Foreign Exchange Intervention and Inelastic Financial Market

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Abstract

Are foreign exchange interventions effective at stabilizing exchange rates? In this paper, we empirically assess the effectiveness of foreign exchange rate interventions by leveraging the rebalancings of a local-currency government bonds index for emerging countries as a natural experiment. We show that the rebalancings create large currency demand shocks that move exchange rates and are uncorrelated with the macroeconomic fundamentals. Our results provide empirical support for models with inelastic financial markets where foreign exchange interventions serve as an additional policy tool to effectively stabilize exchange rates. Under inelastic financial markets, a managed exchange rate does not have to fully compromise monetary policy independence even with free capital mobility, relaxing the classical “Trilemma” constraint. Our results also show that free-floaters are more than five-fold more effective at stabilizing exchange rates than crawling-peggers, as the volatile exchange rates for floaters generate further departure from the “Trilemma” constraint.

JEL Classification: F31, F32, G11, G15, G23
Keywords: Foreign exchange intervention; exchange rates; Inelastic financial market; uncovered interest parity; benchmark investments; sovereign bonds.

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1 Introduction

Are foreign exchange interventions effective at moving exchange rates? If they do, how large should the size of interventions to be to stabilize exchange rates? Policymakers frequently resort to foreign exchange interventions under the premise that they are effective at stabilizing exchange rates. Indeed, interventions typically come in big magnitudes for countries both with fixed- and floating-exchange-rate regimes. For example, during the post-taper-tantrum episode\(^1\), the inflation-targeting Latin American countries encountered a huge selling period of foreign reserves to defend the value of their home currency. In this episode, Mexico (floating) sold foreign reserves worth more than 30 billion USD (3% of GDP) and Peru (managed peg) sold about 10 billion foreign reserves (5% of GDP) (IMF, 2019).

Assessing the effectiveness of the foreign exchange intervention is empirically challenging as exchange rates, the prevailing macroeconomic conditions, and the intervention itself are jointly endogenous. Several papers have provided empirical evidence on the effects of foreign exchange intervention by resorting to confidential and high-frequency data on intervention episodes (Fratzscher et al. (2019); Adler et al. (2019)). Yet, a valid identification calls for a natural experiment that exogenously changes the currency composition of the government bonds in an economy and moves exchange rates and is independent of the macroeconomic conditions.

In this paper, we overcome the identification challenge addressed above and estimate the required size of interventions to stabilize exchange rates through an exogenous currency demand shock from the mechanical rebalancings of the Government Bond Index Emerging Market (GBI-EM) Global Diversified index. Our empirical results provide evidence for the inelastic financial markets where foreign exchange intervention serves as an effective policy tool to stabilize exchange rates without compromising monetary policy independence. Through the lens of a model with inelastic financial markets, we identify the required size of foreign exchange intervention to stabilize exchange rates for countries with both with managed- and floating-exchange-rate regimes.

The exogenous currency demand shock created by the mechanical rebalancings of

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\(^1\)Taper-tantrum refers to the episode with falling capital inflows in emerging countries following the 2013 Fed announcement of tapering down Quantitative Easings (QE). The announcement set off a market reaction – the taper tantrum – affecting the U.S. and nations abroad.
the GBI-EM Global Diversified index is crucial for our identification. The index is the most widely tracked benchmark by mutual funds that invest in local-currency government bonds in emerging markets. The monthly rebalancings cap the benchmark weight of each country in the index at 10% and any excess weight above the cap is redistributed to smaller countries so that all the weights add up to 1. At the rebalancing dates, countries not at the cap experience positive weight increase not due to an improvement in their economic conditions, but purely as a result of the bigger countries hitting the cap. The rebalancing feature, together with the well-documented literature on mutual funds tracking their benchmark investments (Raddatz et al. (2017)), gives rise to cross-border capital flows orthogonal to the macroeconomic condition for countries not at the index cap at the rebalancing dates.

We show that exchange rates, both in the short- and in the long-run (one year), respond significantly to the currency demand shock. On the other hand, central bank monetary policy rates do not respond to the currency demand shock, regardless of the exchange rate regimes. Taken together, our empirical results suggest that exchange rates stabilization is not achieved through compromising monetary policy independence, regardless of the capital mobility. We view this as the most direct evidence supporting the ‘relaxed Trilemma’ constraint (Itskhoki and Mukhin, 2022), under which free capital flows and a managed exchange rate come at the cost of compromising monetary policy independence.

The fact that exchange rates respond to the exogenous currency demand shock is consistent with predictions in models with inelastic financial market. Under models of inelastic financial market (Itskhoki and Mukhin, 2021; Gabaix and Maggiori, 2015), foreign exchange intervention shifts arbitrageurs’ risk-bearing capacity in a similar way as the currency demand shock, giving rise to endogenous deviations in the uncovered interest parity (UIP) condition. Therefore, the inelastic financial market allows foreign exchange intervention to serve as an additional policy instrument to stabilize exchange rates, while the independent monetary policy can be entirely inward-focused on domestic inflation and output gap. Even under free capital flows, an economy can simultaneously have an independent monetary policy and a managed exchange rate through FX intervention, relaxing the classical Trilemma constraint.

We find heterogenous responses in exchange rates to the currency demand shock
across exchange rate regimes. The estimated response of the exchange rates to the currency demand shock is more than four times larger for free floaters relative to peggers. We convert our estimates into USD flows and identify the required size of foreign exchange intervention to stabilize exchange rates through the lens of a model with inelastic financial markets. We show that the required size of intervention (as a share of GDP) is more than five-fold smaller for free-floaters compared to managed-peggers, meaning that foreign exchange rate interventions are more effective in the former. This is because the higher exchange rate volatility in the floaters generates further departure from the classical Trilemma constraint and makes FX interventions more effective.

We also find that to achieve one percentage point exchange rate appreciation (depreciation), the required foreign reserves that the central bank needs to sell (buy) through open market operations is 1.68 billion USD, which is 0.6% GDP for a medium emerging country in our sample. Our results are largely consistent with the early literature on estimating the size of foreign exchange intervention (Adler et al (2019)) and the identified demand elasticities for currencies as in Camanho, Hau and Rey (2021) and Evans and Lyons (2002). Our results contribute to various strands of literature in both macroeconomics and finance and are informative to central bank policymakers.

**Related Literature.** Our paper speaks to several strands of important literature in both Macroeconomics and Finance. First, we contribute to the large empirical literature on the effects of foreign exchange interventions. Most empirical studies on foreign exchange interventions use event studies; for example, Fatum and Hutchison (2003), Blanchard et al. (2015), Fratzscher et al. (2019) and Adler, Lisack and Mano (2019). In these event studies, it’s unclear how far they go to address the inherent endogeneity problem in the effects of intervention on exchange rates. In addition, our empirical specification employs the optimal foreign exchange policy framework in Itskhoki and Mukhin (2022) and are related to a large number of recent work on the cost and benefit of foreign exchange interventions including Jeanne (2012), Amador, Bianchi, Bocola, and Perri (2019), Cavallino (2019), Fanelli and Straub (2021).

Moreover, our paper connects with the broad finance literature on asset demand estimation and evidence for inelastic financial market. Empirical studies using index rebalancing (for example, the rebalancings of S&P 500) to estimate asset demand curves dates back to Shleifer (1986), followed by a series of studies by Lynch and Mendenhall
(1997), Kaul, Mehrotra and Morck (2000), and Chang, Hong and Liskovich (2014) with more refined and cleaner identification strategies. Recent work such as Pandolfi and Williams (2019), Koijen and Yogo (2019, 2020) and Camanho, Hau and Rey (2021) estimate the (global) asset pricing demand system and Gabaix and Koijen (2022) discusses policy implications for inelastic financial markets. However, the literature on asset demand estimation and foreign exchange interventions in open economy have not crossed their path. Our paper applies the empirical strategy of index rebalancing traditionally used to estimate asset demand to the analysis of foreign exchange policy and bridges these two strands of literature.

In addition, our paper speaks to the macro-finance literature on exchange rates dynamics in segmented markets with frictional financial markets. The segmented financial market model we use in this paper builds on Alvarez, Atkeson and Kehoe (2009), Gabaix and Maggiori (2015), Gourinchas, Ray and Vayanos (2019), Greenwood, Hanson, Stein, and Sunderam (2020) and Itskhoki and Mukhin (2021). Another recent work by Jiang, Krishnamurthy and Lustig (2022) produces similar exchange dynamics but features incomplete rather than segmented financial markets.

Finally, our works is related to the large literature on exchange rates prediction. The related work includes but not limited to Fama (1984), Evans and Lyons (2002), Tornell and Gourinchas (2004), Lustig and Verdelhan (2007), Engel (2016), and Jiang, Krishnamurthy and Lustig (2022). While these work mostly leverage taste shocks or expectation errors in forecasting exchange rates, our currency demand shocks for predicting exchange rates relies on a quantity demand shock from the mechanical index rebalancing.

**Outline.** The rest of the paper is structured as follows. Section 2 introduces the exogenous currency demand shock and its institutional background. Section 3 illustrates the stylized empirical facts on our currency demand shock and its relation to the dynamics of exchange rates and interest rates. To interpret the empirical facts, section 4 presents an inelastic financial market model where a currency demand shock leads to endogenous UIP deviations and discuss the implications for FX interventions in such market. Section 5 delves further into the heterogeneity across countries in response to the currency demand shock for verify the theoretical mechanisms. Section 6 coverts the country-specific empirical estimates into the size of intervention required to the stabilize exchange rates. The last section concludes.
2 Introducing the Currency Demand Shock

We leverage the mechanical rebalancing features of a local-currency government bond index for emerging countries to construct the exogenous currency demand shock. We document in detail below the rebalancing rules of the index and introduce our measure for the currency demand shock.

2.1 Mechanical Rebalancings of the GBI-EM Global Diversified Index

Our empirical strategy relies on the mechanical rebalancings of the Government Bond Index Emerging Market (GBI-EM) Global Diversified published by JP Morgan. The GBI-EM Global Diversified is the largest local currency government bonds index for emerging countries. An estimated asset under management of more than 200 billion USD of mutual funds are tracking the index in 2020. There are currently 19 emerging countries in the index with each country weight equal to the share of its market value of the local-currency sovereign bonds in the index. A larger country like Brazil will have a larger weight in the index than a smaller country like Peru or Chile. The country weight fluctuates at the daily frequency as the market price of the sovereign bonds moves up or down due to macroeconomic or financial conditions. At the end of the business day of each month, however, all the country weights are mechanically adjusted following the rebalancing rules imposed by JP Morgan.

The mechanical rebalancings on the country weight cap are crucial for the identification in this paper. At the rebalancing date, the GBI-EM Global Diversified mechanically caps the country-weight at 10% for all countries to limit concentration risk. Any excess weight above the cap is redistributed to smaller countries that are below the cap so that all country weights add up to 100%. In addition, the redistribution is proportional to the smaller countries’ country weights in the index. The rebalancings go on recursively for multiple rounds until all the country weights are either at or below the 10% cap. Table 2.1 gives a simplified rebalancing example.

We argue that the rebalancings on the country weight cap in the GBI-EM Global

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2 Appendix A documents in detail how these countries are chosen to enter/exit the index.
3 The rebalancings are done in three layers in order and the country-weight rebalancing is the last layer following face-amount inclusion and bond maturity threshold. Appendix A discusses the first two layers of rebalancings.
Table 2.1: A rebalancing example at 10% weight cap

Note: This table presents a simplified rebalancing example that caps the country weight at 10%. For simplicity, assume there’re 11 countries in the index and 7 of them are already at 10%. The rebalancings are only applied to country A whose weight (15%) is above the cap, and country B, C, and D below the cap. Each round of rebalancing takes the excess weight of the country and redistribute to smaller countries below the cap proportionally. The rebalancings continue recursively until all country weights are either at or below the 10% cap. Source: JP Morgan Survey Report (2015)

Diversified index create currency demand shocks that are uninformative to the macroeconomic fundamentals of the sovereign. As J.P. Morgan adjusts the country weights, the mutual funds benchmarked against the index have to buy or sell local-currency government bonds to comply with the rebalancing mechanism. For example, if Brazil’s country weight is rebalanced down from 15% to 10% and leads to an increase in the Peru’s country weight, those benchmarked mutual funds have to sell local-currency sovereign bonds of Brazil and buy bonds of Peru. In this rebalancing example, a smaller country like Peru experienced a positive currency demand shock on their local-currency bonds independent of their own macroeconomic/financial conditions and purely as a result of Brazil exceeding the 10% cap.

4Since J.P. Morgan has no direct control on the market price, they adjust the country weight through changing the adjusted face amount of the country in the index.
2.2 Measuring the Currency Demand Shock

We introduce the currency demand shock, defined as the change in change in market-value-implied-by-rebalancings (MIR), from the mechanical rebalancing of the GBI-EM Global Diversified Index.

We define the change in change in market-value-implied-by-rebalancings (MIR) at a rebalancing date as the change in market value of the local-currency sovereign bonds of the country in the index implied from the mechanical rebalancings of the GBI-EM Global Diversified, divided by the country’s market value in the index from the previous rebalancing. A positive MIR implies positive demand shocks on the local-currency sovereign bonds of the country and vice versa. The mathematical form of MIR is given by:

\[
MIR_{c,t} = \frac{(\omega_{c,t} - \omega_{c,t}^{B,H}) \sum_{c'} MV_{c',t}}{MV_{c,t-1}}
\]

(1)

where \(c, t\) are country and time subscripts, respectively. The term \(\sum_{c'} MV_{c',t}\) is the sum of market value of all countries in the index at time \(t\) and \(MV_{c,t-1}\) is the market value of country \(c\) after the last rebalancing at \(t-1\). The weights \(\omega_{c,t}^{B,H}\) and \(\omega_{c,t}\) are the country weight before and after rebalancing at the rebalancing date \(t\), respectively.

Intuitively, the weight \(\omega_{c,t}^{B,H}\) is the buy-and-hold weight of passive investments and is counterfactual of \(\omega_{c,t}\) if the rebalancing at time \(t\) didn’t happen. Specifically, we define \(\omega_{c,t}^{B,H} \equiv \frac{P_{c,t-1} FA_{c,t}}{\sum MV_{c',t}}\) and \(\omega_{c,t} \equiv \frac{P_{c,t} FA_{c,t}}{\sum MV_{c',t}}\), where \(FA_{c,t-1}\) and \(FA_{c,t}\) are the face-amount of the country’s local-currency sovereign bonds in the index from the last and the current rebalancing, respectively; \(P_{c,t}\) is the aggregate market price of the local-currency sovereign bonds at the rebalancing date and is the same in both weights. We construct MIR as a share of country’s own market value as different countries have different “depth” (reflected in the market size) in their sovereign bonds market.

Table 2.2 gives the summary statistics and the time series of the currency demand shock for each country.\(^5\) While most countries experience positive currency demand shocks (MIR > 0), a few bigger countries in our sample, namely Brazil, Mexico and Poland, have mostly negative shocks (MIR < 0) throughout the sample as a result of being rebalanced downwards when their weights exceed the 10% cap. In the empirical analysis in the rest of the paper, we focus only on country-month observations that do

\(^5\)In addition, Table B.2 in the Appendix presents the time series for each country.
not meet the 10% cap. These countries have to change their weights as a result of the bigger countries meeting the cap and therefore their weights change are independent of the macro-fundamentals in their economies, which are smooth around the rebalancing date.

### Table 2.2: Summary Statistics of the Currency Demand Shock (MIR)

<table>
<thead>
<tr>
<th>MIRs including countries at 10% cap</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Obs</td>
<td>2,044</td>
<td>0.295</td>
<td>0.34</td>
<td>-0.63</td>
<td>1.13</td>
<td>0.36</td>
<td>0.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIRs excluding countries at 10% cap</th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs</td>
<td>1,455</td>
<td>0.42</td>
<td>0.23</td>
<td>-0.39</td>
<td>1.13</td>
<td>0.35</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Note: This Table (top) reports the summary statistics on change in market value (MIR) implied by monthly rebalancings of the GBI-EM Global Diversified index. The Figure (bottom) plots the of MIR across time for each country. MIR for Brazil, Poland and Mexico are labeled and bolded. Chile and Argentina are excluded in the figure due to their short time series.

### 2.3 Data Sources

The main data source is the Index Composition and Statistics reports from J.P. Morgan. These reports include monthly information on benchmark weights and rebalancing for their sovereign bonds benchmarks, including GBI-EM Global Diversified index. Our sample includes a panel of 17 countries from 2010 to 2021: Argentina, Brazil, Chile, Cezh Republic, Colombia, Hungary, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland,
Romania, Russia, South Africa, Thailand, and Turkey.\footnote{We exclude China for current analysis due to limited time series in data as China just entered the GBI-EM Global Diversified index in 2020; we exclude Nigeria from the analysis due to limited data on exchange rates.} These J.P. Morgan Markets reports allow us to construct our currency demand shock (measured by MIR) as introduced above.

The second main data source we use is the EPFR Fund Flows data on the asset positions of the emerging market bond funds. We show that MIR is correlated with the changes in asset positions of the mutual funds that track the GBI-EM Global Diversified index in the EPFR data. Moreover, we use the EPFR fund flows data to compute the flows in USD implied by the rebalancings by our currency demand shock.

Finally, we combine the J.P. Morgan reports and EPFR fund flows data with daily data of exchange rates and central bank policy rates data from the Bank for International Settlements. We complement these data with sovereign bonds yields for various maturities for each country from Du and Schruger (2016) with dataset updated to 2021.

3 Currency Demand Shock and Exchange Rates Dynamics

In this section, we present four novel stylized facts on how the currency demand shocks affect exchange rates and interest rates.

**Stylized Fact 1.** The currency demand shock moves exchange rates in the short run. Specifically, a one standard deviation increase of the shock appreciates exchange rates by an average of 0.92%.

Figure 1 reports the estimated coefficients of cumulative exchange rate changes on our currency demand shock as measured by MIR in equation (1). Importantly, we drop all country-month observations that exceeds the 10\% threshold in the regression to ensure our currency demand shock is truly information-free and independent of the macro-fundamentals. The pooled-OLS regression shows that one standard deviation increase of MIR (23 percent increase in the market value of the country in the index, by Table 2.2) appreciates local currency exchange rates by 0.92\% significantly after one rebalancing event, for the cross-country average. Exchange rates are measured in local currencies per USD and the exchange rate change is the cumulative change starting from 28 days.
before the recent rebalancing. The regression includes year- and country-fixed-effects with robust standard errors clustered at the country level.

**Stylized Fact 2.** *The currency demand shock moves exchange rates in long run and the effect persist for about one year after one rebalancing event.*

Figure 2 make clear that the rebalancings effects on exchange rates do not disappear and remain significant for at least 11 months after the one rebalancing event. Compared to the level of exchange rate before the first rebalancing, cumulative exchange rates on average appreciate about 1.5 percentage points in response to to a standard deviation increase in MIR. There’s a reversion-to-mean pattern starting after 12 months after the first rebalancing and the effects from MIR gradually lose significance. The regression results do not control for macro-fundamentals since the variables like GDP and net foreign asset positions are much more slow-moving compared to exchange rates.\(^7\)

**Remark 1.** *How do the index rebalancings create large currency demand shocks?*

We show that mechanical rebalancings of the GBI-EM Global Diversified index create large demand shocks on the local-currency government bonds. Specifically, the mutual funds with large assets under management that are benchmarked against the index are passively trading their positions in compliance with the rebalancing rules. We select all emerging market bond funds from the EPFR dataset whose benchmark indices are the GBI-EM Global Diversified index. We regress the monthly returns of each fund on the returns the index\(^8\), which gives us a medium R-squared of 0.92 (Table 3.1a). We also construct the weighted average return (by asset under management) of all mutual funds tracking the index and regress the weighted return on the index returns, resulting an

\(^7\)In fact, we show in Section 5 Table 5.2 that the macro fundamentals (GDP and net foreign asset positions) are immune to the currency demand shock.

\(^8\)We follow (Amihud and Goyenko (2013)) and Pandolfi and Williams (2019) on using returns regression to test the performance of mutual funds. The method regresses the fund-level monthly returns on the monthly returns of GBI-EM Global Diversified as below:

\[
\begin{align*}
    r_{i,t} &= \alpha + \beta r_{B,t} \\
\end{align*}
\]

where \(r_{i,t}\) is the monthly return from fund \(i\) at time \(t\) and \(r_{B,t}\) is the monthly return from the benchmark – in this case, the JP Morgan GBI-EM Global Diversified index. We then collect the fitted R-squared from each return regression. A higher fitted R-squared indicates the fund tracks the benchmark index more closely.
Figures 1 and 2:

**Fact 1:** Currency demand shock moves exchange rates in the short run

![Graph showing exchange rate changes over days after rebalancing.](image)

**Note:** This figure presents the estimated regression coefficient of exchange rates change on the currency demand shock measured by MIR in equation (1). MIR is standardized by its mean and standard deviation in the regression. Exchange rates change (local currencies per USD) is measured as the cumulative change starting from 28 days before the recent rebalancing at day 0. The regression is performed in a pooled OLS using year- and country-fixed effects with robust standard errors clustered at the country level. The results are reported in point estimates (red) with 95% confidence interval (black).

**Fact 2:** Currency demand shock moves exchange rates in the long run

![Graph showing exchange rate changes over months after rebalancing.](image)

**Note:** This figure plots the estimated coefficients of cumulative exchange rates change on change in market value implied by rebalancings (MIR) in the long horizon of 13 months after rebalancing. The dependent variable is cumulative exchange rate change starting from 28 days prior to the first rebalancing. We use rolling window regression with length of 10 days for each regression. All regressions are performed in a pooled OLS using country fixed effects with robust standard errors clustered at country level. The results are reported in point estimates (red) with 95% confidence interval (black).
Table 3.1: Return performance of mutual funds in the data

![Histogram of fund performance R²](image)

(a) Histogram of fund performance $R^2$

![Weighted (by positions) average returns](image)

(b) Weighted (by positions) average returns

**Note:** This left panel reports the histogram of estimated R-squared of 12-month rolling window regressions of monthly fund returns on the returns of GBI-EM Global Diversified index; the medium R-squared is 0.92. The right panel plots the returns of GBI-EM Global Diversified index and the returns of weighted (by asset under management) of all mutual funds tracking the index; the performance R-squared here is 0.97.

even higher R-squared of 0.97 (Table 3.1b). Both figures in Table 3.1 attest to the fact that the rebalancings of the GBI-EM Global Diversified index create large asset flows that act as demand shocks on local-currency government bonds. Appendix offers detailed documentation on how we select the mutual funds that track the GBI-EM Global Diversified from EPFR data [TBA].

**Remark 2.** How large is one standard deviation of the currency demand shock in USD? What’s the implied currency-demand elasticity?

A one standard deviation of the currency demand shock (measured by MIR) equates 2.25 billion USD flows or a medium country in our sample (for example, Colombia).\(^9\) This implies that the medium currency-demand elasticity is about 2.45 (2.25/0.92), a number consistent with the early estimates for advanced economies (Camanho-Hau-Rey 2021; Evans-Lyons 2002).\(^10\) To convert MIR to USD flows, we estimate the total asset

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\(^9\)The average market value in the index is 63 bn.USD in 2019 with the total index value equals to 1221 bn. The total positions of mutual funds in EPFR that track the Index is 113.6 bn.USD, and it represents about 60% of the total population of mutual funds globally. This means that the USD flows associated with one standard deviation of MIR for Colombia is: $0.23 \times 63 \times \frac{113.6}{1221} = 2.25$ bn.USD.

\(^10\)For example, Hau, Massa, and Peress (2009) and Camanho, Hau and Rey (2021) found that a capital flow of 1 billion USD amounts to an average currency appreciation of 0.38%. As a comparison, Evans and Lyons (2002) estimate that a 1 billion USD FX order flow moves the exchange rate by 0.5%.
under management of the mutual funds that tracks the GBI-EM Global Diversified index globally. Figure B.1 plots the AUM of funds tracking the GBI-EM Global Diversified index in the EPFR data from 2016 to 2022 and Figure (TBA) shows the representation of EPFR data in the total mutual funds population, a number close to 0.6 in 2019.

**Remark 3.** Why do exchange rates start to move before the rebalancing date 0?

As shown in Figure 1, exchange rates start responding significantly to MIR before the rebalancing date at 0 arrives. We state these dynamics are expected and strongly support the “efficient market hypothesis” (cite, TBA). J.P. Morgan Markets typically announces their projection for the end-of-month country weights in the middle of the month, but those projections are very imprecise for smaller countries that won’t meet the 10% cap. Nevertheless, the mutual funds tracking the index start to buy or sell government bonds almost immediately as new information about the next rebalancing comes in and exchange rates start to move before the rebalancing happens, exactly as what the efficient market hypothesis would predict.

**Remark 4.** Can other local-currency emerging market sovereign bonds index also contribute to the observed exchange rate movements?

One concern on identification is that other local-currency emerging market sovereign bonds index (apart from the JP Morgan GBI-EM Global Diversified) would also contribute to the variation in exchange rates and asset prices. We examined carefully the rebalancing mechanisms of all leading local currency government bonds indices for emerging countries and found that most of them have different rebalancing schemes and timing compared to GBI-EM Global Diversified index. One exception is the Russell FTSE Emerging Markets Government Bond Index (EMGBI-Capped). However, a simple aggregation exercise shows that the total asset positions of the funds tracking the EMGBI-Capped is not even 10% of the positions of GBI-EM Global Diversified index in our EPFR dataset. Therefore, we consider the variation created by these indices negligible compared to the rebalancings of the GBI-EM Global Diversified.

**Stylized Fact 3.** Central bank policy rates do not respond to the currency demand shock.

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11FTSE fixed income EMGBI by Russell was introduced in 2018 as a “rebranding” of older Citi Group WGBI index. It’s an emerging market local-currency government bonds index and has an end-of-month country weight cap at 10%.
Fact 3: Policy rates do not respond to the currency demand shock

Note: Pooled regression coefficients of monetary policy rates change (in pp.) on MIR, 95% CI. Monetary policy rates are provided at the daily frequency by the Bank for International Settlements (BIS) and the change is defined from 28 days before rebalancing.

A major concern for identification is that central bank policy rates might respond to the rebalancings of GBI-EM Global Diversified index. If the policy rates were to move, the macro-fundamentals in the economy will also respond, violating the exogeneous nature of the currency demand. We show that this is it not the case.

Central bank policy rates are immune to the exogenous currency demand shock. The OLS regression using changes in central bank policy rates (starting from -28 days before rebalancing) on MIR gives insignificant coefficients for all countries in our sample, as shown both in Figure 3 for the cross-country sample and Table B.3 for the country-by-country regression. The results make clear that the central banks are not using monetary policy rates to offset the exchange rates moves due to the rebalancings of the index. In addition, we find that changes in government bond yields between home and foreign currency also have insignificant response to the currency demand shock (Table B.9).

Stylized Fact 4. Country-specific exchange rates response to the currency demand shocks differ by exchange rate regime; floaters are more than 4 times more responsive than the peggers.

Given the significant response of exchange rates to the shock as shown in Fact 1, we
Fact 4: Floats respond more to the currency demand shock than peggers

Note: This figure gives the relation between country-specific exchange rates response to the currency demand shock (measured by MIR) and the exchange rates regimes classified by Ilzetzki, Reinhart and Rogoff (2021). The y-axis is the estimated exchange rates response to MIR at the horizon 10-20 days after rebalancing; the x-axis is the exchange rate regimes ranging from “de facto peg” (left) to “free falling” (right). All regression estimates are significant at 5% level except for Czech Republic, Indonesia, Malaysia and Thailand. The circle size represent exchange rates volatility of the currency. The larger the circle, the larger the volatility.

We wonder if there exists heterogenous response across countries. We repeat the exercise in Figure 1 for each country instead and collect the estimated coefficient at the horizon 15-20 days after rebalancing (when the exchange rates response to the shock is relatively stable). All currencies respond to MIR significantly and predict the right sign\textsuperscript{12} – a positive MIR and demand shock on local-currency government bonds appreciates local currency exchange rates (less USD per local currency). Table B.5 in the Appendix gives the country-specific exchange rates response.

We find a clear relation between the country-specific exchange rates response and the exchange rates regimes\textsuperscript{13}, as shown in Figure 4. The y-axis is the country-specific estimated exchange rates response to the currency demand shock (measured by MIR); and the x-axis is the exchange rate regimes ranging from “de facto peg” to “free falling” as classified by Ilzetzki, Reinhart and Rogoff (2021). The figure makes clear that floats

\textsuperscript{12}The only exception is Poland. We therefore exclude Poland in the discussion below in Figure 4.

\textsuperscript{13}We also plot the relation between country-specific exchange rate response and macro-fundamentals such as nominal GDP and size of sovereign bonds market. We found no clear relation between the estimated coefficient and GDP nor market size, as shown in Figure B.4 in the Appendix.
are more responsive to MIR (a more negative regression estimate) and have much larger exchange rate volatility (larger circle size). There’s a four-fold larger response of the exchange rates to the shock for free floats (Mexico, South Africa) relative to managed floats (Colombia, Russia, Brazil, with the exception of Turkey which looks closer to a free-falling Argentina than to other pegs). Furthermore, the effect on the exchange rate of crawling peggers (Indonesia, Peru, Phillippines) is nearly nil.

4 Currency Demand Shock and Inelastic Financial Market

We review the major classes of models in international finance and their implications on the uncovered interest parity (UIP) and the the Trilemma constraint. Understanding the features of these models have important implications on the effectiveness of foreign exchange interventions. We divide these models into three broad categories – namely the classic Trilemma models where UIP holds, the alternative models with exogenous financial shocks that violate the UIP conditions but not the classical Trilemma constraint, and finally the model with endogenous UIP deviations where the financial market is inelastic. The model with inelastic financial market generates departure from the Trilemma constraint (or satisfy the “relaxed” Trilemma) where foreign exchange interventions can work effectively to stabilize exchange rates.

4.1 Exogenous vs. Endogenous UIP Shock

We define and discuss the shocks that give rise to deviations from the uncovered interest parity (UIP) condition. We distinguish UIP deviations with exogenous shocks from those with endogenous shocks. Models where UIP holds or with exogenous UIP shocks are characterized by perfectly elastic supply of currencies so that currency demand shocks have no impact on UIP deviations. By comparison, models with exogenous UIP shocks are characterized by inelastic supply of currencies. In the latter class of models, a currency demand shock traces out the supply elasticity and endogenously pins down the UIP deviation.

We start with the definition on UIP. Let $i_t$ and $i_t^*$ returns of home- and foreign-currency bonds; $e_t$ is the exchange rates measured in the number of home currencies per USD (foreign); $\mathbb{E}_t \Delta e_{t+1}$ is the expected change of exchange rates from $t$ to $t+1$.
The uncovered interest parity (UIP) condition implies zero excess-return in the currency carry trade on home- and foreign-bonds. In other words, the expected exchange rates change is fully offset by return differentials and thus no arbitrage profits.

**Definition 1.** If Uncovered Interest Parity (UIP) holds, \((i_t - i_t^*) - E_t \Delta e_{t+1} = 0\).

In this paper, we propose the modified UIP condition where the UIP deviation doesn’t come solely from capital control taxes (Mundell 1962). Specifically, risk-premium shocks (Devereux and Engel 2002; Ivan and Werning 2012) and capital taxes both lead to exogenous UIP deviation and capital flow shocks (Gabaix and Maggiori 2015; Itskhoki and Mukhin 2021) give rise to endogenous UIP deviations. We distinguish and define the exogenous and endogenous UIP shocks, as well as the modified UIP condition below.

**Definition 2.** A UIP shock is exogenous if the UIP is pinned down entirely by the currency supply; a UIP shock is endogenous if the UIP is determined jointly by the demand and supply.

**Definition 3.** The modified Uncovered Interest Parity (UIP) condition is given by:

\[
i_t - i_t^* - E_t \Delta e_{t+1} = \underbrace{\tau_t + \mu_t}_{\text{exogenous}} + \underbrace{\Lambda_t}_{\text{endogenous}}
\]  

(2)

We denote capital control tax as \(\tau_t\), risk-premium shock as \(\mu_t\), and capital flow shock as \(\Lambda_t\). Both \(\tau_t\) and \(\mu_t\) are exogenous UIP shocks in equation (2). We consider capital tax\(^{14}\) imposed as lump sum taxes on the interest rates and the after-tax return differentials between home- and foreign-currency bonds is therefore \((i_t - i_t^*) - \tau_t\). We introduce risk-premium shock \(\mu_t\) as another exogenous wedge between home and foreign country interest rates.\(^{15}\) In a model with only exogenous UIP shocks, the UIP or currency return is pinned down entirely by the supply, which is modeled as perfectly elastic (panel (a) of Table 4.1).

We introduce capital flow shock \(\Lambda_t\) as the endogenous UIP shock in equation (2). Rather than imposing a wedge on return differentials, \(\Lambda_t\) endogenously change the equilibrium allocation of asset allocation and is jointly determined with exchange rates. Models with

---

\(^{14}\)Strictly speaking, there should be separate capital taxes for both the home and foreign. Without loss of generality, we use “net” capital tax defined as the difference in home capital tax minus the foreign.

\(^{15}\)An example of risk-premium shock is a sudden increase in the world interest rate that imposes risk on the home and foreign country with the risk is not shared equally among investors, who deem home assets more risky and demand an excess premium (\(\mu_t > 0\)) on home assets.
Table 4.1: Currency demand shocks in elastic vs. inelastic markets

(a) Perfectly elastic supply

\[ \tau_t + \mu_t = 0 \]

(b) Inelastic supply

\[ \text{UIP} = 0 \]

**Note:** This figure presents the supply and demand diagram for both models with exogenous UIP shocks under perfectly elastic supply (left) and models with endogenous UIP shocks under inelastic supply (right). Currency supply is perfectly elastic in the exogenous UIP models with the UIP deviation immune to currency demand shocks. Absence of exogenous shocks \( (\tau_t, \mu_t) \), the perfectly elastic supply collapses to models where UIP holds. By comparison, currency supply is inelastic in the models with endogenous UIP shocks. A demand shock shifts demand scheme to the right and gives rise to endogenous UIP deviation due to the inelastic supply scheme.

endogenous UIP shocks model supply of currencies as inelastic and upward-sloping (rather than being perfectly elastic). A currency demand shock moves exchange rates and gives rise to endogenous UIP deviation (panel (b) of Table 4.1).

**Remark 5.** *Does our empirical evidence suggest exogenous or endogenous UIP shocks?*

Our stylized empirical facts in section 3 show that an exogenous currency demand shock moves exchange rates both in the short- and long-run, which provides direct evidence in support of models with endogenous UIP shocks. A currency demand shock shifts demand curve in both models with exogenous and endogenous UIP shocks (Table 4.1). However, the demand shock will only lead to UIP deviation in the latter as exchange rates are immune to currency demand shocks in the former and the UIP deviation is directly given by the exogenous capital control taxes and risk-premium shock.

### 4.2 Endogenous UIP shock in Inelastic Financial Market

Our empirical facts on a currency demand shock moves exchange rates points to the model with endogenous UIP shocks. In this section, we present a model for a small
open economy featuring only the financial sector where capital flow shocks change the position of intermediaries and lead to endogenous UIP deviations.

There're four types of agents in the a partially segmented financial market. The international bonds market is segmented in the sense that home households cannot hold foreign currency bonds; vice versa for foreign households. Household demand home-currency bond $b_t$, which is shaped by the macroeconomic fundamentals in the economy. Apart from households, there’re three types of agents who can trade home and foreign currency bonds in the international financial market, Namely, these are noise traders, arbitrageurs and the government, who we assume to all reside in the home country without loss of generality. We describe the problem of these agents below.

Risk-averse arbitrageurs hold zero-capital portfolio $(d_t, d^*_t)$ such that $d_t - i_t = -(e_t + d^*_t - i^*_t)$ with return on one local-currency unit holding of such portfolio given by $\tilde{i}_{t+1} = i_t - i^*_t - E_t \Delta e_{t+1}$. Arbitrageurs choose $(d_t, d^*_t)$ to maximize the mean-variance preferences over profits (with risk aversion coefficient $\omega$) that results in their optimal choice:

$$-d^*_t = \frac{1}{\lambda_t} (i_t - i^*_t - E_t \Delta e_{t+1})$$  \hspace{1cm} (3)

where $\Lambda$ governs the risk-bearing ability of the arbitrageurs. The larger the $\lambda_t$, the lower the arbitrageur’s risk-bearing capacity. Appendix [TBA] drives the optimal portfolio’s problem for arbitrageurs when assuming mean-variance preference in equation (3).

Noise traders hold zero capital portfolio $(n_t, n^*_t)$ and are subject to demand shocks so that $n_t - i_t + e_t + \psi_t = 0$, where $\psi_t \equiv n^*_t - i^*_t$ is the liquidity demand for foreign currency of the noise traders. Importantly, $\psi_t$ is a random variable uncorrelated with the macroeconomic fundamentals. A positive $\psi_t$ means that noise traders short home-currency and buy foreign-currency bonds.

The government holds a portfolio of $(f_t, f^*_t)$ units of home- and foreign-currency bonds, where $f_t$ and $f^*_t$ are policy instruments corresponding to open market operations in foreign exchange interventions for home- and foreign-currency bonds, respectively. A positive (or negative) $f_t$ means buying (or selling) local-currency bonds in the foreign exchange interventions.

We also define $b^*_t$ as the net foreign asset (NFA) position of the home households and government. In our model with only home and foreign countries, $b^*_t$ equates the foreign households holdings of foreign-currency bonds, as foreign households cannot hold home
Figure 5: Segmented International Bonds Market

Note: This figure presents the four types of agents in a segmented international bonds market, where home and foreign households can only hold government bonds in their own currency. Noise trader positions are subject to exogenous currency demand shocks that's uncorrelated with the macroeconomic fundamentals.

currency bonds due to segmented financial market. We use a simple diagram to present the four types of agents and their positions a segmented market in Figure 5.

Using the market clearing condition for home-currency bond, \( b_t + n_t + d_t + f_t = 0 \) and the zero-capital position of noise traders and arbitrageurs, we have the following expression for net foreign asset:

\[
b_t^* = f_t^* + n_t^* + d_t^*
\]  

Combining equation (4) with equation (3) and introduce exogenous capital control taxes and risk-premium shock on return differentials, we arrive at the relation between UIP and arbitrageurs’ position:

\[
i_t - i_t^* - E_t \Delta e_{t+1} = \tau_t + \mu_t + \lambda_t \left( f_t^* + n_t^* - b_t^* \right)
\]

\[
\equiv \Lambda_t
\]

where the capital flows shock is \( \Lambda_t \equiv \lambda_t(f_t^* + n_t^* - b_t^*) \), consistent with the definition in equation (2). A currency demand shock on the noise trader positions moves \( n_t^* \) and in turn the position of the arbitrageurs \(-d_t^* = f_t^* + n_t^* - b_t^*\); \( \lambda_t \) is the impulse response of exchange rates to the currency demand shock, holding constant \( i_t \) and \( i_t^* \) in the short run.
Equation (5) is also consistent with the endogenous UIP shock framework as in Gabaix and Maggiori (2015) and Itskhoki and Mukhin (2021). In both models, a currency demand shock changes the intermediaries position \( d_t^* \) and endogenously determine the equilibrium allocation of assets and exchange rates. There’s albeit a subtle difference in the how they model \( \lambda_t \) in equation (5): Gabaix and Maggiori (2015) features a “financial-constraint” story where intermediaries enlarge their positions to absorb the excess risks from currency demand shock at a constant rate (\( \lambda_t = \bar{\lambda} \)); Itskhoki and Mukhin (2021) features a “risk-based story” where a currency demand shock changes investors’ risk exposure that endogenously depends on the equilibrium volatility of exchange rates (\( \lambda_t = \omega \sigma_t^2 \)), where \( \omega \) is the risk-aversion of arbitrageurs.

### 4.3 Defining the Relaxed Trilemma

In this section, we discuss the Trilemma constraint (Mundell 1962) and its implied trade-off between monetary policy and exchange rates policy. We argue that models with endogenous UIP shocks do not face such direct tradeoff as in the classical Trilemma constraint and would fit into the “relaxed” Trilemma constraint. Under the “relaxed” Trilemma constraint, foreign exchange intervention serves as an additional instrument other than monetary policy to stabilize exchange rates, even if capital flows are perfectly mobile.

**Definition 4.** The Trilemma constraint (or “Impossible Trinity”) states that it’s **impossible** to have all three of the following simultaneously: (1). An independent monetary policy (inward-focused on domestic inflation and output gap); (2). Free capital mobility (absence of capital control taxes); (3). A fixed exchange rate.

A key assumption in the classical Trilemma model (Mundell, 1962) is that there is no deviation from the uncovered interest parity condition (UIP = 0). Capital control taxes directly imposed on the home- and foreign-currency return differentials would give up the capital mobility and violate the UIP condition. Therefore, by assuming UIP, the classical Trilemma model assumes free capital mobility by construction and the economy faces the direct tradeoff between choosing an independent monetary policy and a fixed exchange rate.

However, it’s important to note the definition on Trilemma constraint in definition
4 does not require UIP to hold and capital flows to be perfectly mobile. In fact, the models with exogenous UIP shocks (as in section 4.1) violate UIP condition but still meet the Trilemma condition in definition 4. In those models, if the UIP deviation comes from capital control taxes, the economy can have an independent monetary policy and a fixed exchange rate as it gives up capital mobility. If the UIP deviation comes from risk-premium shocks with no capital controls, the economy again faces the direct tradeoff between monetary policy and exchange rate as in the classical Trilemma model (Mundell, 1962).

In this paper, we introduce and focus on another type of models that do not fit into the Trilemma constraint described in definition 4. Under free capital flows, the economy in models with endogenous UIP shocks do not face the tradeoff in monetary policy and exchange rate as discussed above and can simultaneously have all three things in an otherwise impossible trinity. We refer these models as facing a “relaxed” Trilemma constraint (Itskhoki and Mukhin, 2022) below:

Definition 5. The “relaxed” Trilemma constraint states that it’s possible to have all three of the following simultaneously: (1). An independent monetary policy (inward-focused on domestic inflation and output gap); (2). Free capital mobility (absence of capital control taxes); (3). A fixed exchange rate.

Models with endogenous UIP shocks can have all three conditions as in the relaxed Trilemma in definition 5 because it has an additional policy instrument other than monetary policy to discipline exchange rates – foreign exchange (FX) intervention. As introduced in section 4.2, foreign exchange intervention conducts open market operations ($f_i^*$) that creates demand shocks on the arbitrageurs positions, which moves exchange rates and leads to endogenous deviation in UIP. The central bank, whose objective is to minimize international risk-sharing wedge and domestic output gap\(^{16}\), manages exchange rates through FX interventions rather than using monetary policy that’s domestically-focused to close the output gap. Even under perfectly mobile capital flows, the economy no longer has to compromise monetary policy independence to stabilize exchange rates. Rather, it can achieve a managed exchange rates through FX interventions.

The classical Trilemma model (Mundell 1962) and the models with exogenous UIP

\(^{16}\text{Please refer to Itskhoki and Mukhin (2022) for details on the central bank objective function.}\)
Table 4.2: Trilemma Constraint and UIP

<table>
<thead>
<tr>
<th>Model</th>
<th>Shock</th>
<th>Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>endogenous UIP shock</td>
<td>$\Lambda_t$</td>
<td>Gabaix and Maggiori (2016), Itskhoki and Mukhin (2021)</td>
</tr>
<tr>
<td>exogenous UIP shock</td>
<td>$\tau_t, \mu_t$</td>
<td>Devereux and Engel (2002), Farhi and Werning (2012)</td>
</tr>
<tr>
<td>classic Trilemma</td>
<td>$\text{uip} = 0$</td>
<td>Mundell (1962), Dornbusch (1976), Obstfeld and Rogoff (1995), Gali and Monacelli (2005)</td>
</tr>
</tbody>
</table>

Note: This diagram presents the relation between models where UIP fails (left circle) and models where Trilemma constraint holds (right circle). Region A refer to models under relaxed Trilemma and UIP fails (endogenous UIP shock); region B refer to models where UIP fails but Trilemma holds (exogenous UIP shock); Region C represents the classic Trilemma models where UIP holds. The table lists the papers in each type of models.

shocks (Devereux and Engel 2002; Farhi and Werning 2012) face the Trilemma constraint in definition 4 because FX interventions, even if implemented, would be ineffective in these models to stabilize exchange rates as exchange rates are immune to capital flow shocks. On the other hand, FX interventions are effective in the models with endogenous UIP shocks (Gabaix and Maggiori 2012; Itskhoki and Mukhin 2021) to stabilize exchange rates and can work together with independent monetary policy and no capital controls. Table 4.2 presents relation between classical Trilemma models, models with exogenous UIP shocks, and models with endogenous UIP shocks.\(^{17}\)

### 4.4 FX Intervention under Relaxed Trilemma

The previous section makes clear that in inelastic financial markets, the central bank is no longer constrained by the classical Trilemma and can use FX intervention as an addi-\(^{17}\)It’s debatable whether we should classify Jiang, Krishnamurthy, and Lustig (2021) as endogenous- or exogenous-UIP shock models. Unlike most macro-papers that treat supply as partially elastic, Jiang, Krishnamurthy, and Lustig (2021) models the supply of treasuries as perfectly inelastic. We discuss more on the implications of FXI in this model in the appendix (TBA).
tional policy tool to effectively stabilize exchange rates without compromising monetary policy independence and free capital mobility. In this section, we characterize the policy function of FX intervention in an inelastic financial market setting to stabilize exchange rates.

Holding all else constant, the foreign exchange intervention stabilizes exchange rates by exactly offsetting the noise trader shocks, at the same magnitude and persistence. That is, \( \frac{\partial e_t}{\partial f_t^*} = \frac{\partial e_t}{\partial n_t^*} \). In the texts below, we give two examples on how to map the policy function of foreign exchange rate intervention into certain models.

**Proposition 1.** In the Taylor-rule model (Engel and West 2005) with exchange rate target \( \bar{e} \), where the home- and foreign monetary policy rates follow the form of:

\[
i_t = \beta_0 (e_t - \bar{e}_t) + \beta_1 y_t + \beta_2 \pi_t + v_t, \beta_0 \in (0, 1)
\]

\[
i_t^* = \beta_1 y_t^* + \beta_2 y_t^* + v_t^*
\]

The policy function of foreign exchange intervention is given by:

\[
\frac{\partial e_t}{\partial f_t^*} = \frac{\partial e_t}{\partial n_t^*} = \frac{\omega \sigma^2_e}{(1 + \beta_0 - \rho)}
\]

, under the assumption that (1). \( n_t^* \sim \text{AR}(1) \) with persistence \( \rho \), (2). \( n_t^* \perp f_t^* \), and (3). macrofundamentals are slow-moving compared to noise trader shocks.

**Proof:** See Appendix C.

**Proposition 2.** In the general equilibrium model of Itskhoki and Mukhin (2021) that specifies the budget constraint of a country \( \beta b_t^* - b_t^* = nx_t = \lambda e_t + \bar{e}_t \), the policy function of foreign exchange intervention is given by:

\[
\frac{\partial e_t}{\partial f_t^*} = \frac{\partial e_t}{\partial n_t^*} = \frac{\beta (1 - \alpha)}{(1 - \rho \beta)} \omega \sigma^2_e
\]

, under the assumption that (1). \( n_t^* \sim \text{AR}(1) \) with persistence \( \rho \), (2). \( n_t^* \perp f_t^* \), and (3). macrofundamentals are slow-moving compared to noise trader shocks.

**Proof:** See Appendix C.

---

\(^{18}\)We show in section 5 that all measures except exchange rates in equation (5) are either slow-moving or not responding to the currency demand shock at all. That is, capital controls, macro-fundamentals, as well as the actual FXI data have no correlation with the currency demand shock.
5 Currency Demand Shock and Country Heterogeneity

In this section, we delve into the heterogeneity in the country-specific responses to the currency demand shocks and seek to understand the source of heterogeneity. We first study the causes of heterogeneous exchange rates response as documented in stylized fact 4. We then show that other variables, including interest rates, capital controls and FX interventions, have insignificant response to the currency demand shock. Taken together, our empirical evidence that the currency demand shocks move exchange rates but not monetary policy rates provide direct evidence supporting the relaxed Trilemma (Itskhoki and Mukhin 2022).

5.1 Heterogeneous Responses of Exchange Rates

We found that exchange rates volatility and exchange rates regimes are the source of variation in country-specific responses. This is shown by Table 5.1. By comparison, we found no correlation between the country-specific exchange rates response with macro-fundamentals such as GDP and measures that capture the development or depth of the sovereign bonds market, as documented in Table B.4 in the Appendix.

Our stylized facts on significant exchange rates response to a currency demand shock provide direct support of the models of inelastic financial market with endogenous UIP shocks. Two papers in the recent literature has features endogenous UIP shocks where exchange rates respond to a demand shock: the financial-constraint story by Gabaix and Maggiori (GM) and the risk-based story by Itskhoki-Mukhin (IM). The key difference in the two models is that the IM treats the exchange rates response to a currency demand shock as a constant and allow the adjustment in balance sheet to accommodate the shock, while IM models the exchange rates response as endogenous to the volatility of exchange rates.

We view the correlation between exchange rates response with exchange rate regimes as well as exchange rate volatility (Table 5.1) as the evidence supporting the risk-based story (Itskhoki-Mukhin). Nevertheless, this does not mean we nullify Gabaix-Maggiori as we lack the data on balance sheet positions to test the mechanism on financial constraint.
Table 5.1: Exchange Rates Response Correlates with Exchange Rates Volatility

(a) ER Vol. & country-specific response

(b) ER Vol. & Regime

Note: This figure (a) and (b) presents the relation between the country-specific response to currency demand shock (measured by MIR) and the exchange rates volatility a) and the relation between exchange rates regime and exchange rates volatility (b), where the red line is the fitted regression for the x- and y-axis variables.

5.2 Responses of Other Variables

In this section, we study whether variables other than exchange rates have significant and sizable response to the currency demand. The central bank policy rates do not respond to the demand shock with yields response close to nil (TBA), according to the stylized fact 3. We show below that capital controls, macroeconomic conditions, and FX interventions in equation (5), are also either slow-moving or not responding to the currency demand shock.

Capital control taxes do not respond to the currency demand shock, as shown in column (1) of Table 5.2. Our capital controls measure is from the Fernandez-Klein-Rebucci-Schindler-Uribe dataset. We use the \( k_a \) index that measures the overall restriction of both inflows and outflows for all asset categories at annual frequency. A summary statistics in Table B.7 states that the all emerging countries in our sample have some degree of capital controls ("gate") with an average \( k_a \) index that equals 0.51. In addition, the capital control measures have close-to-zero movements except for a few countries like Argentina and Turkey, as shown in Table B.6 for the country-specific plots.

Macro-fundamentals, measured by net foreign asset positions \( b_t^* \) in equation (5) and nominal GDP, do not respond the currency demand shock. This is given by column (2)
and (3) of Table 5.2. Unlike exchange rates, the macro-fundamentals are slow-moving and do not respond or are driven by the exogenous currency demand shock due to monthly index rebalancings.

In addition, the foreign exchange interventions data from Adler-Chang-Mno-Shao (2021) shows no correlations with currency demand shock, as given in the last column of Table 5.2. This suggests the central banks are not actively using FX interventions \( f_t^* \) in equation (5)) to offset the noise trader shocks from the exogenous currency demand.  

We use the monthly spot FX intervention data from Adler-Chang-Mno-Shao (2021) as a share of (3-year-average) GDP. Table B.8 provides the summary statistics on FX intervention data.

Table 5.2: Capital controls, macro-fundamentals, and FXI are immune to the shock

<table>
<thead>
<tr>
<th></th>
<th>(1) capital controls</th>
<th>(2) NFA</th>
<th>(3) GDP</th>
<th>(4) FXI over GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currency Demand Shock (MIR)</td>
<td>-0.0208 (0.0231)</td>
<td>-188.8 (160.0)</td>
<td>-1.783 (1.541)</td>
<td>0.124 (0.109)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.525*** (0.00658)</td>
<td>146.0*** (44.12)</td>
<td>1.332*** (0.452)</td>
<td>0.0447* (0.0314)</td>
</tr>
<tr>
<td>Observations</td>
<td>1956</td>
<td>2016</td>
<td>2171</td>
<td>2144</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.9752</td>
<td>0.9401</td>
<td>0.9297</td>
<td>0.0315</td>
</tr>
<tr>
<td>Adjusted ( R^2 )</td>
<td>0.975</td>
<td>0.940</td>
<td>0.929</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

* \( p < 0.2 \), ** \( p < 0.10 \), *** \( p < 0.05 \)

**Note:** This table shows the OLS regression results of the following independent variables on the currency demand shock (MIR): capital control measures (Fernandez-Klein-Rebucci-Schindler-Uribe), net foreign asset positions, nominal GDP, and measured spot FX interventions over GDP. Capital controls, NFA (trillions of local currency) and GDP (billions of local currency) are in annual frequency. FXI data and MIR are both in monthly frequency. All regressions include country fixed effects with robust standard errors clustered at the country level.

5.3 **Taken Together: Evidence on Relaxed Trilemma**

Our stylized facts show significant response of exchange rates to the currency demand shock but no response in policy rates, regardless of the exchange rates regimes. This

19 However, we cannot deny that the zero correlation could due to the data frequency on FXI do not align perfectly with our monthly rebalancing window.
implies that central banks are not implementing monetary policy rates by offsetting the one-to-one movements in exchange rates, regardless of the capital controls. Table 5.3 puts the both response of exchange rates and policy rates to the currency demand shock side by size and summarizes this result. Although our result cannot reject the classical Trilemma constraint, we view this as the most direct evidence of the “relaxed” Trilemma constraint discussed above.

Table 5.3: Evidence on Relaxed Trilemma

- (a) exchange rates
- (b) policy rates

Note: Scatter plot of country-specific exchange rates (left) and policy rates (right) response to MIR against the exchange rates regime (from strict to relaxed) as classified by Ilzetzki, Reinhart and Rogoff (2021).

6 Intervention in Inelastic FX Market

In this section, we identify the required size of foreign exchange intervention to stabilize exchange rates and discuss the effectiveness of the intervention across different exchange rate regimes. We find that countries with floating exchange rate regimes are on average more effective in stabilizing exchange rates, require less amount of reverse relative to GDP compared to countries with managed exchange rates regimes.
6.1 Converting the estimates to the size of intervention

We proceed to estimate the elasticity of exchange rates to the currency demand shock in two steps by imposing assumptions on the relation between \( f_i^* \) and \( n_i^* \). We first assume \( f_i^* \) and \( n_i^* \) are independent to each other. This is consistent with the fact on no correlation between \( f_i^* \) and our currency demand shock that we found above.

We convert the currency demand shock into implied capital flows to estimate the required size intervention to stabilize exchange rates. We take the country specific estimate on exchange rates response to MIR (at 15-20 days after rebalancing) and calculate the implied flows of mutual fund tracking the GBI-EM Global Diversified index. For example, our estimates show that in one standard deviation of MIR (0.23, by Table 2.2) moves exchange rates by 1.13% for Colombia, whose average market value in the index is 63 bn.USD in 2019 with the total index value equals to 1221 bn. We also estimate that the total positions of mutual funds in EPFR that track the Index to be 113.6 bn.USD, and the EPFR represents about 60% of the total population of mutual funds globally. This means that the required flows to move exchange rates by one percent for Colombia is:

\[
\frac{1}{1.13} \times 0.23 \times 63 \times \frac{113.6}{0.6} \times \frac{1}{1221} = 1.98 \text{ bn.USD.}
\]

6.2 Identifying the Size of FX Intervention

We find that countries with floating exchange rates require much less intervention (and thus are more effective) to stabilize exchange rates on average compared to countries with pegged exchange rates, as shown in Table 6.1. For example, the required FXI over GDP to move exchange rates by 1 percent is about 2% of GDP for Czech Republic (de facto peg), and 1.2 for the group average of countries with crawling peg (Hungary, Peru, Romania, Philippines). The number is more than 10 times bigger than countries with free floating/falling exchange rate regimes (Mexico, Turkey, South Africa or Argentina).

Our calculation shows that to move exchange rates by 1 percent, the medium required foreign exchange intervention is 1.68 bn.US Dollars or about 0.6% of annual GDP. Our results are largely consistent with the empirical literature on foreign exchange intervention including Adler et al (2019), who estimated that foreign exchange intervention with the magnitude 1% of GDP results in exchange rates depreciation of 2 percentage points. Our estimates are also consistent with the asset pricing literature on measuring
Table 6.1: FXI required to induce 1 % exchange rate change

<table>
<thead>
<tr>
<th>Country</th>
<th>ER regime (code)</th>
<th>Required FXI</th>
<th>FXI over GDP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CzechRepublic</td>
<td>de facto peg (1)</td>
<td>5.31</td>
<td>2.072</td>
</tr>
<tr>
<td>Indonesia</td>
<td>crawling peg (2)</td>
<td>37.99</td>
<td>3.335</td>
</tr>
<tr>
<td>Hungary</td>
<td>crawling peg (2)</td>
<td>1.68</td>
<td>1.037</td>
</tr>
<tr>
<td>Peru</td>
<td>crawling peg (2)</td>
<td>2.17</td>
<td>0.945</td>
</tr>
<tr>
<td>Romania</td>
<td>crawling peg (2)</td>
<td>1.52</td>
<td>0.611</td>
</tr>
<tr>
<td>Philippines</td>
<td>crawling peg (2)</td>
<td>0.27</td>
<td>0.070</td>
</tr>
<tr>
<td>Thailand</td>
<td>managed floating (3)</td>
<td>33.3</td>
<td>5.944</td>
</tr>
<tr>
<td>Chile</td>
<td>managed floating (3)</td>
<td>1.92</td>
<td>0.723</td>
</tr>
<tr>
<td>Malaysia</td>
<td>managed floating (3)</td>
<td>2.65</td>
<td>0.719</td>
</tr>
<tr>
<td>Colombia</td>
<td>managed floating (3)</td>
<td>1.98</td>
<td>0.615</td>
</tr>
<tr>
<td>Brazil</td>
<td>managed floating (3)</td>
<td>4.85</td>
<td>0.265</td>
</tr>
<tr>
<td>Russia</td>
<td>managed floating (3)</td>
<td>1.58</td>
<td>0.089</td>
</tr>
<tr>
<td>Mexico</td>
<td>managed/free floating (3.5)</td>
<td>1.37</td>
<td>0.106</td>
</tr>
<tr>
<td>Turkey</td>
<td>managed floating/free falling (3.5)</td>
<td>0.26</td>
<td>0.0363</td>
</tr>
<tr>
<td>SouthAfrica</td>
<td>free floating (4)</td>
<td>0.97</td>
<td>0.241</td>
</tr>
<tr>
<td>Argentina</td>
<td>free falling (5)</td>
<td>0.0398</td>
<td>0.011</td>
</tr>
</tbody>
</table>

Average by group

<table>
<thead>
<tr>
<th>Exchange rate regime</th>
<th>Required FXI</th>
<th>FXI over GDP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>crawling peg</td>
<td>1.41</td>
<td>0.67</td>
</tr>
<tr>
<td>managed floating</td>
<td>2.58</td>
<td>0.42</td>
</tr>
<tr>
<td>free floating/falling</td>
<td>0.66</td>
<td>0.099</td>
</tr>
</tbody>
</table>

whole sample average      | 5.44         | 0.94             |
whole sample medium       | 1.68         | 0.61             |

Note: This table reports the country-specific required size of FX intervention to stabilize exchange rate by 1% in billions of USD (column 3) and as a share (%) of each country’s 2019 nominal GDP (column 4). We sort countries by their exchange rate regimes (column 2, as classified by Iltzetki, Rogoff and Reinhart 2021) from de facto peg to free floating/falling. For countries having multiple exchange rate regime codes during our sample 2010-2021, as with Mexico and Turkey, we take the average across time.

The required size of intervention is computed using the country-specific exchange rate response to the currency demand shock at the 15-20 day horizon after the rebalancing date. All estimates are significant at 5% level except for Czech Republic, Malaysia, Indonesia and Thailand. We therefore drop these four countries when computing the average in their respective exchange rate regime group. Nevertheless, the whole sample average/medium include all countries in the sample. A full table with the country’s GDP and market value can be found in Table B.1 in the appendix.
the demand elasticities of currencies, including Hau, Massa, and Peress (2009).

**Remark 6. Why are floats more effectiveness at stabilizing exchange rates?**

The empirical results that the floats are much more effective at stabilizing exchange rates than peggers are consistent with the model mechanism in equation (5). Recall \( \lambda_t(.) \equiv \omega \sigma^2_t \) governs the response of exchange rates to the currency demand shock. The more stable/managed exchange rates would therefore imply a smaller or close-to-zero exchange rates volatility (\( \sigma^2_t \)). In the limit of exchange rates being fully pegged, the entire term involving \( \lambda_t(.) \) on the capital flows shock vanishes and and we are back are back to the model with exogenous UIP shocks that are immune to currency demand shocks as well as the Trilemma constraint. In other words, FX interventions are more effective with floats precisely because they have larger exchange rate volatility (Fact 4) and further away from the Trilemma constraint.

### 7 Conclusion

In this paper, we use a well-identified currency demand shock on the noise traders that give rise to endogenous uncovered interest parity (UIP) deviations under an inelastic financial market. Our results show that the exogenous currency demand shock moves exchange rates significantly both in the short- and long-run but not monetary policy rates, providing direct support for models with inelastic financial market and the “relaxed Trilemma” constraint. We assess the effectiveness of foreign exchange intervention for an emerging market central bank to stabilize exchange rates under the inelastic financial market hypothesis. When markets are inelastic, foreign exchange rate intervention works as an additional policy tool to move exchange rates without compromising monetary policy independence, providing evidence relaxing the classical Trilemma constraint. Our results contribute to various strands of literature including the foreign exchange intervention and asset demand estimation and are informative to policymakers at emerging market central banks.
References


Appendix

A  Data Description and Background

A.1  More on GBI-EM

Published by J.P. Morgan in 2005, the GBI-EM Global Diversified index is the largest local-currency government bonds index for emerging countries. It’s also the most popular index among the GBI-EM family of a total of six different indexes. According to the J.P. Morgan Market Survey, the asset under management for the mutual funds tracking the GBI-EM Global Diversified is more than 200 billion US Dollars in 2020 (cite the size of the sovereign market here, [TBA]). There are currently 19 emerging countries in the index. These countries are chosen to enter (and remain in) the index if their Gross National Income per capita are below the J.P. Morgan defined Index Income Ceiling for three consecutive years and the country’s long term local currency sovereign credit rating is A-/A3/A- (inclusive) or above for three consecutive years.

The monthly rebalancings of the GBI-EM Global Diversified index have three layers, which are done in order on the last weekday of the month. The first layer uses a diversification methodology that includes only a portion of a country’s current face amount outstanding into the index. The included face amount outstanding – called the adjusted face amount – is based on the respective country’s relative size in the index and the average size of all countries. The adjusted face amount is then used to compute the market value of each country in the index. The second layer focuses on the bonds maturity threshold that drops bonds with less than 13 months to maturity from the index. As the third and last layer of control, the index rebalancing caps the weight of each country, computed using the adjusted face amount, at 10%.
A.2 More on MIR

Table B.2 in the Appendix gives the country-level time series on the MIR from 2010 to 2021. Two facts worth pointing out on the country-level dynamics: First, while most countries experience persistent positive MIRs (for example, Argentina, Chile, Hungary, etc.), some countries (for example, Brazil and Mexico) have negative MIRs in most of their episodes. This is because large countries like Brazil and Mexico are more likely to hit the 10% country weight cap during rebalancings. Their excess weights are redistributed to smaller countries that are below the cap such that the weights of all countries in the index sum up to 100%.

Second, data for some countries (for example, Argentina, Nigeria, Uruguay) are available only in a small number of months between 2010 and 2021 for the reason(s) that these countries fail to meet either the income ceiling or the credit rating requirement of the index in those episodes. A big country like Brazil can also be excluded from the GBI-EM Global Diversified index from time to time – as shown by the discontinuous MIR time-series for Brazil from 2010 to 2019. In those months, Brazil was included the GBI-EM Broad (another more inclusive index of the J.P Morgan GBI-EM family) instead possibly due to its intensive capital controls [TBA source].

A.2.1 Converting MIR into flows of noise trader shocks

To convert MIR into flows in USD implied by rebalancings (FIR), we use the following relation:

\[
FIR \equiv \text{MIR} \times \frac{\text{AUM}_t}{\sum_{c'} \text{MV}_{c'}} = \frac{(\omega_{c,t} - \omega_{c,t}^{B,H})\text{AUM}_t}{\text{MV}_{c,t-1}} \tag{6}
\]

The FIR definition in equation (6) is the same as in Pandolfi and Williams (2019). The term AUM\(_t\) is the asset-under-management of the the mutual funds that are passively tracking the GBI-EM Global Diversified Index at time \(t\). Intuitively, FIR captures the information-free capital flows (in US Dollars) that are supposed to leave to enter the emerging country from the mechanical rebalancings of GBI-EM Global Diversified index.
We address how to estimate AUM$_t$ accurately in the later section.

To see how the flows implied by rebalancings connect to the model of segmented markets, we decompose noise trader positions $n^*_t$ into two components: the first component is the buy-and-hold portfolio of benchmark invesments who are subject to mechanical rebalancings ($\tilde{n}^*_t$); the second component is the part of noise trader positions unexplained by rebalancings ($\tilde{\varepsilon}^*_t$). The two components are additive and orthogonal to each other.

\[ n^*_t = \tilde{n}^*_t + \tilde{\varepsilon}^*_t, \quad \text{where} \quad \tilde{n}^*_t \perp \tilde{\varepsilon}^*_t \]

Holdings of benchmark investments ($\tilde{n}^*_t$) are subject to noise trader shocks ($\tilde{\psi}_t$) when rebalancing happens. Noise traders shocks are orthogonal to macroeconomic fundamentals just as illustrated in the model. The position $\tilde{n}^*_t$ at time $t$ is:

\[
\tilde{n}^*_t = \begin{cases} 
\left( \frac{\tilde{n}^*_{t-1}}{\tilde{R}^*_{t-1}} \right) R^*_t & \text{o.w} \\
\tilde{\psi}_t R^*_t & \text{if } t = \text{rebalancing date} 
\end{cases}
\]

At the rebalancing date:

\[
\tilde{n}^*_t = \tilde{\psi}_t R^*_t = \underbrace{\tilde{\psi}_t R^*_t - \left( \frac{\tilde{n}^*_{t-1}}{\tilde{R}^*_{t-1}} \right) R^*_t}_{\text{flows implied by rebalancings}} + \underbrace{\left( \frac{\tilde{n}^*_{t-1}}{\tilde{R}^*_{t-1}} \right) R^*_t}_{\text{market value buy-and-hold}}
\]

\[ = \text{FIR}_{c,t} + \text{market value}^B_{c,t} \]

Therefore, we can re-write the noise trader shocks $n^*_t$ as:

\[ n^*_t = \text{FIR}_{c,t} + \text{market value}^B_{c,t} + \tilde{\varepsilon}^*_t \]

where $\tilde{\varepsilon}^*_t \perp \text{FIR}_{c,t}$, that is, the components of noise trader shocks unexplained by rebalancings are orthogonal to the flows implied by rebalancings of the GBI-EM Global Diversified.
A.2.2 Dynamics of the Noise Trader Shocks in Data

We show that the time series of the MIR (and the dynamics of the noise trader shocks in data) follow a persistent process. We explore different time series processes to fit the dynamics of MIR and find that ARIMA (1,1,1), the linear autoregressive moving average (ARMA) process with first-difference and first-order in both the AR and MA roots, is the most parsimonious process that generates a good fit of the data. This is equivalent to say that $\Delta MIR_t$ follows ARMA(1,1), where $t$ is the rebalancing date at each month. We fit MIR for each country with our conjectured time series and its estimated coefficients are reported in Table B.12 and B.13 in the Appendix.

To further the test, we perform unit root tests on the eigenvalue stability condition of both the autoregressive and the moving average roots. Of all the countries in our sample, only the moving average root of Argentina is unstable and lies outside the unit circle. We collect the residuals from the regressions after fitting ARIMA(1,1,1) and preform Portmanteau test for white noise with the null hypothesis that the residuals are white noise and follow a random walk process. All countries except Colombia, Chile, and Malaysia are able to reject the null at 5% significance level. In summary, we can conclude that the MIR in most countries follow a process similar to ARIMA(1,1,1). The p-values of the Portmanteau tests can also be found in Table B.12 and B.13.
B Additional Figures and Tables

Table B.1: FXI required to induce 1 pp. exchange rate depreciation (or appreciation)

<table>
<thead>
<tr>
<th>Country</th>
<th>2019 mkt value</th>
<th>2019 GDP</th>
<th>Required FXI</th>
<th>FXI over GDP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>6.65</td>
<td>360.57</td>
<td>0.0398</td>
<td>0.011</td>
</tr>
<tr>
<td>Brazil</td>
<td>205.72</td>
<td>1833.49</td>
<td>4.85</td>
<td>0.264</td>
</tr>
<tr>
<td>Chile</td>
<td>29.72</td>
<td>262.98</td>
<td>1.92</td>
<td>0.729</td>
</tr>
<tr>
<td>Colombia</td>
<td>62.86</td>
<td>321.81</td>
<td>1.98</td>
<td>0.615</td>
</tr>
<tr>
<td>CzechRepublic</td>
<td>38.09</td>
<td>256.02</td>
<td>5.31</td>
<td>2.072</td>
</tr>
<tr>
<td>Hungary</td>
<td>40.20</td>
<td>161.72</td>
<td>1.68</td>
<td>1.037</td>
</tr>
<tr>
<td>Indonesia</td>
<td>137.43</td>
<td>1138.96</td>
<td>37.99</td>
<td>3.336</td>
</tr>
<tr>
<td>Malaysia</td>
<td>55.98</td>
<td>369.14</td>
<td>2.65</td>
<td>0.719</td>
</tr>
<tr>
<td>Mexico</td>
<td>153.18</td>
<td>1297.19</td>
<td>1.37</td>
<td>0.106</td>
</tr>
<tr>
<td>Peru</td>
<td>33.07</td>
<td>229.93</td>
<td>2.17</td>
<td>0.945</td>
</tr>
<tr>
<td>Philippines</td>
<td>2.63</td>
<td>384.63</td>
<td>0.27</td>
<td>0.070</td>
</tr>
<tr>
<td>Romania</td>
<td>24.33</td>
<td>249.67</td>
<td>1.52</td>
<td>0.611</td>
</tr>
<tr>
<td>Russia</td>
<td>84.76</td>
<td>1764.64</td>
<td>1.58</td>
<td>0.089</td>
</tr>
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<td>SouthAfrica</td>
<td>107.15</td>
<td>400.25</td>
<td>0.96</td>
<td>0.241</td>
</tr>
<tr>
<td>Thailand</td>
<td>98.98</td>
<td>560.20</td>
<td>33.3</td>
<td>5.944</td>
</tr>
<tr>
<td>Turkey</td>
<td>36.91</td>
<td>725.20</td>
<td>0.26</td>
<td>0.036</td>
</tr>
<tr>
<td><strong>Average (whole sample)</strong></td>
<td><strong>5.44</strong></td>
<td><strong>0.94%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Medium (whole sample)</strong></td>
<td><strong>1.68</strong></td>
<td><strong>0.61%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Column 4 of this table gives the required foreign reserves an emerging market central bank needs to buy (or sell) to depreciate (appreciate) local-currency exchange rate by 1 percentage point. Column 5 computes the required foreign reserves in the intervention as a share of its 2019 annual GDP (reported Column 3). Column 2 gives the average market value of the local-currency government bonds of each country in the GBI-EM Global Diversified in 2019 (with the except of Argentina that we use the average between 2017-2019 due to limited data). All values are in billions of US Dollars.
Table B.2: Change in Market Value Implied by Rebalancings (MIR)

(a) Argentina  (b) Brazil  (c) Chile  (d) Colombia
(e) Czech Republic  (f) Hungary  (g) Indonesia  (h) Malaysia
(i) Mexico  (j) Peru  (k) Philippines  (l) Poland
(m) Romania  (n) Russia  (o) South Africa  (p) Thailand  (q) Turkey

Note: Table B.2 reports the country-level time-series of market value change as implied by rebalancings (MIR) of GBI-EM Global Diversified index. The series are in monthly frequency from January 2010 to January 2021. Disconnected lines for a country indicates missing MIRs and that the country is excluded from the GBI-EM Global Diversified index in those months (although the country can be in other versions of GBI-EM indices).
Figure B.1: AUM of Funds tracking GBI-EM Global Diversified in EPFR Data

Note: This figure reports the time series of the total asset under management (AUM) in billions of USD of bond funds in the EPFR dataset whose benchmark indices track the JP Morgan GBI-EM Global Diversified or their performance R-squared are at least 0.9. Observations are in monthly frequency from January 2016 to December 2021. Mutual Fund Flows data are from EPFR Global.
Table B.3: Change in Policy Rates in Response to MIR

Note: This panel of figures provide the regression coefficients of country-specific central bank policy rates (in percentage points) in response to our instrument MIR. The change in central bank policy rates are provided by Bank of International Settlements (BIS) and measured as the change since 28 before rebalancing dates.
Table B.4: Exchange Rates Response do not correlates with GDP nor Market Size

Note: This Figure gives the elation between the estimated country-level $\beta_{c,MIR}$ and their macrofundamentals. Panel (a) plots the relation between $\beta_{c,MIR}$ and average country-level nominal between 2009 and 2020; panel (b) plots the relation between $\beta_{c,MIR}$ and the average market value of the local currency government bonds included in the GBI-EM Global Diversified index by JP Morgan. All values are in billions of US Dollars and we take the log value of them for the scatter plot.
Table B.5: Country-level Exchange rates on MIR (95% conf. interval)

(a) Argentina  (b) Brazil  (c) Chile
(d) Colombia  (e) Czech Republic  (f) Hungary
(g) Indonesia  (h) Malaysia  (i) Mexico
(j) Peru  (k) Philippines  (l) Poland
(m) Romania  (n) Russia  (o) South Africa
(p) Thailand  (q) Turkey

Note: This panel of figures reports the regression coefficient of country-level cumulative exchange rates change (in % or $100 \times \Delta \log(.))$ in response to MIR. Exchange rates change are defined as the change since 28 days before the current rebalancing. Black lines indicate confidence interval of 95%. All countries have the same scale of vertical axis except for Argentina.
Table B.6: Capital Controls Overall Restriction Index

Note: This panel of figures presents the overall capital restriction index (the average of capital inflow and outflow restriction) for each country provided by Fernandez-Klein-Rebucci-Schindler-Uribe dataset. The measure is in annual frequency.
Table B.7: Summary Statistics of Control Restriction Index

<table>
<thead>
<tr>
<th></th>
<th>Obs</th>
<th>Mean</th>
<th>Std.</th>
<th>Min</th>
<th>Max</th>
<th>Medium</th>
<th>90%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>340</td>
<td>0.513</td>
<td>0.28</td>
<td>0</td>
<td>1</td>
<td>0.6</td>
<td>0.85</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Note: This table presents the summary of statistics on the overall capital restriction index provided by Fernandez-Klein-Rebucci-Schindler-Uribe dataset. Data are in annual frequency.

Table B.8: Summary Statistics of Spot FXI over GDP

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean</th>
<th>Std.</th>
<th>Min</th>
<th>Max</th>
<th>Medium</th>
<th>90%</th>
<th>10%</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>.013</td>
<td>.51</td>
<td>-3.08</td>
<td>1.49</td>
<td>.01</td>
<td>-.49</td>
<td>.58</td>
<td>276</td>
</tr>
<tr>
<td>Brazil</td>
<td>.065</td>
<td>.29</td>
<td>-1.06</td>
<td>1.53</td>
<td>.01</td>
<td>-.21</td>
<td>.41</td>
<td>276</td>
</tr>
<tr>
<td>Chile</td>
<td>.0006</td>
<td>.42</td>
<td>-2.11</td>
<td>2.75</td>
<td>.005</td>
<td>-.35</td>
<td>.34</td>
<td>276</td>
</tr>
<tr>
<td>Colombia</td>
<td>.048</td>
<td>.238</td>
<td>-1.29</td>
<td>1.13</td>
<td>.04</td>
<td>-.15</td>
<td>.29</td>
<td>276</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>.248</td>
<td>1.584</td>
<td>-4.53</td>
<td>10.82</td>
<td>.125</td>
<td>-1.14</td>
<td>1.66</td>
<td>276</td>
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<tr>
<td>Hungary</td>
<td>.04</td>
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<td>1.89</td>
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<tr>
<td>Indonesia</td>
<td>.041</td>
<td>.42</td>
<td>-1.64</td>
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<td>.01</td>
<td>-.38</td>
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<td>.117</td>
<td>1.138</td>
<td>-6.38</td>
<td>5.64</td>
<td>.06</td>
<td>-.79</td>
<td>1.33</td>
<td>276</td>
</tr>
<tr>
<td>Mexico</td>
<td>.048</td>
<td>.215</td>
<td>-1.47</td>
<td>1.05</td>
<td>.04</td>
<td>-.17</td>
<td>.27</td>
<td>276</td>
</tr>
<tr>
<td>Peru</td>
<td>.106</td>
<td>.71</td>
<td>-2.81</td>
<td>3.48</td>
<td>.04</td>
<td>-.61</td>
<td>.94</td>
<td>276</td>
</tr>
<tr>
<td>Philippines</td>
<td>.134</td>
<td>.49</td>
<td>-1.82</td>
<td>3.17</td>
<td>.08</td>
<td>-.36</td>
<td>.71</td>
<td>276</td>
</tr>
<tr>
<td>Poland</td>
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<td>3.99</td>
<td>.03</td>
<td>-.73</td>
<td>1.02</td>
<td>276</td>
</tr>
<tr>
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<td>1.02</td>
<td>-6.12</td>
<td>5.29</td>
<td>.09</td>
<td>-.66</td>
<td>.87</td>
<td>273</td>
</tr>
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<td>Russia</td>
<td>.257</td>
<td>.808</td>
<td>-3.86</td>
<td>3.77</td>
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<td>-.42</td>
<td>1.11</td>
<td>276</td>
</tr>
<tr>
<td>South Africa</td>
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<td>.99</td>
<td>.02</td>
<td>-.11</td>
<td>.21</td>
<td>276</td>
</tr>
<tr>
<td>Thailand</td>
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<td>.707</td>
<td>-2.02</td>
<td>3.38</td>
<td>.18</td>
<td>-.58</td>
<td>1.03</td>
<td>275</td>
</tr>
<tr>
<td>Turkey</td>
<td>-.022</td>
<td>.481</td>
<td>-1.89</td>
<td>1.36</td>
<td>-.01</td>
<td>-.62</td>
<td>.52</td>
<td>276</td>
</tr>
</tbody>
</table>

Note: This table reports the summary statistics of spot FXI over (3 year average) GDP for the countries in our sample for the year 2000 to 2021. FXI data are at monthly frequency and from Adler-Chang-Mano-Shao (2021).
Table B.9: Double-difference Interest rates (one-year) on MIR

(a) Brazil  
(b) Chile  
(c) Colombia  
(d) Hungary  
(e) Indonesia  
(f) Malaysia  
(g) Mexico  
(h) Peru  
(i) Philippines  
(j) Poland  
(k) Russia  
(l) South Africa  
(m) Thailand  
(n) Turkey

**Note:** This panel of figures reports the regression coefficient of “double-interest-rates-differentials” of one-year tenor (in basis points, not annualized) on our instrument MIR. The black line indicates 95% confidence interval. We define “double-interest-rates-differentials” as change in the yield differentials on home and foreign (USD) government bonds since -28 before rebalancing. All countries have the same scale for vertical axis except for Turkey.
Table B.10: Short-run cumulative exchange rates change on MIR

<table>
<thead>
<tr>
<th>Days to rebalancing</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-28 to -26</td>
<td>-25 to -20</td>
<td>-20 to -15</td>
<td>-15 to -10</td>
<td>-10 to -5</td>
<td>-5 to 0</td>
<td>0 to 5</td>
<td>5 to 10</td>
<td>15 to 15</td>
<td>15 to 20</td>
<td>20 to 25</td>
</tr>
<tr>
<td>Standardized MIR</td>
<td>-0.167**</td>
<td>-0.905***</td>
<td>-1.494***</td>
<td>-1.895***</td>
<td>-1.873***</td>
<td>-1.872***</td>
<td>-2.409***</td>
<td>-2.639***</td>
<td>-2.407***</td>
<td>-2.317***</td>
<td>-2.261**</td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td>(0.166)</td>
<td>(0.309)</td>
<td>(0.430)</td>
<td>(0.466)</td>
<td>(0.557)</td>
<td>(0.721)</td>
<td>(0.733)</td>
<td>(0.560)</td>
<td>(0.686)</td>
<td>(0.816)</td>
</tr>
<tr>
<td>Log (market-value)</td>
<td>-0.070</td>
<td>-0.529</td>
<td>-1.179**</td>
<td>-1.465***</td>
<td>-1.209**</td>
<td>-1.358**</td>
<td>-1.667***</td>
<td>-1.751***</td>
<td>-1.303**</td>
<td>-0.963</td>
<td>-0.896*</td>
</tr>
<tr>
<td></td>
<td>(0.118)</td>
<td>(0.401)</td>
<td>(0.408)</td>
<td>(0.391)</td>
<td>(0.488)</td>
<td>(0.542)</td>
<td>(0.502)</td>
<td>(0.503)</td>
<td>(0.572)</td>
<td>(0.554)</td>
<td>(0.475)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.708</td>
<td>5.541</td>
<td>12.65**</td>
<td>15.61***</td>
<td>13.01**</td>
<td>14.88**</td>
<td>18.05***</td>
<td>19.00***</td>
<td>14.38**</td>
<td>10.87*</td>
<td>10.21*</td>
</tr>
<tr>
<td>Observations</td>
<td>1671</td>
<td>1509</td>
<td>1696</td>
<td>1840</td>
<td>1313</td>
<td>1606</td>
<td>1971</td>
<td>1656</td>
<td>1504</td>
<td>1711</td>
<td>1777</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.02</td>
<td>0.0845</td>
<td>0.0895</td>
<td>0.1111</td>
<td>0.0900</td>
<td>0.0818</td>
<td>0.1155</td>
<td>0.1215</td>
<td>0.1024</td>
<td>0.0842</td>
<td>0.0787</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.012</td>
<td>0.073</td>
<td>0.080</td>
<td>0.102</td>
<td>0.102</td>
<td>0.077</td>
<td>0.107</td>
<td>0.112</td>
<td>0.092</td>
<td>0.074</td>
<td>0.069</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01

Note: This table reports the ordinary-least-squares regression results of the following equation in a rolling-window estimation:

\[ e_{c,t+z} - e_{c,t} = \delta_c + \beta_{MIR} \times \text{MIR}_{c,t} + \gamma \times \text{Mkt}_{c,t-1} + \epsilon_{c,t} \quad z \in \{-28, 25\} \]

Each column specifies the window the regression is based on. For example, column (1) uses the window from \( z = -28 \) days to \( z = -25 \) days (before the rebalancing date); all other columns use windows with 5 days in length. Dependent variable is cumulative exchange rates change starting from 28 days before rebalancing. Market value change implied by rebalancings (MIR) is defined as \( \text{MIR}_{c,t} = \frac{\sum c' \text{MV}_{c',t} - \sum c' \text{MV}_{c',t-1}}{\text{MV}_{c,t-1}} \) and is standardized by its mean (0.29) and standard deviation (0.35) in the regression. Log (market value) is the log of the market value of the local-currency sovereign bonds in the GBI-EM Global Diversified at the rebalancing date. All regressions are performed with country fixed effects and standard errors are robust and clustered at country level.
<table>
<thead>
<tr>
<th>Months after rebalancing</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized MIR</td>
<td>-2.091&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-2.363&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-2.993&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-3.293&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-2.957&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-2.888&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-3.371&lt;sup&gt;***&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(0.618)</td>
<td>(0.622)</td>
<td>(0.761)</td>
<td>(0.826)</td>
<td>(0.876)</td>
<td>(0.984)</td>
<td>(1.125)</td>
</tr>
<tr>
<td>Log (market-value)</td>
<td>-1.515&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-1.137&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-0.416</td>
<td>0.381</td>
<td>1.359</td>
<td>2.116</td>
<td>2.809*</td>
</tr>
<tr>
<td></td>
<td>(0.488)</td>
<td>(0.506)</td>
<td>(0.706)</td>
<td>(0.955)</td>
<td>(1.130)</td>
<td>(1.304)</td>
<td>(1.506)</td>
</tr>
<tr>
<td>Constant</td>
<td>16.46&lt;sup&gt;***&lt;/sup&gt;</td>
<td>12.61&lt;sup&gt;**&lt;/sup&gt;</td>
<td>5.297</td>
<td>-2.769</td>
<td>-12.74</td>
<td>-20.34</td>
<td>-27.31</td>
</tr>
<tr>
<td>Observations</td>
<td>1122</td>
<td>2230</td>
<td>2213</td>
<td>2194</td>
<td>2162</td>
<td>2130</td>
<td>2100</td>
</tr>
<tr>
<td>R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.0106</td>
<td>0.0978</td>
<td>0.1235</td>
<td>0.1562</td>
<td>0.1839</td>
<td>0.2212</td>
<td>0.2698</td>
</tr>
<tr>
<td>Adjusted R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.088</td>
<td>0.090</td>
<td>0.116</td>
<td>0.149</td>
<td>0.177</td>
<td>0.215</td>
<td>0.263</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Months after rebalancing</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>1 year</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized MIR</td>
<td>-3.455&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-3.643&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-4.101&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-3.821</td>
<td>-2.675</td>
<td>-1.788</td>
<td>-1.829</td>
</tr>
<tr>
<td></td>
<td>(1.258)</td>
<td>(1.395)</td>
<td>(1.750)</td>
<td>(2.199)</td>
<td>(2.344)</td>
<td>(2.389)</td>
<td>(2.394)</td>
</tr>
<tr>
<td>Log (market-value)</td>
<td>4.031&lt;sup&gt;**&lt;/sup&gt;</td>
<td>5.466&lt;sup&gt;**&lt;/sup&gt;</td>
<td>6.509&lt;sup&gt;**&lt;/sup&gt;</td>
<td>7.217&lt;sup&gt;**&lt;/sup&gt;</td>
<td>8.304&lt;sup&gt;***&lt;/sup&gt;</td>
<td>9.673&lt;sup&gt;***&lt;/sup&gt;</td>
<td>10.24&lt;sup&gt;***&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(1.715)</td>
<td>(1.985)</td>
<td>(2.287)</td>
<td>(2.547)</td>
<td>(2.710)</td>
<td>(2.851)</td>
<td>(2.966)</td>
</tr>
<tr>
<td>Constant</td>
<td>-39.90&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-54.77&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-65.49&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-72.52&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-83.38&lt;sup&gt;**&lt;/sup&gt;</td>
<td>-97.31&lt;sup&gt;***&lt;/sup&gt;</td>
<td>-103.2&lt;sup&gt;***&lt;/sup&gt;</td>
</tr>
<tr>
<td>R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.3142</td>
<td>0.3575</td>
<td>0.3985</td>
<td>0.4285</td>
<td>0.4573</td>
<td>0.4897</td>
<td>0.5053</td>
</tr>
<tr>
<td>Adjusted R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.308</td>
<td>0.352</td>
<td>0.393</td>
<td>0.423</td>
<td>0.452</td>
<td>0.485</td>
<td>0.496</td>
</tr>
</tbody>
</table>

Note: This table reports the ordinary-least-squares regression results of the following equation in a rolling-window estimation:

\[ e_{c,t+m} - e_{c,t} = \delta_c + \beta_{MIR} \times MIR_{c,t} + \gamma \times Mkt_{c,t-1} + \epsilon_{c,t} \quad m \in \{0, 13\} \]

Each column specifies the window the regression is based on. The window lengths are all of one month. For example, column (1) uses the window starting from -28 before rebalancing until rebalancing happened \((m=0)\). Column (2) uses the window from rebalancing to one month \((m=1)\) after rebalancing. Dependent variable is cumulative exchange rates change starting from 28 days before the rebalancing (before the first month). Market value change implied by rebalancings (MIR) is defined as in the previous table(s) and is standardized by its mean and standard deviation. Log (market value) is the log of the market value of the local-currency sovereign bonds in the GBI-EM Global Diversified at the rebalancing date. All regressions are performed with country fixed effects and standard errors are robust and clustered at country level.
Table B.12: Fits MIR with ARIMA(1,1,1) process

<table>
<thead>
<tr>
<th>Country</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.00645***</td>
<td>0.00483</td>
<td>-0.00910</td>
<td>0.00729</td>
<td>0.00445</td>
<td>0.0112</td>
<td>-0.00158</td>
<td>-0.00676</td>
<td>0.00519</td>
<td>0.00259</td>
</tr>
<tr>
<td></td>
<td>(0.00215)</td>
<td>(0.00609)</td>
<td>(0.00689)</td>
<td>(0.0107)</td>
<td>(0.00405)</td>
<td>(0.0160)</td>
<td>(0.00479)</td>
<td>(0.00445)</td>
<td>(0.00364)</td>
<td>(0.00489)</td>
</tr>
<tr>
<td>ARMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR root</td>
<td>-0.215</td>
<td>-0.275**</td>
<td>0.438**</td>
<td>-0.472</td>
<td>0.253</td>
<td>-0.242</td>
<td>0.0210</td>
<td>-0.108</td>
<td>0.146</td>
<td>-0.162</td>
</tr>
<tr>
<td></td>
<td>(0.390)</td>
<td>(0.132)</td>
<td>(0.180)</td>
<td>(0.293)</td>
<td>(0.195)</td>
<td>(0.252)</td>
<td>(0.131)</td>
<td>(0.162)</td>
<td>(0.151)</td>
<td>(0.216)</td>
</tr>
<tr>
<td>AR stable?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MA root</td>
<td>-1.000</td>
<td>-0.415***</td>
<td>-0.776***</td>
<td>0.195</td>
<td>-1.000</td>
<td>-0.772***</td>
<td>-0.589***</td>
<td>-0.514***</td>
<td>-0.663***</td>
<td>-0.449***</td>
</tr>
<tr>
<td></td>
<td>(.)</td>
<td>(0.102)</td>
<td>(0.194)</td>
<td>(0.320)</td>
<td>(127.2)</td>
<td>(0.259)</td>
<td>(0.122)</td>
<td>(0.122)</td>
<td>(0.148)</td>
<td>(0.168)</td>
</tr>
<tr>
<td>MA stable?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>31</td>
<td>119</td>
<td>90</td>
<td>129</td>
<td>45</td>
<td>31</td>
<td>134</td>
<td>136</td>
<td>134</td>
<td>136</td>
</tr>
<tr>
<td>Portmanteau Test</td>
<td>P-value</td>
<td>0.2762</td>
<td>0.9989</td>
<td>0.0008</td>
<td>0.0000</td>
<td>0.7532</td>
<td>0.7115</td>
<td>0.7924</td>
<td>0.9836</td>
<td>0.0474</td>
</tr>
</tbody>
</table>

**Standard errors in parentheses**

* p < 0.1, ** p < 0.05, *** p < 0.01

**Note:** This table and B.13 test if the market value change implied by rebalancings (MIR) of GBI-EM Global Diversified follows an ARIMA(1,1,1) process. The table reports the estimated ARIMA(1,1,1) roots and tests if the eigenvalues of the roots lie inside the unit circle (stability). The table also reports the Portmanteau white noise test on the residuals after fitting the ARIMA(1,1,1). The Null hypothesis of the Portmanteau test is that the error terms of ARIMA(1,1,1) follows a random walk.
Table B.13: Fits MIR with ARIMA(1,1,1) process, cont’d

<table>
<thead>
<tr>
<th>Country</th>
<th>(1) Nigeria</th>
<th>(2) Peru</th>
<th>(3) Philippines</th>
<th>(4) Poland</th>
<th>(5) Romania</th>
<th>(6) Russia</th>
<th>(7) South Africa</th>
<th>(8) Thailand</th>
<th>(9) Turkey</th>
<th>(10) Uruguay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.0187***</td>
<td>-0.00241</td>
<td>-0.00194</td>
<td>0.00641</td>
<td>0.00474</td>
<td>-0.00302</td>
<td>-0.00207</td>
<td>-0.000612</td>
<td>-0.000202</td>
<td>0.00549</td>
</tr>
<tr>
<td></td>
<td>(0.00350)</td>
<td>(0.00388)</td>
<td>(0.00350)</td>
<td>(0.00426)</td>
<td>(0.00737)</td>
<td>(0.00489)</td>
<td>(0.00462)</td>
<td>(0.00463)</td>
<td>(0.00383)</td>
<td>(0.0113)</td>
</tr>
<tr>
<td>ARMA AR root</td>
<td>-0.0907</td>
<td>0.0457</td>
<td>0.156</td>
<td>-0.182</td>
<td>-0.198</td>
<td>0.0726</td>
<td>-0.164*</td>
<td>-0.144</td>
<td>0.215</td>
<td>-0.334***</td>
</tr>
<tr>
<td></td>
<td>(0.248)</td>
<td>(0.191)</td>
<td>(0.0947)</td>
<td>(0.115)</td>
<td>(0.191)</td>
<td>(0.138)</td>
<td>(0.0905)</td>
<td>(0.120)</td>
<td>(0.154)</td>
<td>(0.128)</td>
</tr>
<tr>
<td>AR stable?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MA root</td>
<td>-1.000</td>
<td>-0.498***</td>
<td>-0.667***</td>
<td>-0.582***</td>
<td>-0.474***</td>
<td>-0.644***</td>
<td>-0.656***</td>
<td>-0.492***</td>
<td>-0.768***</td>
<td>-0.675***</td>
</tr>
<tr>
<td></td>
<td>()</td>
<td>(0.176)</td>
<td>(0.0785)</td>
<td>(0.0958)</td>
<td>(0.174)</td>
<td>(0.101)</td>
<td>(0.0701)</td>
<td>(0.113)</td>
<td>(0.108)</td>
<td>(0.134)</td>
</tr>
<tr>
<td>MA stable?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>134</td>
<td>122</td>
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<td>126</td>
<td>136</td>
<td>136</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Portmanteau Test</td>
<td>0.5891</td>
<td>0.1054</td>
<td>0.9985</td>
<td>0.9999</td>
<td>0.3696</td>
<td>0.9258</td>
<td>0.9997</td>
<td>0.9680</td>
<td>0.1879</td>
<td>0.7335</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
* p < 0.1, ** p < 0.05, *** p < 0.01

Note: This table and B.12 test if the market value change implied by rebalancings (MIR) of GBI-EM Global Diversified follows an ARMA(1,1,1) process. The table reports the estimated ARIMA(1,1,1) roots and tests if the eigenvalues of the roots lie inside the unit circle (stability). The table also reports the Portmanteau white noise test on the residuals after fitting the ARIMA(1,1,1). The Null hypothesis of the Portmanteau test is that the error terms of ARIMA(1,1,1) follows a random walk.
C Derivation and Proofs

C.1 Proposition 1 and 2

The UIP deviation can be written as:

$$E_t \Delta z_{t+1} \equiv i_t - i_t^* - E_t \Delta e_{t+1} = \tau_t + \rho_t - \bar{\omega} \sigma^2_e (ib_t^* - n_t^* - f_t^*)$$

(9)

We can re-write equation (9) above as:

$$E_t \Delta e_{t+1} = -\tau_t^d + (i_t - i_t^*) + \bar{\omega} \sigma^2_e (ib_t^* - n_t^* - f_t^*)$$

$$\equiv -x_t + u_t$$

(10)

where $x_t$ is the component of exchange rate $e_t$ when the trilemma condition holds; term $u_t$ is the additional component for models of exchange rates when trilemma doesn’t hold. Specifically, under trilemma models, the effective risk-aversion of the arbitrageurs $\bar{\omega} = 0$ or exchange rates are fixed (so that $\sigma_e = 0$), arbitrageurs have infinite capacity absorb exchange rates risk an UIP deviation disappears in the limit. The term $u_t$ therefore vanishes under trilemma models where the UIP condition holds.

Iterating (10) forward, we have:

$$e_t = E_t e_\infty + E_t \sum_{j=0}^\infty x_{t+j} + E_t \sum_{j=0}^\infty u_{t+j}$$

(11)

and $e_\infty = 0$ if exchange rate $e_t$ follows a stationary process. Below, we introduce both partial equilibrium models (Engel and West 2005) and general equilibrium models (Itskhoki and Mukhin 2021) to solve for the process of exchange rates.
Engel West (2005) Taylor Rule model

Let $\pi_t = p_t - p_{t-1}$ be the inflation rate and $y_t$ the output gap. The home country (in our setting the emerging country) follows a Taylor rule of the form:

$$i_t = \beta_0(e_t - \bar{e}_t) + \beta_1 y_t + \beta_2 \pi_t + v_t$$

(12)

where exchange rate target $\bar{e}_t$ ensures PPP so that $\bar{e}_t = p_t - p^*_t$ and $\beta_0 \in (0, 1)$.

The foreign country (US) follows the Taylor rule of the form:

$$i_t^* = \beta_1 y_t^* + \beta_2 \pi_t^* + v_t^*$$

(13)

Interest rate difference $i_t - i_t^*$ can thus be written as:

$$i_t - i_t^* = \beta_0(e_t - \bar{e}_t) + \beta_1(y_t - y_t^*) + \beta_2(\pi_t - \pi_t^*) + (v_t - v_t^*)$$

Using the UIP condition in equation (10) to substitute out $(i_t - i_t^*)$:

$$\mathbb{E}_t e_{t+1} = e_t - \tau_t^a + \beta_0(e_t - \bar{e}_t) + \beta_1(y_t - y_t^*) + \beta_2(\pi_t - \pi_t^*) + (v_t - v_t^*) - u_t$$

$\Rightarrow (1 + \beta_0)e_t = \tau_t^a + \mathbb{E}_t e_{t+1} + \beta_0(p_t - p_t^*) - \beta_1(y_t - y_t^*) - \beta_2(\pi_t - \pi_t^*) - (v_t - v_t^*) + u_t$

$\Rightarrow e_t = \frac{1}{1 + \beta_0} \tau_t^a + \beta_0(p_t - p_t^*) - \frac{\beta_1}{1 + \beta_0}(y_t - y_t^*) - \frac{\beta_2}{1 + \beta_0}(\pi_t - \pi_t^*) + \cdots$

$- \frac{1}{1 + \beta_0}(v_t - v_t^*) + \frac{1}{1 + \beta_0}u_t + \frac{1}{1 + \beta_0}\mathbb{E}_t e_{t+1}$

Therefore, we can write the solution of exchange rate under Taylor rule in the similar manner as equation (10)

$$e_t = X_t + U_t + \frac{1}{1 + \beta_0}\mathbb{E}_t e_{t+1}$$

(14)

where $\beta_0 \in (0, 1)$, $U_t = \frac{1}{1 + \beta_0}u_t = -\frac{1}{1 + \beta_0} \sigma^2 \epsilon_t (ib_t^* - n_t^* - f_t^*)$ is the component of non-
trilemma models and \( X_t = \frac{1}{1+\beta_0} x_t + \frac{\beta_0}{1+\beta_0} (p_t - p_t^*) - \frac{\beta_1}{1+\beta_0} (y_t - y_t^*) - \frac{\beta_2}{1+\beta_0} (\pi_t - \pi_t^*) + \frac{1}{1+\beta_0} (v_t - v_t^*) \) is the component of trilemma models.

Iterate (14) forward, we have:

\[
e_t = E_t \sum_{j=1}^{\infty} \frac{1}{(1+\beta_0)^j} X_{t+j} + E_t \sum_{j=1}^{\infty} \frac{1}{(1+\beta_0)^j} U_{t+j} + E_t \lim_{j \to \infty} \frac{1}{(1+\beta_0)^j} e_\infty
\]

and \( \lim_{j \to \infty} \frac{1}{(1+\beta_0)^j} = 0 \) in the limit, so the term with \( e_\infty \) vanishes.

If we impose the assumption that (1). \((n_t^* + f_t^*)\) inside \(u_t\) is an AR(1) process with persistence \(\rho\), that is, \(n_{t+1}^* + f_{t+1}^* = \rho(n_t^* + f_t^*) + \epsilon_t\) and 2) financial shock \(>\) macro-fundamental shocks so that \(\iota = 0\). We can re-write the solution of \(e_t\) as:

\[
e_t = E_t \sum_{j=1}^{\infty} \frac{1}{(1+\beta_0)^j} X_{t+j} + \frac{\omega^2}{(1+\beta_0-\rho)} (n_t^* + f_t^*)
\]

where the second line uses the additional assumption that \(f_t^* = -\alpha n_t^*\). Therefore, the impulse response of exchange rate \(e_t\) in response to \(n_t^*\) is:

\[
\frac{\partial e_t}{\partial n_t^*} = \frac{\omega^2}{(1+\beta_0-\rho)} > 0
\]

Therefore, on impact, a foreign currency demand shock depreciates home currency (so \(e_t\) rises). Let \(\frac{\partial E_t e_\infty}{\partial n_t^*} = \kappa \frac{\partial e_t}{\partial n_t^*}\). When \(\kappa = 1\), this is the fully persistent random walk shock and the level of exchange rates is not identified as the financial market doesn’t discipline the levels.
Apart from equation (10), the budget constraint of a country:

\[ \beta b_t^* - b_{t-1}^* = nx_t = \lambda e_t + \xi_t \]  

(15)

where \( \lambda \ (> 0, \text{no particular restriction}) \) is a structural parameter pinned down from the price equations in the goods market, and \( \xi_t \) is shock to the net export \( nx_t \) orthogonal to \( e_t \). We can therefore combine the UIP condition with the country budget constraint and iterate forward:

\[ b_{t-1}^* + \mathbb{E}_t \lambda \sum_{j=0}^{\infty} \beta^j e_{t+j} = \lim_{T \to \infty} \beta^T b_{t+T-1} = 0 \]  

(16)

by No-Ponzi Game Condition (NPGC) of the budget constraint.

From equation (11) and under the assumption that \( \iota = 0, f_t^* = -\alpha n_t^\ast \) and that \( n_t^\ast \sim AR(1) \) with persistence \( \rho \), we have:

\[ e_t = \mathbb{E}_t e_\infty + \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} + \bar{\omega} \sigma_e^2 \left( \frac{1-\alpha}{1-\rho} \right) n_t^* \]  

(17)

Therefore, \( \mathbb{E}_t e_{t+j} = \mathbb{E}_t e_\infty + \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} + \bar{\omega} \sigma_e^2 \frac{\rho^j(1-\alpha)}{(1-\rho)} n_t^* \). Combine with equation (16):

\[ b_{t-1}^* + \lambda \sum_{j=0}^{\infty} \beta^j \left( \mathbb{E}_t e_\infty + \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} + \bar{\omega} \sigma_e^2 \frac{1-\alpha}{1-\rho} n_t^* \right) = 0 \]

\[ \Rightarrow b_{t-1}^* + \frac{\lambda}{1-\beta} \mathbb{E}_t e_\infty + \lambda \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} + \bar{\omega} \sigma_e^2 \frac{1-\alpha}{1-\rho} \frac{\lambda}{1-\rho \beta} n_t^* = 0 \]

\[ \Rightarrow b_{t-1}^* + \frac{\lambda}{1-\beta} \left( e_t - \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} - \bar{\omega} \sigma_e^2 \frac{1-\alpha}{1-\rho} n_t^* \right) + \lambda \mathbb{E}_t \sum_{j=0}^{\infty} x_{t+j} + \bar{\omega} \sigma_e^2 \frac{1-\alpha}{1-\rho} \frac{\lambda}{1-\rho \beta} n_t^* = 0 \]

where the last line substituted the expression of \( \mathbb{E}_t e_\infty \) from equation (17).
From above, we have the relation between $e_t$, $b_{t-1}^*$, $x_t$ and $n_t^*$:

$$\frac{\lambda}{1-\beta} e_t + b_{t-1}^* + X_t - \frac{\beta \lambda \omega \sigma_e^2 (1-\alpha)}{(1-\rho \beta)(1-\beta)} n_t^* = 0$$

(18)

where $X_t \equiv -\frac{\lambda}{1-\beta} \sum_j x_{t+j} + \lambda \sum_j x_{t+j}$ is the non-financial component (or Trilemma component) of exchange rates and do not respond to financial shocks $n_t^*$.

If we only want to look compute the impact of $n_t^*$ on levels of $e_t$ on impact and treat $b_t^*$ as a constant, then

$$\frac{\partial e_t}{\partial n_t^*} = \frac{\beta (1-\alpha)}{(1-\rho \beta)} \sigma_e^2 > 0$$

However, it’s important to note that $b_{t-1}^*$ is an endogenous variable that can be potentially correlated with $n_t^*$ tomorrow. We therefore need to solve for the law of motion of $b_t^*$ as a function of $n_t^*$. We do so by substituting equation (18) into the country budget constraint (15):

$$\beta b_t^* - b_{t-1}^* = (1-\beta) \left( \frac{\beta \lambda \omega \sigma_e^2 (1-\alpha)}{(1-\rho \beta)(1-\beta)} n_t^* - b_{t-1}^* - X_t \right) + \xi_t$$

$$\Rightarrow \beta (b_t^* - b_{t-1}^*) = \frac{\beta \lambda \omega \sigma_e^2 (1-\alpha)}{(1-\rho \beta)} n_t^* - (1-\beta) X_t + \xi_t$$

$$\Rightarrow \Delta b_{t-1}^* = \frac{\lambda \omega \sigma_e^2 (1-\alpha)}{(1-\rho \beta)} n_t^* - \frac{(1-\beta)}{\beta} X_t + \frac{1}{\beta} \xi_t$$

To use $\Delta b_{t-1}^*$ as a function of the shock $n_t^*$, we re-write equation (18) in difference form:

$$\frac{\lambda}{1-\beta} E_t \Delta e_t + \Delta b_{t-1}^* + E_t \Delta X_t - \frac{\beta \lambda \omega \sigma_e^2 (1-\alpha)}{(1-\rho \beta)(1-\beta)} E_t \Delta n_t^* = 0$$

(19)

Note that $E_t \Delta n_t^* = (\rho - 1) n_t^*$ if $n_t^* \sim AR(1)$ with persistence $\rho$. Substituting the
expression of $\Delta b_{t-1}^*$, we can simplify equation (19):

$$
\frac{\lambda}{1-\beta} E_t \Delta e_t + \frac{\lambda \bar{\omega}_c^2 (1 - \alpha)}{(1 - \rho \beta)} n_t^* - \frac{(1 - \beta)}{\beta} X_t + \frac{1}{\beta^2} E_t \Delta X_t - \frac{\beta \lambda \bar{\omega}_c^2 (1 - \alpha)}{(1 - \rho \beta)(1 - \beta)} (\rho - 1) n_t^* = 0
\Rightarrow E_t \Delta e_t + \frac{\bar{\omega}_c^2 (1 - \alpha)}{(1 - \rho \beta)} (2 - \beta - \rho) n_t^* - \frac{(1 - \beta)^2}{\beta \lambda} X_t + \frac{1 - \beta}{\beta \lambda} E_t \Delta X_t + \frac{1 - \beta}{\beta \lambda} \xi_t = 0
$$

The impulse response of exchange rate in response to $n_t^*$ is therefore:

$$
\frac{\partial \Delta e_t}{\partial n_t^*} = \frac{\bar{\omega}_c^2 (1 - \alpha)}{(1 - \rho \beta)} (\beta + \rho - 2) < 0
$$

Intuitively, a positive demand shock for foreign currency bonds increase the position of $n_t^*$ and depreciate home currency today. This is why $\frac{\partial \Delta e_t}{\partial n_t^*} > 0$. But the impulse response for $\frac{\partial \Delta e_t}{\partial n_t^*} < 0$ moving forward and captures the expected component of exchange rate change. The result is consistent with Figure 2 on properties of exchange rate process in Itskhoki-Mukhin 2021.

**C.2 Estimating Intervention $\alpha_f$**

We define $\beta_{c,MIR}$ as the country-specific exchange rates response to MIR. We also define open market operations $f_t^* = -\alpha_f n_t^*$, where $\alpha_f \in [0, 1]$ and is the share of noise trader shocks offset by open market operations through foreign exchange interventions to stabilize exchange rates. A country with more floating exchange rates regime is expected to have a smaller $\alpha_f$; vice versa for countries with more stringent (or pegged) regime.

Under these assumptions, the exchange rates solution in equation (??) becomes:

$$
\Delta e_{c,t+1} = \frac{\beta \omega_{c,e}^2 (1 - \alpha_{c,f}) n_{c,t}^*}{1 - \bar{\rho} \beta} \equiv \beta_{c,f}
$$

where $\beta$ is the impatience parameter of the household; $\rho$ the persistence of the AR (1)
process of the noise trade shocks; $\omega$ the risk aversion parameter of the arbitrageurs that conduct currency carry trade; $\sigma_{c,e}^2$ the volatility of exchange rates; and finally $\alpha_{c,f} \in [0, 1]$ is the share of noise trade shocks offset by open market operations in foreign exchange interventions.

Parameters $\rho$, $\omega$ and $\beta$ are homogenous across countries. Exchange rates volatility $\sigma_{c,e}^2$ and the size of intervention $\alpha_{c,f}$ are the only source of heterogeneity across countries.

Given two countries $c_1$ and $c_2$, their relative exchange rates response to noise trader shocks $\beta_{c_1,f}$ are determined by the relative exchange rates volatility of two countries $\frac{\sigma_{c_1,e}^2}{\sigma_{c_2,e}^2}$ as well as the relative size of (residual) foreign exchange rate intervention $(1 - \alpha_{c_1,f}) (1 - \alpha_{c_2,f})$.

We use the estimated country-specific $\beta_{c,MIR}$ to identify $\beta_{c,f} \equiv \frac{\beta_{\omega \sigma_{c,e}^2}}{\rho} (1 - \alpha_f)$. Using equation (6) for converting MIR into flows of noise trader shocks, we arrive at the following relation:

$$\frac{\beta_{c_1,MIR}}{\beta_{c_2,MIR}} = \frac{\kappa_{c_2}}{\kappa_{c_1}} \times \frac{\sigma_{c_1,e}^2(1 - \alpha_{c_1})}{\sigma_{c_2,e}^2(1 - \alpha_{c_2})}$$

where $\kappa_c = MV_c \times \frac{AUM}{\sum_{c'} MV_{c'}}$; $MV_c$ is the market value of the local currency sovereign bonds in the GBI-EM Global Diversified index; AUM is the asset under management of all the mutual funds closely tracking the index. Equation (21) suggests that countries with larger market size, more volatile exchange rates, and more floating exchange rates regime (less foreign exchange intervention) should expect a larger coefficient of exchange rates in response to MIR.

Parameter $\alpha_f$ measures the share of noise trader shocks offset by central banks through the foreign exchange rate interventions. The exact value of $\alpha_f$ is unobservable in the data. In this section, we seek to identify the value of $\alpha_f$ using the country-specific estimates on exchange rates responses to MIR.

Consider two countries with different exchange rate regimes. Fix country $c_2$ as the benchmark country with free-floating (or free-falling) exchange rate regime and define $\alpha^* \equiv \alpha_{c_2} = 0$. For any country $c$ that doesn’t have a free-floating (or free-falling) exchange
rate regime, we can therefore identify its $\alpha_c$ below following equation (21):

$$\alpha_c = 1 - \left( \frac{\beta_{\text{MIR},c}/\sigma_{\epsilon,c}^2}{\hat{\beta}_{\text{MIR},c^*}/\sigma_{\epsilon,c^*}^2} \times \frac{\kappa_c}{\kappa_{c^*}} \right)$$

(22)

where $k^* = MV_{c^*} \times \frac{\sum_{c'} AUM_{c'}}{MV_{c'}}$ for the benchmark country under free-floating (or free-falling) exchange rates regime and the central bank does not intervene with exchange rates at all ($\alpha^* = 0$).

We set South Africa as the benchmark country with $\alpha^* = 0$ in our sample. South Africa is classified as “free-floating” throughout some sample years from 2009 to 2021 under the exchange rates regime classification by Ilzetzki, Reinhart and Rogoff (2019, 2021). Moreover, it was included in the GBI-EM Global Diversified index in almost all the sample years with the exception of a few months, as reported in Table B.2.

Using South Africa is the benchmark country, we report the estimated intervention $\alpha_f$ in Table C.1 (left panel). The relation of estimated $\alpha_f$ with exchange rates regimes displayed a clear downward trend: the more floating the exchange rates, the smaller the intervention $\alpha_f$ from the central banks to offset the noise trader shocks. The calibrated intervention $\alpha_f$ reported in Table C.1 are all between 0 and 1, as expected by theory.

The calibrated intervention $\alpha_f$ for each country is largely consistent with the actual historical intervention data, as reported in the right panel of Table C.1. The intervention data is the monthly spot foreign exchange intervention as a percentage share of 3-year moving average annual GDP of the country, as provided by Adler et al (2021). We average the intervention data for each country over 2010 - 2021 for the months the country is included the J.P Morgan GBI-EM Global Diversified index. To measure the magnitude of intervention, we also take the absolute value of the interventions data rather than distinguishing the purchase (positive FXI in the data) or sale (negative) of reserves.

Another country (Argentina, “free-falling”) also qualifies as our benchmark country by its exchange rate regime classification. However, Unlike South Africa, Argentina is only included in the GBI-EM Global Diversified index from early 2018 to 2020.
Table C.1: Calibrated Intervention $\alpha_f$ and Actual Intervention

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<tr>
<th>Country</th>
<th>α_1</th>
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**Note:** This table (left panel) gives the calibrated intervention $\alpha_f$ and their relation to exchange rates regimes, with South Africa chosen as the benchmark country with $\alpha^* = 0$. The right panel reports the average spot FXI as a share of country’s GDP for each country as provided by Adler et al (2021). Estimates for Argentina, Poland and Mexico are not reported.