do not—which deserve further attention.

Our cycle-specific misalignment approach also offers a new perspective on how to think about exchange rate misalignments. This approach emphasizes the short-, medium-, and long-cycle factors driving exchange rates. The findings in this paper suggest that intervening to reduce exchange rate misalignments arising from long-run macroeconomic factors is not likely to be effective. However, in line with the theoretical literature, intervening to reduce exchange rate misalignments arising from financial frictions is more likely to yield results.

Econometrically, this paper demonstrates the usefulness of band spectrum estimation techniques in understanding dynamics of exchange rate misalignments. Certainly, there is more to be learned from our approach. Potential fruitful lines of future research include a more nuanced investigation into the conditions determining when exchange rate intervention is likely to be most effective. This will likely involve delving into the underlying mechanisms driving the misalignments, such as the risk-bearing capacity of global financial institutions. We also leave for future research extensions that incorporate intervention strategies based on market conditions such as market depth and liquidity, intervention tactics with respect to the most effective sizes and types of foreign asset purchases and sales, and the role of policy communication.

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VII. APPENDIXES

Appendix A: Data Details

Table A.1 Data Sources

Variable	Source
Real per capita GDP	IMF World Economic Outlook
Real effective exchange rate index	IMF International Financial Statistics
Real US bilateral exchange rate	IMF International Financial Statistics
Net foreign assets	IMF Balance of Payments and International Investment Position; WB World Development Indicators
Exports & Imports	IMF Balance of Payments
Government consumption	IMF International Financial Statistics
Commodity terms of trade (ToT)	IMF Commodity ToT (see Gruss and Kehaj (2019) for details)
Policy rates	IMF International Financial Statistics
VXO volatility index	St. Louis Federal Reserve FRED database;
Reserves	Composition of Official Foreign Exchange Reserves (COFER) database
FX intervention	Central Banks websites and IMF staff estimates. NFA data: IMF Data Template on International Reserves and Foreign Currency Liquidity; Currency composition of reserves: COFER database.

Table A.2 Country Coverage

	Country	Obs.	De facto ER 2018 AREAR	Classification
1	Australia	113	Free floating	AE
2	Brazil	113	Floating	EM
3	Canada	112	Free floating	AE
4	Chile	110	Free floating	EM
5	China	15	Stabilized arrangement	EM
6	Colombia	90	Floating	EM
7	Czech Republic	94	Floating	EM
8	Denmark	113	Floating	AE
9	Hong Kong SAR*	105	Floating	EM
10	Hungary	104	Floating	EM
11	India	106	Floating	EM
12	Indonesia	112	Floating	EM
13	Israel	111	Floating	AE
14	Kazakhstan	76	Floating	EM
15	Korea	112	Floating	AE
16	Malaysia	76	Floating	EM
17	Mexico	113	Free floating	EM
18	New Zealand	85	Floating	AE
19	Norway	112	Free floating	AE
20	Peru	112	Floating	EM
21	Philippines	113	Floating	EM
22	Poland	73	Free floating	EM
23	Romania	108	Stabilized arrangement	EM
24	Russia	69	Free floating	EM
25	Singapore	94	Crawl-like arrangement	AE
26	South Africa	113	Floating	EM
27	Sweden	113	Free floating	AE
28	Switzerland	113	Floating	AE
29	Thailand	113	Floating	EM
30	Turkey	113	Floating	EM
	Total	**3,353**		

* Hong Kong SAR is a territory of the People’s Republic of China with its own currency.

Table A.3 Summary Statistics

Country	REER	USRER	GDP per capita	Gov't cons	NFA	Reserves	FXI	Openness	Chinn-Ito	Real policy rate	Comm ToT
Australia	86.6	1.2	38,537	-1.5	-1.0	0.9	0.0	9.9	1.4	3.3	1.1
Brazil	83.9	1.5	12,471	-4.8	-0.5	4.4	0.2	5.6	-1.1	7.0	1.1
Canada	90.9	1.3	39,972	-2.8	-0.4	0.4	0.0	15.6	2.3	1.0	1.1
Chile	106.2	386	15,302	0.7	-0.4	1.8	0.3	15.3	-0.2	0.7	1.1
China	119.7	6.5	5,221	-1.4	0.8	6.5	1.0	12.0	-1.3	0.3	1.5
Colombia	94.5	1,296	10,265	-2.0	-0.7	2.4	0.2	8.4	-1.0	3.3	0.9
Czech Republic	78.5	24.3	31,216	-3.0	-0.4	1.8	0.8	30.0	1.7	0.3	1.1
Denmark	95.8	7.0	45,774	-0.9	0.3	1.7	0.2	20.4	1.8	1.3	1.1
Hong Kong SAR*	117.0	8.0	38,303	1.5	1.9	2.3	1.2	87.7	2.3	1.0	0.9
Hungary	84.5	128	21,535	-4.7	-0.6	1.3	0.4	31.8	0.6	1.0	1.2
India		33.5	2,917	-7.9	-0.3	2.7	0.3	7.5	-1.2	-0.1	1.3
Indonesia		5,660	6,415	-1.1	-0.2	2.5	0.2	11.4	1.4	2.5	1.1
Israel	102.5	2.7	28,459	-3.2	0.1	2.4	0.1	17.0	0.6	2.2	1.2
Kazakhstan		169	16,748	1.9	-0.7	1.9	0.5	19.3	-1.2	0.2	0.9
Korea	124.4	877	23,001	1.6	0.3	2.1	0.3	17.3	-0.1	0.7	1.1
Malaysia	115.8	3.2	15,781	-1.6	1.6	2.0	0.5	40.7	0.7	1.0	1.0
Mexico	99.5	7.4	16,965	-2.5	-0.6	1.6	0.1	11.2	0.5	1.8	0.8
New Zealand	94.0	1.5	32,273	-0.5	-0.8	1.3	0.2	14.6	2.0	2.2	1.9
Norway	95.7	7.0	51,553	7.3	1.3	1.8	0.0	17.7	1.4	2.7	0.8
Peru		2.0	8,150	-0.4	-0.7	4.1	0.5	9.7	1.2	0.8	1.1
Philippines	100.9	29.4	5,225	-1.1	-0.3	3.2	0.4	14.8	-0.5	1.2	1.1
Poland	88.4	2.1	17,772	-3.9	-0.7	1.6	0.2	20.8	-0.6	2.9	1.1
Romania	85.6	2.1	16,978	-2.9	-1.0	1.9	0.3	17.1	-0.1	-8.9	1.1
Russia	80.8	30.6	20,220	0.6	1.0	3.8	0.6	12.6	0.0	1.6	0.8
Singapore	100.2	1.9	56,794	3.8	4.5	2.1	1.2	89.8	2.3	0.1	1.0
South Africa	110.9	5.8	12,449	-2.5	-0.6	1.9	0.1	12.5	-1.3	3.3	1.3
Sweden	115.9	7.7	40,465	-1.0	0.3	0.9	0.1	17.9	1.8	0.6	1.0
Switzerland	97.0	1.7	59,500	-0.3	2.5	3.6	0.8	27.3	2.3	0.5	1.1
Thailand		29.2	10,500	-0.7	0.1	2.9	0.5	24.6	-0.4	0.2	1.3
Turkey		1.3	16,548	-3.9	-0.5	1.8	0.1	10.1	-0.7	1.0	1.3

Notes: Table reports the mean of each variable over the period 1990-2018. REER index; DSP per capita in real USD; government consumption, NFA, openness, as percent of GDP; reserves in percent of quarterly imports; FXI as FX purchases in percent of GDP; capital account openness index from Chinn-Ito; real policy rate in percentage points; commodity terms of trade as index.

* Hong Kong SAR is a territory of the People's Republic of China with its own currency.

Appendix B: Foreign Exchange Intervention Proxy

The FXI data used in this paper have been adjusted for valuation effects. The methodology for doing so is found in Brandao-Marques et al. (2020) and Adler et al. (2019). They define the FXI proxy as,

$$FXI_{j,t} = \Delta NFA_{j,t} - \Delta^{Val} Sec_{j,t} - \Delta^{Val} CurDep_{j,t}.$$

This measure approximates FXI with the change in the central bank's Net Foreign Assets (NFA), adjusted for valuation changes and the currency composition. $\Delta NFA_{j,t}$ denotes the change in NFA for country j and time t. The breakdown to foreign securities ($Sec_{j,t,c}$), and foreign currency and deposits ($CurDep_{j,t,c}$), where c stands for currency, is given by the IMF's Data Template on International Reserves and Foreign Currency Liquidity. The currency composition of each asset class is assumed to be the same and to follow what is published by the IMF's Currency Composition of Official Foreign Exchange Reserves (COFER) database. These currencies include: US dollar, Australian dollar, Canadian dollar, British pound, Japanese yen, Swiss Franc and Euro.

We follow Dominguez (2012) and assume securities to be all government securities and cash is assumed to earn zero returns beyond the exchange rate return. The valuation adjustment involves: subtracting from the change in NFA a COFER-weighted foreign currency total return index[27] (using the US dollar as the numeraire); and subtracting the total return of the government bond indexes of each reserve currency, multiplied by the weight of each currency and share of securities in the central bank's NFA.[28]:

$$\Delta^{Val} Sec_{j,t} = \sum_{c \in C} Sec_{j,t,c} \, R^{Sec}_{j,t-1,c}$$

$$\Delta^{Val} CurDep_{j,t} = \sum_{c \in C} CurDep_{j,t,c} \, R^{Cur}_{j,t-1,c}$$

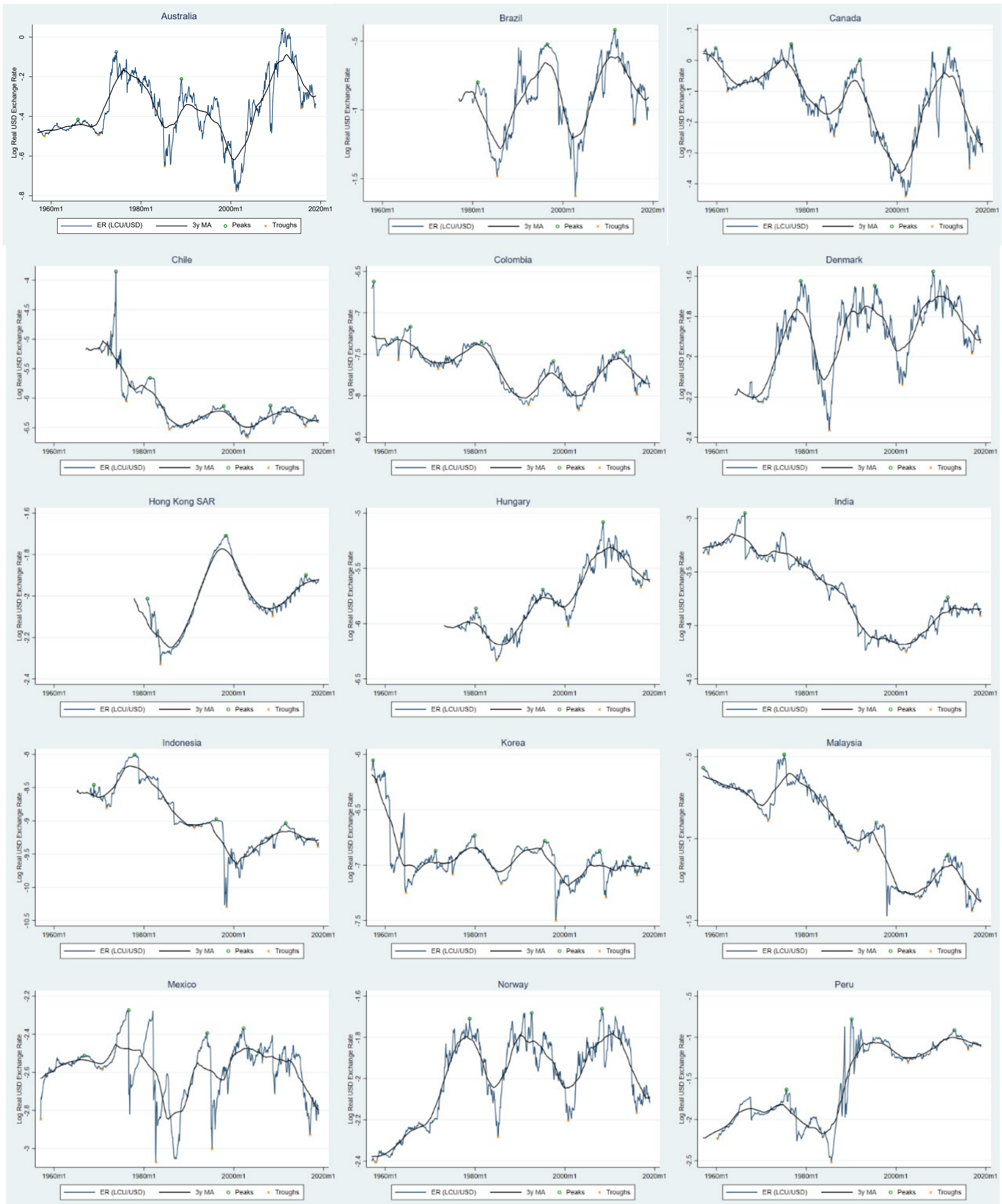
We scaled both the actual FXI and proxy series using the respective country's annual GDP and correlated the actual data with our proxy measure. The correlation is high for emerging markets in particular, where we lack actual intervention data and use proxy values.

27 $R^{Cur}_{j,t-1,c}$ is the 3-month interbank rate, from Haver Analytics

28 $R^{Sec}_{j,t-1,c}$ is the treasury's total return index for the past three months, from Thomson Reuters Datastream

Appendix C: Supplementary Exchange Rate Figures

Figure C.1: Peaks and Troughs in Real Exchange Rates



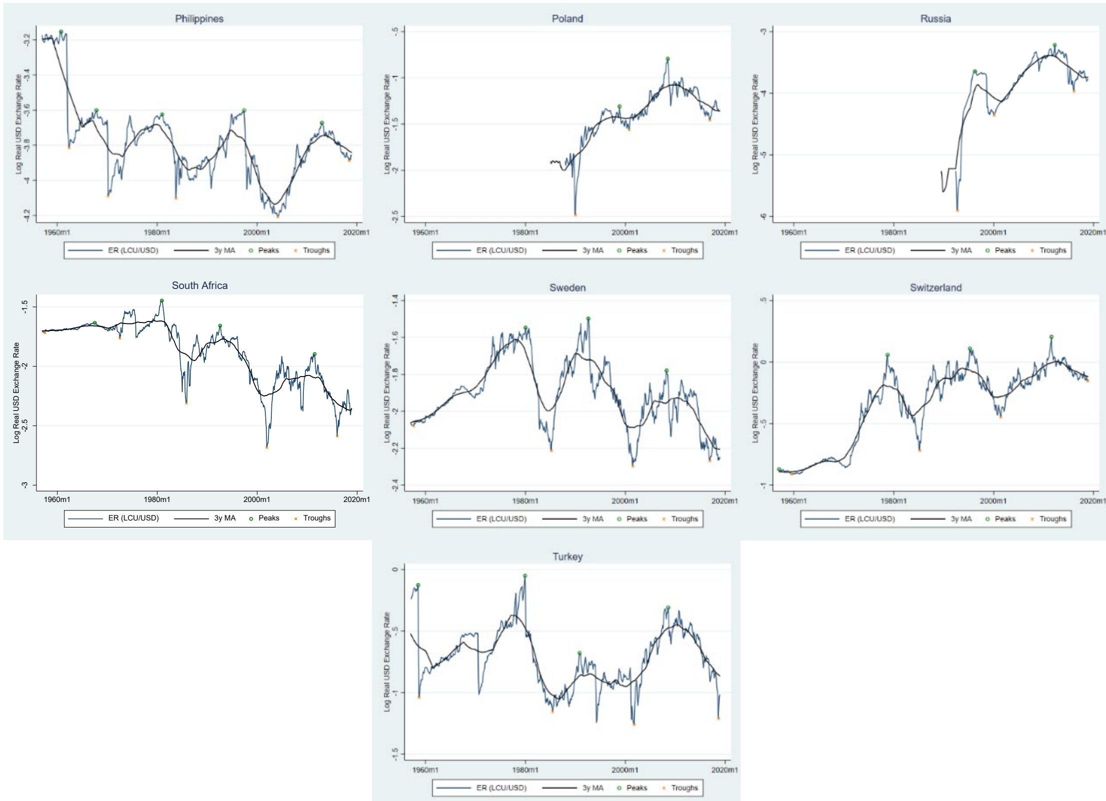
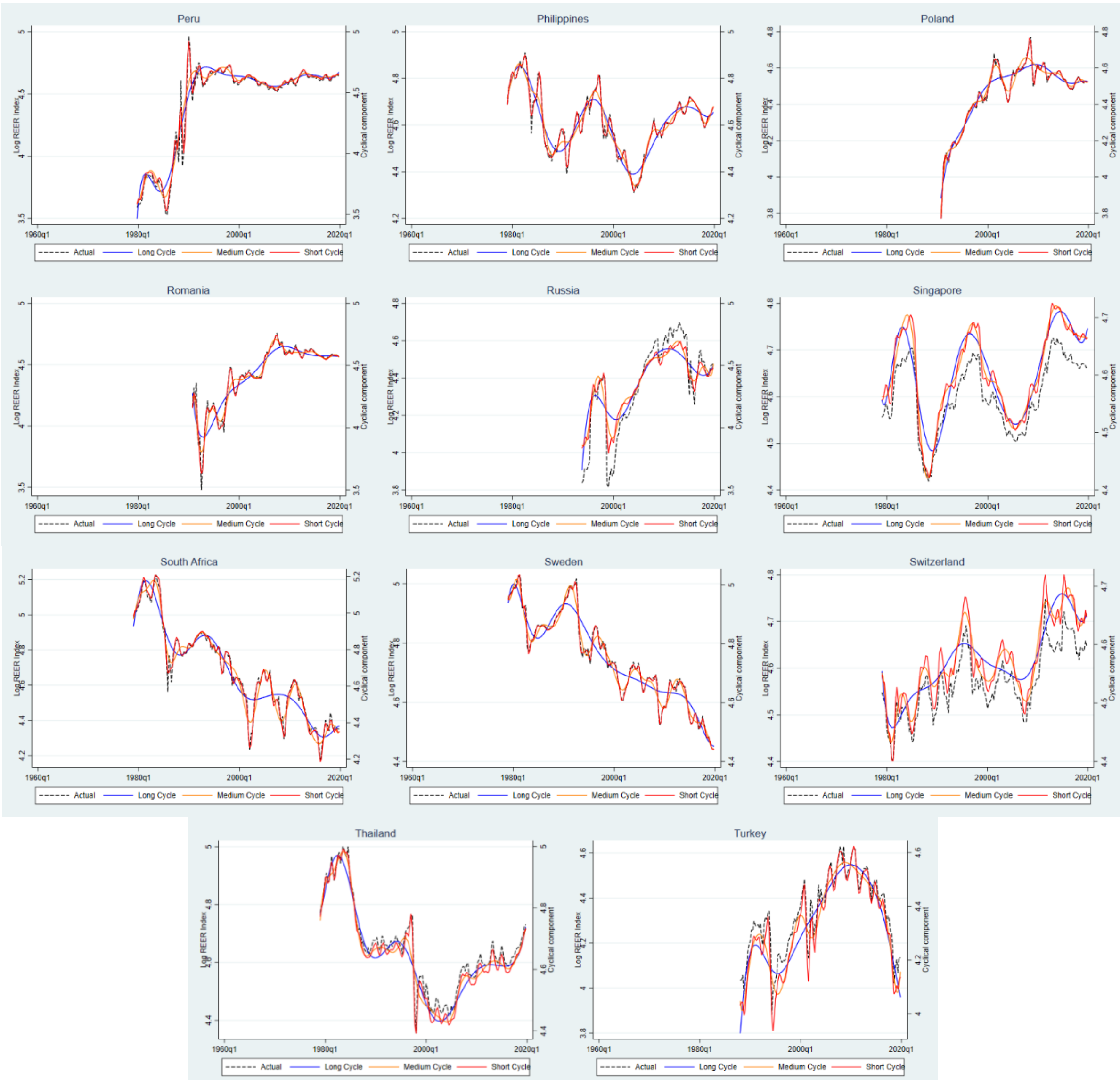

Philippines
Poland
Russia
South Africa
Sweden
Switzerland
Turkey
Log Real USD Exchange Rate
1960m1
1980m1
2000m1
2020m1
ER (LCU/USD)
3y MA
Peaks
Troughs

Figure C.2: Real Exchange Rate Spectral Decomposition


Peru
Philippines
Poland
Romania
Russia
Singapore
South Africa
Sweden
Switzerland
Thailand
Turkey
Log REER Index
Cyclical component
1960q1
1980q1
2000q1
2020q1
Actual
Long Cycle
Medium Cycle
Short Cycle