Global Investors in Local-Currency Bond Markets: Implications for Bond Yields and Exchange Rates*

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April 19, 2025

Abstract

In emerging economies—unlike in advanced ones—higher bond term premia are typically associated with higher currency premia. We attribute this pattern to the prevalence of global investors in local-currency bond markets. Using transaction-level data from Colombia's bond and foreign exchange markets, we document that any foreign investors' bond transaction is simultaneously associated with a corresponding transaction in the spot foreign exchange market. We incorporate these *correlated flows* into a portfolio-balance model alongside short-term interest rate risk. The model explains the comovement in bond yields and exchange rates, the patterns of positions and returns in bond and foreign exchange markets, the effects of quantitative easing and foreign exchange interventions, and their differences between advanced and emerging economies.

Keywords: global investors, local-currency bond markets, exchange rates, financial intermediaries
JEL Classification: E43, E52, F31, G12

*We thank Thomas Mertens, and seminar and conference participants at American University, the International Monetary Fund, Northeastern University, and the 10th Annual West Coast Workshop in International Finance for useful comments.
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1 Introduction

Long-term bond yields and exchange rates influence borrowing, saving, and international trade in open economies, and thus play a central role in the transmission of monetary and asset purchase policies. In this paper, we highlight fundamental differences in the joint behavior of long-term bond yields and exchange rates between advanced and emerging economies. We argue that these differences can be traced to the varying importance of global investors in local-currency sovereign bond markets, and that they influence the properties of capital flows, bond and currency risk premia, and the transmission of asset purchase policies.

The comovement between bond yields and exchange rates differs markedly between advanced and emerging economies. Specifically, in advanced economies, local-currency excess bond returns—defined as the return from borrowing short-term and lending long-term in domestic currency—are negatively correlated with excess currency returns—defined as the return from borrowing short-term in foreign currency and lending short-term in domestic currency (Lustig et al., 2019). In contrast, we document that in emerging economies, these returns are positively correlated, both across countries and over time. We further show that default risk, proxied by credit default swap (CDS) spreads, does not play a significant role in shaping these comovement patterns. This evidence challenges leading portfolio balance models, originally developed for advanced economies, which imply a negative comovement between excess bond and currency returns due to their common exposure to short-term interest rate risk (Greenwood et al., 2023; Gourinchas et al., 2022).

We attribute the distinct comovement observed in emerging markets to the dominant role of *global investors*—those domiciled outside the country—in local-currency bond markets. The participation of global investors in these markets has grown substantially over time and, importantly, it exhibits greater volatility than that of domestic investors, unlike in advanced economies.[1] A central feature of global investors is that their bond market transactions are closely tied to foreign exchange transactions—a phenomenon we refer to as *correlated flows*. Using transaction-level data from Colombia's sovereign bond and foreign exchange markets, we show that when global investors purchase local-currency bonds, they simultaneously acquire domestic currency; conversely, they sell domestic currency when liquidating bond positions. Importantly, we find that these bond-related flows account for the majority of global investor activity in the spot foreign exchange market and they are *not* offset by transactions in the forward market, indicating that these positions are largely unhedged.

[1]We show that countries where global investors account for a larger share of the variation in bond flows tend to exhibit more positive comovement between excess bond and currency returns.

We develop a portfolio balance model in which global investors generate correlated flows across long-term bond and currency markets. Apart from this feature, the structure of our small open economy model follows Greenwood et al. (2023) and Gourinchas et al. (2022). In our model, local financial intermediaries absorbs net flows in both bond and currency markets, with a portion of these flows reflecting the correlated demand of global investors.

In equilibrium, returns on bonds and currencies are affected by two main sources of correlated risk. First, short-term interest rate risk affects bond and currency returns in opposite ways: an unanticipated increase in the local short-term interest rate lowers the price of long-term bonds while appreciating the domestic currency, thereby generating a negative correlation between excess bond and currency returns. Second, correlated flows from global investors simultaneously alter local intermediaries' exposure to both yield-curve trade and UIP trade, and thus induces positively correlated revisions in term and currency premia. For example, global investors' outflows lead local intermediaries to require higher excess bond and currency returns simultaneously—achieved through an equilibrium decline in bond prices and currency depreciation.

The covariance between bond and currency returns ultimately hinges on the relative strength of the two sources of risk outlined above. In countries where global investors account for a large share of the variation in bond flows—as in emerging economies—excess bond and currency returns tend to be positively correlated.

We derive testable implications from the model regarding asset returns and the trading behavior of different market participants, and we confront them with transaction-level data from Colombia's sovereign bond and foreign exchange markets. We begin by providing evidence that it is *local* financial intermediaries—rather than global banks—that primarily absorb imbalances in these markets. Using a rebalancing event in a major local-currency government bond index that triggered large purchases of long-term bonds by foreign investors, we show that local intermediaries absorbed the resulting demand in both bond and FX markets. During this episode, global investors simultaneously purchased Colombian government bonds and Colombian pesos, which were supplied by local primary dealers and FX market intermediaries. In many cases, the same financial institutions operates as dealers in both markets. Moreover, changes in their bond and FX positions are positively correlated, not only during the rebalancing episode but also more generally, consistent with the presence of correlated flows.

In addition, we measure the returns earned by these intermediaries between 2012 and 2019, conditional on changes in their positions. Consistent with the predictions of the model, changes in the positions of local intermediaries in bonds and FX market are positively correlated with subsequent movements in excess returns: when intermediaries accumulate a position in a given market, they earn significant and positive returns in that market. In contrast, purchases by global investors and other domestic investors (excluding intermediaries) are followed by declines in excess returns.

The correlation between bond and currency returns shapes the transmission of asset purchase policies, such as foreign exchange interventions (FXI) and quantitative easing (QE). We show that even if these policies are implemented in a single market, they can generate spillovers across both bond and currency markets if bond and currency returns reflect correlated risks. Because local intermediaries operate across markets, a shift in the net supply of one asset alters their aggregate exposure, influencing the premia they require in both asset classes. The direction and magnitude of these spillovers depend on the covariance structure of asset returns—ultimately governed by the relative strength of correlated global investor flows versus interest rate shocks.

In particular, when correlated flows dominate, a central bank purchase of foreign currency (FXI) increases intermediaries' exposure to "correlated flow risk" intrinsic in both yield-curve and UIP trades, thus leading to lower bond prices and currency depreciation. Analogously, a central bank purchase of government bonds (QE) reduces intermediaries' exposure to these risks, resulting in higher bond prices and an appreciation of the domestic currency.

We test these predictions using proprietary data from 641 central bank auctions conducted in Colombia between 2008 and 2014 for the central bank to acquire U.S. dollars. Exploiting a regression discontinuity design around the auction cutoff price, we find that winning an FXI auction, and thus selling dollar for pesos, leads to both a depreciation of the exchange rate and a decline in long-term bond prices in secondary markets (the identification involves comparing the secondary market trading behaviors of intermediaries that barely won and barely lost a given U.S. dollar auction). This is consistent with the model's prediction outlined above. These model implications also helps rationalize the empirical observation that central bank QE tends to appreciate the currency in emerging markets (Rebucci et al., 2022), but depreciate it in advanced ones (Bhattarai and Neely, 2022).

We emphasize that our findings have broader relevance beyond emerging markets, applying to any economy—or specific episodes—where foreign investors play a significant role in local-currency government bond markets.

Related literature We document that excess bond and currency returns are positively correlated in emerging economies, in contrast to evidence for advanced economies (Lustig et al., 2019).[2] Bond yields and exchange rates also display an opposite relationship in these two group of countries (Kekre and Lenel, 2024). Taking a portfolio-balance approach, Greenwood et al. (2023) and Gourinchas et al. (2022) propose that bonds and currencies exposure to interest rate risk implies a negative correlation in excess bond and currency returns.[3] We show that correlated flows in bond and currency markets—characteristic of global investors' behavior—force a positive correlation in bond and currency returns in otherwise standard models of portfolio balance, and rationalize micro-level patterns of flows in currency and bond markets as well as the observed effects of asset purchase policies in these economies.

We propose a new channel through which global investors in local-currency bond markets shape the dynamics of bond yields and exchange rates.[4] Carstens and Shin (2019) highlight that local-currency bonds shift currency mismatch from emerging market borrowers to foreign lenders, and propose a "U.S. dollar exchange rate risk-taking channel," by which U.S. dollar appreciations alter the risk-taking capacity of constrained global investors that evaluate returns in U.S. dollar terms (see also Bruno and Shin, 2015, and Hofmann et al., 2022a). This channel is consistent with Bertaut et al.'s (2024) evidence that international mutual funds reduce their holdings of emerging market local-currency bonds following dollar appreciations.[5] In contrast, we emphasize that local-currency bond markets change the patterns of flows that local intermediaries must absorb, influencing equilibrium bond yields and exchange rates. This mechanism formalizes how flows influence currencies in the thinking of market participants and policymakers, and operates whether or not global investors are constrained or whether or not they evaluate returns in U.S. dollar terms; hence, these are complementary channels.

Our proposed mechanism builds on transaction-level evidence of global investors exerting correlated pressure on bond and currency markets, absorbed by local intermediaries, and shaping the joint dynamics of bond yields and exchange rates. Our analysis is closely related to Hau and Rey's (2006) and Camanho et al.'s (2022) equilibrium analyses of exchange rates, equity prices, and equity flows. Consistent with the notion of correlated flows, Hau and Rey (2006) and Camanho et al. (2022) document that net equity flows

[2] See also Lloyd and Marin (2024).
[3] Zou (2024) examines the role of time-varying convenience yields in this class of models.
[4] A related literature studies the determinants and dynamics of a country's sovereign debt currency composition (Ottonello and Perez, 2019; Du and Schreger, 2022; Engel and Park, 2022).
[5] In the context of bond markets, some evidence shows that broad-based dollar appreciations around advanced economies' monetary policy announcements are associated with an increase in emerging market bond spreads and real activity (Hofmann et al., 2020) and a reduction in emerging market bond holdings by foreign investment funds (Hofmann et al., 2022b). In the context of equity markets, Bruno et al. (2022) show that exchange rate fluctuations also tend to amplify stock market returns in emerging market economies, once expressed in U.S. dollar terms.

into the foreign market are associated with a foreign currency appreciation.[6] At the same time, Hau and Rey (2006) documents a *negative* correlation between excess equity returns (differentials) and excess currency returns across 17 OECD economies, and interpret it through endogenous portfolio rebalancing: whenever foreign equity holdings outperform domestic holdings, domestic investors repatriate some of the foreign equity wealth to decrease the exchange rate exposure, leading to a foreign currency depreciation. Camanho et al. (2022) provides fund-level evidence in support of this channel. Rey and Stavrakeva (2024) proposes an exchange rate decomposition based on international equity market clearing conditions, and use it to characterize the transmission of U.S. macroeconomic and risk aversion news. Koijen and Yogo (2020) estimates a demand system to study exchange rates jointly with short-term rates, long-term yields and equity prices. Pandolfi and Williams (2019) examines how capital flows driven by mechanical rebalancings of benchmark indexes impact government bond prices, liquidity, and exchange rates. Williams (2018) uses Colombia's inclusion in *J.P. Morgan*'s emerging markets debt index to study how increased foreign access to sovereign debt markets boosts private credit availability.

This paper speaks to a broader literature on the role of global investors in emerging economies' real and financial fluctuations (Calvo et al., 1993), the determinants of short-term market rates (De Leo et al., 2024a), deviations from covered interest parity (De Leo et al., 2024b), deviations from uncovered interest parity (Kalemli-Ozcan, 2019; di Giovanni et al., 2021; Cormun and De Leo, 2024), sovereign and firm borrowing costs (Fang et al., 2024; Zhou, 2024; Morelli et al., 2022; Moretti et al., 2024; Morais et al., 2019), the patterns of capital flows (Avdjiev et al., 2022), and the co-movement of a country's long-term yields with global bond markets (Xu, 2024).

Furthermore, this paper belongs to a growing literature that emphasizes the key role of local banks in financial intermediation and asset prices determination in emerging economies, such as, for example, di Giovanni et al. (2021); Gutierrez et al. (2023); Keller (2024); De Leo et al. (2024b); Fendoglu et al. (2019).

2 Bond Yields and Exchange Rates in Emerging Economies

Across advanced economies, Lustig et al. (2019) document that returns to currency carry trade diminish as the bond maturities increase. This pattern points to a negative correlation between excess bond returns and excess currency returns in these economies. In contrast to

[6]The notion of correlated flows is also central in the identification strategy of Hau et al. (2010).

advanced economies, this section shows that emerging economies (EMs) feature a positive correlation between excess bond currency returns.

2.1 Correlation between bond and currency excess returns

Definitions We denote $P_t^{(n)}$ as the price of a zero-coupon bond of maturity n in local-currency terms at time t, with the continuously compounding yield on this bond given by $y_t^{(n)} = -\frac{1}{n}\log P_t^{(n)}$. The short-term risk-free rate r_t^f is the yield on a one-period bond.

The local-currency bond excess return on the domestic zero-coupon bond in local currency $rx_{t+1}^{(n)}$ is defined as:

$$rx_{t+1}^{(n)} = -(n-1)y_{t+1}^{(n-1)} + ny_t^{(n)} - r_t^f.$$

It represents the excess return on the "yield-curve trade"—the trade that borrows short-term and lends long-term in domestic currency.

We use Q_t to denote the nominal spot exchange rate in terms of domestic currency per U.S. dollar, where $\Delta q_{t+1} = \log\left(\frac{Q_{t+1}}{Q_t}\right)$ represents the rate of domestic currency depreciation.

The excess return on home currency, rx_{t+1}^q, is

$$rx_{t+1}^q = r_t^f - r_t^{f,US} - \Delta q_{t+1}.$$

It represents the return on the "UIP trade"—the trade that borrows short-term in foreign currency and lends short-term in domestic currency.

Data We select all emerging economies with bond benchmark indexes on *Datastream*. We use monthly data from January 2006 to December 2021.[7] The dataset includes spot exchange rates, 10-year government bond total return indexes, and 3-month deposit rates.[8] Our sample includes 8 countries that have available data for the above variables: Czech Republic, India, Indonesia, Mexico, Poland, South Africa, South Korea and Thailand.[9]

For comparison, when appropriate, we also include advanced economies, selected following the same criteria as emerging economies. Our sample of advanced economies includes Australia, Canada, Denmark, the Eurozone, Japan, New Zealand, Sweden, Switzerland, and the United Kingdom.

[7]While some countries' sample starts in December 1999, the data is sparse before 2006, and thus we start our analysis in 2006. We exclude data beyond December 2021 to avoid incorporating recent inflation dynamics.

[8]Note that the long maturity bond return data from *Datastream* may pertain to coupon government bonds.

[9]Datastream also has data on China. Given capital controls in China can distort foreign flows and correlated inflows, we exclude China from our analysis. All of our results are similar when including China to our sample.

Table 1
Foreign exchange and local-currency bond excess returns

	Annualized foreign exchange excess returns					
	Advanced economies			Emerging Markets		
	(1)	(2)	(3)	(4)	(5)	(6)
Annualized local-currency bond return	-0.42***	-0.73***	-0.42***	0.47***	0.29***	0.48***
(in local currency)	(0.06)	(0.09)	(0.06)	(0.07)	(0.06)	(0.07)
Time FE	No	Yes	No	No	Yes	No
Currency FE	No	No	Yes	No	No	Yes
N	1,719	1,719	1,719	1,161	1,161	1,161
R-squared	0.05	0.07	0.05	0.08	0.04	0.09

Note: Columns (1) and (4) of the table report the estimated slope coefficient for the following baseline regression $rx^{q}_{j,t+1} = \alpha + \beta rx^{(10y)}_{j,t+1} + \epsilon_{j,t+1}$. Columns (2) and (5) add time (month) fixed effects. Columns (3) and (6) add currency fixed effects. Standard errors are in parentheses. In all panels, HAC standard errors were used, allowing for 12-month autocorrelation. Significance stars follow conventional levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Analysis Table 1 report the estimated slope coefficients in a set of regressions of foreign exchange excess returns, $rx^{q}_{j,t+1}$, on local-currency bond excess returns, $rx^{(10y)}_{j,t+1}$. We report the results for three specifications: no fixed effects, time (month) fixed effects, currency fixed effects. Across all specifications, there is a negative association between local currency excess bond returns and currency excess returns for advanced economies, while there is a positive relationship in emerging economies. In emerging economies high excess bond returns are associated with high excess currency returns both in the cross-section of currencies and in the time series.

2.2 Does default risk explain the comovement in bond-currency returns?

A possible explanation for the positive association between bond and currency excess returns in emerging economies is default risk. An increase in default risk can lead to lower excess returns on both bonds and currencies, driven by currency depreciation and lower bond prices.

Using credit default swaps (CDS) to measure default risk, we show that default risk is not the primary driver of the relationship between excess bond and currency returns in emerging economies. Table 2 incorporates CDS spreads as a control in the baseline regression analysis. The positive correlation between bond and currency returns remains, whether or not one includes time or country fixed effects. While multicollinearity could be a potential concern, the low correlations between CDS spreads and excess bond returns ($\rho = -0.03$) and between CDS spreads and excess currency returns ($\rho = 0.07$) mitigate this issue.

To isolate returns from default risk, we regress excess currency returns on CDS spreads to derive residuals representing excess currency returns net of default risk, and similarly

Table 2
Foreign exchange and local-currency bond excess returns: CDS spreads

	Annualized foreign exchange excess returns					
	Emerging E. (w/o CDS spreads)			Emerging E. (w/ CDS spreads)		
	(1)	(2)	(3)	(4)	(5)	(6)
Annualized local-currency bond return	0.47***	0.29***	0.48***	0.51***	0.31***	0.51***
(in local currency)	(0.07)	(0.06)	(0.07)	(0.07)	(0.07)	(0.07)
CDS spread (%)				4.59***	2.94**	7.31**
				(1.72)	(1.34)	(3.00)
Time FE	No	Yes	No	No	Yes	No
Currency FE	No	No	Yes	No	No	Yes
N	1,161	1,161	1,161	942	942	942
R-squared	0.08	0.04	0.09	0.10	0.05	0.11

Note: The first three columns show the slope of baseline regression $rx^{q}_{j,t+1} = \alpha + \beta rx^{(10y)}_{j,t+1} + \epsilon_{j,t+1}$ using different sets of fixed effects. The last three columns add to the baseline regression credit default swaps as controls and also reports those coefficients for various sets of fixed effects. Standard errors are in parentheses. In all panels, HAC standard errors were used, allowing for 12-month autocorrelation. Significance stars follow conventional levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

regress bond excess returns on CDS spreads to obtain excess bond returns net of default risk. Figure A.3 depicts the relationship between currency and bond excess returns after accounting for default risk. The scatterplot of these residuals confirms that the positive correlation between bond and currency excess returns persists, reinforcing the conclusion that default risk does not account for the bulk of this relationship.

We further investigate the relationship between excess bond and currency returns by categorizing CDS spreads into low, medium, and high groups based on relative CDS levels within each country. Specifically, Panel A of Table 3 sorts each country's excess returns into CDS buckets according to its own historical CDS spreads over time. The positive correlation between bond and currency excess returns persists even during periods when countries experience low CDS levels relative to their own history. This relationship appears robust and is not driven by specific dates or countries. Across all CDS environments (low, medium, and high relative to a country's history), the positive correlation remains significant, even after controlling for month and country (currency) fixed effects.

Panel B of Table 3 extends this analysis by categorizing CDS spreads at the monthly level. In this framework, countries are sorted into low, medium, and high CDS groups within each month, enabling a cross-sectional analysis where all countries are compared relative to one another during the same time period. The positive correlation between bond and currency excess returns persists. Similar to the results obtained when sorting CDS spreads by country, these correlations are not attributable to specific countries or particular dates.

Table 3
Correlation of bond and foreign exchange excess returns sorted by CDS spread

Panel A: Correlation of excess returns: CDS spreads sorted by country

	Annualized foreign exchange excess returns								
	Low CDS spread			Medium CDS spread			High CDS spread		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Annualized local-currency bond return	0.57***	0.29*	0.57***	0.55***	0.15	0.54***	0.79***	0.49**	0.80***
(in local currency)	(0.14)	(0.15)	(0.15)	(0.13)	(0.15)	(0.13)	(0.12)	(0.20)	(0.13)
Time FE	No	Yes	No	No	Yes	No	No	Yes	No
Currency FE	No	No	Yes	No	No	Yes	No	No	Yes
N	263	229	263	216	159	216	199	139	199
R-squared	0.13	0.04	0.13	0.16	0.02	0.15	0.20	0.10	0.20

Panel B: Correlation of excess returns: CDS sorted each month

	Annualized foreign exchange excess returns								
	Low CDS spread			Medium CDS spread			High CDS spread		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Annualized local-currency bond return	0.21**	0.19	0.24**	0.59***	0.28*	0.58***	0.81***	0.51**	0.82***
(in local currency)	(0.10)	(0.15)	(0.10)	(0.14)	(0.16)	(0.14)	(0.10)	(0.24)	(0.11)
Time FE	No	Yes	No	No	Yes	No	No	Yes	No
Currency FE	No	No	Yes	No	No	Yes	No	No	Yes
N	336	292	336	242	180	242	267	230	267
R-squared	0.02	0.02	0.03	0.13	0.05	0.13	0.27	0.11	0.27

Note: Panel A and Panel B show the correlation between the FX excess returns and local currency bond excess returns for emerging market countries, sorted by either their own sample-average CDS spreads (Panel A) or by its CDS magnitude across countries within the same month (Panel B).
Standard errors are in parenthesis. In all panels, HAC standard errors were used, allowing for 12-month autocorrelation. Significance stars follow conventional levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3 Global Investors and Correlated Flows

A potential explanation for the comovement documented in Section 2 hinges on the important role of global investors in local-currency bond markets of emerging economies. To purchase local currency bonds, these investors purchase domestic currency, giving rise to positively correlated flows into bond and foreign exchange spot markets.

3.1 Global investors in local-currency bond markets

There is extensive evidence on the increased share of foreign investors in emerging economies' local-currency bond markets (*e.g.*, Carstens and Shin, 2019). Foreign investors held about 20% of outstanding local-currency sovereign debt on average in 2019, with some emerging markets reaching 40% (So et al., 2019).

In this section, we present evidence on their importance relative to other domestic investors,

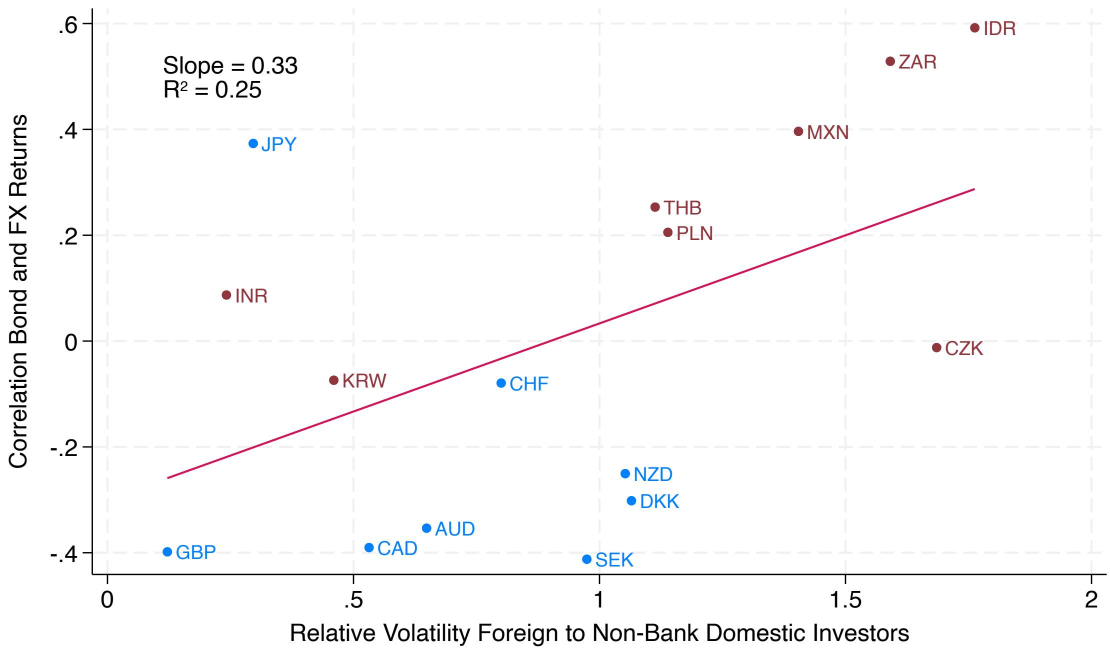
Table 4
Volatility of Foreign and Domestic Investors in Local-Currency Bond Markets

Country	Foreigners (Std. Dev. Share)	Domestic Non-Bank (Std. Dev. Share)	Ratio (1)/(2)
Emerging Markets (median)	**8.19%**	**6.72%**	**1.27**
Argentina	10.49%	8.33%	1.26
Brazil	3.99%	3.52%	1.13
Chile	4.73%	10.81%	0.44
China	4.02%	1.46%	2.76
Colombia	7.87%	8.68%	0.91
Czech Republic	6.90%	4.10%	1.69
Egypt	11.16%	8.09%	1.38
Hungary	11.60%	6.70%	1.73
India	1.12%	4.63%	0.24
Indonesia	11.68%	6.63%	1.76
Korea	5.37%	11.68%	0.46
Malaysia	5.03%	3.94%	1.28
Mexico	12.44%	8.85%	1.40
Peru	13.71%	4.90%	2.80
Philippines	3.66%	4.94%	0.74
Poland	8.51%	7.47%	1.14
Romania	4.50%	7.67%	0.59
Russia	9.55%	9.39%	1.02
Slovenia	14.46%	11.84%	1.22
South Africa	9.89%	6.22%	1.59
Thailand	4.22%	3.79%	1.11
Turkey	6.94%	3.68%	1.89
Ukraine	10.36%	6.75%	1.53
Uruguay	13.09%	7.47%	1.75
Advanced Economies (median)	**6.71%**	**8.94%**	**0.74**
Australia	6.97%	10.74%	0.65
Canada	3.27%	6.15%	0.53
Denmark	6.45%	6.05%	1.06
Japan	3.50%	11.80%	0.30
New Zealand	8.74%	8.31%	1.05
Norway	9.38%	10.78%	0.87
Sweden	8.81%	9.05%	0.97
Switzerland	7.07%	8.83%	0.80
United Kingdom	2.96%	24.28%	0.12
United States	3.91%	5.82%	0.67

Note: This table contains the standard deviation in the share of local-currency sovereign debt securities by foreigners (column 1) and non-bank domestic investors (column 2) using data from Arslanalp and Tsuda (2012) and Arslanalp and Tsuda (2014b). Column 3 presents the ratio between these two numbers. For advanced economies, we assume that all outstanding sovereign debt securities are issued in local-currency.

especially comparing emerging and advanced economies. Using the data on emerging and advanced market debt from Arslanalp and Tsuda (2014a) and Arslanalp and Tsuda (2012),

Figure 1
Relative Volatility of Global Investors and Comovement in Excess Returns



Note: This figure displays the correlation of bond and currency excess returns (y-axis) and the the ratio of foreign to non-bank domestic investor share standard deviation (x-axis). Countries in red (blue) are part of the emerging (advanced) economies sample.

respectively, we compute the share of foreign investors in local-currency government debt securities. Additionally, we construct the share of non-bank domestic investors (excluding both banks and central bank holdings).[10] We focus on non-bank domestic investors, as we later show that domestic banks act as dealers in long-term bond and currency markets. Then, for each country in our sample, we calculate the standard deviation of both foreign and non-bank domestic investors, which we present in Table 4.

Table 4 highlights the larger relative volatility of foreign investors compared to domestic investors in emerging economies. While there is considerable variation across emerging economies, the average (median) ratio of the standard deviation of the foreign to non-bank domestic share of local-currency sovereign debt is 1.33 (1.27). In contrast, in advanced economies, non-bank domestic investors tend to be more volatile than foreign investors, with an average (median) ratio of 0.7 (0.74). Foreign investors play a more significant role in terms of overall volatility in emerging economies compared to non-bank domestic investors.

Furthermore, the relative volatility is related to the comovement of bond and currency returns that we highlight in Section 2. Figure 1 plots the correlation in bond and currency

[10]For emerging economies, we construct these shares based on the share of non-bank domestic investors for all sovereign debt since there is no breakdown for local-currency government debt securities.

returns for each sample country against the ratio of foreign to non-bank domestic investor share standard deviation. One can clearly observe a positive association between both variables, as countries that have a higher relative volatility of foreign investors also display a more positive correlation in bond and currency excess returns. The model outlined in Section 4 highlights that relative volatility is the relevant measure of global investors' relevance in local-currency bond markets, and it is indeed positively related to the equilibrium correlation in excess bond and currency returns.

3.2 Correlated flows in bond and currency markets

Given the significant role of foreign investor flows in local-currency bond markets, we dig deeper into the characteristics of these flows. To this end, we leverage transaction-level data from Colombia's government bond and foreign exchange markets, which provide insights into foreign investors' behavior in both arenas. Colombia offers a representative example of a small open economy with levels of foreign participation in its sovereign bond market comparable to those of other emerging markets.

3.2.1 Institutional setup and data

Government bonds (*Títulos de Tesorería*, TES) Since the 2000s, the majority of Colombia's sovereign debt is denominated in domestic currency (COP). For instance, in 2020, the total fiscal debt reached USD 177 billion, equivalent to approximately 65% of GDP. Two-thirds of total debt was denominated in COP, comprising 20% in inflation-adjusted bonds and 46% in standard COP-denominated instruments.

The *Ministry of Finance* annually publishes rankings of financial sector participants competing for inclusion in the "primary dealers" (PD) program for TES. Due to limited membership, only institutions ranked above a specified threshold—10^{th} place prior to 2022, and 15^{th} place thereafter—qualify as primary dealers. On average, the primary market issues approximately COP 300 billion (less than USD 100 million) worth of TES bonds daily. In contrast, the secondary market for TES, detailed below, experiences a significantly higher daily turnover of around COP 2 trillion (USD 500 million).

Colombia foreign exchange market (FX) The COP-USD spot and forward interdealer market in Colombia is highly centralized. A single electronic trading platform, *SET-ICAP FX*, accounts for approximately 95% of total market volume. Offshore trading is restricted by regulatory measures. Transactions in the foreign exchange market are restricted to authorized dealers (*Intermediarios del Mercado Cambiario*, IMC). Consequently, all market participants must conduct transactions through one of these 50 authorized dealers. These intermediaries include banking institutions, financial corporations, financial cooperatives, and stock brokerage firms. On average, the daily turnover for the spot market is USD 1.5 billion, while the forward market sees a turnover of USD 4 billion.

Colombia micro-level data We use several datasets to perform our analysis. Transactions involving purchases and sales of TES in the secondary market take place on two trading platforms: (i) the Colombian Electronic Market (MEC), operated by the Colombian Stock Exchange, and (ii) the Electronic Trading System (SEN), managed by the Central Bank of Colombia. All trades executed on these platforms are registered in the Central Securities Depository (DCV), overseen by the Central Bank of Colombia. To identify trades involving foreign investors, we use data from the "Declarations of Foreign Exchange Transactions" (*Declaraciones de Cambio*), which records all transactions involving foreign exchange and is compiled by the Technical and Economic Information Department of the Central Bank of Colombia. Additionally, we analyze FX Spot, Next-Day, and Forward markets in the interdealer market using data from *SET-ICAP FX*.[11]

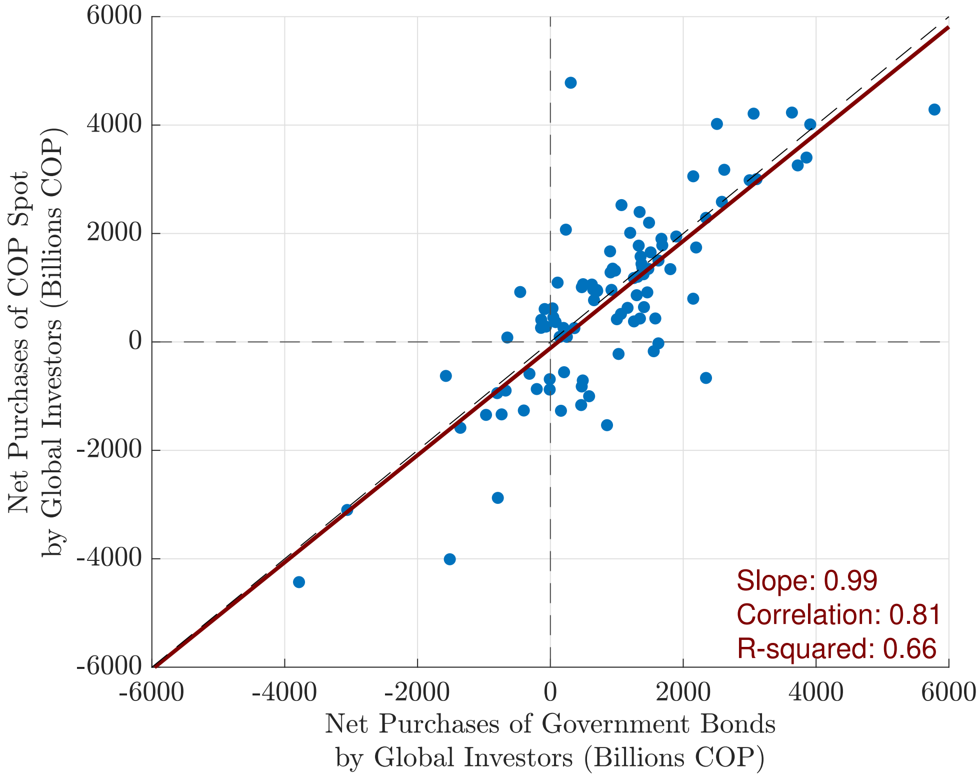
3.2.2 Evidence on correlated flows in bond and currency markets

Central to our analysis is the simple observation that when foreign investors purchase local-currency government bonds, they simultaneously need to purchase COP through the foreign exchange market. Figure 2 plots the monthly-level foreign investor purchases of COP (in exchange for foreign currency) through the FX market (y-axis) together with the foreign purchases of TES through the secondary market for government bonds (x-axis).[12] Purchases in both markets from foreign investors align tightly around the 45-degree line. A regression of COP purchases by foreigners on TES purchases by foreigners has a slope that is statistically not different from 1, with an R-squared of 65%. Overall, this evidence suggests that foreign flows to local-currency sovereign bond markets occur simultaneously with flows to the spot FX market. In addition, it suggests that a large portion of spot FX market transactions by foreign investors is due to their purchase or sale of Colombia sovereign bonds. We denote the occurrence of these simultaneous flows as "correlated flows."

[11] A challenge we face is that, while TES trades can be directly attributed to individual foreign investors, FX transactions may be conducted either directly by these investors or through intermediaries, obscuring the identity of the ultimate buyer. Consequently, it is not possible to establish a precise link between FX transactions and TES trades at the individual transaction level.

[12] For context, during this period total outstanding debt in TES market was around COP 250 trillion, and around one-quarter of it was held by global investors.

Figure 2
Correlated Flows in TES and COP Spot Markets

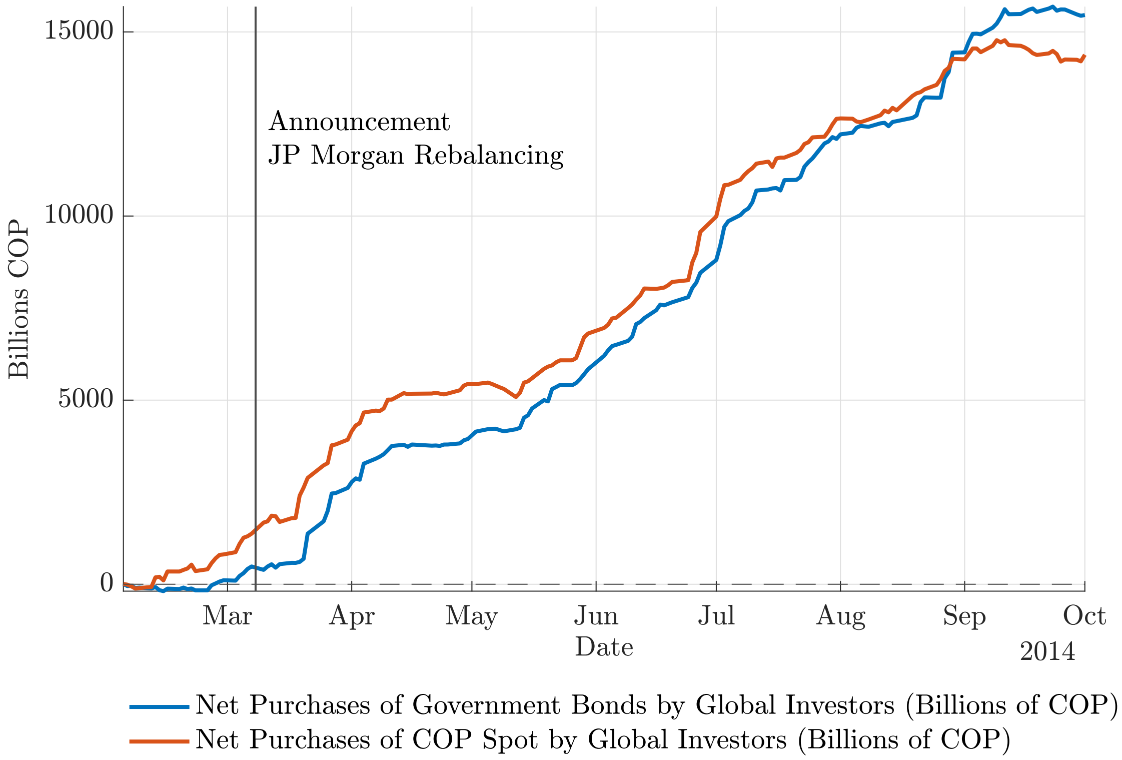


Note: This figure displays the monthly net purchases of TES bonds by global investors in billions COP (x-axis) and the monthly net purchases of COP in the spot market by global investors (y-axis). "Slope" is the estimate of the slope of a linear regression of the y-axis variable on the x-axis variable, with the corresponding R-squared.

Correlated flows during episode of large foreign purchases of local-currency bonds

We provide further evidence of these correlated flows through an episode of significant foreign investor purchases of TES. In March 2014, J.P. Morgan announced the inclusion of five Colombian local-currency government bonds in its flagship benchmark index for emerging market local-currency government bonds. This resulted in massive purchases by index-tracking investors, who acquired nearly 10% of the outstanding TES bonds from the announcement until the full inclusion was effective in October 2014 (Williams, 2018). Figure 3 illustrates foreign investor purchases of both TES and COP (in the spot market) during this period. The two lines track each other closely, with the volume of purchases in both markets being very similar. This shock plausibly originates in the local-currency bond market and spills over into the FX market through correlated flows from foreign investors.

Figure 3
Purchases of TES and COP in J.P. Morgan Rebalancing



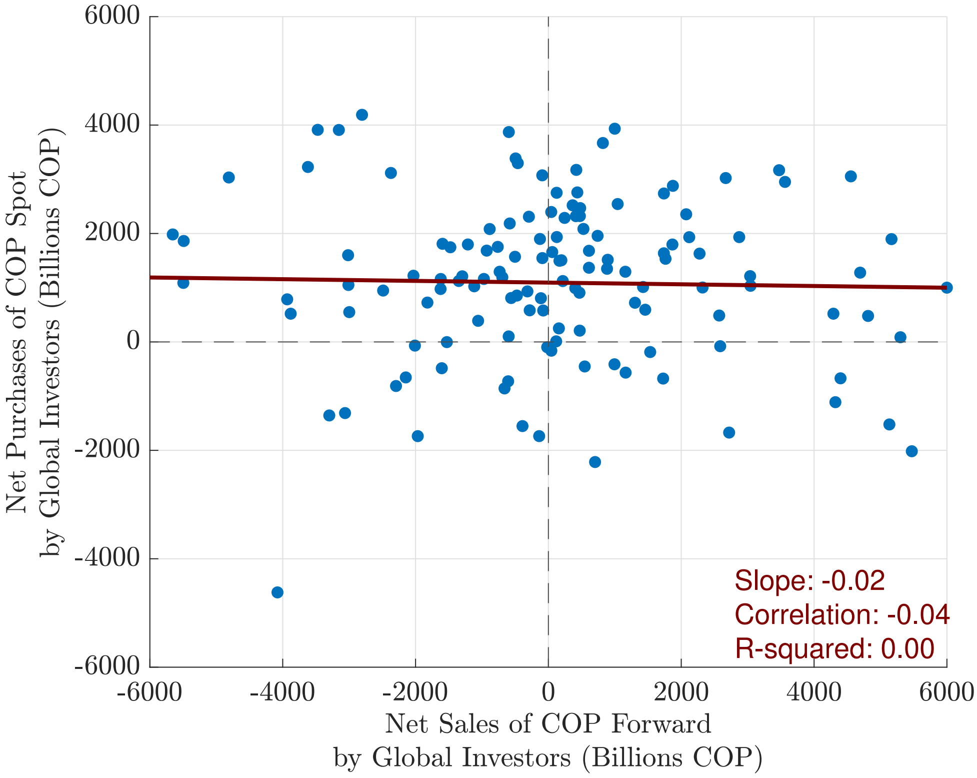
Note: This figure displays the evolution of the daily accumulated foreign purchases of of TES bonds together with the daily accumulated foreign purchases of COP in the spot market during the J.P. Morgan rebalancing in 2014. The black vertical line denotes 19th of March 2014, the day the rebalancing was announced.

3.3 Do global investors hedge emerging market currency risk?

Correlated flows from foreign investors may have limited implications for currency markets overall if foreign investors systematically hedge their domestic currency exposure by selling it in forward markets to offset their spot market purchases of COP. As a result, their net exposure to the local currency—and that of other investors—may not necessarily change with flows into the government bond market. To investigate this, we analyze data from Colombia's forward markets as well as from international mutual funds' bond holdings and currency derivative usage.

Figure 4 reports foreign investor purchases of COP in the spot market (on the y-axis) and their sales of COP in the forward market (on the x-axis). If all foreign investor purchases in the spot market were fully hedged in the forward market, we would observe the data points to align along the 45-degree line, while a partial hedge would result in a positive relationship between the two variables. However, we observe no consistent relationship, indicating that

Figure 4
Purchases of COP Spot and Sales in Future Markets



Note: This figure displays the monthly-level foreign purchases of COP in the spot market (x-axis) and the monthly-level foreign sales of COP in the forward market (y-axis). Slope is the slope of a regression of the y-axis variable on the x-axis variable, with the corresponding R-squared.

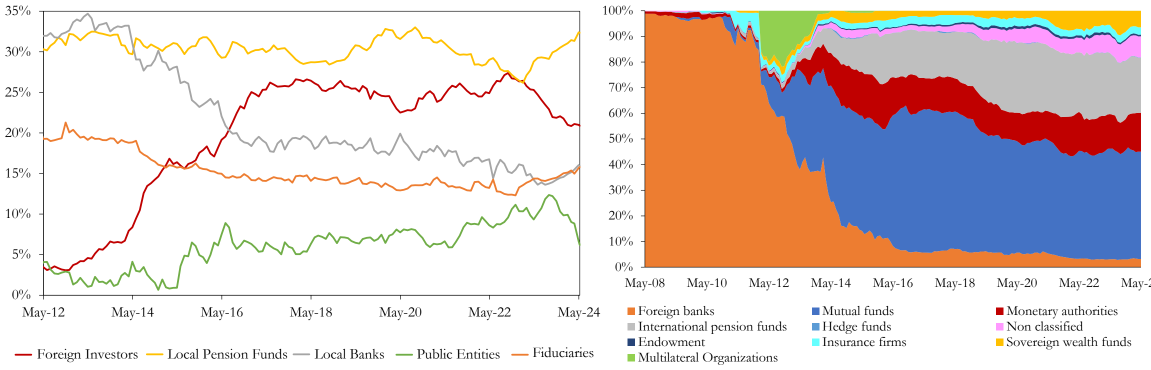
foreign investors are not systematically hedging their positions.[13]

Our evidence from Colombia suggests that foreigners tend to produce correlated flows in bond and currency markets. Additionally, the extent of currency hedging from foreigners that purchase local-currency government bonds seem negligible. We next explore the extent of currency hedging by foreign investors exploring data beyond Colombia.

EM currency risk management of foreign investors First, we identify the type of foreign investors operating in Colombia's sovereign bond market. As shown in Figure 5a, foreign participation in Colombia's bond market was limited before 2012 but increased significantly thereafter. This growth was partly driven by regulatory reforms implemented between 2010 and 2013, which facilitated investment through local managers and simplified tax reporting for fixed-income securities. Furthermore, a 2012 tax reform reduced income tax

[13]This evidence, including the observation that foreign investors' transactions in the forward exchange market are around three times larger than their transactions in the spot exchange market, aligns with De Leo et al.'s (2024b) analysis, which suggests that foreign investors primarily utilize the forward market for currency speculation rather than for hedging purposes.

Figure 5
Participation in the Colombian TES market



(a) Total bond holdings by entity (b) Bond holdings across foreign investors

Note: The data presented correspond to all trades registered with the Central Securities Depository (DCV), which operates under the supervision of the Central Bank of Colombia. Panel A shows the TES participation (percentage of total outstanding TES volume) across major entities, while Panel B focuses specifically on the share held by foreign investors, detailing the distribution among different types of foreign investors within the total foreign share.

on TES for non-resident investors from 33% to 14%. The country's investment-grade credit rating, awarded in 2011 by credit rating agencies such as *S&P*, *Moody's*, and *Fitch Ratings*, and its increased weight in *J.P. Morgan*'s emerging market debt indices in 2014, also played a key role in attracting international capital.

Figure 5b shows the share of bond holding across foreign investors. Before 2014 foreign banks held the largest share of sovereign bonds among foreign investors, although their overall market participation was relatively low. Since 2014, mutual funds have become the dominant investors, followed by international pension funds and monetary authorities, collectively holding about 80% of the foreign investor base, which is now more significant relative to the total outstanding debt.

Overall, foreign investors that participate in the TES market in Colombia are primarily institutional investors such as mutual and pension funds.[14] We thus explore the extent of currency hedging by global mutual funds that are present in emerging economies local-currency bond markets. We use data from *Morningstar Direct* to collect information on hedging patterns of international mutual funds investing in fixed income. Table 5 displays summary statistics for foreign funds investing in advanced and emerging economies fixed income such as government bonds. For advanced economies (left panel), we observe a significant amount of hedging for these funds with a total hedging of 27%. This is largely consistent with the evidence in Sialm and Zhu (2024).

[14] Fang et al. (2024) show that non-banks—private investors who are not banks—drive most of the variation in foreign holdings of emerging market sovereign debt. Similarly, investment and mutual funds explain the bulk of the variation in Euro Area investors' holdings of emerging market sovereign debt.

Table 5
Hedging Ratios of Foreign Mutual Funds and ETFs

Holdings of AEs' Fixed Income				Holdings of EMs' Fixed Income (local currency)			
Top-20 AEFI holdings	***Type***	***USD bn***	***% hedged***	***Top-20 EMFI holdings***	***Type***	***USD bn***	***% hedged***
iShares	ETF	112.59	25.6%	PIMCO	ETF	4.67	0.0%
JPMorgan	OEF	31.45	18.7%	Colchester	OEF	4.28	2.1%
AllianceBernstein	OEF	28.78	13.6%	BlackRock	OEF	3.93	7.0%
UBS	OEF	20.45	46.9%	Degroof Petercam	OEF	3.68	0.0%
Fidelity International	OEF	15.94	16.4%	State Street	OEF	3.59	0.0%
PIMCO	OEF	15.76	27.9%	State Street	OEF	3.28	0.0%
Vanguard	ETF	12.76	32.3%	iShares	ETF	3.27	0.0%
State Street	ETF	10.92	3.0%	Legal & General	ETF	3.17	0.0%
BlackRock	OEF	10.38	50.8%	VanEck	OEF	2.77	0.0%
AXA IM	OEF	10.26	34.7%	Pictet	OEF	2.20	10.2%
Lord Abbett	OEF	9.63	7.3%	HSBC	OEF	2.09	7.2%
Xtrackers	ETF	8.29	51.8%	Deka	ETF	2.03	0.0%
Amundi	OEF	7.46	28.9%	Ninety One	OEF	1.95	10.0%
Neuberger Berman	OEF	7.45	45.9%	LGT	OEF	1.82	25.0%
Nomura	OEF	7.40	24.7%	Aktia	OEF	1.81	0.0%
Amundi	ETF	6.97	42.5%	Franklin Templeton	ETF	1.81	6.7%
Nordea	OEF	6.79	86.8%	Barings	OEF	1.72	1.4%
JPMorgan	ETF	6.71	51.3%	Capital Group	ETF	1.64	0.1%
Goldman Sachs	OEF	6.16	12.2%	Ashmore	OEF	1.43	29.0%
UBS	ETF	6.13	48.7%	abrdn	ETF	1.34	0.0%
Total Top-20		342.31	28.3%	Total Top-20		52.49	3.7%
All other		120.24	23.1%	All other		24.70	7.4%
TOTAL		***462.55***	***26.9%***	***TOTAL***		***77.76***	***4.9%***
Mean (Top-50)		*8.36*	*28.3%*	*Mean (Top-50)*		*1.48*	*6.7%*
Standard Deviation (Top-50)		*16.24*	*26.1%*	*Standard Deviation (Top-50)*		*1.15*	*11.4%*
25th Percentile (Top-50)		*2.02*	*6.3%*	*25th Percentile (Top-50)*		*0.61*	*0.0%*
Median (Top-50)		*3.58*	*25.1%*	*Median (Top-50)*		*1.04*	*0.2%*
75th Percentile (Top-50)		*7.46*	*46.7%*	*75th Percentile (Top-50)*		*1.92*	*8.4%*

Notes: The table reports information on hedging practices by global mutual funds and exchange-traded funds that invest in emerging and advanced economies' fixed-income securities. The data sources is *Morningstar Direct*. For emerging economies, we include only funds that belong to 'local currency bonds' category of *Morningstar*. We exclude funds that invest in their country of origin.

We also provide a similar analysis for international mutual funds and ETFs that invest in local-currency emerging market government bonds (right panel). The hedging ratios for these fixed income funds are substantially smaller than those that invest in advanced economies. The total hedging ratio is slightly below 5%, with the median fund almost not hedging at all. This evidence is consistent with the little amount of currency hedging by foreign investors that purchase local treasury bonds in Colombia, and suggests that currency hedging by institutional investors that target local-currency emerging market bonds is limited, in line with the evidence in Chen and Zhou (2025).

This behavior is consistent with the fact that foreign investors are typically attracted to emerging markets by the significantly higher interest rate differentials compared to advanced economies. Hedging currency risk in such scenarios is costly, as it effectively involves paying away the interest rate differential.[15] Moreover, several emerging economies (sovereign and corporates) issue debt in U.S. dollars, offering an alternative to buying local-currency assets with (costly hedging), which could be part of the explanation on the difference in hedging ratios across these types of countries.

In summary, global investors play a significant role in the local-currency bond markets of emerging economies, and, notably, they exhibit correlated flows in both bond and currency markets, with minimal to no hedging in the forward exchange market. We next incorporate these dynamics into a portfolio-balance model.

4 Bond and Currency Premia in a Model of Correlated Flows

Our baseline model extends the portfolio-balance models of Greenwood et al. (2023) and Gourinchas et al. (2022) to a setting with correlated flows in bond and foreign exchange market, consistent with the micro-level evidence from Section 3.[16]

In our small-open economy model, sovereign bond and foreign-exchange markets are integrated with one another but segmented from other financial markets. A group of local intermediaries trades in both of these markets, conducting both the "yield-curve trade"—the trade that borrows short-term and lends long-term in domestic currency—and the "UIP trade"—the trade that borrows short-term in foreign currency and lends short-term in domestic currency. These two distinct trades are exposed to two sources of risk: interest rate risk, as in Greenwood et al. (2023) and Gourinchas et al. (2022), and risk associated with correlated flows due to global investors in local-currency bond markets.

In this section, we show that interest rate risk and correlated flows imply opposite correlations between bond and currency returns. If advanced and emerging economies are differently exposed to these sources of risk, they would present different comovement patterns, consistent with Section 2. In Section 5 we present additional testable implications of the model and confront it with data from Colombia's long-term local-currency bond and foreign exchange markets. In Section 6 we present the model's implication for the asset price effects

[15]This has led many investment advisors, such as Meketa Investment Group (2022) to recommend clients to avoid hedging currency exposure in emerging markets, while suggesting hedging is more appropriate for investments in advanced economies.

[16]Greenwood et al. (2023) and Gourinchas et al. (2022) build on Vayanos and Vila (2021) and Gabaix and Maggiori (2015).

of asset purchase policies.

4.1 Baseline Model

The discrete-time small-open economy model includes four financial assets: domestic and foreign short- and long-term bonds, denominated in their respective currency. There are two types of agents: local and global bond investors and local intermediaries. Bond investors have a preference— resulting in inelastic demand—for assets of specific currencies and maturities. Local intermediaries, on the other hand, are specialized investors who absorb the net supply of domestic long-term bonds and foreign exchange resulting from exogenous demand shocks. Consistent with the small open economy setting, the returns on foreign short- and long-term bonds, such as U.S. dollar treasuries, follow an exogenous process. We follow Greenwood et al. (2023) and express returns in logs.

Short-term bonds Short-term bonds in both currencies are supplied perfectly elastically, and short-term interest rates are determined exogenously according to AR(1) processes with potentially correlated shocks:

$$i_{t+1} = \bar{\imath} + \phi_i(i_t - \bar{\imath}) + \varepsilon_{i_{t+1}}; \tag{1}$$

$$i^\star_{t+1} = \bar{\imath} + \phi_i(i^\star_t - \bar{\imath}) + \varepsilon_{i^\star_{t+1}}, \tag{2}$$

where $\bar{\imath} > 0$, $\phi_i \in (0, 1)$, $\text{var}_t[\varepsilon_{i_{t+1}}] = \text{var}_t[\varepsilon_{i^\star_{t+1}}] = \sigma_i^2 > 0$, and $\text{corr}[\varepsilon_{i_{t+1}}, \varepsilon_{i^\star_{t+1}}] = \rho \in [0, 1]$.

Long-term bonds Long-term bonds are default-free perpetuities whose payments decline geometrically. The domestic currency return on long-term domestic bonds from t to $t+1$ is

$$r^y_{t+1} = y_t - \frac{\delta}{1-\delta}(y_{t+1} - y_t) - g_t, \tag{3}$$

where y_t is the log yield-to-maturity on domestic long-term bonds, and parameter $\delta \in (0, 1)$ is the bond's payment decline rate.[17] Equation (3) expresses the bond's return as consisting of three components: (i) a carry component, y_t; (ii) a capital gain component, $\frac{\delta}{1-\delta}(y_{t+1} - y_t)$; and (iii) a stochastic, time-varying wedge to bond returns, g_t. This last term introduces a time-varying wedge in the price of domestic long-term bonds without directly influencing the fundamental value of the exchange rate. It can be interpreted as a time-varying tax on local-currency bond returns, or a time-varying convenience yield, and does not play an

[17] Equation (3) is derived in Appendix B.1 and uses Campbell and Shiller (1988) approximation for log returns.

essential role in the analysis. This time-varying wedge in bond returns follows:

$$g_t = \phi_g g_{t-1} + \varepsilon_{g_t}, \tag{4}$$

where $\phi_g \in [0, 1)$, and $\text{var}_t[\varepsilon_{g_t}] = \sigma_g^2 \geq 0$

Let rx^y_{t+1} denote the excess return on domestic bonds, that is the return on the "yield-curve trade"—the trade that borrows short-term and lends long-term in domestic currency. Iterating equation (3) forward and taking expectations, one obtains:

$$y_t = (1-\delta)\sum_{j=0}^{\infty}\delta^j \,\mathrm{E}_t[i_{t+j} + rx^y_{t+j+1} + g_{t+j}], \tag{5}$$

which indicates that the domestic long-term yield can be decomposed into the standard expectations hypothesis and term premium components, as well as a term that accounts for all current and future expected wedge ("taxes") on bond returns.

The yield on foreign long-term bond is determined as

$$y^\star_t = (1-\delta)\sum_{j=0}^{\infty}\delta^j \,\mathrm{E}_t[i^\star_{t+j} + rx^{y,\star}_{t+j+1}], \tag{6}$$

where $rx^{y,\star}_{t+j+1}$ is exogenous from the perspective of the small open economy. For simplicity, we assume that local intermediaries do not hold foreign long-term bonds.

Foreign exchange Let q_t denote the log nominal exchange rate, expressed as units of home currency per unit of foreign currency. The log excess return on home currency, i.e. on the "UIP trade"—the trade that borrows short-term in foreign currency and lends short-term in domestic currency, is:

$$rx^q_{t+1} = (i_t - i^\star_t) - (q_{t+1} - q_t). \tag{7}$$

Iterating this expression forward and taking expectations yields:

$$q_t = \sum_{j=0}^{\infty}\mathrm{E}_t[(i^\star_{t+j} - i_{t+j}) + rx^q_{t+j+1}] + \mathrm{E}_t\, q_{t+\infty}. \tag{8}$$

Equation (8) expresses the exchange rate as the sum of three components: (i) the expected future sum of interest rate differentials, *i.e.* the UIP component; (ii) a foreign exchange risk premium; and (iii) the expected long-run nominal exchange rate. We assume that the long-term nominal exchange rate follows a random walk. That is:

$$q_{t+\infty} = \varepsilon_{q_t}, \tag{9}$$

where $\text{var}_t[\varepsilon_{q_t}] = \sigma_q^2 \geq 0$. Time variation in the long-term value of the nominal exchange rate introduces an additional, yet independent, source of risk for the UIP trade. While it is unmodeled here, time variation in the value of the long-term nominal exchange rate arises naturally in open-economy macroeconomic models with differential inflation rates across countries, while maintaining real exchange rate stationarity.

Local intermediaries Local intermediaries are the marginal investors in domestic long-term bond and foreign exchange market. They maximize their next-period wealth through mean-variance preferences with a risk tolerance parameter τ. Let d_t^y denote the market value of the intermediary' holdings of long-term domestic bonds and d_t^q denote the value of the intermediary's position in the borrow-foreign and lend-domestic FX trade, all denominated in domestic currency. Defining $\mathbf{d}_t \equiv [d_t^y, d_t^q]'$ and $\mathbf{rx}_{t+1} \equiv [rx_{t+1}^y, rx_{t+1}^q]'$, intermediaries solve:

$$\max_{\mathbf{d}_t} \left\{ \mathbf{d}_t' \, \text{E}_t[\mathbf{rx}_{t+1}] - \frac{1}{2\tau} \mathbf{d}_t' \, \text{var}_t[\mathbf{rx}_{t+1}] \mathbf{d}_t \right\}, \tag{10}$$

Taking first-order condition yields the optimality condition faced by local intermediaries:

$$\text{E}_t[\mathbf{rx}_{t+1}] = \tau^{-1} \, \text{var}_t[\mathbf{rx}_{t+1}] \mathbf{d}_t. \tag{11}$$

Equation (11) links the intermediaries' expected excess returns on different assets to their asset holdings. The variance-covariance matrix of excess returns governs the equilibrium relationship of excess returns across the yield-curve trade and the UIP trade.

Net supplies and correlated flows In each period, domestic long-term bonds are available in a given net supply, denoted as s_t^y, which is equal to their gross issuance minus the demand from bond investors. The net supply of domestic long-term bonds follow AR(1) process:

$$s_{t+1}^y = \bar{s}^y + \phi_{s^y}(s_t^y - \bar{s}^y) + \varepsilon_{s_{t+1}^y}. \tag{12}$$

where $\bar{s}^y > 0$, $\phi_{s^y} \in [0, 1)$, $\varepsilon_{s_{t+1}^y} = \eta_{t+1} + \eta_{t+1}^\star$, $\text{var}_t[\varepsilon_{s_{t+1}^y}] = \sigma_\eta^2 + \sigma_{\eta^\star}^2 \geq 0$. We distinguish here between demand shocks coming from local investors, η_{t+1}, and global investors, $\eta_{t+1}^\star$, and we allow them to have different stochastic properties.

Let the net supply of home currency (that is, net of the demand from local and global investors), denominated in units of domestic currency, follow a stochastic process such that

$$s_{t+1}^q = \phi_{s^q} s_t^q + \varepsilon_{s_{t+1}^q}, \tag{13}$$

where $\phi_{s^q} \in [0, 1)$, $\varepsilon_{s_{t+1}^q} = \gamma_{t+1} + \gamma_{t+1}^\star$, and $\text{var}_t[\varepsilon_{s_{t+1}^q}] = \sigma_\gamma^2 + \sigma_{\gamma^\star}^2 \geq 0$, distinguishing between demand shocks coming from local investors, γ_{t+1}, and global investors, $\gamma_{t+1}^\star$.

Departing from the framework of Greenwood et al. (2023) and Gourinchas et al. (2022), we allow for a non-zero correlation between the demand of domestic long-term bond and foreign exchange by global investors. In particular, consistent with the micro evidence from Section 3, we assume that any purchase of domestic long-term bonds by foreign bond investors is accompanied by a simultaneous purchase of home currency—of same local-currency amount. That is:

$$\text{corr}_t(\eta^\star_{t+1}, \gamma^\star_{t+1}) = 1. \tag{14}$$

This correlation arises naturally, as global investors intending to purchase domestic long-term bonds must inevitably acquire a corresponding amount of the home currency.

To the contrary, bond and currency demand of *domestic* investors are uncorrelated:

$$\text{corr}_t(\eta_{t+1}, \gamma_{t+1}) = 0. \tag{15}$$

As a result, the overall correlation in net supply is (using eqs. (12), (13), (14) and (15)):

$$\text{corr}_t(s^y_{t+1}, s^q_{t+1}) = \frac{\text{cov}_t[s^y_{t+1}, s^q_{t+1}]}{\sqrt{\text{var}_t(s^y_{t+1})}\sqrt{\text{var}_t(s^q_{t+1})}} = \frac{\sigma_{\eta^\star}\sigma_{\gamma^\star}}{\sqrt{(\sigma^2_\eta + \sigma^2_{\eta^\star})}\sqrt{(\sigma^2_\gamma + \sigma^2_{\gamma^\star})}} \equiv \Omega. \tag{16}$$

The cross-market correlation in global investors' flows generates correlation of net supply across bond and foreign exchange markets in proportion to the relative importance of foreign flows in domestic bond and foreign exchange markets. Equation (16) highlights that the relative importance of global investors in local-currency bond markets can be measured in terms of their relative volatility.

Market clearing The market clearing condition is:

$$\mathbf{s}_t = \mathbf{d}_t, \tag{17}$$

where $\mathbf{s}_t = [s^y_t, s^q_t]'$ denote a vector of net supplies.

Equilibrium Equilibrium expected excess returns must satisfy the intermediaries' optimality condition (11) as well as the market clearing condition (17), implying:

$$\text{E}_t[\mathbf{rx}_{t+1}] = \tau^{-1}\,\text{var}_t[\mathbf{rx}_{t+1}]\mathbf{s}_t. \tag{18}$$

To pin down equilibrium bond yields and exchange rates, y_t and q_t, we follow Greenwood et al. (2023) and conjecture that prices are linear functions of the state vector $\mathbf{z}_t$, which contains all stochastic processes, $\mathbf{z}_t = [i_t - \bar{\iota}, i^*_t - \bar{\iota}, g_t, q_{t+\infty}, s^y_t - \bar{s}^y, s^q_t]'$. Appendix B.2 contains the full mathematical solution, provides a characterization of equilibrium bond yield and exchange rate, as well as a discussion on equilibrium multiplicity and selection.

4.2 Comovement of excess bond and currency returns

To characterize the correlation between excess bond and foreign exchange returns, we first present analytical results for a special case of the model, and then turn to a numerical analysis of the calibrated model. Consider the following special case of the model:

Assumption 1. *Short-term interest rates are deterministic ($\sigma_i = 0$), asset-specific shocks are transitory ($\phi_g = 0$) and feature same volatility ($\sigma_g = \sigma_q$), and net supply shocks are transitory ($\phi_{s_y} = \phi_{s_q} = 0$) with same investor-specific volatilities ($\sigma_\eta = \sigma_\gamma$, and $\sigma_{\eta^\star} = \sigma_{\gamma^\star}$). Besides, the long-term bonds has near-infinite duration ($\delta \to 1$), and agents are sufficiently risk-tolerant (τ is large enough).*

Under these restrictions, we highlight the following result:

Proposition 1. *Under Assumption 1,* $\text{corr}_t(rx^y_{t+1}, rx^q_{t+1}) > 0$ *if and only if* $\Omega > 0$*.*

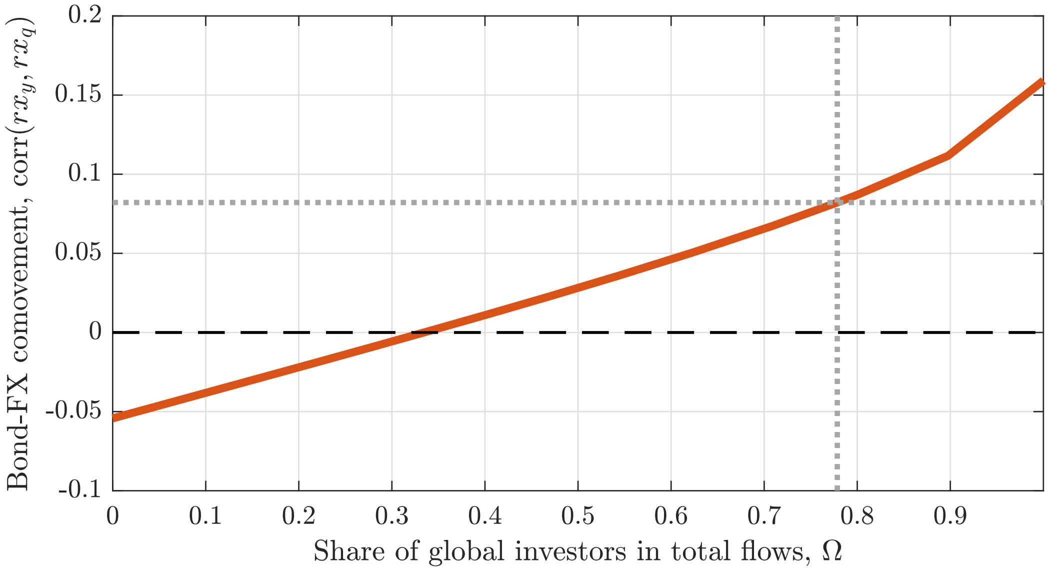
Proof. See Appendix B.3. □

Proposition 1 demonstrates that, in a simplified version of the model without interest rate risk, the correlation between excess bond and foreign exchange returns is positive whenever global investors operate in the local-currency bond market, and thus net supplies are positively correlated (see eq. (16)). Without interest rate shocks, the fundamental sources of risk are asset-specific *independent* shocks (fluctuations in the bond return wedge and long-term nominal exchange rate). If net supply fluctuations were independent, bond and FX premia would also be uncorrelated. However, when net supply fluctuations are correlated, their comovement is reflected in the joint distribution of premia.

Correlated flows generate correlated returns as they directly link the net supply in bond and currency markets that local intermediaries must absorb, and thus in the premia they require. This effect occurs even in models where intermediaries managing bonds and currency are distinct entities. That said, whenever local intermediaries operate across both markets, these effects are amplified, as changes in positions in one market impart correlated changes in returns in both markets, as we discuss in Section 6.

We now turn to examine the determinants of the bond-FX comovement using a calibrated version of the baseline model, which includes short-term interest rate risk.

Figure 6
Correlation in bond and currency excess returns



Note: The figure depicts the equilibrium correlation in bond and currency excess returns for different levels of correlation in net supplies, $\Omega \equiv \text{corr}_t(s^y_{t+1}, s^q_{t+1})$ (achieved by different relative importance of foreign to home standard deviations of supply shocks, see eq. (16)). Table B.1 reports the baseline calibration.

Calibration Our calibration approach does not target directly the empirical comovement in excess bond and currency returns. Instead, it relies on the time series properties of short-term interest rates as well as net supply volumes, the standard deviations of excess bond returns and excess currency returns, and conventional parameter values whenever possible. The model is calibrated on Colombian data at a quarterly frequency. To discipline the processes of short-term interest rates (ϕ_i, σ_i, ρ), we use 3-month interbank rates from Colombia and the United States. To discipline the processes of net supply shocks (ϕ_{s^y}, ϕ_{s^q}, σ_η, σ_γ, $\sigma_{\eta^\star}$, $\sigma_{\gamma^\star}$), we use Colombian transaction-level data in bond and FX markets. We compute the quarterly positions of local intermediaries in both markets, as a fraction of the market value of the local currency government bond market, as well as their fluctuations stemming from local and global investors.[18] We set the risk aversion of local intermediaries ($1/\tau$) to 40, in line with the value chosen by Gourinchas et al. (2022). We calibrate the unobservable asset-specific shocks (σ_g, σ_q) to match the standard deviation of excess 10-year Colombian bond returns and excess currency returns. Table B.1 reports the values of the resulting baseline parameters.

Figure 6 depicts the correlation between excess bond and currency returns, for different composition of investors' flows. Two key insights emerge. First, the correlation in excess

[18] For simplicity, we calibrate the parameters of the net supply processes as symmetric across markets, which represents a reasonable approximation of the properties of the data.

bond and currency returns increases with the relevance of global investors, governed by Ω (see eq. (16)). A higher variance of global investors' flows (for a given total variance of flows) increases the correlation in bond and currency net supply movements and thus the correlation of bond and currency returns. Second, absent correlated flows ($\Omega = 0$), the correlation in excess returns is negative, as the only source of correlated risk are short-term interest rates shocks—a result originally presented in Greenwood et al. (2023) and Gourinchas et al. (2022). Interest rate risk, in fact, affects the yield-curve trade and the UIP trade in opposite directions. An increase in domestic short-term rates results in lower domestic long-term bond prices, which is detrimental to the yield-curve trade, but it simultaneously appreciates the domestic currency, benefiting the UIP trade.[19]

Notwithstanding its simplicity, the calibrated model generates a sizable degree of comovement at its baseline calibration (where $\Omega \approx 80\%$), namely a correlation in returns of around 10%. In Colombian data the correlation in returns is around 20%. Complementary mechanisms discussed in Section 7, not modeled here, can contribute to increasing the positive correlation in returns.

5 Positions and Returns of Global Investors and Local Intermediaries

Our model has two broad implications that speak to positions and returns of intermediaries in bond and currency markets. First, intermediaries earn positive excess returns in both markets on average, as we outline in Proposition 2 below. Second, if correlated flows are a dominant force driving returns in both markets, the positions of intermediaries in both markets should be positively correlated, as reflected in equation (16). In this section, we outline these implications and confront them with micro-level data from Colombia.

The following proposition outlines the properties of the model with respect to the returns accrued from the positions held by local intermediaries.

Proposition 2. *Under Assumption 1, local intermediaries gain positive excess returns, on average, on both their bond and currency positions. That is,* $\mathbb{E}(d_t^y rx_{t+1}^y) \geq 0$ *and* $\mathbb{E}(d_t^q rx_{t+1}^q) \geq 0$*, where* $\mathbb{E}$ *is the unconditional expectation operator.*

[19]Short-rate risk only influences the correlation in returns if short-rate fluctuations are not perfectly correlated across countries. Correlated short-rate fluctuations limit the variation in the short-rate *differential*, thereby reducing the impact of interest rate risk on the UIP trade. Short-rate movements in emerging economies are synchronized with those in the U.S., weakening the relative importance of interest rate risk in determining the bond-currency return correlation in these economies. The correlation in innovations in short-term rates is around 65% for Colombia *vis a vis* the U.S., and around 35% for Germany *vis a vis* the U.S. (c.f. Gourinchas et al. (2022)).

Proof. Using equation (11), one can show that

$$\mathbb{E}(d_t^y rx_{t+1}^y) = \tau^{-1}\left[\text{var}_t(rx_{t+1}^y)\mathbb{E}\left((d_t^y)^2\right) + \text{cov}_t(rx_{t+1}^y, rx_{t+1}^q)\mathbb{E}\left(d_t^q d_t^y\right)\right]; \tag{19}$$

$$\mathbb{E}\left(d_t^q rx_{t+1}^q\right) = \tau^{-1}\left[\text{var}_t(rx_{t+1}^q)\mathbb{E}\left((d_t^q)^2\right) + \text{cov}_t(rx_{t+1}^y, rx_{t+1}^q)\mathbb{E}\left(d_t^y d_t^q\right)\right]. \tag{20}$$

Using the market clearing condition (17), the processes of net supplies, (12) and (8), the properties of foreign and home investors' flows, (14) and (15), as well as Proposition 1, one can show that $\mathbb{E}(d_t^y rx_{t+1}^y) \geq 0$ and $\mathbb{E}(d_t^q rx_{t+1}^q) \geq 0$.

Furthermore, equation (17) then implies that inelastic demand of local and foreign investor delivers negative excess returns, on average. □

Local intermediaries play a central role in these dynamics. In Colombia, designated dealers in both markets are the natural counterparties absorbing bond and currency demand shocks. We refer to the designated dealers in the treasury market as PDs and those in the foreign exchange market as IMCs.

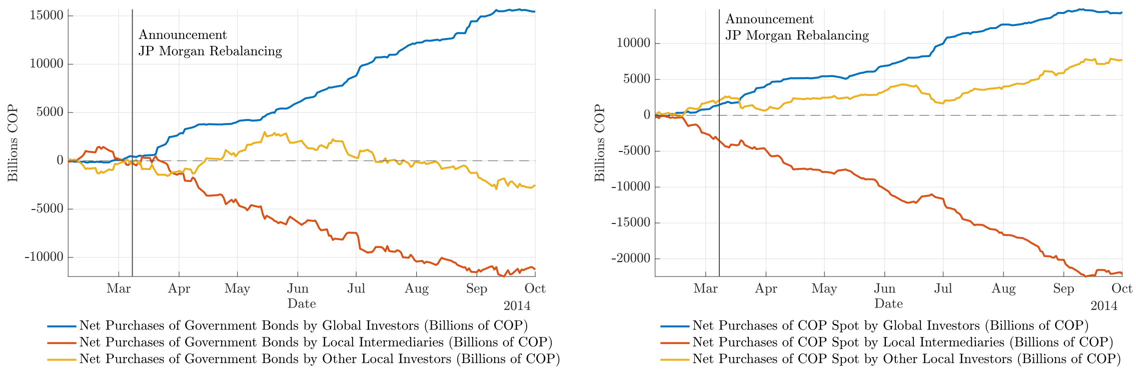
To provide suggestive evidence that these financial institutions act as intermediaries in both markets, we analyze their behavior during the *J.P. Morgan* rebalancing described in Section 3. In principle, intermediaries absorb demand shocks from other investors. Generally, it is difficult to encounter in the data arguably exogenous demand shocks. In the case of the *J.P. Morgan* rebalancing, one can argue that its announcement triggers a portfolio rebalancing that is exclusive to foreigners and affects the treasury (TES) market directly. Additionally, through the simultaneous purchase of domestic currency, it also affects the foreign exchange market as highlighted in Figure 3. In Figure 7 we expand the analysis to the behavior of both PDs (TES market), IMCs (FX market), and other domestic investors, during this episode. In both bond and foreign exchange markets, designated dealers are the ones largely absorbing the demand shock from foreign investor, consistent with them being the relevant "arbitrageurs" in Colombia's bond and foreign exchange markets.

Next, we test whether these intermediaries earn positive excess returns in both markets. To do so, we construct monthly-level returns for different investor groups in the two markets. More specifically, for the returns from currency trade we compute:

$$\text{Curr Trade Ret}_{t,h}^j = X_t^{Curr,j} \times rx_{t+h}^q \qquad h = 1, 3, 6, 12. \tag{21}$$

where $X_t^{Curr,j}$ is the flow of investor j associated with the sale of USD in exchange for COP (measured in USD). rx_{t+h}^q are the currency returns described in Section 2 for a holding period

Figure 7
Behavior of Local Intermediaries during *J.P. Morgan* Rebalancing



(a) TES Market (b) COP Spot Market

Note: This figure displays the evolution of the daily accumulated purchases of of TES bonds (Panel A) and the daily accumulated purchases of COP in the spot market (Panel B) during the J.P. Morgan rebalancing in 2014 for different investor groups. PDs and IMCs are designated dealers in the TES and FX spot market, respectively. The black vertical line denotes 19th of March 2014, the day the rebalancing was announced.

of h months. For the yield-curve trade return we compute:

$$\text{Yield-Curve Trade Ret}_{t,h}^{j} = X_t^{Bond,j} \times rx_{t+h}^{(n)} \qquad h = 1, 3, 6, 12. \tag{22}$$

where $X_t^{Bond,j}$ is the flow of investor j associated with the purchase of long-term government bonds in domestic currency. $rx_{t+h}^{(n)}$ are the yield trade return described in Section 2. For simplicity, we compute these returns using the 10-year local-currency government bond and we measure returns in domestic currency. In both markets we consider three investor groups: local intermediaries (either IMCs or PDs), foreign investors, and other domestic intermediaries. After calculating the trade returns for various holding periods, we perform mean t-Tests to evaluate whether the trade returns are significantly different from zero, with the null hypothesis being that the returns are equal to zero.

We present results of these analyses in Table 6. In general, we find that currency (yield) trade returns are positive for IMCs (PDs), and negative both for foreigners and other domestics. Results are noisier for the 1 and 3-month holding period, but all average returns (both positive and negative) are statistically different from zero for 6 and 12-month holding periods. These findings support the model's implication outlined in Proposition 2, as well as our conjecture about the investor group acting as intermediaries in Colombia.

Next, we explore another implication of the model concerning the positions of intermediaries in both markets. Specifically, for the group of PDs and IMCs, we compute their purchases of TES and COP (in the FX spot market), respectively, measured in domestic currency. We aggregate these purchases over different horizons, computing the 1, 3, 6 and 12-month totals

Table 6
Currency and Yield-Curve Trade Returns

Panel A: Trade Returns FX				
	1M	3M	6M	12M
Intermediaries	3.393	15.251**	38.845***	74.420***
	(2.397)	(7.049)	(11.839)	(21.646)
Foreigners	0.929	-5.264	-19.877*	-46.449**
	(2.264)	(5.031)	(10.240)	(17.715)
Others	-4.322**	-9.988**	-18.968***	-27.972**
	(1.960)	(4.725)	(6.883)	(13.473)
Observations	83	81	78	72

Panel B: Trade Returns Yield Curve				
	1M	3M	6M	12M
Intermediaries	4.540	13.224**	18.645***	24.924***
	(5.181)	(6.141)	(6.992)	(8.157)
Foreigners	-0.427	-1.847	-3.828	-9.814***
	(1.830)	(1.988)	(2.691)	(3.639)
Others	-4.113	-11.377**	-14.817**	-15.110*
	(4.422)	(5.531)	(6.104)	(7.659)
Observations	120	120	120	120

Note: This table reports results from mean t-Tests of currency (Panel A) and yield curve (Panel B) trade returns for different investor groups. Currency trade returns are computed following equation (21) and yield curve trade returns are computed using equation (22). The 1M, 3M, 6M, and 12M columns denote test for average returns with holding periods of 1, 3, 6, and 12-month, respectively. The null hypothesis is that average returns are equal to zero. *, **, and *** denote statistically significant at the 10%, 5%, and 1% level, respectively.

in both markets, in order to analyze both short-term correlations as well as medium-run trends. To test the relationship between these variables, we estimate the following regression:

$$\text{COP}_t^{h,IMC} = \theta_y + \theta_m + \beta\text{TES}_t^{h,PD} + \varepsilon_t \qquad h = 1, 3, 6, 12. \tag{23}$$

where $\text{COP}_t^{h,IMC}$ are the h-month purchases of COP in the FX spot market by IMCs, and $\text{TES}_t^{h,PD}$ are the h-month purchases of TES by PDs. θ_y and θ_m are year and month fixed effects that control for long-run trends and seasonality effects.

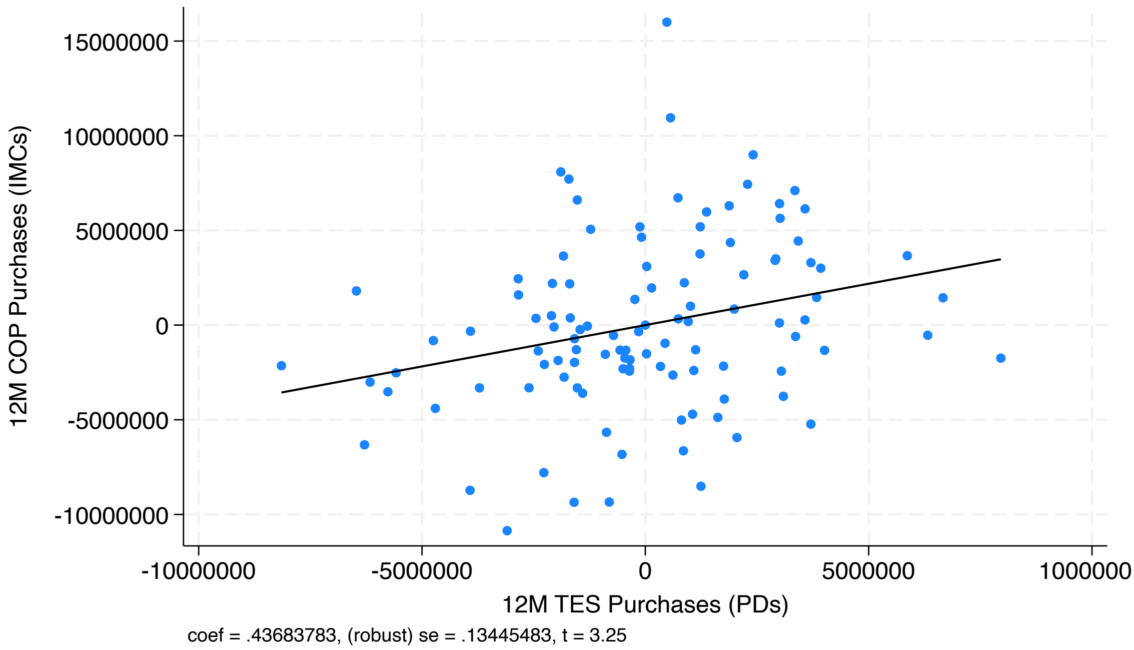
The estimates show a positive relationship between both variables (Table 7). This relationship is noisier when we consider the 1-month change in positions, being positive but not statistically different from zero. However, as we consider change in the positions of the intermediaries over longer horizons, the relationship becomes stronger. The magnitude of the estimated coefficients increases and they are statistically different from zero at conventional significance levels.

Table 7
Correlation in Intermediaries Position Changes

Dependent Variable: COP Purchases by IMC	1M		3M		6M		12M	
TES Purchases by PD	0.156	0.168	0.200**	0.212	0.245**	0.411**	0.361***	0.437***
	(0.106)	(0.110)	(0.098)	(0.135)	(0.107)	(0.157)	(0.123)	(0.134)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	120	120	118	118	115	115	108	108
R-Squared	0.28	0.41	0.55	0.62	0.66	0.70	0.82	0.83

Note: This table presents OLS estimations of COP purchases in the spot market by IMCs on TES purchases in the bond market by PDs with different types of fixed effects. The different columns displays the h-month accumulated purchases for $h = 1, 3, 6, 12$. Robust standard errors are presented in parenthesis. *, **, and *** denote statistically significant at the 10%, 5%, and 1% level, respectively.

Figure 8
Change in Positions of Intermediaries in TES and FX market



Note: This figure presents a partial correlation scatter plot of 12-month COP purchases by IMCs in the FX spot market on the 12-month TES purchases by PDs with both year and month fixed effects. Both y and x-axis are in billions COP.

We complement the regressions with a partial correlation scatter plot of the 12-month level purchases from intermediaries in both markets (Figure 8). We observe a strong positive relationship along the fitted positive slope, with limited outlier observations. Additionally, we compute the correlations between both variables after residualizing for year and month fixed effects. We obtain correlations of 0.16 (1-month), 0.17 (3-month), 0.24 (6-month), and 0.28

(12-month). All of these are statistically different from 0 at the 10% significance level. The overall positive relationship in the positions of intermediaries lends support to the idea that correlated flows are a significant driver of flows and premia in both the bond and currency markets.

6 The Effects of Asset Purchases in Emerging Economies

The portfolio balance model described above yields clear predictions regarding the effects of asset purchases, including quantitative easing (QE) and foreign exchange interventions (FXI). These predictions are formalized in the following proposition.

Proposition 3.

(a) A domestic central bank's purchase of foreign currency, modeled as an increase in γ_t in equation (13), causes a home currency depreciation and a decrease in the price of long-term bonds if and only if $\text{cov}_t(rx^y_{t+1}, rx^q_{t+1}) > 0$.

(b) A domestic central bank's purchase of local-currency long-term bonds, modeled as a reduction in η_t in equation (12), causes an increase in the price of long-term bonds and home currency appreciation if and only if $\text{cov}_t(rx^y_{t+1}, rx^q_{t+1}) > 0$.

Proof. Consider a unit decrease in η_t in (12), which implies a reduction in bond net supply s_y without a corresponding movement in currency net supply (i.e. $s_q = 0$). By the equilibrium solution of the exchange rate, eq. (B.12) derived in Appendix B.2, such impulse causes a currency appreciation if and only if $\text{cov}_t(rx^y_{t+1}, rx^q_{t+1}) > 0$. This proves part (b). The proof of part (a) is analogous, and follows from considering a unit increase in γ_t in (13). □

Proposition 3 characterizes the effects of asset purchase policies that are confined to a single market on both bond yields and exchange rates. It shows that FXI—interventions in the FX market—can influence the price of long-term bonds, while QE—purchases of long-term bonds—can affect the exchange rate. These cross-market effects arise from two central features of our small open economy framework.

First, local intermediaries simultaneously intermediate positions in both the bond and currency markets. As a result, a shift in the net supply of one asset alters their exposure and induces changes in the required risk premia on both assets. Second, the magnitude and direction of these effects depend on the stochastic properties of bond yields and exchange rates, embodied in the covariance of excess returns. As discussed earlier, this covariance reflects the relative strength of correlated foreign investor flows versus short-term interest rate shocks (see, for example, Figure 6).

In economies where correlated flows dominate, the risks associated with the UIP trade and the yield-curve trade are positively correlated. In such settings, a central bank purchase of foreign currency (i.e., FXI) increases intermediaries' exposure to domestic yield curve risk, thus lowering the equilibrium price of long-term domestic bonds. Analogously, a central bank purchase of domestic bonds (i.e., QE) reduces intermediaries' exposure to currency risk, leading to an appreciation of the domestic currency.

Taken together, when foreign investors play a significant role in local-currency bond markets, FXI tends to raise the price of long-term bonds, while QE tends to appreciate the exchange rate. Crucially, these cross-asset spillovers arise even though each policy targets only one market at a time—i.e., they occur despite the absence of simultaneous interventions in both markets.[20]

We now turn to examine how these predictions hold up in the data.

Central bank U.S. dollar auctions (FXI) We present empirical evidence that sterilized foreign exchange interventions have significant effects on both the exchange rate and long-term bond prices.[21] We test Proposition 3(a) using proprietary data from 651 multiunit uniform price auctions conducted daily in Colombia between June 2008 and December 2014. The auction mechanics were as follows: prior to each auction, the central bank announced the maximum amount of U.S. dollars to be purchased. Each auction lasted three minutes, during which participants could submit and revise their bids, specifying both an ask price in COP/USD and the total dollar amount offered. At the close of the auction, bids were ranked in ascending order by price. The central bank then accepted offers starting with the lowest ask price, purchasing sequentially until its pre-announced demand was fulfilled. The cutoff price (applied uniformly to all winning bids) was thus determined by the highest ask price among those from whom the central bank acquired a positive amount.

Descriptive statistics for the auctions are presented in Table 8. On average, each auction involved eight participating financial institutions, primarily private banks (the list of authorized bidders is publicly available). The central bank purchased an average of USD 23 million per day, with amounts occasionally reaching up to USD 50 million. For

[20]Formally, QE in our model should be interpreted as a central bank bond purchase carried out under the full variance-covariance structure implied by all exogenous processes, rather than as the effect of a bond purchase in a counterfactual setting where asset purchases are the sole source of variation.

[21]Sterilized FXI are aimed at (i) accumulating international reserves, (ii) correcting short-term exchange rate misalignments, and (iii) reducing excessive exchange rate volatility.

Table 8
U.S. Dollar Auctions: Summary Statistics

	Mean	St. Dev.	Min	Pctl(25)	Median	Pctl(75)	Max
Cutoff price[(a)]	1,885	93.9	1,756	1,804	1,882	1,932	2,372
Ask price std. dev.	0.59	0.49	0.07	0.30	0.46	0.66	4.14
Ask price range	1.71	1.40	0.10	0.90	1.30	2.00	9.18
Announced demand[(b)]	23.2	10.1	10.0	15.0	20.1	31.9	50.0
Total offered	47.5	21.9	5.0	29.5	46.0	61.0	135.5
Total purchased	23.1	10.0	5.0	15.0	20.1	30.5	50.0
Number of bidders	8.14	2.58	2	6	8	10	15
Number of winners	4.91	2.10	1	3	5	6	11
Number of losers	3.23	2.20	0	2	3	5	10

Note: This table presents summary statistics for all 641 auctions in our sample. Ask price range is the difference between the highest and the lowest ask price submitted by bidders in each auction. Announced demand is the maximum amount of USD that the CBC announces it will purchase at each auction. [(a)] Prices are measured in COP/USD. [(b)] Amounts are measured in million USD.

context, during the same period, the total daily turnover in the Colombian COP/USD spot market was approximately USD 950 million, with an average individual transaction size of USD $785,000$.

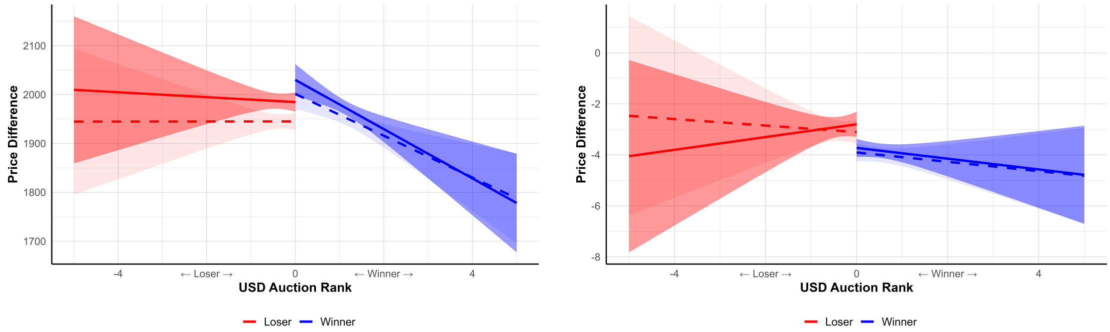
In this context, we exploit the inherent discontinuity generated by the auction's cutoff price to compare the behavior of marginal winners and marginal losers in their subsequent trading activity in both the bond and foreign exchange secondary markets. We argue that, within a narrow window around the cutoff, the exchange rate becomes locally decoupled from broader macroeconomic and financial variables, thereby creating a localized quasi-experimental setting. This identification strategy relies on the assumption that bidders near the threshold (barely winners and barely losers) are ex-ante similar.

Formally, we estimate the following regression discontinuity design (RDD) centered around the auction cutoff price:

$$\arg\min_{\boldsymbol{\gamma}} \sum_{i=1}^{I} \left[y_i - \gamma_0 + \gamma_1 D_i + \gamma_2 (bid_i - c) + \gamma_3 (bid_i - c) \times D_i\right]^2 K\left(\frac{bid_i - c}{h}\right) \tag{24}$$

where y_i denotes either bond prices or USD prices in the *secondary market*, measured during the trading day following the auction, but still within the same day; $(bid_i - c)$ is the standardized distance of bid i from the auction cutoff price c (positive for winners, negative for losers); $D_i = \mathbb{1}\{bid_i \geq c\}$ is a treatment indicator equal to one if bid i was accepted; and $K(\cdot)$ is a triangular kernel function with bandwidth h. The parameter of interest, γ_1, captures the local average treatment effect of winning the auction on subsequent market outcomes.

Figure 9
Effects of FXI (U.S. Dollar Purchases) on Secondary Market Prices



(a) Exchange Rate (b) Long-term Bond Price

Note: This figure presents the results from estimating equation (24), with robust standard errors. The dotted line represents a linear fit weighted by the trading volume of sovereign bonds that each bank conducts with foreign investors. The bandwidth is selected optimally according to the procedure proposed by Calonico et al. (2014), and statistical significance is evaluated at the 5% level.

Results are presented in Figure 9, where panel (a) depicts the effects on the spot exchange rate and panel (b) shows the effects on bond prices, consisent with Proposition 3(a). As observed, central bank U.S. dollar purchases lead to both an exchange rate depreciation and a decline in bond prices. More formally, Table C.1 shows that FX auction winners (dealers that sell USD to the central bank) subsequently trade bonds at prices that are 1.15% lower than those of auction losers. Conversely, auction winners trade FX at prices that are 47.3 COP/USD higher than losers, indicating a more depreciated local currency.

Quantitative Easing Using a high-frequency identification strategy, Rebucci et al. (2022) show that quantitative easing—central bank purchases of long-term government bonds—led to currency appreciation in emerging market economies during the COVID-19 period (see also Arslan et al., 2020). This stands in contrast to the experience of advanced economies, where QE is typically associated with currency depreciation (Bauer and Neely, 2014; Neely, 2015; Swanson, 2021; Bhattarai and Neely, 2022), evidence that motivated the theoretical analysis in Greenwood et al. (2023) and Gourinchas et al. (2022).

The differing effects of QE across emerging and advanced economies can be understood through the lens of the covariance structure of bond yields and exchange rates. As emphasized in Proposition 3, when excess returns on bonds and currencies are driven primarily by correlated flows, QE tends to appreciate the currency. By contrast, when short-term interest rate risk dominates, QE is more likely to lead to depreciation. Thus, the response of exchange rates to QE hinges on the underlying sources of risk in each economy.

7 Discussion

Our analysis is framed within a portfolio-balance model à la Greenwood et al. (2023). We adopt a number of simplifying assumptions to illustrate the key implications of correlated flows that we emphasize. As concluding remarks, this section discusses some elements commonly explored in the literature that, while not altering our main insights regarding the role of correlated flows in bond-yield comovement and the impact of asset purchase policies, could enrich and extend the conclusions of our analysis.

Spot and forward exchange flows by global investors Section 3 shows that currency hedging by global institutional investors targeting emerging economies is very limited. Accordingly, our baseline model abstracts from currency hedging. That said, hedging may be more prevalent among other global investors—such as global banks, due to their regulatory environment—or when investing in advanced economies' sovereign bonds, where hedging costs are lower. Relaxing the no-hedging assumption would reduce the correlation between bond and currency flows by global investors, as spot market purchases of currency would be at least partially offset by forward market sales. In particular, the degree of correlated flows would effectively fall, implying $\text{corr}_t(\eta^*_{t+1}, \gamma^*_{t+1}) < 1$ in equation (14).

Moreover, the correlation of global investor flows also depends on the source of their currency spot purchases. Figure 2 shows that most spot market transactions by global investors are linked to sovereign bond purchases in Colombia. However, in countries where non-residents use the spot market to acquire other assets—such as equities or local-currency corporate bonds—or to engage in trade of goods and services denominated in local currency, these factors generally act to lower $\text{corr}_t(\eta^*_{t+1}, \gamma^*_{t+1})$ in equation (14).[22]

To the extent that currency hedging and equity/trade-related spot purchases are more common in advanced economies, these features help explain the lower correlation between bond and currency returns observed in those countries, even for similar investor compositions.

The sources of global investors' flows In our baseline model, following Greenwood et al. (2023), we assume that global investors' bond demand is exogenous and inelastic. However, global investors' demand is clearly more nuanced in practice. For instance, global investors' time-varying risk-bearing capacity can influence bond positions (Morelli et al., 2022; Akinci

[22]Similarly, equation (15) assumes that demand shocks from non-bank domestic investors are uncorrelated across bond and currency markets. This assumption is consistent with our data from Colombia and with evidence that emerging economies impose strict limits on the ability of pension and mutual funds to invest abroad. In countries where domestic institutional investors do systematically invest in foreign assets, this would imply that $\text{corr}_t(\eta_{t+1}, \gamma_{t+1}) \neq 0$ in equation (15), with implications for bond-currency return comovement.

et al., 2022). Risk bearing capacity, in turn, may depend on investors' wealth, possibly linked to shifts in U.S. monetary policy (Kekre et al., 2024; Miranda-Agrippino and Rey, 2020) or fluctuations in the value of the U.S. dollar (Carstens and Shin, 2019; Bruno and Shin, 2015; Hofmann et al., 2022a).

We stress that correlated flows and their implications arise regardless of the underlying source of global investors' bond demand, yet the equilibrium correlation in bond and currency returns may vary depending on the specific sources underlying investors' demand.

General equilibrium effects Our baseline model treats short-term interest rate fluctuations as exogenous. Embedding it within a general equilibrium framework would shed light on how endogenous movements in short-term rates contribute to the correlation of excess bond and currency returns. For instance, if capital inflows from global investors lead to a temporary appreciation of the home currency—by compressing currency risk premia—this would increase current home consumption via expenditure switching, and lower the home short-term interest rate. The endogenous decline in the short-term rate would raise *realized* excess returns on long-term bonds, along with the higher *realized* excess currency returns due to the exchange rate appreciation, thereby generating a positive correlation in excess bond and currency returns, amplifying the effects of correlated flows. Kekre and Lenel (2024) argue that an analogous mechanism—stemming from shocks to the UIP condition emphasized by Itskhoki and Mukhin (2021)—is a natural candidate explanation for why long-term yields in emerging markets tend to be relatively low when the U.S. dollar is weak.[23]

Investor heterogeneity Another natural extension would recognize that investors differ in their characteristics—such as risk tolerance, portfolio elasticity, or investment horizon—and that sovereign bonds across countries are held by different types of investors (Fang et al., 2022; Zhou, 2024). While our analysis intentionally focuses on a stylized setting, incorporating this heterogeneity could offer a more granular understanding of how differences in investor composition shape the comovement of asset prices across markets. A more disaggregated approach would allow for a richer quantification of the role played by investor base composition in driving cross-asset and cross-country return dynamics.

[23]Local-currency debt, portfolio-balance frictions and correlated flows can be incorporated in the analyses of emerging economies' financial crises (Calvo et al., 2006; Calvo, 1998; Caballero and Krishnamurthy, 2001; Mendoza, 2010; Bocola and Lorenzoni, 2020; Fontanier, 2024), and more broadly in emerging economies' business cycles (Neumeyer and Perri, 2005; Uribe and Yue, 2006; Aguiar and Gopinath, 2007; García-Cicco et al., 2010; Fernández and Gulan, 2015; Fernández-Villaverde et al., 2011; Coulibaly, 2023; Arellano et al., 2020).

We highlight the role of correlated flows—a mechanism frequently cited by policymakers and market participants but largely overlooked in the international finance literature—and explore its implications. Embedding correlated flows into macroeconomic frameworks with endogenous bond demand and investor heterogeneity can offer further insight into the comovement of asset prices, the transmission of quantitative easing and foreign exchange interventions, and a broader set of related questions.

8 Conclusion

The composition of investors holding local-currency bonds shapes the equilibrium dynamics of a country's exchange rate. When local intermediaries face portfolio-balance constraints, the flows they must absorb influence bond prices and exchange rates by affecting term premia and currency premia. Using micro-level data from Colombia's local-currency sovereign bond market, along with spot and forward exchange markets, we document that global investor flows into the bond market are systematically linked to corresponding flows into the foreign exchange spot market, but not into the forward market. Incorporating these features into an equilibrium model, we show that correlated flows increase the co-movement between bond and currency premia, consistent with macro-level evidence on excess bond and currency returns as well as micro-level evidence on investor-specific returns in these markets.

The stochastic properties of a country's exchange rates, in turn, determine the impact of policies that alter the net supply of bonds or foreign currency. For instance, quantitative easing policies that reduce the net supply of sovereign bonds mediated by local intermediaries, lead to a simultaneous increase in bond prices *and* the value of the home currency, a prediction supported by the data. Analogously, foreign exchange interventions that reduce the net supply of foreign currency mediated by local intermediaries, depreciate the value of the domestic currency *and* lower bond prices, for which we provide empirical support.

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Appendix

A Additional Evidence on Excess Bond and Currency Returns

In the cross section, Figure A.1 shows that it has a positive correlation for EM while a negative correlation for AE. For this plot, we have used foreign exchange excess returns using a 3-month deposit rate, but the plot is virtually the same if we use currency excess returns using forwards. In the time series, Figure A.2 shows the 3-month moving average of the cross-country averages of excess returns for both currency and bonds.[24] The time series correlation within country remains positive for emerging economies while in advanced economies one observes the opposite.

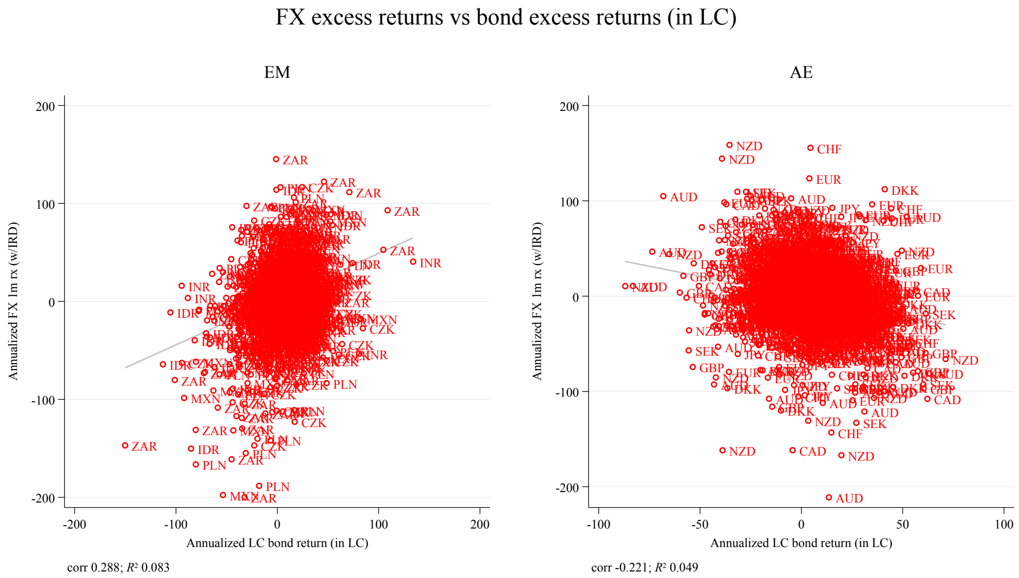

Figure A.1
Cross-section:Excess returns bonds and currencies (local currency)

[24]We applied a 3-month moving average (including two lags and the current month) to present smoother monthly returns. However, the findings remain consistent when using 1-month excess returns.

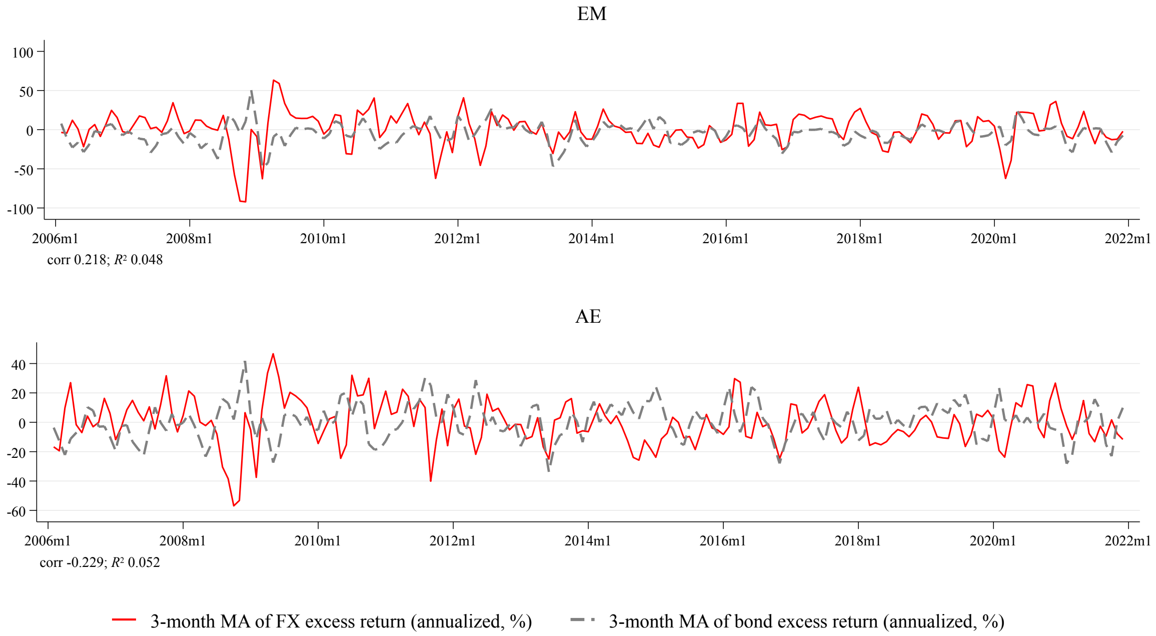

Figure A.2
Time Series: Excess returns bonds and currencies (local currency)

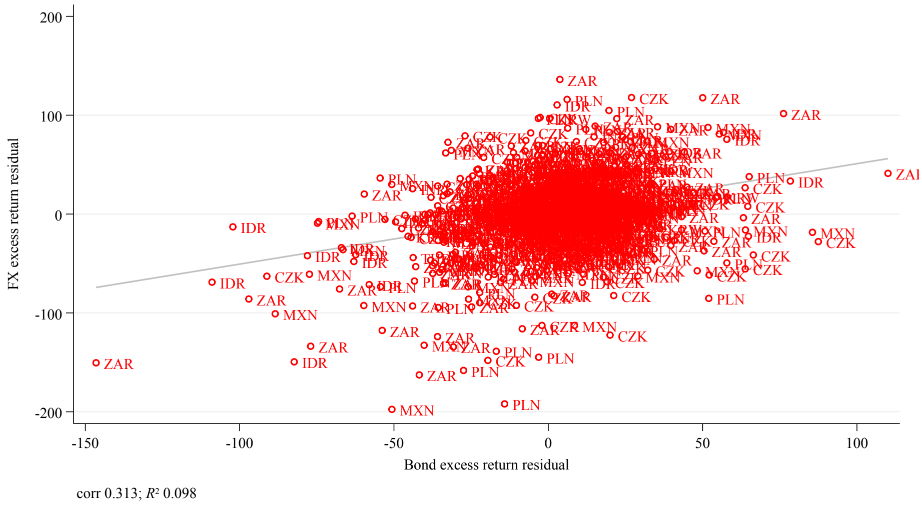

Figure A.3
Correlation of residualized excess returns

B Model Appendix

B.1 Return of a Perpetuity: Campbell-Shiller Approximation

We use the Campbell and Shiller (1988) log-linear approximation to model the before-tax return on default-free long-term bonds. We assume that agents take as given the exogenous tax described in the model section. These bonds are self-amortizing perpetuities whose payments decline geometrically, are free of default risk, and have a face value of 1 at time t. Let P_t^y be the price and Y_t the yield-to-maturity of these long-term bonds at time t. At $t+1$, this instrument will offer a coupon payment of C, a principal repayment of $1-\kappa$ for some $\kappa \in [0,1]$, and κ units of the asset. Here, κ is the amortization rate. The gross before-tax return on long-term bonds from t to $t+1$ is thus

$$1 + R_{t+1}^y = \frac{C + 1 - \kappa + \kappa P_{t+1}^y}{P_t^y}, \tag{B.1}$$

where

$$P_t^y = \sum_{j=1}^{\infty} \frac{\kappa^{j-1}(1-\kappa+C)}{(1+Y_t)^j} = \frac{1+C-\kappa}{1+Y_t-\kappa}. \tag{B.2}$$

Taking a log-linear approximation of the long-term bond's return around the point where it is trading at par at $t+1$ obtains

$$r_{t+1}^y \approx \theta + \delta p_{t+1}^y - p_t^y, \tag{B.3}$$

where $\theta \equiv \ln(1+C)$ and $\delta \equiv \kappa/(1+C)$ are parameters. We can iterate this equation forward and apply this approximation to Y_t to get

$$p_t^y \approx \frac{1}{1-\delta}\theta - \frac{1}{1-\delta} y_t. \tag{B.4}$$

We plug equation (B.4) into (B.3) to get the approximate one-period log return on the long-term bond

$$r_{t+1}^y \approx \frac{1}{1-\delta} y_t - \frac{\delta}{1-\delta} y_{t+1}, \tag{B.5}$$

where $D = (1-\delta)^{-1}$ is the Macaulay duration when the instrument is trading at par.

Lastly, one can subtract the tax g_t from this return to get expression (3).

B.2 Solving the Baseline Model

In this subsection, we derive the system of equations necessary to solve the baseline model presented in Section 4.1. We follow Greenwood et al. (2023) by conjecturing that equilibrium prices are a linear function of a state vector of shocks and arrive at a system of three equations with three unknowns. The resulting equations can be studied to derive qualitative implications about the model. We close out Appendix B by proving the main propositions of the paper.

B.2.1 Equilibrium Conjecture and Properties

Equilibrium Conjecture We conjecture that the two prices that we need to pin down in equilibrium, y_t and q_t, are a linear function of a state vector of z_t

$$y_t = \alpha_0^y + \alpha_1^{y'} z_t;$$

$$q_t = \alpha_0^q + \alpha_1^{q'} z_t,$$

where the 6×1 state vector $\mathbf{z}_t = [i_t - \bar{\iota}, i_t^* - \bar{\iota}, g_t, q_{t+\infty}, s_t^y - \bar{s}^y, s_t^q]'$ follows a VAR(1) process $\mathbf{z}_{t+1} = \Phi \mathbf{z}_t + \varepsilon_{t+1}$, with $\text{var}_t[\varepsilon_{t+1}] = \Sigma$ and $\Phi = \text{diag}(\phi_i, \phi_i, \phi_g, 0, \phi_{s^y}, \phi_{s^q})$. In vector form the two prices yield $\mathbf{y}_t + \mathbf{a} + \mathbf{A}\mathbf{z}_t$, where $\mathbf{y}_t = [y_t, q_t]'$, $\mathbf{a} = [\alpha_0^y, \alpha_0^q]'$, and $\mathbf{A} = [\alpha_1^y, \alpha_1^q]'$.

Rational Expectations Equilibrium Let $f(\alpha_0)$ be an operator that gives the price-impact coefficients that clear the markets for long-term bonds and FX when agents conjecture that $\alpha = \alpha_0$, where $\alpha = vec(\text{A})$. We say that a rational expectations equilibrium in this model is a fixed point

$$\alpha^* = f(\alpha^*). \tag{B.7}$$

Within this context, local intermediaries must form beliefs—specifically, price-impact coefficients—about how the net supplies of long-term bonds and foreign exchange, s_t^y and s_t^q, influence equilibrium asset prices, y_t and q_t. A rational expectations equilibrium is therefore a fixed point of a specific operator involving these price-impact coefficients.

Equilibrium Properties The presence of supply risk in this model makes the risk tolerance of investors τ a key variable. If agents are not risk-tolerant enough, then an equilibrium does not exist. However, for high levels of risk tolerance, stochastic supply shocks generate multiple equilibria. The different equilibria correspond to different self-fulfilling beliefs (price-impact coefficients) that investors might have about the risk of holding the different assets. For example, if investors believe that supply shocks barely affect prices, they will perceive these assets as less risky. Consequently, investors will absorb large supply shocks and will not require large compensations through a fall in asset prices. However, if investors believe supply shocks will have greater impact on prices, they demand a large decline in prices as compensation for absorbing these shocks.

Despite multiple equilibria, there is always a unique stable equilibrium. Denoting by $\{\lambda_i\}$ the eigenvalues of the Jacobian $D_\alpha f(\alpha^*)$, we see that α^* is stable if $|\lambda_i| < 1$. The importance of a unique stable equilibrium lies in the fact that we can infer qualitative implications from our model. It also implies that comparative statics on our equilibrium price-impact coefficients α^* offer an easy and informative interpretation.

B.2.2 Equilibrium Solution

The first-order condition of the local intermediaries that we derived is written again for completeness

$$\mathrm{E}_t[\mathbf{rx}_{t+1}] = \tau^{-1}\,\mathrm{var}_t[\mathbf{rx}_{t+1}]\mathbf{d}_t. \tag{B.8}$$

This, coupled with the usual market clearing condition that supply equals demand ($\mathbf{d}_t = \mathbf{s}_t$), and letting $\mathbf{V} = \mathrm{var}_t[\mathbf{rx}_{t+1}]$, we get

$$\mathrm{E}_t[\mathbf{rx}_{t+1}] = \tau^{-1}\mathbf{V}\mathbf{s}_t, \tag{B.9}$$

with

$$\mathbf{V} = \mathrm{var}_t[\mathbf{rx}_{t+1}] = \begin{bmatrix} V_y & C_{y,q} \\ C_{y,q} & V_q \end{bmatrix}.$$

We can write out equation (B.8), yielding individual excess return equations:

$$\mathrm{E}_t\left[rx^y_{t+1}\right] = \frac{1}{\tau}\left[V_y \cdot s^y_t + C_{y,q} \cdot s^q_t\right]; \tag{B.10a}$$

$$\mathrm{E}_t\left[rx^q_{t+1}\right] = \frac{1}{\tau}\left[C_{y,q} \cdot s^y_t + V_q \cdot s^q_t\right], \tag{B.10b}$$

where $V_y \equiv \mathrm{var}_t[rx^y_{t+1}]$, $V_q \equiv \mathrm{var}_t[rx^q_{t+1}]$, and $C_{y,q} \equiv \mathrm{cov}_t[rx^y_{t+1}, rx^q_{t+1}]$. Note that $\mathbf{V}$ is constant in equilibrium and we hereafter drop the time subscripts.

Using these equilibrium excess return equations, along with asset prices equations (5) and (8), as well as the exogenous processes, we can characterize equilibrium bond yields and foreign exchange prices:

$$y_t = \left\{\bar{\iota} + \frac{1-\delta}{1-\delta\phi_i}\cdot(i_t - \bar{\iota})\right\} + \frac{1-\delta}{1-\delta\phi_g}g_t + \left\{\tau^{-1}V_y \cdot \bar{s}^y\right\} + \tau^{-1}\left\{\frac{1-\delta}{1-\delta\phi_{s^y}}V_y \cdot (s^y_t - \bar{s}^y) + \frac{1-\delta}{1-\delta\phi_{s^q}}C_{y,q}\cdot s^q_t\right\}; \tag{B.11}$$

$$q_t = \left\{\frac{1}{1-\phi_i}\cdot(i^\star_t - i_t)\right\} + \mathrm{E}_t\, q_{t+\infty} + \tau^{-1}\left\{C_{y,q}\bar{s}^y + \frac{1}{1-\phi_{s^y}}C_{y,q}\cdot(s^y_t - \bar{s}^y) + \frac{1}{1-\phi_{s^q}}V_q \cdot s^q_t\right\}. \tag{B.12}$$

We now focus on the fixed-point problem. The vector of excess returns is

$$\mathbf{rx}_{t+1} \equiv \begin{bmatrix} rx^y_{t+1} \\ rx^q_{t+1} \end{bmatrix} = \begin{bmatrix} \frac{1}{1-\delta} y_t - \frac{\delta}{1-\delta} y_{t+1} - i_t - g_t \\ i_t - i^\star_t - (q_{t+1} - q_t) \end{bmatrix} = \mathbf{B}_0 \mathbf{y}_t + \mathbf{B}_1 \mathbf{y}_{t+1} + \mathbf{R}_1 \mathbf{z}_t + \mathbf{r}_0.$$

where I have used equations (1), (2), (3), (7), and the fact that $rx^y_{t+1} \equiv r^y_{t+1} - i_t$. Additionally,

$$\mathbf{B}_0 = \begin{bmatrix} \frac{1}{1-\delta} & 0 \\ 0 & 1 \end{bmatrix}, \quad \mathbf{B}_1 = \begin{bmatrix} -\frac{\delta}{1-\delta} & 0 \\ 0 & -1 \end{bmatrix}, \quad \mathbf{R}_1 = \begin{bmatrix} -1 & 0 & -1 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \end{bmatrix}, \mathbf{r}_0 = \begin{bmatrix} -\bar{\imath} \\ 0 \end{bmatrix}.$$

Note that when conjecturing the equilibrium, we defined $\mathbf{y}_t = \mathbf{a} + \mathbf{A}\mathbf{z}_t$. Iterating this expression one period forward and using that $\mathbf{z}_{t+1} = \Phi \mathbf{z}_t + \varepsilon_{t+1}$, one can obtain that

$$\mathbf{y}_{t+1} = \mathbf{a} + \mathbf{A}\mathbf{z}_{t+1} = \mathbf{a} + \mathbf{A}\Phi\mathbf{z}_t + \mathbf{A}\varepsilon_{t+1}. \tag{B.13}$$

Recall that Φ is a diagonal matrix with the AR(1) coefficients of the 6 different exogenous processes. Going back to the equation for $\mathbf{rx}_{t+1}$ I just derived yields

$$\mathbf{rx}_{t+1} = [\mathbf{B}_0\mathbf{a} + \mathbf{B}_1\mathbf{a} + \mathbf{r}_0] + [\mathbf{B}_0\mathbf{A} + \mathbf{B}_1\mathbf{A}\Phi + \mathbf{R}_1]\mathbf{z}_t + [\mathbf{B}_1\mathbf{A}]\varepsilon_{t+1}, \tag{B.14}$$

which implies that

$$E_t[\mathbf{rx}_{t+1}] = [\mathbf{B}_0\mathbf{a} + \mathbf{B}_1\mathbf{a} + \mathbf{r}_0] + [\mathbf{B}_0\mathbf{A} + \mathbf{B}_1\mathbf{A}\Phi + \mathbf{R}_1]\mathbf{z}_t; \tag{B.15}$$

$$\mathbf{V} \equiv \text{var}_t[\mathbf{rx}_{t+1}] = \mathbf{B}_1\mathbf{A}\Sigma\mathbf{A}'\mathbf{B}_1'. \tag{B.16}$$

Going back to the market-clearing condition in equation (B.9), $\mathbf{s}_t = [s^y_t, s^q_t]'$ can be written as $\mathbf{s}_t = \mathbf{s}_0 + \mathbf{S}_1\mathbf{z}_t$, where

$$\mathbf{S}_1 \equiv \begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}, \quad \text{and} \quad \mathbf{s}_0 = \begin{bmatrix} \bar{s}^y \\ 0 \end{bmatrix},$$

which allows us to write equation (B.9) as

$$[\mathbf{B}_0\mathbf{a} + \mathbf{B}_1\mathbf{a} + \mathbf{r}_0] + [\mathbf{B}_0\mathbf{A} + \mathbf{B}_1\mathbf{A}\Phi + \mathbf{R}_1]\mathbf{z}_t = \tau^{-1}(\mathbf{B}_1\mathbf{A}\Sigma\mathbf{A}'\mathbf{B}_1')(\mathbf{s}_0 + \mathbf{S}_1\mathbf{z}_t). \tag{B.17}$$

Equation (B.17) is the main equation which will be used to solve the fixed-point problem. We first separate the terms that contain $\mathbf{z}_t$ from the terms that do not. For the constant terms we find that

$$(\mathbf{B}_0 + \mathbf{B}_1)\mathbf{a} = \left[\tau^{-1}\mathbf{B}_1\mathbf{A}\Sigma\mathbf{A}'\mathbf{B}_1'\mathbf{s}_0 - \mathbf{r}_0\right]. \tag{B.18}$$

Recall how $\mathbf{B}_0$ and $\mathbf{B}_1$ look like. The last row of the sum only contains zeros. Therefore, the domestic long-term bond yield is pinned down in equilibrium - but the constant for the exchange rate is not.

For the terms containing $\mathbf{z}_t$, note that $\mathbf{B}_0, \mathbf{B}_1$, and Φ are diagonal, and thus it follows that

$$[\mathbf{B}_0 \mathrm{A} + \mathbf{B}_1 \mathrm{A}\Phi] = \mathbf{A} \circ [\mathbf{B}_0 \mathbf{E} + \mathbf{B}_1 \mathbf{E}\Phi], \tag{B.19}$$

where $\circ$ is the element-wise matrix multiplication and $\mathbf{E}$ is a 3×5 matrix of 1s. Thus, we get

$$[\mathbf{B}_0 \mathbf{E} + \mathbf{B}_1 \mathbf{E}\Phi] = \begin{bmatrix} \frac{1-\delta\phi_i}{1-\delta} & \frac{1-\delta\phi_i}{1-\delta} & \frac{1-\delta\phi_g}{1-\delta} & \frac{1}{1-\delta} & \frac{1-\delta\phi_{s^y}}{1-\delta} & \frac{1-\delta\phi_{s^q}}{1-\delta} \\ 1-\phi_i & 1-\phi_i & 1-\phi_g & 1 & 1-\phi_{s^y} & 1-\phi_{s^q} \end{bmatrix}.$$

Using this, the terms containing $\mathbf{z}_t$ have to equate on both sides. That is,

$$[\mathbf{A} \circ (\mathbf{B}_0 \mathbf{E} + \mathbf{B}_1 \mathbf{E}\Phi) + \mathbf{R}_1]\mathbf{z}_t = \tau^{-1}(\mathbf{B}_1 \mathbf{A} \Sigma \mathbf{A}' \mathbf{B}_1')\mathbf{S}_1 \mathbf{z}_t. \tag{B.20}$$

Solving for the $\mathbf{A}$ in the LHS yields

$$\mathbf{A} = [\tau^{-1} \mathbf{B}_1 \mathbf{A} \Sigma \mathbf{A}' \mathbf{B}_1' \mathbf{S}_1 - \mathbf{R}_1] \oslash [\mathbf{B}_0 \mathbf{E} + \mathbf{B}_1 \mathbf{E}\Phi], \tag{B.21}$$

where $\oslash$ is element-wise matrix division. To further characterize the solution to the problem in (B.21), we can partition $\mathbf{z}_t$ as $\mathbf{z}_t = [\mathbf{z}_{1,t}', \mathbf{z}_{2,t}', \mathbf{z}_{3,t}']'$, where $\mathbf{z}_{1,t} = [i_t - \bar{\imath}, i_t^* - \bar{\imath}, g_t]'$, $\mathbf{z}_{2,t} = q_{t+\infty}$, and $\mathbf{z}_{3,t} = [s_t^y - \bar{s}^y, s_t^q]'$. Similarly, we partition $\mathbf{A} = [\mathbf{A}_1, \mathbf{A}_2, \mathbf{A}_3]$, where $\mathbf{A}_1$ is the 2×3 matrix of loadings on $\mathbf{z}_{1,t}$, $\mathbf{A}_2$ is the 2×1 matrix of loadings on $\mathbf{z}_{2,t}$, and $\mathbf{A}_3$ is the 2×2 matrix of loadings on $\mathbf{z}_{3,t}$.

For an arbitrary matrix $\mathbf{X}$, denote $\mathbf{X}^{[n-m]}$ for $n < m$ be the submatrix of $\mathbf{X}$ consisting of columns $n, n+1, ..., m-1, m$. Therefore, given the form of $\mathbf{R}_1$ and $\mathbf{S}_1$ ($\mathbf{S}_1^{[1-3]} = \mathbf{0}_{2\times 3}$) we can define submatrix $\mathbf{A}_1$ as

$$\mathbf{A}_1 = -\mathbf{R}_1^{[1-3]} \oslash [\mathbf{B}_0 \mathbf{E} + \mathbf{B}_1 \mathbf{E}\Phi]^{[1-3]} = \begin{bmatrix} \frac{1-\delta}{1-\delta\phi_i} & 0 & \frac{1-\delta}{1-\delta\phi_g} \\ -\frac{1}{1-\phi_i} & \frac{1}{1-\phi_i} & 0 \end{bmatrix}.$$

This matrix displays the price-impact coefficients of the domestic short-term rate (first column), the foreign short-term rate (second column), and the bond-specific shock (third column), on the domestic long-term yield (first row), and on FX (second row).

For $\mathbf{A}_2$, which contains the FX-specific shock, we can already see from the equilibrium price in equation (B.12) that $\mathbf{A}_2 = [0, 1]'$. In other words, the specific shock on the price of the exchange rate has no impact on the long-term bond price, while affecting the FX rate one-for-one.

Lastly, we now move to the supply shocks; that is, pinning down $\mathbf{A}_3$. Due to the orthogonality of the different shocks, the variance-covariance matrix Σ can be partitioned as

$$\Sigma = \begin{bmatrix} \Sigma_1 & 0_{3\times1} & 0_{3\times2} \\ 0_{1\times3} & \Sigma_2 & 0_{1\times2} \\ 0_{2\times3} & 0_{2\times1} & \Sigma_3 \end{bmatrix} \quad \text{where} \quad \Sigma_1 = \begin{bmatrix} \sigma_i^2 & \rho\sigma_i^2 & 0 \\ \rho\sigma_i^2 & \sigma_i^2 & 0 \\ 0 & 0 & \sigma_g^2 \end{bmatrix}, \quad \Sigma_3 = \begin{bmatrix} \sigma_{sy}^2 & \sigma_{\eta^*}\sigma_{\gamma^*} \\ \sigma_{\eta^*}\sigma_{\gamma^*} & \sigma_{sq}^2 \end{bmatrix},$$

and $\Sigma_2 = \sigma_q^2$. The variance-covariance matrix of excess returns ($\mathbf{V} \equiv \text{var}_t[\mathbf{rx}_{t+1}]$) becomes

$$\mathbf{V} = (\mathbf{B}_1\mathbf{A}_1\Sigma_1\mathbf{A}_1'\mathbf{B}_1') + (\mathbf{B}_1\mathbf{A}_2\Sigma_2\mathbf{A}_2'\mathbf{B}_1') + (\mathbf{B}_1\mathbf{A}_3\Sigma_3\mathbf{A}_3'\mathbf{B}_1'). \tag{B.22}$$

Making use of the form $\mathbf{S}_1$ and $\mathbf{R}_1$ ($\mathbf{R}_1^{[5-6]} = \mathbf{0}_{2\times2}$), the following fixed-point problem involving $\mathbf{A}_3$ is obtained

$$\mathbf{A}_3 = \mathbf{F}_3(\mathbf{A}_3) \equiv \tau^{-1}[(\mathbf{B}_1\mathbf{A}_1\Sigma_1\mathbf{A}_1'\mathbf{B}_1')+(\mathbf{B}_1\mathbf{A}_2\Sigma_2\mathbf{A}_2'\mathbf{B}_1')+(\mathbf{B}_1\mathbf{A}_3\Sigma_3\mathbf{A}_3'\mathbf{B}_1')]\oslash[\mathbf{B}_0\mathbf{E}+\mathbf{B}_1\mathbf{E}\Phi]^{[5-6]}. \tag{B.23}$$

The operator $\mathbf{F}_3(\mathbf{A}_3)$ gives the price function $\mathbf{y}_t = \text{g}(\mathbf{A}_3) + \mathbf{A}_1\mathbf{z}_{1,t} + \mathbf{A}_2\mathbf{z}_{2,t} + \mathbf{F}_3(\mathbf{A}_3)\mathbf{z}_{3,t}$ that will clear the markets for long-term bonds and FX when agents conjecture that the risk of holding of assets is determined by the price function $\mathbf{y}_{t+1} = \mathbf{a}_0 + \mathbf{A}_1\mathbf{z}_{1,t+1} + \mathbf{A}_2\mathbf{z}_{2,t+1} + \mathbf{A}_3\mathbf{z}_{3,t+1}$.

From equation (B.23), and using $\mathbf{V}$ in its matrix form, the equilibrium price-impact coefficients must satisfy

$$\begin{bmatrix} \alpha_{sy}^y & \alpha_{sq}^y \\ \alpha_{sy}^q & \alpha_{sq}^q \end{bmatrix} = \tau^{-1}\begin{bmatrix} \frac{1-\delta}{1-\delta\phi_{sy}}V_y & \frac{1-\delta}{1-\delta\phi_{sy}}C_{y,q} \\ \frac{1-\delta}{1-\delta\phi_{sy}}C_{q,y} & \frac{1-\delta}{1-\delta\phi_{sy}}V_q \end{bmatrix}. \tag{B.24}$$

The var.-cov. matrix in the absence of supply risk is $[(\mathbf{B}_1\mathbf{A}_1\Sigma_1\mathbf{A}_1'\mathbf{B}_1') + (\mathbf{B}_1\mathbf{A}_2\Sigma_2\mathbf{A}_2'\mathbf{B}_1')] =$

$$\begin{bmatrix} \left(\frac{\delta}{1-\delta\phi_i}\right)^2\sigma_i^2 + \left(\frac{\delta}{1-\delta\phi_g}\right)^2\sigma_g^2 & -\frac{\delta}{1-\delta\phi_i}\frac{1}{1-\phi_i}\sigma_i^2(1-\rho) \\ -\frac{\delta}{1-\delta\phi_i}\frac{1}{1-\phi_i}\sigma_i^2(1-\rho) & \left(\frac{1}{1-\phi_i}\right)^2 2\sigma_i^2(1-\rho)+\sigma_q^2 \end{bmatrix}. \tag{B.25}$$

Solving for the contribution of supply risk to the variance-covariance matrix, one can additionally find $\mathbf{B}_1\mathbf{A}_3\Sigma_3\mathbf{A}_3'\mathbf{B}_1'$. Note that one can recast the fixed-point problem in terms of the variance-covariance matrix, instead of using the 2×2 matrix $\mathbf{A}_3$. This is convenient because $\mathbf{V}$ is symmetric, effectively reducing the fixed-point problem to one involving three unknowns instead of four. One needs to find a fixed point in the form $\mathbf{V} = \mathbf{G}(\mathbf{V})$. Plugging the α's of equation (B.24) in the contribution of supply risk to the variance-covariance matrix, and using this and (B.25) in (B.22), along with denoting the constants

$$g_y \equiv \tau^{-1}\frac{\delta}{1-\delta\phi_{sy}}\sigma_\eta,\quad g_y^* \equiv \tau^{-1}\frac{\delta}{1-\delta\phi_{sy}}\sigma_{\eta^*},\quad g_q \equiv \tau^{-1}\frac{\delta}{1-\delta\phi_{sq}}\sigma_\gamma,\quad g_q^* \equiv \tau^{-1}\frac{\delta}{1-\delta\phi_{sq}}\sigma_{\gamma^*}, \tag{B.26}$$

$$h_y \equiv \tau^{-1}\frac{1}{1-\phi_{s^y}}\sigma_\eta, \;\; h_y^* \equiv \tau^{-1}\frac{1}{1-\phi_{s^y}}\sigma_{\eta^*}, \;\; h_q \equiv \tau^{-1}\frac{1}{1-\phi_{s^q}}\sigma_\gamma, \;\; h_q^* \equiv \tau^{-1}\frac{1}{1-\phi_{s^q}}\sigma_{\gamma^*}.$$

we get that $\mathbf{V}$ must satisfy the following system of three equations in three unknowns:

$$V_y = \left(\frac{\delta}{1-\delta\phi_i}\right)^2\sigma_i^2 + \left(\frac{\delta}{1-\delta\phi_g}\right)^2\sigma_g^2 + (V_y)^2(g_y^2+g_{y^*}^2) + (C_{y,q})^2(g_q^2+g_{q^*}^2) + 2g_{y^*}g_{q^*}V_yC_{y,q}; \tag{B.27a}$$

$$V_q = \left(\frac{1}{1-\phi_i}\right)^2 2\sigma_i^2(1-\rho) + \sigma_q^2 + (C_{y,q})^2(h_y^2+h_{y^*}^2) + (V_q)^2(h_q^2+h_{q^*}^2) + 2h_{y^*}h_{q^*}V_qC_{y,q}; \tag{B.27b}$$

$$C_{y,q} = -\frac{\delta}{1-\delta\phi_i}\frac{1}{1-\phi_i}\sigma_i^2(1-\rho) + V_yC_{y,q}(g_yh_y+g_{y^*}h_{y^*}) + V_qC_{y,q}(g_qh_q+g_{q^*}h_{q^*}) \tag{B.27c}$$

$$+ (C_{y,q})^2 g_{q^*}h_{y^*} + V_yV_qg_{y^*}h_{q^*}.$$

where $C_{y,q} = C_{q,y}$ and

$$\mathbf{V} = \text{var}_t[\mathbf{rx}_{t+1}] = \begin{bmatrix} V_y & C_{y,q} \\ C_{y,q} & V_q \end{bmatrix}.$$

which completes the full write-down of the solution method. One must now combine these three equations to find qualitative properties of the three unknowns. Instead, in the next subsection we prove Proposition 1, which effectively reduces this system of equations into a more manageable set that yields qualitatively siimlar implications.

B.3 Proof of Proposition 1

Proof of Proposition 1. The assumptions spelled out imply that $V_y = V_q$, which simplifies our system of equations to the following

$$V_y = \sigma_g^2 + (V_y)^2\tau^{-2}(\sigma_\eta^2+\sigma_{\eta^*}^2) + (C_{y,q})^2\tau^{-2}(\sigma_\eta^2+\sigma_{\eta^*}^2) + 2V_yC_{y,q}\tau^{-2}\sigma_{\eta^*}^2; \tag{B.28a}$$

$$C_{y,q} = 2V_yC_{y,q}\tau^{-2}(\sigma_\eta^2+\sigma_{\eta^*}^2) + (C_{y,q})^2\tau^{-2}\sigma_{\eta^*}^2 + (V_y)^2\tau^{-2}\sigma_{\eta^*}^2. \tag{B.28b}$$

We can use equation (16) to rewrite this system as

$$V_y = \sigma_g^2 + \tau^{-2}(\sigma_\eta^2+\sigma_{\eta^*}^2)\left[(V_y)^2 + (C_{y,q})^2 + 2\Omega V_yC_{y,q}\right]; \tag{B.29a}$$

$$C_{y,q} = \tau^{-2}(\sigma_\eta^2+\sigma_{\eta^*}^2)\left[2V_yC_{y,q} + (C_{y,q})^2\Omega + (V_y)^2\Omega\right]. \tag{B.29b}$$

First, setting $\Omega = 0$, it can be readily seen from equations (B.29a)-(B.29b) that the only real solution implies $C_{y,q} = 0$. Second, differentiating both sides of this equation with respect to

Ω, we achieve

$$\frac{d(C_{y,q})}{d\Omega} = \tau^{-2}(\sigma_\eta^2 + \sigma_{\eta^*}^2)\left[2V_y\frac{d(C_{y,q})}{d\Omega} + 2C_{y,q}\frac{d(C_{y,q})}{d\Omega}\Omega + C_{y,q}^2 + V_y^2\right]. \tag{B.30}$$

Next, collecting all terms that contain $\frac{dC_{y,q}}{d\Omega}$ on the left-hand side yields

$$\frac{d(C_{y,q})}{d\Omega} = \frac{\tau^{-2}(\sigma_\eta^2 + \sigma_{\eta^*}^2)\left[C_{y,q}^2 + V_y^2\right]}{1 - \tau^{-2}(\sigma_\eta^2 + \sigma_{\eta^*}^2)\left(2V_y + 2C_{y,q}\Omega\right)}. \tag{B.31}$$

To ensure that the denominator is positive, we require agents to be risk-tolerant enough. That is, for τ sufficiently large, we get that $\frac{d(C_{y,q})}{d\Omega} > 0$, which completes our proof.

□

B.4 Calibration

Parameter	Interpretation	Value
τ	Risk-tolerance	1/40
δ	Maturity of long-term bonds	0.90
ϕ_i	Persistence of short-term rates	0.965
ϕ_g	Persistence of bond-specific shocks	0
ϕ_{s^y}; ϕ_{s^q}	Persistence of net supply shocks	0.82
σ_i	Std. dev. of interest rate shocks	0.0015
σ_g	Std. dev. of bond-specific shocks	0.05
σ_q	Std. dev. of long-term q shocks	0.05
σ_η; σ_γ	Std. dev. of domestic net supply shocks	0.016
$\sigma_{\eta^\star}$; $\sigma_{\gamma^\star}$	Std. dev. of foreign net supply shocks	0.03

Table B.1
Baseline calibration

C Additional Tables and Figures

Table C.1
RDD estimates for bond and FX prices

VARIABLES	Bond (TES) Price	FX Price
Rank	0.250	-5.010
	(0.450)	(15.56)
dummy	-1.151*	47.32*
	(0.677)	(28.04)
dummy * Rank	-0.475	-42.36**
	(0.495)	(20.40)
dummy * Exposure	-0.000749	-0.0771***
	(0.000478)	(0.0238)
Constant	-2.551***	1,980***
	(0.654)	247

Note: Authors' calculations. Standard errors in parentheses. (*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$). The *Exposure* variable (centered) refers to the trading volume of sovereign bonds that each bank conducts with foreign investors. Bond (TES) prices are expressed as deviations from the daily mean price. FX selling prices are denoted in COP/USD. A bandwidth of rank 2 was used for this estimation, consistent with Calonico et al. (2014).