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India's Foreign Reserves and Global Risk§

ABSTRACT India has accumulated a sizable stock of foreign exchange reserves over the past three decades, common with many other emerging economies. Its current reserves surpass several thresholds for adequacy used by the International Monetary Fund and others. An assessment of whether the stock of reserves is appropriate depends on an evaluation of the benefits and costs of reserves. An important precautionary benefit is the role that reserves provide in terms of self-insurance against sudden financial outflows by non-resident investors or resident savers. Following the "at-Risk" literature to study the size of reserves and capital flows, we estimate probability densities of future gross capital flows for India, as a function of global financial conditions, policy frameworks, reserves, and domestic structural characteristics. We find that foreign exchange reserves play a significant role in shifting the empirical distribution of gross flows wherein the probability of large (negative) outflows is substantially reduced. Higher reserves reduce both extreme inflows and outflows of foreign capital. Following the approach in Devereux and Wu (2022), we find that an increase in the reserves to GDP reduces the risk premium on reserves, so that the sovereign interest rate spread over-estimates the marginal cost of reserves in India. This suggests that additional reserves reduce currency risk. Our results suggest that reserve accumulation continues to provide a precautionary reserve benefit for India. The precautionary benefits of reserves could well increase as India becomes further integrated to international financial markets.

Keywords: *Quantile Regressions, Foreign Exchange Reserves, Foreign Portfolio Flows, Precautionary Reserves, Global Financial Shocks*

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1. Introduction

Since the 1991 balance of payments crisis, India has accumulated a substantial stock of foreign exchange reserves. This rise in reserves accords with the pattern of reserve accumulation by many large emerging market economies. The hoarding of reserves by emerging markets has raised several questions about how these countries use their reserves, whether they hold adequate reserves for appropriate purposes, and if the marginal benefit of greater reserves outweighs the cost. Determining the appropriate size of reserves to hold as a precaution against extreme capital outflows is an important topic of monetary policy for policy-making and academic research.

Figure 1 shows that in January 1991, India's total foreign reserves were US $6.4 billion. In August 2024, they were $682 billion.[1] The average annual compound growth rate in reserves during this period is 16 percent. As of August 2024, approximately 3.4 percent of reserves were in Special Drawing Rights (SDRs) and the reserve tranche position. Approximately 9 percent of reserves were held in gold.

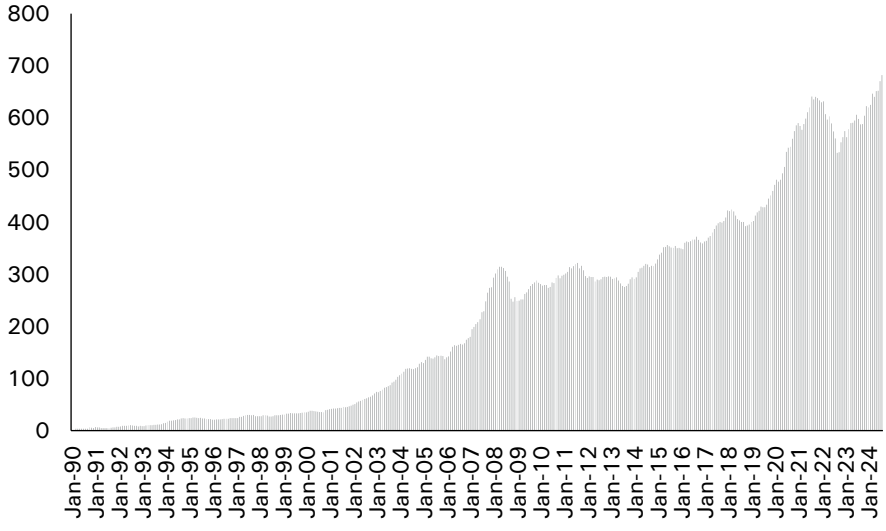
There are three primary motives for central banks to hoard reserves. First, the reserves provide self-insurance against runs on domestic financial markets and institutions by foreign and domestic asset holders. Reserves can be held as a precautionary measure to mitigate the impact of global financial or domestic shocks on external capital flows. Second, reserves are used for intervention in the foreign exchange market to reduce short-term exchange rate volatility. A third, mercantilist, motive concerns systematic purchases of reserves to maintain export competitiveness with a depreciated exchange rate.[2]

In this paper, we focus on the first motive and analyze the impact of reserves on international capital flows between 2004 and 2023 for India. Our empirical approach follows Adrian et al. (2019). This research adopts an approach from capital-at-risk analysis, which uses quantile regressions. To quantify the impact of reserves on international capital flows over the global financial cycle, as in Muduli, Behera, and Patra (2022), and Gelos et al. (2022), we use quantile regressions for India to estimate the marginal effect of reserves as a share of GDP on gross capital flows across the distribution of external and internal shocks given global financial, growth, and monetary policy risks. We focus

1. The Reserve Bank of India does not publicly report the composition of its reserves beyond the break-up in Figure 1.

2. Eichengreen (2007) suggests that countries that have historically maintained a competitively valued exchange rate, thereby allowing resources to move to the export sector, performed better in terms of medium-term economic growth rates. Barguelli, Ben-Salah, and Zmami (2018) show that exchange rate volatility negatively impacts economic growth, though the effect of exchange rate volatility on growth depends on the exchange rate regime and the degree of financial openness. Volatility is more harmful in countries with flexible exchange rate regimes and more financial openness.

FIGURE 1. Foreign Reserves, India (Billion $)



Source: RBI Database of the Indian Economy.

on gross capital inflows, which matter most for financial stability concerns, and amounted to about 1 percent of GDP in 2023.[3] By interacting risks with reserve holdings, we demonstrate that additional reserves reduce large outflows of foreign-owned capital in adverse events. Higher reserves can reduce both extreme inflows and outflows of foreign capital. We analyze the effects for foreign portfolio debt and foreign portfolio equity flows separately. We find that foreign exchange reserves play a significant role in shifting the empirical distribution of gross flows wherein the probability of large (negative) outflows is substantially reduced. The estimates suggest that reserve accumulation continues to provide a precautionary reserve benefit for India.

A natural policy question arises: when does the RBI have enough, or too many, reserves? Additions to reserves beyond what is needed to cover potential

3. We follow a large literature and the data provided by the OECD (see Mehigan 2018) in defining gross capital inflows as net sales of domestic financial instruments to foreign residents, or non-residents. An alternative classification differentiates between gross/net flows by non-residents and residents. In this classification, gross inflows are referred to as non-resident net inflows, or non-resident inflows minus outflows. Resident net outflows are resident outflows minus inflows, and are referred to as gross outflows. Hence, gross inflows are synonymous with non-resident net inflows, and gross outflows are synonymous with resident net outflows with the difference between gross inflows and gross outflows referred to as net inflows. See Bhargava et al. (2023, Footnote 6). Gross capital inflows arise when the economy incurs more external liabilities (inflows with a positive sign) or the economy reduces its external liabilities (inflows with a negative sign). Also see Broner et al. (2013).

sudden capital outflows and import needs can provide assurance to creditors and other market participants that the central bank will not hesitate to intervene as much and as long as necessary. Reserves may reduce the risks due to global and domestic financial shocks reducing the incidence of capital flow reversals and the risk premium on government debt whether denominated in domestic currency or foreign currency.

The adequacy of precautionary reserves has traditionally been defined in terms of the potential demand for reserve currency in the short run. Assessments were based on ratios of reserves to rule-of-thumb measures of an economy's exposure to sudden outflows or reversals of inflows. These include short-term external debt exposure (months of imports, and the ratio of reserves to broad money. These adequacy metrics, however, are increasingly viewed as ad hoc.

Starting in 2016, the IMF moved towards assessing reserve adequacy with a more forward-looking approach. The Assessing Reserve Adequacy (ARA) metric provides broader assessment of a country's external vulnerabilities based on IMF projections.[4] For emerging markets, reserves are broadly considered adequate for precautionary reasons if they range between 100 to 150 percent of the ARA metric (see IMF 2016). In 2024, the IMF noted that India's reserves were 114 percent of the ARA metric, at the lower end of what would be considered adequate.[5]

Floating exchange rate regimes raise the question of whether reserves should be held for the purpose of intervening in response to foreign capital outflows due to global or domestic shocks. Advanced economy central banks typically allow exchange rate movements to absorb the effects of global financial cycles. As Obstfeld (2015) argues, financial markets in emerging market economies are vulnerable to stress from large exchange rate changes. He suggests that the use of reserves to mitigate large depreciations associated with capital flow reversals can be warranted. Over the last two decades, capital flows to India have risen to the level of other major Emerging Market and Developing

4. The ARA is a composite metric which includes not only broad money and short-term debt as in the traditional metrics, but also other liabilities such as medium- and long-term debt, and exports. The weight on each variable depends on whether a country follows a fixed or flexible exchange rate regime. For instance, a higher weight is placed on broad money if a country's capital account is more open because of the potential for domestic flight. The ARA metric is also separately calculated depending on whether a country is advanced, emerging, or low income.

5. The External Sector Report for 2024 presents the assessment of reserve adequacy as follows: "Various criteria confirm that the official FX reserves are adequate for precautionary purposes. As of the end of 2023, they represented about 219 percent of short-term debt (on residual maturity), 109 percent of the IMF's composite metric (for a de facto stabilized exchange rate arrangement), and more than eight months of import coverage. In view of India's moderately strong external position, generally deep and liquid FX markets, limited FX mismatches, well-anchored inflation expectations, and adequate reserves level, Integrated Policy Framework analysis indicates that FX interventions should be limited to addressing disorderly market conditions." (See IMF 2024, p. 74).

Economies (EMDEs), and the economy's exposure to external financial shocks has risen. The RBI tends to respond to shocks by expending its reserves as the rupee depreciates.

The quantile regression analysis provides a way of estimating the effect of additional reserves on foreign capital flows.[6] Reserves held as a precaution against liquidity crises can affect the probability of crises and their impact on financial markets. The anticipation that reserves will be available to mitigate the effects of global financial shocks and to meet sudden outflows of foreign capital is likely to affect the amount and nature of foreign capital inflows. Self-insurance is purposed toward financial stability and, hence, more efficient investment financing. Higher reserves that are seen to reduce financial fragility could improve the maturity structure of capital inflows reducing exposure to short-term capital outflows.

Weighing against the benefits of having reserves are the opportunity costs of holding them. These costs include the interest differential between Government of India and U.S. Treasuries, changes in the valuation of reserves, and the carry cost of foreign reserves. We estimate a model of the interest rate spread and find that spreads decline with the ratio of reserves to GDP. The marginal cost of reserves appears to be less than the interest rate spread. Our results show that increasing reserves appear to reduce the overall sovereign bond spread by reducing both currency risk and credit risk using the 10-year US-India bond spread.

The paper is organized as follows. Following the Introduction in Section 1, Section 2 gives a selective review of the literature on reserve adequacy and the dynamics of capital flows to emerging markets. Empirical research on international capital flows concentrates on cross-country analysis. Our summary highlights the results for emerging markets collectively or selectively that can directly inform discussions of policy and prospects for India. Section 3 provides a narrative overview of capital flows for India, reserve policy, and risks. Section 4 describes and reports the analysis of gross capital flows using quantile regressions. Section 5 discusses the cost of reserves and estimates the marginal effect of reserves on interest rate spreads. Section 6 presents the conclusion.

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6. As noted in Eguren Martin et al. (2021), modeling the probability distribution of the variable under consideration involves using information from extreme observations. Given that extreme observations tend to be rare by definition, the exclusion of such observations could lead to a change in results. We show that our results are robust to a variety of different formulations. Saleh and Saleh (2021) discuss some of the limitations of the quantile regression approach, such as the non-monocity problem, or the "crossing problem."

2. International Capital Flows and Emerging Market Reserves: A Literature Review

The series of financial crises in emerging markets between 1980 and 2000 has motivated a large academic literature as well as advocacy by economists and multilateral financial institutions for central banks to raise reserve holdings as a buffer stock against sudden stops and avoid fixed exchange rates. It is well recognized that reversals lead to nominal depreciations, which can be sharp or severe, if not managed by foreign exchange intervention. Large capital episodes, in turn, can have implications for financial stability if a country's external obligations are denominated in foreign currency. Large capital episodes can also have consequences for inflation, depending on the pass-through from extreme exchange rate movements, which motivates reserve sales in episodes of Foreign Portfolio Investment (FPI) reversals caused by external shocks.

By accumulating a sufficient level of reserves, emerging market economies would be able to sell reserves to accommodate sudden reversals of capital inflows. Such self-insurance could allow countries to avoid the sharp drops in output and domestic absorption caused by financial shocks.[7] The accumulation of a stock of reserves might also reduce the incidence of capital flow runs, for example, when crises are self-fulfilling. In addition to precautionary reserve holding, proposed and adopted measures include macroprudential policies and capital controls.

The notion of precautionary reserves leads to the question of determining the optimal level of reserves for a central bank. Heller (1966) argues that given the opportunity cost of holding reserves, the level of reserves should be determined by the trade-off between this cost and the welfare cost of crisis risk. Jeanne and Ranciere (2011) derive a formula for optimal reserves to protect against sudden stops based on the idea that reserves replicate an insurance contract against sovereign default. An underlying concept is that the call on reserves and the holding cost should be discounted and priced using a stochastic discount factor in a forward-looking model. By the formula, optimal reserves equal the sum of the potential capital outflow and the output loss due to the sudden stop discounted for the probability of a crisis and flow opportunity cost of reserves. Jeanne and Sandri (2020) take a similar approach to model optimal reserves for a country that is financially closed but open to trade. When calibrated for countries with very low private capital flows and low short-term external public debt, their model generates optimal reserves equal to 3.3 months of imports matching the conventional import cover rule very well.

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7. The policy response can be a mix of allowing the exchange rate to float (and thus act as a "shock-absorber") and intervening in the foreign exchange market to limit the rate of depreciation.

Empirically, Jeanne and Ranciere show that the reserves held by emerging market central banks exceed the optimal level for the precautionary reserves predicted. The empirical results of Aizenman and Lee (2007) and others find that the reserves accumulated by East Asian countries after the 1998-99 crisis can only be partly explained as precautionary savings against external liabilities. Durdu et al. (2009) argue that financial globalization increases volatility, leading to larger precautionary reserves. Their empirical analysis finds that the reserve growth can be explained by financial globalization and sudden stop risk, but not by domestic output fluctuations. Calvo, Izquierdo, and Loo-Kung (2013) find similar results.

A large literature considers the role of gross flows for the financial vulnerability of EMDEs and, hence, for precautionary reserve accumulation and macroprudential policies. For instance, Forbes and Warnock (2012) and Broner et al. (2013) define capital flow regimes using data on gross capital inflows and outflows, and identify factors that affect these flows. Gross flows can be very large and volatile, respond to global financial cycles, and are associated with emerging market financial crises. Following Calvo, Leiderman, and Reinhart (1993), Forbes and Warnock distinguish between external (push) factors on gross flows and domestic (pull) factors on flows. Negative global financial shocks typically lead to large outflows of foreign-owned capital (stops), and inflows of domestic-owned capital abroad (retrenchments). Global shocks induce gross flows that are much larger than the net flows. Forbes and Warnock show that global shocks drive gross flows but that domestic factors such as GDP growth do not. Gross flows are positively correlated with the global cycle. During periods of global financial volatility or uncertainty, foreign capital leaves and domestic assets return. Broner et al. show that the overall dynamics of gross capital flows hold for different types of flow (portfolio debt, portfolio equity, direct investment, and other flows) individually. Koepke (2019) surveys the empirical literature on the response of gross flows to shocks. Estimates of the effects of macroprudential policies on gross capital flows tend to be insignificant or inconclusive (see Forbes and Warnock 2012; Beirne and Friedrich 2014; and Galati and Moessner 2018).

Using a sample of 34 emerging market economies, Eichengreen, Gupta and Masetti (2018) show that while capital inflows (both FDI and non FDI) into emerging markets conform with conventional wisdom on their relative volatility, outflows from emerging markets behave differently. In particular, FDI outflows from emerging markets have become more volatile since the turn of the century. They also show that there is a significant increase in bank intermediated capital outflows from EMEs. However, for India, gross domestic portfolio outflows are restricted by capital flow management measures and are dominated by portfolio inflows. Over the last two decades, the mean foreign portfolio inflows were more than 30 times the mean foreign portfolio outflows

for India. Their relatively small size means that outflows do not quantitatively influence the demand for precautionary reserves. In comparison to middle-income emerging markets, capital flight and retrenchment do not feature in the Indian response to global shocks. For these reasons, we focus only on portfolio inflows (debt and equity) in this paper.[8]

Obstfeld, Shambaugh, and Taylor (2010) argue that international reserves can provide liquidity, often of higher quality, against capital outflows from domestic financial markets during periods of distress (an internal drain). They conclude that depth of domestic financial markets can contribute to an economy's risk exposure and motivate larger reserve holdings. They confirm the significance of M2 empirically for explaining emerging market reserves share of GDP. The inclusion of the reserves to M2 ratio in IMF evaluation of reserve adequacy reflects this. Financial crises are often associated with the unwillingness of creditors to refinance maturing public and private debt. Hur and Kondo (2016) and Bianchi, Hatchondo, and Martinez (2018) model how rollover risk can motivate additional reserves for precautionary reasons. In these articles, reserve accumulation reduces the probability of a crisis in the presence of potential sovereign default.

The current account reversal in a sudden stop episode is the net outflow of capital. Bianchi and Mendoza (2020) estimate this to be around 3.7 percent of GDP for a typical sudden stop in emerging market economies over the period 1979 to 2016. These episodes are clustered around global financial events. The exposure of the economy to global shocks may be better measured by the dynamics of gross outflows and gross inflows than by net flows. Surges in capital inflows are associated with the accumulation of foreign liabilities and exchange appreciation that can create significant financial vulnerabilities, including asset price bubbles, raising the likelihood of banking, debt, and currency crises. In terms of gross flows, a sudden stop is characterized by a sharp reversal of foreign inflows. Reserve accumulation provides liquidity to the central bank to act in the event of surge reversals and serves to counter real appreciation pressures.

2.1. Quantile Regressions

A new approach to estimating the effects of shocks and policies on gross flows is proposed by Gelos et al. (2022). They use quantile regressions following the literature on value-at-risk to estimate the entire probability distribution of external portfolio capital flows using a panel dataset of emerging markets. We adopt this approach in our paper. The objective is to estimate how the future distribution of gross portfolio flows in short and medium runs varies with

8. See Eichengreen and Gupta (2013) for a discussion on how Indian banks fared during the Great Financial Crisis.

global shocks, country characteristics, policy frameworks, and policy actions. Of particular interest is the impact of global shocks on extreme capital flows in the tails of the distribution under alternative policies. In terms of country characteristics, they estimate how exchange rate regimes, institutional quality, monetary policy frameworks, and domestic financial depth affect capital flows. The findings indicate that more flexible exchange rate regimes are associated with more capital flow volatility in the short run and less in the medium run. Central bank transparency, stronger institutions, and deeper financial markets reduce the volatility of capital outflows in the medium term. The authors find that macroprudential policies seem to reduce volatility while the imposition of capital controls in response to adverse global shocks exacerbates gross flows.

Eguren Martin et al. (2021) use the same quantile regression approach using a cross-country panel. An innovation is the construction of global and domestic financial conditions indices from asset prices using high-frequency data. Effects for foreign direct investment, portfolio equity flows, portfolio debt flows, and banking flows are estimated separately. They find that push (global) shocks affect portfolio and banking flows the most and foreign direct investment the least. Pull shocks affect each type of flows, but most strongly affect banking flows. The effects of global shocks diminish quickly. Capital controls on outflows do not change the distribution of flows, while control on inflows tend to reduce extreme inflows and outflows.

Most empirical analysis of capital flows and reserves for emerging markets relies on cross-country variation, often in panel datasets, for sufficient variation in country characteristics and policies. The 'capital flows at risk' approach is adaptable to the study of a single country. Quantile regressions suggest a way to estimate the risk of extreme capital outflows during global financial shocks or in response to domestic shocks and quantify the precautionary requirement for reserves. Precautionary reserve models and estimates are based on a measure of the potential portfolio capital outflows caused by adverse shocks. The outflows at risk can originate from both foreign and domestic holdings of domestic assets. Estimating the tails of a distribution of capital flows might more accurately measure the exposure that needs to be covered by reserves than balance sheet items.

One use of these regressions could be to estimate a value for setting a lower bound on precautionary reserves. Another is to estimate the effects of additional reserves on gross capital outflows and inflows in the presence of global shocks. If additional reserves reduce the risk of outflows during financial turbulence, then holding reserves in excess of the base amount needed to match outflows in the event should be beneficial. For example, Gourinchas and Obstfeld (2012) show empirical evidence that the frequency of banking crises, currency crises, and debt crises all fall with increasing reserve ratios.

In our analysis, we use time series data to estimate the probability distribution of gross cross-border flows for India using conditional quantile regressions for India. The effects of reserves on gross capital flows at the margin are estimated using interactions with financial shocks and monetary policy changes. We examine whether reserves reduce the risk of extreme capital outflows, by how much, and how these effects vary across types of flows. Muduli, Behera, and Patra (2022) have already used the approach of Gelos et al. (2022) to analyze the distribution of capital inflows over global shocks. Their dependent variables are net capital flows so that extreme outflow events should be interpreted as current account reversals. Our approach treats gross capital inflows (increases in domestic assets owned by non-residents) and gross capital outflows (decreases in domestic assets owned by non-residents) separately. This approach follows Gelos et al. (2022). Our analysis of how reserves affect gross flows over the global financial cycle is new.

3. Reserves and Gross Flows for India

In common with many emerging market central banks, the Reserve Bank of India accumulated international reserves at a rapid pace over the first decade of the 2000s. The ratio of reserves to GDP (measured in USD) rose from about 6 percent in July 1996 to 25 percent in May 2009. India's reserve accumulation began a decade earlier following the currency crisis of early July 1991. In a speech before Parliament, the then Minister of Finance, Dr Manmohan Singh noted that India's less than $1billion of foreign exchange reserves barely covered two weeks of imports in mid-1991.[9] The steady accumulation of reserves over the 1990s appears to have been a priority for monetary policy. Following the start of the Global Financial Crisis, the ratio of reserves to GDP declined until 2013, then growing in trend with nominal output until the COVID-19 lockdown**.** Figure 2 depicts the trends in reserves as a share of GDP.

Gross Foreign Portfolio Inflows (FPIs) to India tend to be very responsive to the global financial cycle and have experienced large reversals during global shocks. Sudden and large outflows of capital provide a basis for the self-insurance motive for maintaining a stock of reserves. The use of precautionary reserves should result in substantial large reserve outflows in times of large FPI outflows. Between 2004 and 2024, reserves fell annually in six events during the years 2008-09, 2011, 2013, 2018, 2020, and 2021-22. Each of these can be associated with a period of global financial turbulence facing emerging markets: the GFC, the European debt crisis, the Taper Tantrum, monetary tightening by the Federal Reserve (2016-19), the COVID-19 lockdown, and the U.S. rate increases and Russian-Ukrainian War. Each of these episodes lasted from two

9. Presentation of the interim budget for 1996-97 on 28 February 1996.

to several months. Nath et al. (2024) provide detailed plots of daily foreign portfolio inflows and cumulative FPI flows, as well as time-series plots of global volatility for each episode except the start of the lockdown. The monthly data for gross capital flows are depicted in Figure 3, and the corresponding descriptive statistics are given in Table 1.

FIGURE 2. Reserves as a Percent of GDP

Source: RBI, IMF International Financial Statistics.

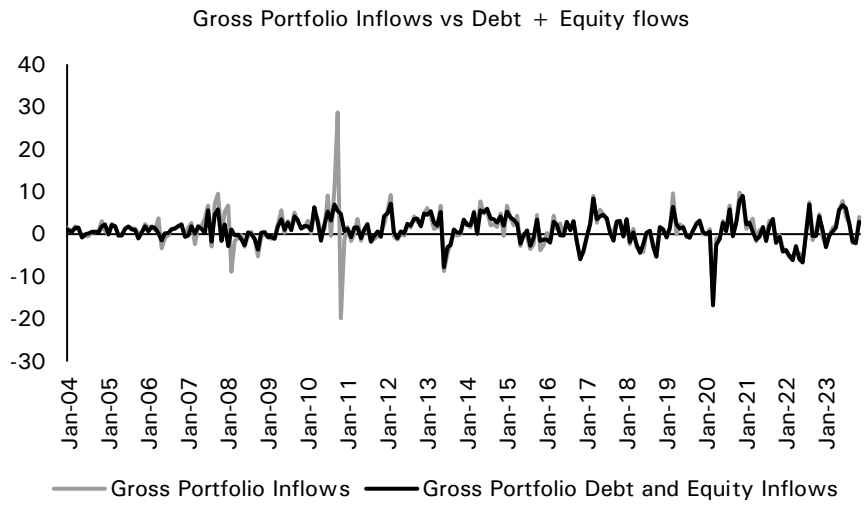
TABLE 1. Descriptive Statistics for Monthly Capital Flows (USD Billions)

	Debt Inflows	*Equity Inflows*	*FDI Inflows*	*Gross Portfolio Inflows*	*FDI Outflows*	*Gross Portfolio Outflows*
Mean	0.245	0.759	2.568	1.070	0.831	0.084
Median	0.128	0.805	2.227	0.919	0.804	-0.050
Min	-8.284	-8.503	-2.159	-19.811	-0.517	-2.233
Max	4.239	8.438	18.699	28.704	3.428	2.042

Source: OECD Monthly Capital Flow Dataset.
Note: Statistics for gross inflows are for the period January–December 2023. OECD data for gross portfolio outflows are available for the period March 2011–December 2023.

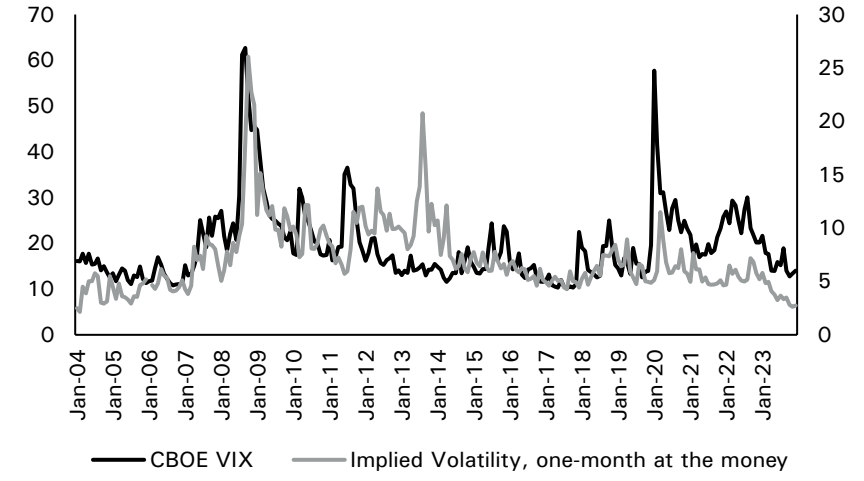
As can be seen in Table 2, around the Great Financial Crisis in 2008-2009, India experienced gross foreign capital outflow from May 2008 through March 2009, reaching a cumulative gross foreign portfolio outflow over $24 billion. This gross flow was 7.6 percent of reserves held by the RBI in May 2008.

FIGURE 3. Foreign Portfolio Inflows (USD Billions)



Source: OECD Monthly Capital Flow Dataset.

FIGURE 4. CBOE VIX and Implied Volatility Index



Source: Federal Reserve Bank of St. Louis FRED, Bloomberg.

In the European debt crisis, FPI was negative for the months of September and October 2011. The cumulative foreign portfolio outflow was $1.5 billion despite substantial global financial volatility.

In the Taper Tantrum, FPI flows were negative from May to November 2013. The total outflow over these six months was over $15 billion, which was equal to 5.4 percent of reserves in May 2013. After the Federal Reserve began raising the federal funds rate, India had cumulative gross foreign portfolio outflows between April and November of 2018, reaching a peak cumulation equal to $18 billion. Sudden outflows at the beginning of the pandemic lockdowns were $16 billion (USD) in March 2020 alone, followed by additional foreign portfolio debt outflows in April and May. The post-pandemic increases in U.S. rates and the Russian-Ukrainian war saw monthly outflows in excess of one standard deviation from December 2021 to June 2022.[10] The cumulative outflow over these seven months was $33 billion, equal to 5 percent of total initial reserves. In this event, U.S. monetary policy was reflected by a sharp rise in long-term U.S. treasury yields, absent in each of the others. As can be seen in Table 2, because of reserve accumulation, there has been a diminishment in the amount of movement in the exchange rate as measured by peak deprecation after 2008.

Shown together in Figure 4, with the exception of the Taper Tantrum (May 2013), significant financial shocks for India are global shocks. The Volatility Index (VIX) is a leading measure of global financial volatility, while the implied volatility for the rupee-dollar exchange rate by Bloomberg is a measure of the impact of global financial conditions on India. Around the great financial crisis of 2008-2009, both the local (implied volatility by Bloomberg, dark blue line) and the global (Chicago Board Options Exchange (CBOE) VIX, light blue line) proxy for uncertainty rose in concondance. In the Taper Tantrum in 2013, the Bloomberg implied volatilty increases more than CBOE VIX, suggesting that India was part of an emerging market sell-off episode (Gupta and Jain 2021). In COVID, there is a reversal, with the CBOE VIX rising much more than the implied volatilty, suggesting that global uncertainty dominated.

TABLE 2. Large Gross Foreign Portfolio Outflows (in USD Billions)

Event	*Duration*	*Cumulative Outflow (USD)*	*Fraction of Reserves*	*Peak Depreciation*
2008-09	14 months	$24.4 billion	7.6%	29.6%
2011	2 months	$1.5 billion	0.5%	9.0%
2013	6 months	$15.7 billion	5.4%	28%
2018	7 months	$18.1 billion	4.0%	14.5%
2020	3 months	$18.0 billion	3.8%	6.4%
2021-22	7 months	$33.1 billion	5.2%	6.9%

Source: Authors' calculations.

10. The standard deviation is calculated for monthly flows from January 2000 to November 2023.

Table 2 also shows that portfolio capital outflows are substantially smaller than measures of reserve adequacy for India based on short-term external debt exposure. Nearly all of India's short-term external debt is denominated in foreign currency (primarily, U.S. dollars). For the third quarter of 2023, 97 percent of short-term debt exposure, reported by the World Bank, was denominated in foreign currency. External debt payments due within 12 months at the end of March 2023 were 44 percent of reserves, and original maturity short-term debt at the end of March 2023 was 22.2 percent of reserves (Government of India 2023). The residual value exceeded a year's amortization of debt by more than 100 percent. The ratio of India's reserves at the end of the third quarter of 2023 to imports over the quarter also exceeded the traditional target by 3.4 times. Reserves were 21 percent of broad money (M3). These are depicted in Figures C.1, C.2, and C.3 in Appendix C. For 2023 and 2024, the ratio of Reserves to the ARA metric has been 1.14.[11]

Central banks use reserves to intervene in the foreign exchange market. One purpose of central bank intervention is to stabilize the level of the exchange rate or its rate of change. The bank may seek to reduce the impact of market volatility on the exchange rate or resist trends toward appreciation or depreciation. It may be "leaning against the wind" or acting as a mercantilist, trying to gain or maintain export competitiveness. Moving a market-clearing exchange rate necessitates changing the money supply, which is achieved by unsterilized intervention.

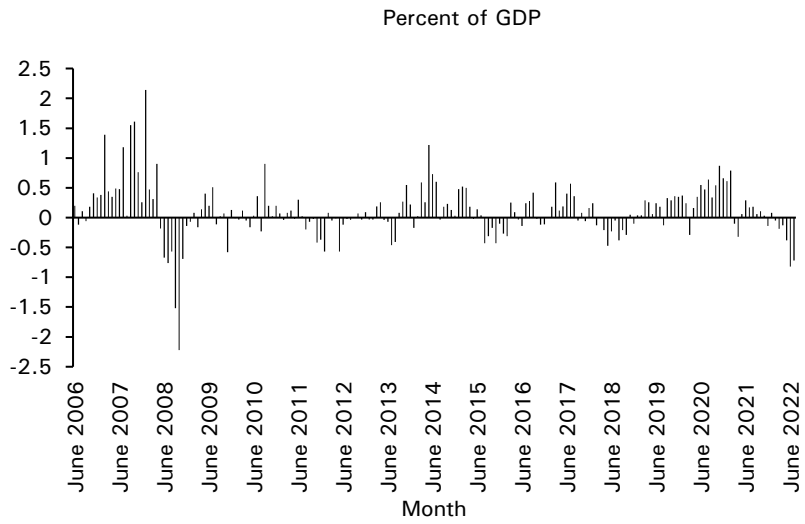
A second motive for intervention arises when the exchange market faces a liquidity constraint. The central bank can supply foreign or domestic currency to ease liquidity shortages in the spot or forward market through sterilized interventions. Du, Tepper, and Verdelhan (2018) demonstrate that deviations from covered interest parity are common in forward markets for EME currencies. Sterilized intervention can provide resources for private party arbitrage in these markets. Central banks will realize carry trade returns on their positions, which can be positive or negative.

The Reserve Bank frequently intervenes in spot and forward exchange markets, including the non-deliverable forward offshore market. The non-deliverable forward markets are most active in the currencies that cannot be delivered offshore due to capital controls. RBI intervention in the NDF market provides necessary liquidity in the rupee and accommodates arbitrage.

11. The IMF considers the INR-dollar exchange rate to have been relatively tightly managed by the RBI, and therefore considers India closer to a fixed exchange rate regime, which lowers the adequacy rate of reserves under the ARA metric as compared to what would be considered adequate if the exchange rate regime were floating.

A new IMF database[12] provides monthly estimates of foreign exchange intervention by 122 central banks, including the RBI. Adler et al. (2024) document the construction of a broad proxy for foreign exchange intervention that provides a comprehensive measure of foreign exchange intervention based on a precise definition of exchange intervention.[13] It includes an indicator showing whether the monthly intervention was fully sterilized or not fully sterilized. The sterilization indicator is reported for June 2006 through July 2022. For this period, fully sterilized intervention is reported for 153 months out of 194 months. The absolute value of monthly interventions over this period has a mean of 0.31 percent of GDP and standard deviation of 0.34. Interventions during the GFC were very large, reaching a maximum of 2.22 percent of GDP in October 2008. Monthly intervention as a percentage of a three-year moving average of annual GDP for India is shown in Figure 5. Interventions classified as not fully sterilized are shown in Figure 6, which shows that unsterilized interventions are clustered and mostly occur around the GFC.

FIGURE 5. Foreign Exchange Intervention (Monthly)



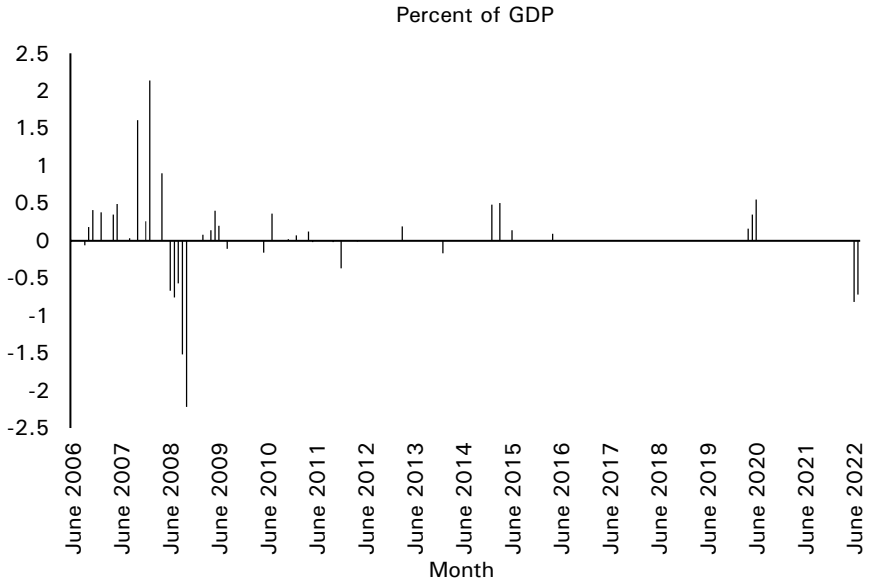
Source: IMF, Foreign Exchange Intervention Data and Proxies.

12. https://www.imf.org/en/Publications/WP/Issues/2021/02/19/Foreign-Exchange-Intervention-A-Dataset-of-Public-Data-and-Proxies-50017.

13. The broad proxy measures active central bank intervention in spot and derivative markets that change its foreign currency position. It does not include passive changes (valuation effects and investment income) or offsetting spot and forward positions. It includes unpublished confidential reports of central bank activities vis-à-vis non-residents and residents reported to the IMF but not published. For more details, see Adler et al. (2024).

The duration and depth of extreme FPI outflows is informative, but it does not seem be a good guide for reserve adequacy. In particular, gross capital flows are conditional on policy responses and the stock of reserves in place. Additional reserves on hand may reduce the vulnerability of the economy to extreme FPI outflows caused by either global or domestic shocks. Using quantile regressions, the next section provides an empirical analysis of this effect of precautionary reserves.

FIGURE 6. Not Fully Sterilized FX Intervention (Monthly)



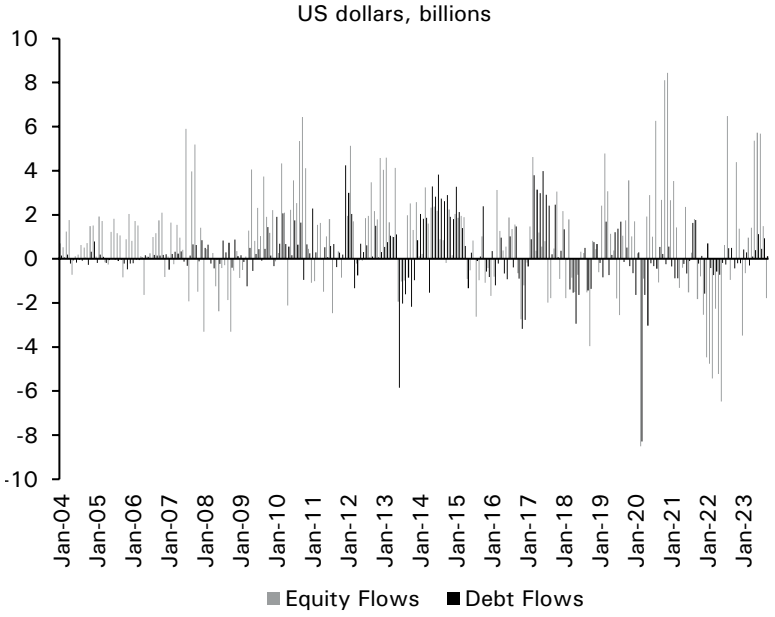
Source: IMF, Foreign Exchange Intervention Data and Proxies.

4. Quantitative Analysis

In this section, following Gelos et al. (2022) and Muduli, Behera, and Patra (2022), we estimate the empirical distribution function of capital flows in India using a quantile regression approach. The main advantage of using quantile regressions is that one can model the entire conditional distribution of the dependent variable, thereby allowing the effects of the co-variates to differ across quantiles. Based on the estimated conditional distribution, the risks to capital flows can then be quantified by estimating the size of outflows for a given quantile (e.g., 5 percent). The key departure from Gelos et al. (2022) and Muduli, Behera, and Patra (2022) in our paper is that we analyze the role

that foreign exchange reserves have for mitigating portfolio capital outflows at different quantiles. Given the current level of reserves, we are able to quantify the benefit of having more foreign exchange reserves.

FIGURE 7. Equity versus Debt Capital Flows India



Source: OECD Monthly Capital Flow Dataset.

While a large literature has concentrated on net capital flows,[14] following Gelos et. al. (2022), we use gross capital flows. More specifically, we use "non-resident" portfolio (debt and equity) inflows as our proxy for gross capital flows. We obtain gross portfolio debt and equity inflows (in USD) for India from the OECD Monthly Capital Flows Dataset (De Crescenzio and Lepers, 2024). Figure 7 plots portfolio equity (gray line) and debt capital flows (black line) into India between January 2004 to September 2023.[15] As pointed out in Gelos et al. (2022), non-resident portfolio inflows are the most volatile component of capital flows (compared to banking flows and FDI flows), and sensitive to

14. See Footnote 3. Net capital flows are defined as the difference between in gross capital flows, i.e., the net purchases of domestic assets by foreign agents minus the net purchases of domestic assets by foreign agents.

15. See Footnote 3. Gross inflows are net sales of domestic financial instruments to foreign residents. Gross capital inflows arise when the economy incurs more external liabilities (inflows with a positive sign) or the economy reduces its external liabilities (inflows with a negative sign) See Mehigan (2018).

external factors.[16] Hence, gross inflows are salient when it comes to financial stability considerations.[17]

More formally, for quantile q ∈ (0,1), the quantile regression can be represented as

$$y_{t+h}^{q} = \beta_q X_t + \varepsilon_t^q \tag{1}$$

with horizon h and with the error term ε ~ N(0, σ). The variable, y_t, refers to capital flows (total portfolio, debt, or equity inflows) and X_t is a set of covariates. From the quantile regressions, we generate empirical forward-looking probability density functions of capital flows. Following Adrian et al. (2019) and Gelos et al. (2022, p. 4), we fit a skewed t-distribution to the empirical distribution of predicted future flows. Azzalini and Capitanio (2003) provide the following skewed t-distribution:

$$f(y;\mu,\sigma,\vartheta) = \frac{2}{\sigma}\left(\frac{y-\mu}{\sigma};\vartheta\right) T\left(\theta\frac{y-\mu}{\sigma}\sqrt{\frac{\vartheta+1}{\vartheta+\frac{y-\mu}{\sigma}}};\vartheta+1\right) \tag{2}$$

with four parameters: the mean (μ), the standard deviation (σ), skewness (α) and kurtosis (ν) and where dT (.) and T(.) denote the probability density functions and cumulative density function of the skewed t-distribution. Because of the flexibility of the skewed t-distribution, it allows one to be agnostic about the shape of the distribution of future flows.[18]

4.1. Discussion of Data

Our analysis considers several covariates that seek to capture the effects of global (push) factors and domestic (pull) factors. A detailed listing of the data and sources are in Appendix A.[19] Global factors include global financial uncertainty, global monetary shocks, and foreign real output growth. The policy

16. Between January 2004 and September 2023, the coefficient of variation of equity flows is 2.96, for debt is 5.80, as compared to 0.77 for FDI.

17. Gross foreign portfolio inflows respond most sharply to financial shocks and display much greater volatility than foreign direct investment flows. For India, gross domestic portfolio outflows are restricted by capital flow management measures and are dominated by portfolio equity outflows. These are small and do not quantitatively influence the demand for precautionary reserves. In comparison to middle-income emerging markets, capital flight and retrenchment do not feature in the Indian response to global shocks.

18. See Gelos et al. (2022) for details. See Eguren Martin et al. (2021) for a discussion of boot-strapping standard errors, which provide Heteroskedasticity- and Autocorrelation-Consistent (HAC) standard errors for quantile regression coefficient estimators. See also Fitzenberger (1998).

19. The list of co-variates that we use in our analysis are: CBOE VIX (FRED); Term Premium India (10-year yield, Bloomberg, minus WACR, RBI); India – US Spread (WACR – Fed Funds Rate, FRED); India – US Growth Differential (Monthly GDP Data, IFS Interpolated minus Brave Butters Kelly); Reserves/GDP lagged; and the interaction terms: (a) VIX * Reserves/GDP (lagged) (b) Spread * Reserves/GDP (lagged); (c) India Term Premium * Reserves/GDP (lagged). (See Appendix A).

variables for India include the RBI's policy interest rate, the term premium on 10-year G SEC bonds, and the stock of international reserves. Global financial conditions are measured by the CBOE VIX, which is highly correlated with contemporaneous foreign portfolio flows for India in monthly data, but lagged observations do not. Although there may well be lagged effects of the news contained in the VIX at a daily frequency, portfolio capital flows accumulated over the month suggest that uncertainty shocks are absorbed quickly. We, therefore, treat this index as a contemporaneous exogenous shock.

Our regressions use the spread between the RBI policy rate, measured by the Weighted Average Call Rate (WACR), and the U.S. Federal Funds Rate. This is lagged to account for the possible endogeneity of the call rate, as is the term premium for the 10-year G SEC over the WACR. The differential between real GDP growth rate for India and the U.S. is lagged by three months.

The regressors of interest measure the stock of reserves held by the RBI before the month over which portfolio capital flows are measured. These are a state variable determined by past reserve management policy actions. Because current changes in reserves (a flow) are policy choices that respond to foreign portfolio flows, reserves are lagged to account for reverse causality. In the reported results, reserves are lagged by a quarter so that the stock is measured three months before the first day of the month of capital flows used in the dependent variable.

In the main analysis, reserves are measured in US dollars, as reported by the RBI. USD denominated assets comprise the majority of reserves held. Using reserves denominated in foreign currency avoids including valuation effects due to conversion to rupees. Reserves in USD are scaled by nominal GDP for India. Nominal GDP in rupees is reported quarterly. Quarterly figures are linearly interpolated to monthly and converted to dollars using the average monthly rupee to dollar exchange rate. This is an imperfect solution to retain monthly variation in foreign portfolio flows and foreign reserves. To alleviate the problem of noise introduced by the exchange rate, we also report regressions using an alternative measure of reserves denominated in rupees divided by broad money (M3), reported monthly by the RBI. The drawback of the ratio of reserves to M3 is that the numerator is converted from foreign currency into rupees and includes valuation changes in reserves. The results using M3 are qualitatively similar and are reported in Appendix B (Table B2).

In sum, explanatory variables used in all the analysis are VIX, the term premium for India, the India-US policy interest rate spread, the India-US growth rate differential, and the reserves-to-GDP ratio. Reserves are included in alternative specifications as the reserves-to-GDP ratio, reserves to GDP interacted with the VIX, reserves to GDP interacted with the interest rate spread, and reserves to GDP interacted with the India term premium. In Appendix B, we show robustness with a six-month lag on reserves to GDP (Table B1).

The time period for the analysis is January 2004 through September 2023. The start date has been chosen to avoid the effects of major relaxations of capital controls. The rapid accumulation of foreign reserves as a share of GDP from the beginning of 2000 to the end of 2003 is correlated with a high growth rate of foreign portfolio inflows, with a 48 percent correlation. Including these trends would bias results in favor of our hypothesis. Thus, we excluded this period as well.

4.2. Empirical Results

The results of regressions of Equation (1) include quantile regressions and a linear regression for different measures of the effect of the stock of reserves (lagged three months) on foreign portfolio flows.[20] Our baseline case regresses total FPI flows on the VIX, the term premium for India (India 10-year G-Sec –WACR), the India-US interest rate spread (India WACR–US Fed Funds Rate), the India-US monthly real GDP growth differential, and the reserves-to-GDP ratio lagged three months.[21] The results of the baseline quantile regression in Equation (1) are shown in Figure 8 and Table 3. In the figure of coefficient plots across quantiles, the black dotted line shows the estimated coefficient, and the shaded region indicates the 95 percent confidence interval. The solid gray line shows the coefficient estimate for the linear regression for means and the dotted gray lines indicate its 95 percent confidence interval.[22]

The global uncertainty shock, VIX, impacts FPI inflows into India negatively, and is statistically significant at all but the highest quantiles and shows that the risk of FPI outflows due to a rise in global uncertainty (VIX) is particularly strong in bad states of the world. As can be seen from Table 3, the coefficients for the ratio of reserves to GDP, lagged one quarter (three months), are positive and significant at the 0.05 quantile, the median, and the mean. These suggest that a larger prior stock of reserves increases foreign portfolio inflows unambiguously. In the presence of an adverse global shock, pre-existing reserves reduce capital flow reversals (events in the left tail of the distribution of flows). As can be seen in the coefficient plots for the ratio of reserves to GDP across quantiles in Figure 8, the coefficient on foreign reserves is positive and statistically significant at the lower quantiles.

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20. Our regression results are robust to the exclusion of gold in reserves. We, therefore, run all quantile regressions on aggregate reserves as in Figure 1.

21. See Camara, Christiano, and Dalgic (2024) for a small open economy DSGE model that models the effects of US monetary contractions on non-US countries. Since US GDP data are available on a quarterly basis, they use monthly data by multivariate interpolation.

22. The term premium for India and the India-US interest rate spread are lagged by one month. The India-US monthly real GDP growth differential is lagged by three months. This is applicable for all regressions in this section.

TABLE 3. Baseline Regression Results

Dependent Variable: Debt and Equity Flows	*0.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.327***	-0.117***	-0.153***
	(0.058)	(0.027)	(0.026)
India 10-year term premium	-0.168	0.225	0.090
	(0.270)	(0.186797)	(0.177)
India-US policy spread	-0.035	0.328***	0.245**
	(0.159)	(0.106)	(0.100)
India-US growth diff.	-0.021	0.0216*	0.029**
	(0.0208)	(0.013)	(0.012)
Reserves/GDP	3.140***	1.450**	1.767***
	(0.759)	(0.707)	(0.669)
Constant	-4.950**	-2.318	-1.995
	(2.290)	(1.736)	(1.643)
Number of observations = 237		Adj R-squared = 0.133	

Source: Data sources are listed in Appendix A.

Note: Reserves/GDP are lagged three months. Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

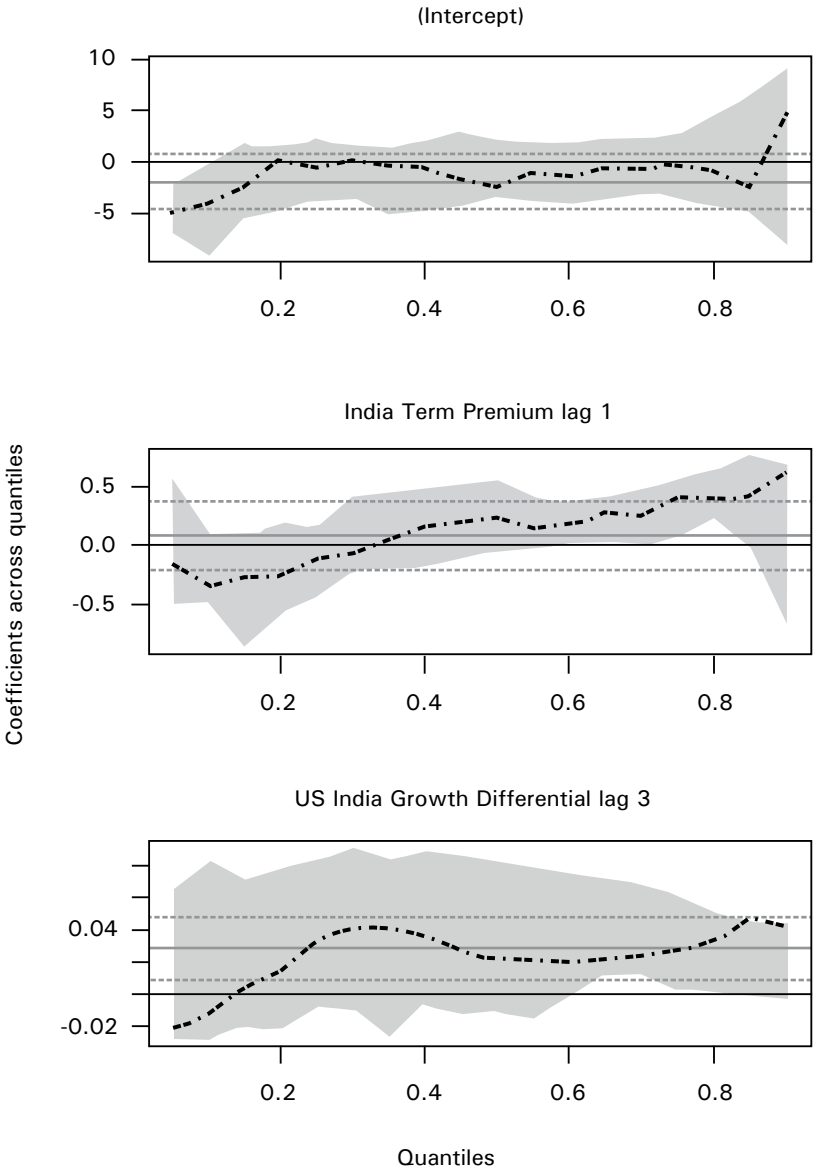
Table 3 shows that a larger stock of reserves relative to GDP lagged by one quarter reduces mean and median gross foreign portfolio inflows and has a stronger effect in left tail events. Prior holdings of reserves may positively influence capital inflows by signaling the capacity of the RBI to address capital outflows. By lagging this variable, we try to avoid conflating the accumulation of reserves from capital outflows with this role. For robustness, Table B.1 in Appendix B reports these regressions using the ratio of reserves to GDP lagged 6 months. The estimated coefficient on Reserves/GDP is very similar and remains significant at the 1 percent level for the 0.05 quantile regression.[23] Table B.2 in Appendix B reports the baseline regression replacing GDP as the denominator for reserves with broad money. The coefficient on Reserves/M3 lagged three months remains positive and significant at the 1 percent level.

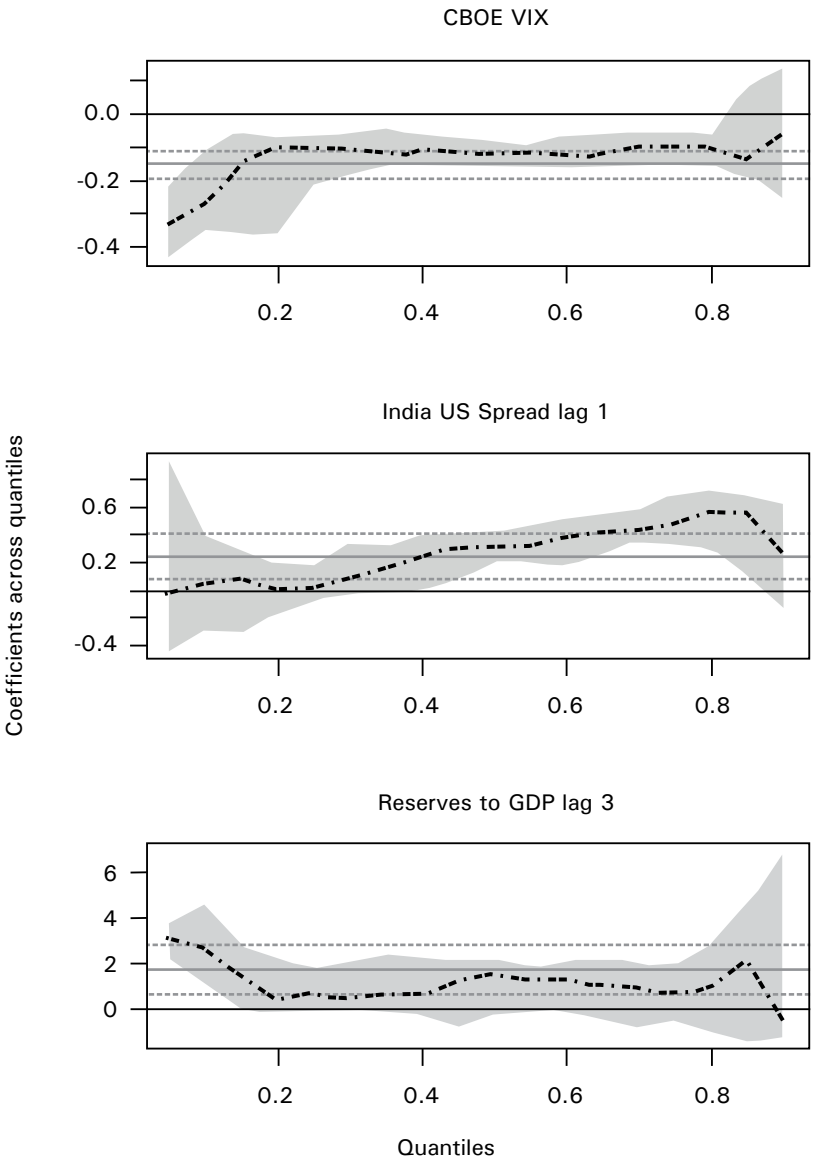
Figures B.1(a)–B.1(d) in Appendix B plot the empirical conditional density functions based on the quantile regression when VIX, the term premium, the interest rate spread, and the growth rate are shocked by one standard deviation.[24] In Figure B.1(a), a shock to global uncertainty, represented by a shock to VIX, shows that the conditional distribution of gross portfolio flows shifts to the left, with a fall in median flows. As seen in Figure B.1(a), the probability of (negative)

23. The mean estimate remains significant but at the 5 percent level.

24. Our use of the predicted empirical distributions is similar to Muduli, Behera, and Patra (2022).

FIGURE 8. Baseline Quantile Regression Results–Dependent Variable = Gross FPI Flows





Source: Authors' estimates; data described in Appendix A.

outflows in the lower quantiles increases. The probability of (positive) inflows in the upper quantiles falls.

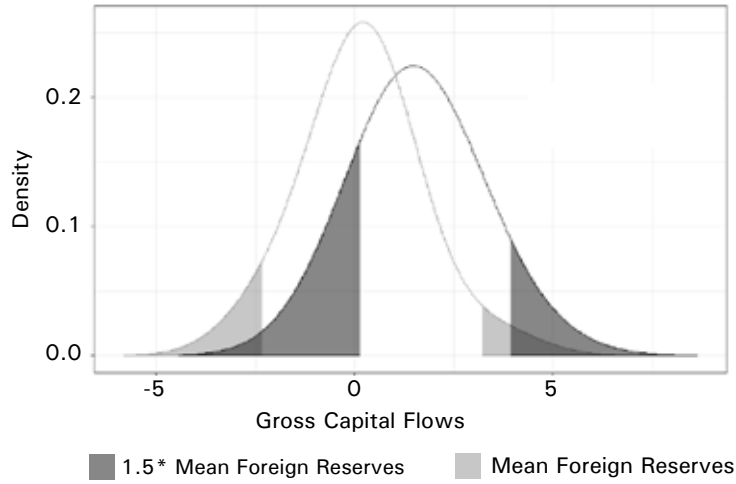
In contrast, a shock to the India term premium in Figure B.1(b), which corresponds to an increase in the steepness of the Indian yield curve (difference between the Indian 10-year G-Sec and the WACR) does not display a discernible impact on gross capital flows either at the tails or the median. However, a shock to the India-US rate spread (e.g., tightening of Indian monetary policy or loosening of US monetary policy), as seen in Figure B.1(c), leads to a small increase in median inflows. This is intuitive as a higher spread makes rupee-denominated debt instruments more attractive relative to the US. This shows up in a slight rightward shift in the empirical density function for gross flows. The probability of (positive) inflows in the upper quantiles (right tail) also increase.

Surprisingly, a shock to the India-US real GDP growth differential has no discernible effect on gross flows either at the median or the tails, though it has a small positive and significant coefficient in the mean regression.

We consider the counterfactual of a larger pre-determined stock of reserves. The counterfactual increases reserves by an amount equal to 50 percent of mean reserves over the sample. This increase approximates the reduction in the IMF reserve adequacy ratio made in 2023.[25] A larger stock of reserves as a share of GDP leads to a large rightward shift in the conditional distribution of gross flows, as seen in Figure 9 for an increase of 50 percent times over the sample mean ratio. While the probability of positive inflows increases, there is large reduction in the probability of large negative flows (outflows). What we take away from this exercise is that foreign exchange reserves play a significant role in shifting the empirical distribution of gross flows wherein the probability of large (negative) outflows is substantially reduced. At the 0.01 quantile (a bad shock), a 50 percent increase in mean reserves reduces the estimated FPI reversal in an event that occurs once every 8.33 months, rising from $3.7 billion to $1.3 billion each month. This represents a reduction in the sudden outflow of FPI by about 60 percent in extreme events.

25. We do not use a moment from the time series of reserves, such as the standard deviation, as we do for the VIX and other global shocks because changes in reserves about their trend reflect valuation changes, foreign exchange interventions, and fluctuations in capital flows. The counterfactual for reserves considers a different policy and not the effects of shocks on reserves.

FIGURE 9. An Increase in Reserves: Pre- and Post-Predicted Distributions

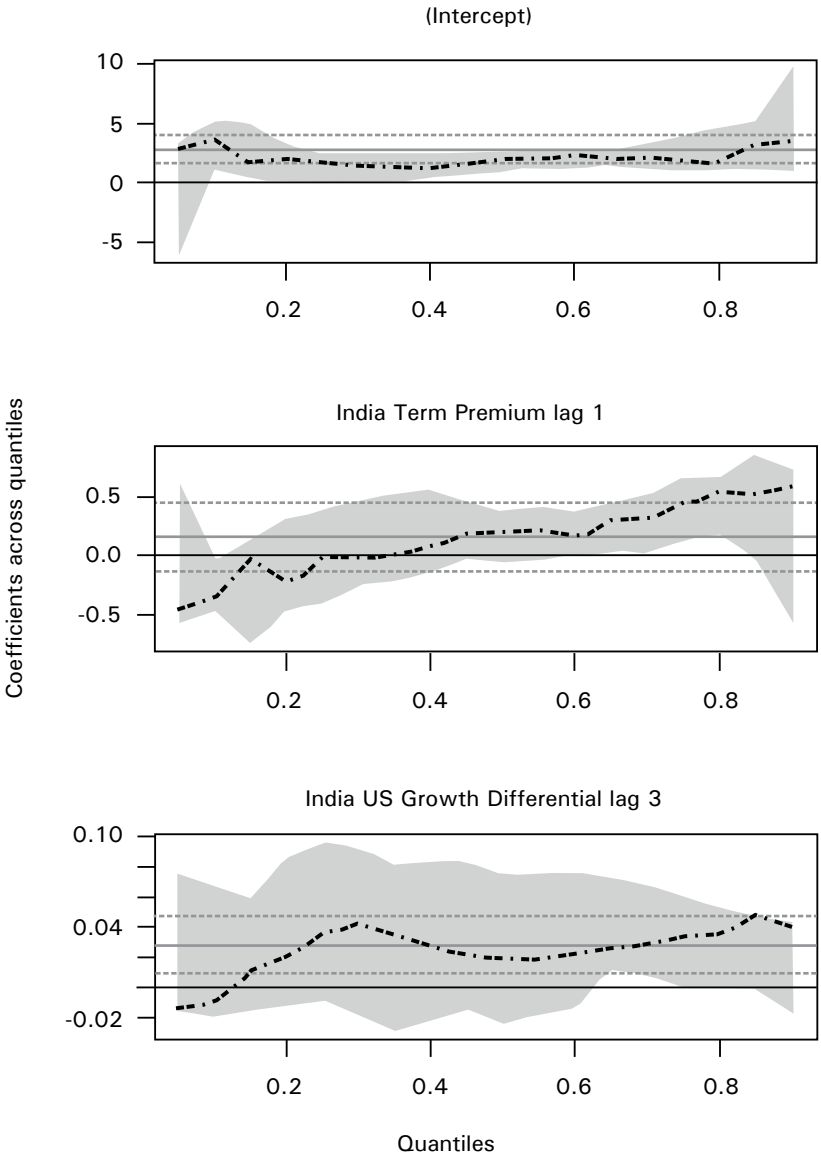


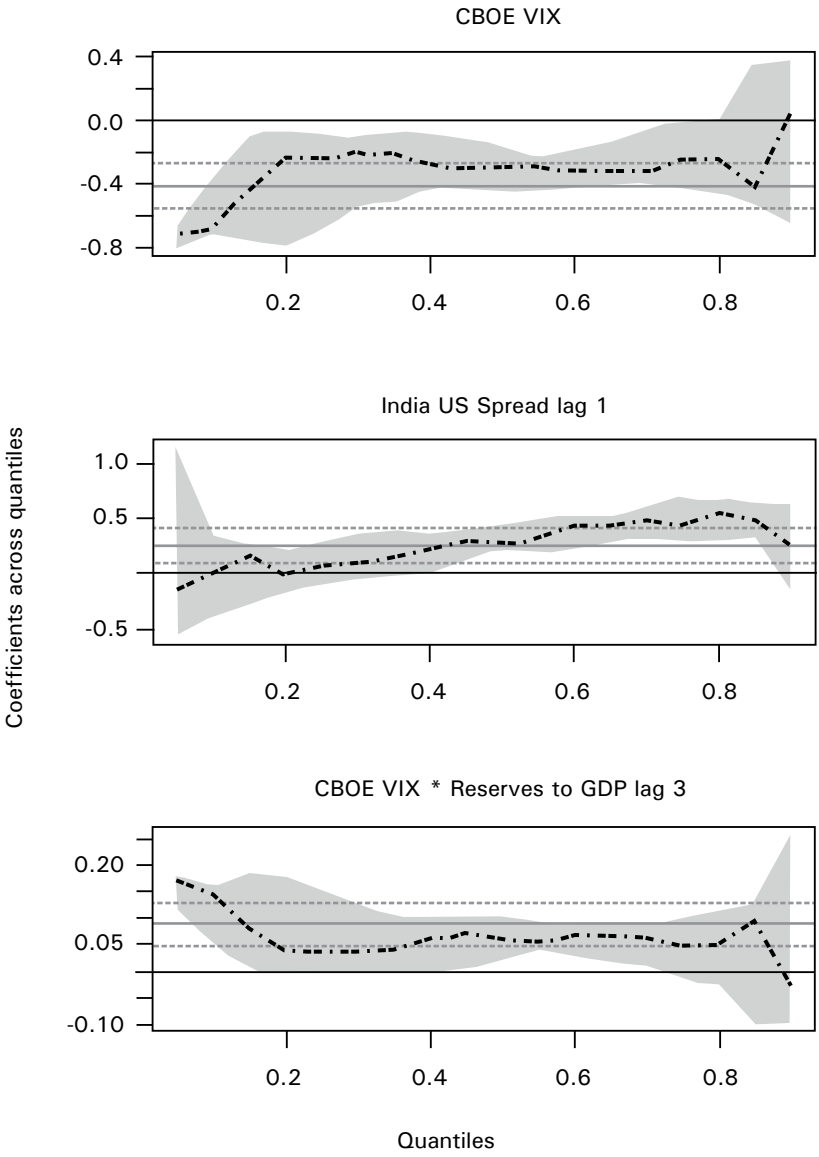
Source: Authors' estimates; data described in Appendix A.

When we estimate the quantile regression in Equation (1) by replacing reserves to GDP with an interaction variable that interacts VIX with reserves to GDP (lagged three months), we see that global uncertainty continues to have a negative and significant effect on gross portfolio flows into India. These impacts are smaller at the lower quantiles as compared to Figure 8 where there is no interaction and the ratio of reserves to GDP is a standalone independent variable. The regression results in Table 4 show that the interaction of VIX with reserves has positive significant effects on inflows at the 0.05 quantile, median, and mean.

The plots of the coefficients across quantiles of the quantile regressions for gross portfolio inflows with reserves interacting with VIX are displayed in Figure 10. Table 4 shows the regression results for the 0.05 quantile, median, and mean of foreign capital inflows. The coefficient on the interaction variable is significant with a positive sign in the lower quantiles suggesting that reserves counter the negative effects of VIX on outflows against adverse shocks. Figure 11 shows the effect of our counterfactual that the reserves to GDP ratio is 50 percent greater than its mean (a multiple of 1.5). This leads to a predicted 120 percent increase in median monthly inflows (by $1.1 billion per month over the sample median of $0.9 billion per month (Table 1)), and a substantial reduction in the probability of large (negative) outflows in the left tail of the distribution. Negative foreign portfolio inflows at the 0.01 quantile fall by 75 percent from $4.0 billion to $1.1 billion per month.

FIGURE 10. Quantile Regression Results - Dependent Variable = Gross FPI Flows. Reserves Interacted with VIX





Source: Authors' estimates; data described in Appendix A.

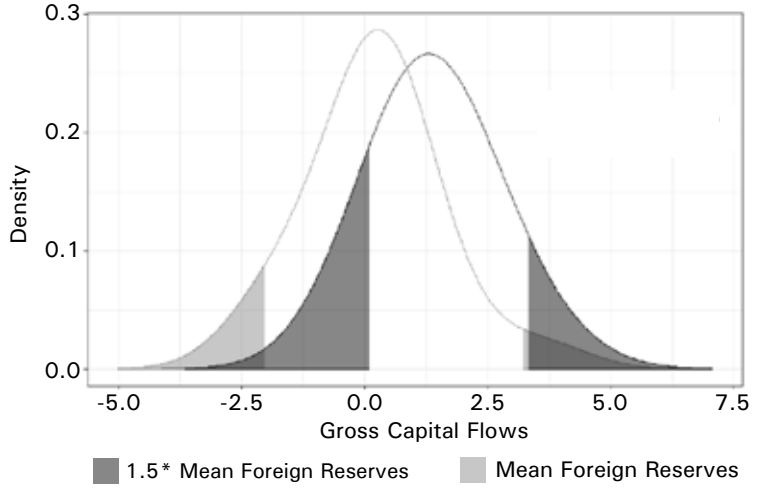
TABLE 4. Interaction of VIX with Reserves Regression Results

Dependent Variable: Debt and Equity Flows	*0.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.713***	-0.283***	-0.408***
	(0.098)	(0.089)	(0.085)
India 10-year term premium	-0.450**	0.195	0.160
	(0.224)	(0.179)	(0.172)
India-US policy spread	-0.140	0.267**	0.246**
	(0.166)	(0.103)	(0.098)
India-US growth diff	-0.014	0.020	0.028**
	(0.020)	(0.013)	(0.012)
VIX*Reserves/GDP	0.167***	0.059**	0.0901***
	(0.031)	(0.026)	(0.025)
Constant	2.98***	2.019**	2.800***
	(0.937)	(0.789)	(0.755)
Number of observations = 237		Adj R-squared = 0.153	

Source: Data sources are listed in Appendix A.

Note: Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

FIGURE 11. Interaction of Reserves and VIX: Pre- and Post-Predicted Distributions for an Increase in Reserves



Source: Authors' estimates; data described in Appendix A.

We next consider interactions between the India-US interest rate spread and ratio of reserves to GDP using portfolio debt and equity flows separately. The coefficient estimates on debt flows for the 0.05 quantile, median, and mean regressions are given in Table 5. The interaction of lagged reserves to GDP with the monetary policy rate differential leads to an increase in foreign portfolio debt inflows in the 0.05 quantile and at the mean. The absence of an effect on a higher prior stock of reserves on debt inflows at the median suggests that the positive effect in the mean regression depends on outliers. Reserves tend to alleviate gross foreign debt inflow reversals. The quantile coefficient estimates for this interaction is shown for gross portfolio debt flows in Figure 12. A shock to the difference between policy rates displays a negative effect by increasing debt outflows in the left tail, and a positive effect on debt inflows on the right tail. This suggests that an increase in the policy rate by India for a constant U.S. Fed Funds Rate raises the volatility of portfolio debt inflows. Figure 13 shows that the coefficient for the interaction term (the India-US spread times reserves to GDP) is positive and statistically significant for low quantiles (negative debt inflows). This means that an increase in reserves reduces the incidence of portfolio debt outflows in the presence of a positive shock to the spread of the WACR over the U.S. Federal Funds Rate.

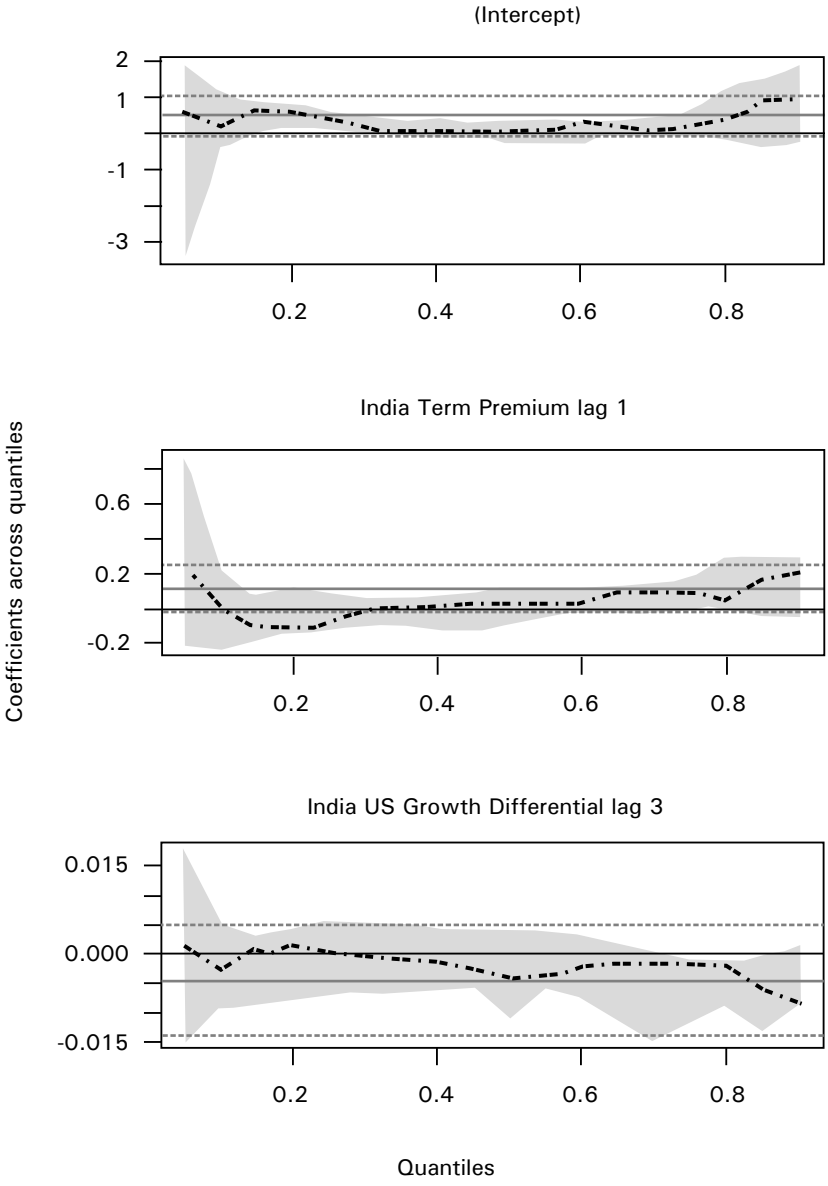
TABLE 5. Interaction of India-US Policy Interest Rate with Reserves Regression Results – Debt Flows

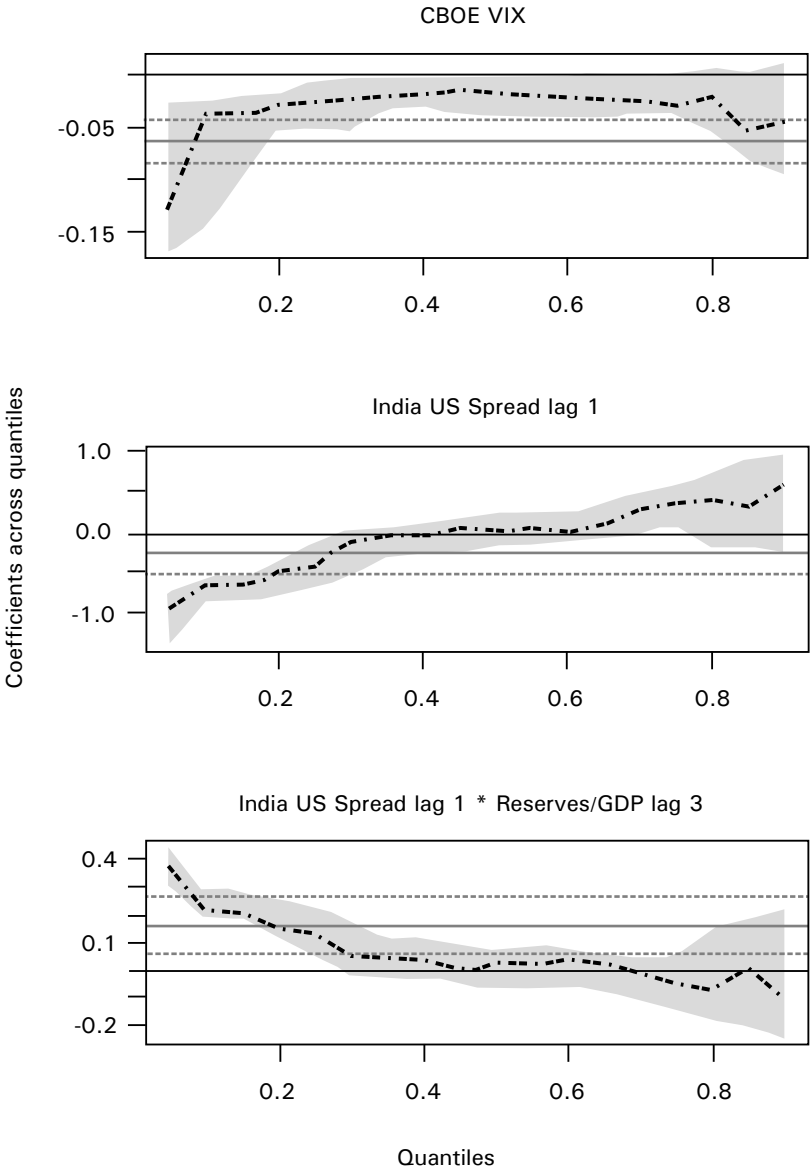
Dependent Variable: Debt Flows	*0.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.127***	-0.017	-0.062***
	(0.038)	(0.011)	(0.013)
India 10-year term premium	0.252*	0.030	0.120
	(0.149)	(0.068)	(0.080)
India-US policy spread	-0.938***	0.024	-0.254*
	(0.177)	(0.130)	(0.154)
India-US growth diff	0.001	-0.004	-0.004
	(0.005)	(0.014)	(0.006)
Interest spread* Reserves/GDP	0.374***	0.027	0.170***
	(0.066)	(0.054)	(0.063)
Constant	0.535	0.113	0.501
	(0.440)	(0.292)	(0.345)
Number of observations = 237		Adj R-squared = 0.101	

Source: Data sources are listed in Appendix A.

Note: Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

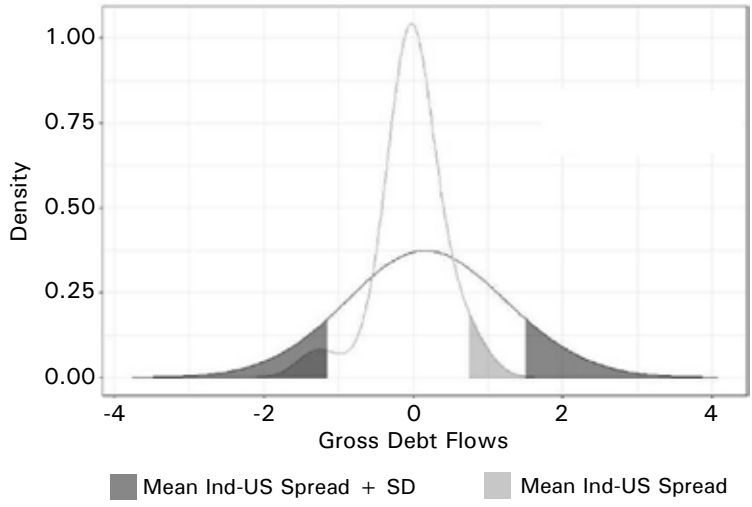
FIGURE 12. Quantile Regression Results - Dependent Variable = Debt Flows Reserves Interacted with India-US Spread





Source: Authors' estimates; data described in Appendix A.

FIGURE 13. Interaction of Reserves and India-US Spread: Pre- and Post-Predicted Distributions for a Shock to India-US Spread



Source: Authors' estimates; data described in Appendix A.

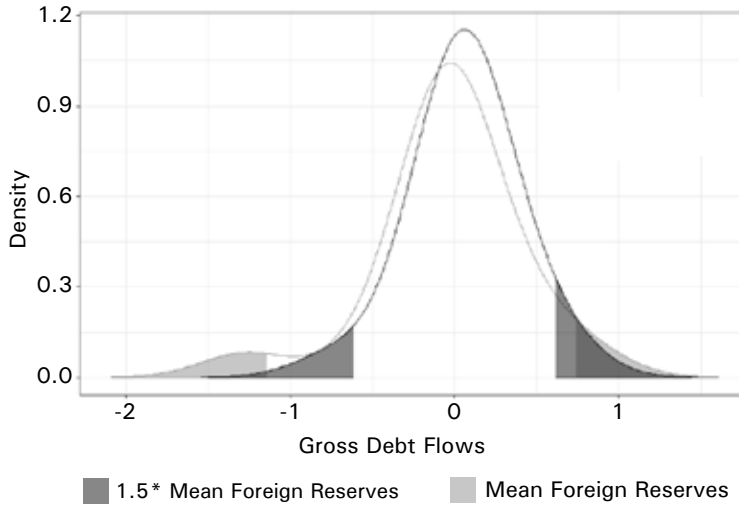
The effect of a shock to the India-US interest rate spread on the probability distribution of gross debt inflows is shown in Figure 13. When shocks lead to negative debt flows, relative monetary tightening increases outflows. These are typically events in which global shocks are negative, and the U.S. tends to reduce the Fed Funds Rate. Increases in global uncertainty are associated with retrenchment of capital flows back to the U.S. Conversely, in events in which portfolio debt inflows to emerging markets are high, increases in the WACR relative to the Fed Funds Rate should mitigate these inflows.

Figure 14 shows that the counterfactual of increasing lagged reserves by 50 percent tends to reduce the volatility of foreign portfolio debt flows in response to relative tightening of monetary policy for India vis-à-vis the U.S. Both tails contract towards the median, compressing the distribution. Large debt outflows in bad times are reduced and sharp debt inflows in good times are also reduced. Increases in reserves stabilize portfolio debt inflows. Portfolio debt outflows at the 0.01 quantile fall from $2.4 billion to $1.8 billion.

The effects on gross portfolio equity flows of the interaction effects between the India-US interest rate spread and the reserves to GDP ratio are reported in Table 6 and Figure 15. The coefficient for the interaction term for the spread with reserves to GDP is significant at the 0.05 quantile, but not at either the mean or the median. The regression confirms the intuition that debt flows are more sensitive to relative policy rate changes than equity inflows, but reserves

tend to reduce gross equity inflow reversals. VIX is significant for both portfolio equity and debt inflows at low quantiles and the mean.

FIGURE 14. Interaction of Reserves and India-US Spread: Pre- and Post-Predicted Distributions for an Increase in Reserves



Source: Authors' estimates; data described in Appendix A.

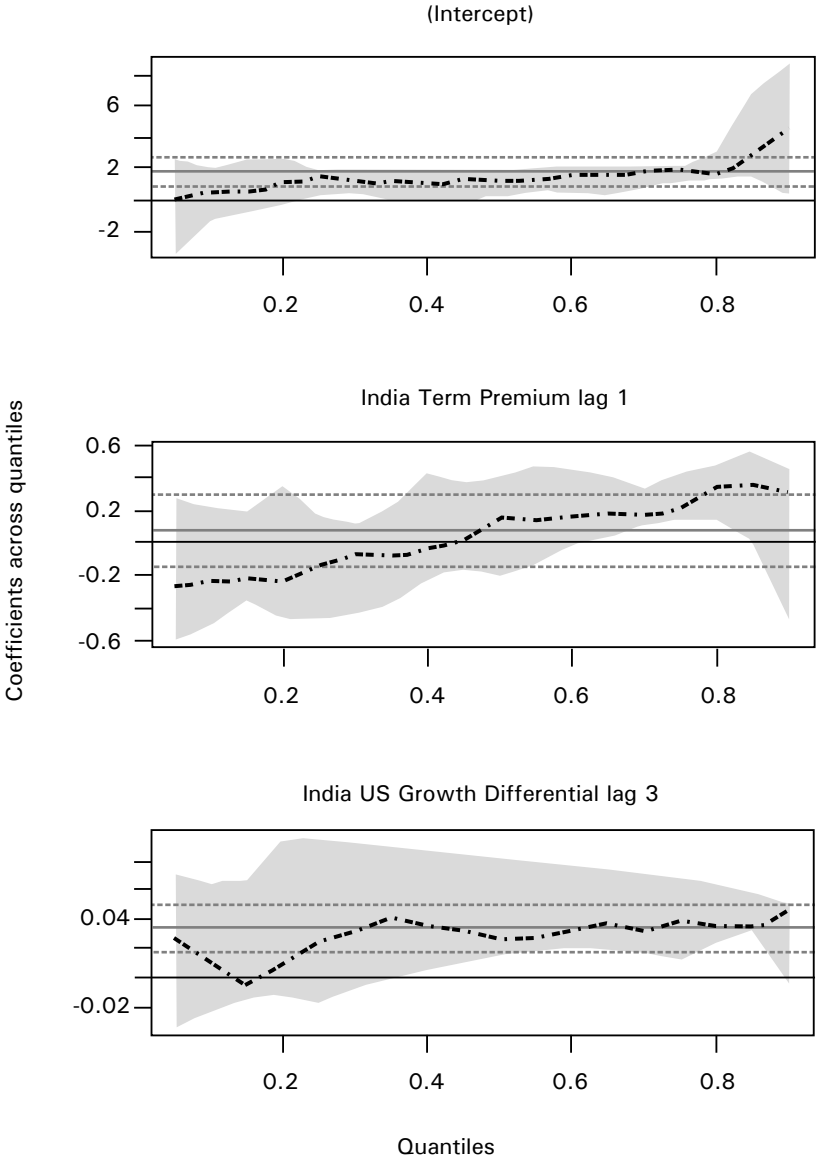
TABLE 6. Interaction of India-US Policy Interest Rate with Reserves Regression Results – Equity Flows

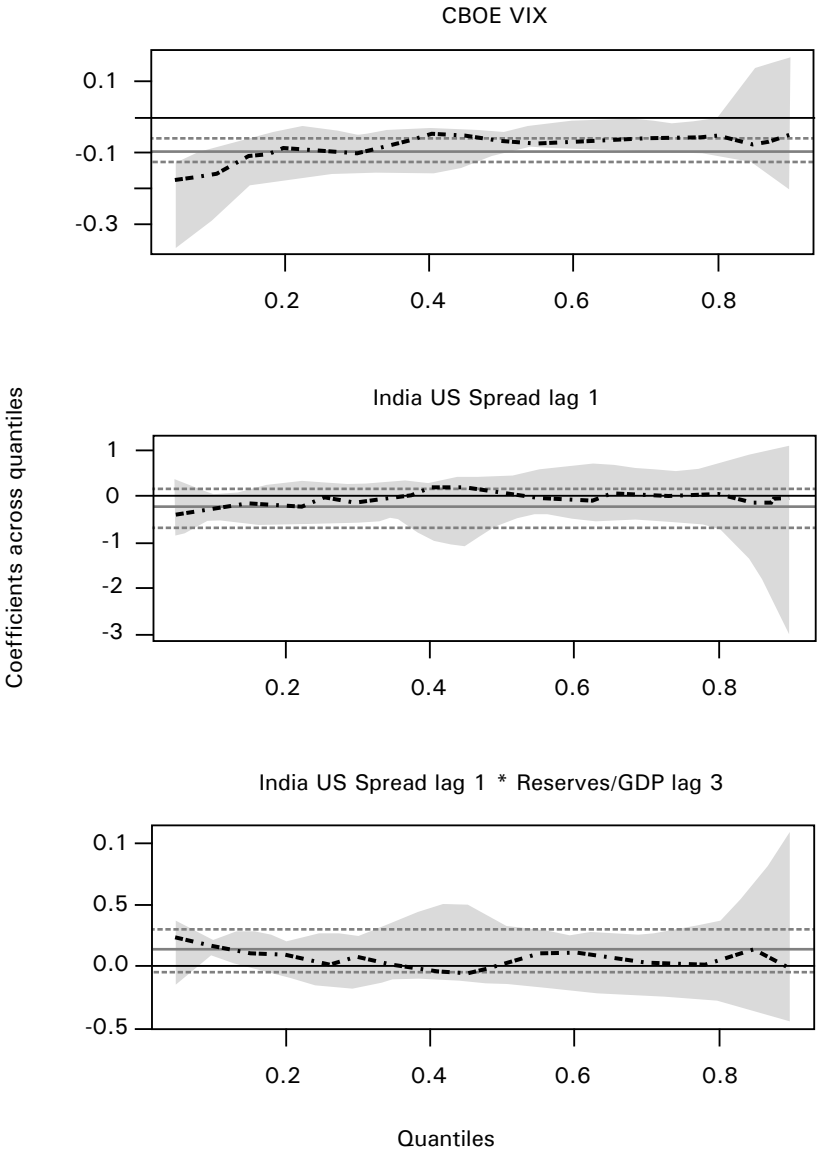
Dependent Variable: Equity Flows	*0.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.177***	-0.062***	-0.092***
	(0.050)	(0.023)	(0.022)
India 10-year term premium	-0.271	0.143	0.074
	(0.195)	(0.143)	(0.137)
India-US policy spread	-0.386	0.080	-0.239*
	(0.263)	(0.274)	(0.261)
India-US growth diff	0.027	0.027	0.034***
	(0.049)	(0.010)	(0.010)
Interest spread* Reserves/GDP	0.223**	0.013	0.131
	(0.101)	(0.113)	(0.063)
Constant	0.535	1.160	1.847
	(0.440)	(0.615)	(0.587)
Number of observations = 237		Adj R-squared = 0.101	

Source: Data sources are listed in Appendix A.

Note: Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

FIGURE 15. Quantile Regression Results - Dependent Variable = Equity Flows Reserves Interacted with India-US Spread





Source: Authors' estimates; data described in Appendix A.

Finally, we estimate the quantile regressions for shocks to the India 10-year bond to WACR term premium for all three dependent variables—gross portfolio inflows, gross portfolio debt inflows, and gross portfolio equity inflows. The source of an increase in the term premium for India is ambiguous and could well differ qualitatively between events in the low quantiles and events in the high quantiles of gross portfolio inflows. An increase in expected inflation or in expected productivity growth can raise the term premium. A temporary decrease in the policy rate can increase the premium.

The regression coefficients for the total foreign portfolio inflows are reported in Table 7. The regression coefficients for gross portfolio debt and equity inflows plots are displayed in Figure B.2(a), B.2(b), and B.2(c) in Appendix B. The coefficients for the term premium and its interaction with reserves to GDP are significant and have expected signs in Table 7. The empirical predicted distribution for a shock to the term premium in Figure 16 reveals that a higher stock of reserves reduces the adverse effect of a rise in the India term premium on gross foreign portfolio debt and equity inflows.

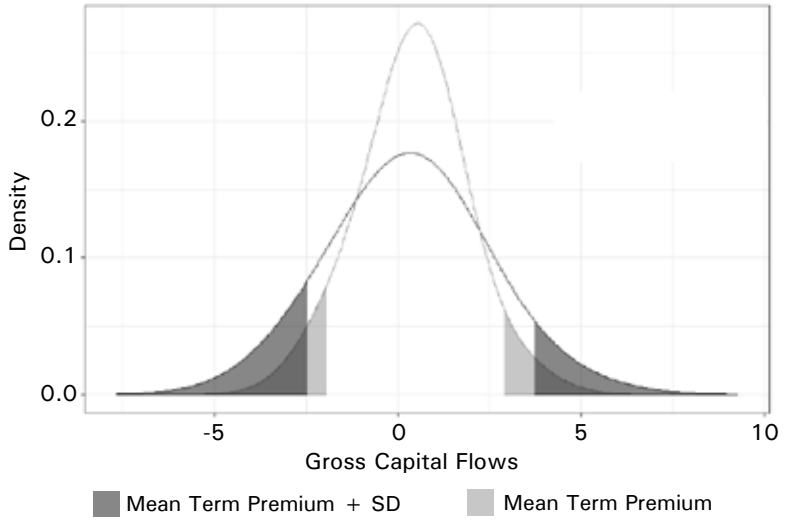
TABLE 7. Interaction of India 10-year Term Premium with Reserves Regression Results

Dependent Variable: Debt and Equity Flows	*0.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.327***	-0.106***	-0.121***
	(0.066)	(0.023)	(0.022)
India 10-year term premium	-4.458***	1.856*	-2.386**
	(1.412)	(1.023)	(0.987)
India-US policy spread	-0.172	0.217**	0.160
	(0.162)	(0.104)	(0.261)
India-US growth differential	0.021	0.020	0.029**
	(0.021)	(0.013)	(0.012)
India term premium* Reserves/GDP	1.601***	0.707**	0.869***
	(0.505)	(0.342)	(0.330)
Constant	3.591***	1.924**	2.496
	(1.139)	(0.782)	(0.755)
Number of observations = 237		Adj R-squared = 0.133	

Source: Data sources are listed in Appendix A.

Note: Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

FIGURE 16. Pre- and Post-Shock Predicted Distribution due to a Shock to the India Term Premium



Source: Authors' estimates; data described in Appendix A.

Figure B.2(a) shows that the coefficient for the interaction term between lagged ratio of reserves to GDP and the India term premium is significant and positive in the lowest quantiles for (negative) capital outflows. Median and mean gross portfolio inflows rise with an increase in reserves.

Separating portfolio debt and equity inflows reveals different effect of the term premium and reserves. Figure B.2(b) shows that an increasing India term premium raises the volatility of portfolio debt inflows. Shocks to the India term spread increase the absolute value of debt outflows at low quantiles (negative flows) and increase debt inflows at high quantiles (increase positive inflows). The interaction term between the term premium and reserves is significant only for portfolio debt flow reversals (low quantiles) indicating that larger reserves mitigate the impact of a higher term premium on portfolio debt outflows.

The effects of the India term premium on portfolio equity flows are shown in Figure B.2(c). Here, the coefficients on the interaction term between the term premium and reserves are significant at the median and in the mean regression. At low quantiles (left tail), having more reserves does not reduce the impact of shocks that raise the term premium on portfolio equity flows.

5. Cost of Holding Reserves

While reserves provide benefits in terms of self-insurance and exchange market intervention, they are costly to hold. Conceptually, the cost of reserves equals the difference between returns to reserve assets and the opportunity return to investments foregone. The cost of reserves is typically estimated by comparing the interest paid on a country's sovereign debt and that received on reserve assets of similar maturity. This measure of the cost of holding reserves combines the sovereign risk premium with a term premium expressed in a reserve currency. The purposes to which reserves are used as well as how they are accumulated can matter and deserve consideration.

For reserves held as a buffer stock for insurance against the impact of global financial shocks and domestic financial crises, the marginal cost of holding reserves should be determined by the marginal opportunity cost of the debt implicitly issued to purchase reserves net of the returns on reserve assets. Reserves can be exchanged for outstanding government debt in a sterilized sale by the central bank. A quasi-fiscal cost of reserves is incurred when a central bank uses open market operations to sterilize the expansionary impact of reserve accumulation on the money supply.[26]

If government debt is issued in foreign currency, its marginal cost equals the sovereign risk premium plus the risk-free rate of interest. The yield on U.S. treasury securities is typically chosen as an appropriate proxy for the risk-free return. For government debt issued in domestic currency, as in the case for India, the quasi-fiscal cost of reserves must account for exchange rate risk. The effect of currency risk on *ex ante* sovereign spreads can be measured by the market exchange rate risk premium on government debt. Because exchange rate losses and gains are not realized until reserve assets are sold, the quasi-fiscal cost of reserves should include the central bank's net losses on what are essentially carry trades.[27]

Reserve assets tend to be of shorter maturity than domestic sovereign debt. For the purpose of self-insurance, reserves need to be readily available in ample supply in the event of a financial crisis. This means that precautionary reserves ought to be held in reserve currency debt that remains liquid in times of global financial turbulence. Short-maturity bond yields need to be adjusted by term spreads to match the average maturity for sovereign debt. Estimates of the cost of holding reserves *ex ante* use term premiums to adjust yields. Changes in the valuation of the reserve asset portfolio are additional quasi-fiscal costs or benefits.

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26. The concept of the quasi-fiscal cost of sterilization is introduced by Calvo (1991).

27. The cost of sterilized reserves discussed is sometimes labelled as the direct quasi-fiscal cost. Indirect cost refers to possible real effects of sterilized intervention that delay real exchange rate and current account adjustment. The effects of sterilized intervention are beyond the scope of this paper.

The way in which reserves are accumulated should affect the opportunity cost of reserves. Reserves can be accumulated through unsterilized purchases, issuance of foreign currency-denominated debt, and sales of domestic currency government debt. Raising precautionary reserves by issuing foreign currency debt can increase the risk of currency and debt crises exposing the economy to sudden stops.

Intervention countering exchange rate volatility results in positive or negative carry profits. Levy-Yeyati and Gomez (2022) point out that carry risk is an appropriate cost to consider when reserves are used for either unsterilized or sterilized intervention. When covered interest parity holds, the interest differential between foreign currency bonds and domestic currency bonds equals the forward premium. Carry profits for the RBI can be illustrated by calculating three-month carry trade return using daily data for the three-month forward premium for the rupee against the dollar and the three-month ex-post depreciation of the rupee against the dollar from the updated database from Du, Im, and Schreger (2018).[28] The average carry return to selling dollars forward for rupees for three months over the last full four years of their dataset (March 2017 through February 2021) was 2.04 percent. Expected valuation gains or losses also associated with holding reserves. Valuation changes are calculated by the RBI and published semi-annually, although reports do not consistently provide annual amounts. The average annual return to reserves due to valuation changes over the same fiscal years can be calculated from publicly available data. It was 0.84 percent.

The opportunity cost of holding a stock of reserves for India is not measured by the difference between the yield on liquid sovereign bonds issued in rupees and the class of foreign currency bonds held as reserve assets. We estimate the opportunity cost to the RBI of holding reserves by accounting for the exchange rate risk between Government of India bonds and reserve assets evaluated on identical tenor. Holding a rupee-denominated bond involves two risks relative to holding a risk-free bond in dollars: exchange rate risk and credit risk. For example, the spread for a 10-year Indian treasury bond (G-Sec) equals the 10-year U.S. treasury yield plus the price of exchange rate risk and of pure credit risk. The cost of carrying reserves in dollars is included in the term-adjusted spread. Currency risk is measured by the forward premium for the tenor of the bonds. Forward markets exist only for short-maturity contracts. For longer maturities, cross currency swaps can be constructed by combining dollar-rupee cross currency basis swaps with interest swaps in each currency as proposed by Du and Schreger (2016). We update the database from Du, Im, and Schreger (2018) to obtain yield spreads between treasury bonds in rupees for India and U.S. treasuries. The India-US spread is the simple difference between

28. See https://sites.google.com/view/jschreger/CIP.

yields in each currency. By subtracting the cross-currency spread from this yield differential, Du, Im, and Schreger derive the rupee credit risk on Central Government debt. We use the series for India. They use this residual to study deviations from covered interest parity and the term structure of sovereign yields. We follow this interpretation by assuming that U.S. treasuries as risk-free and attribute deviations from covered interest parity on long-term bonds to pure credit risk.

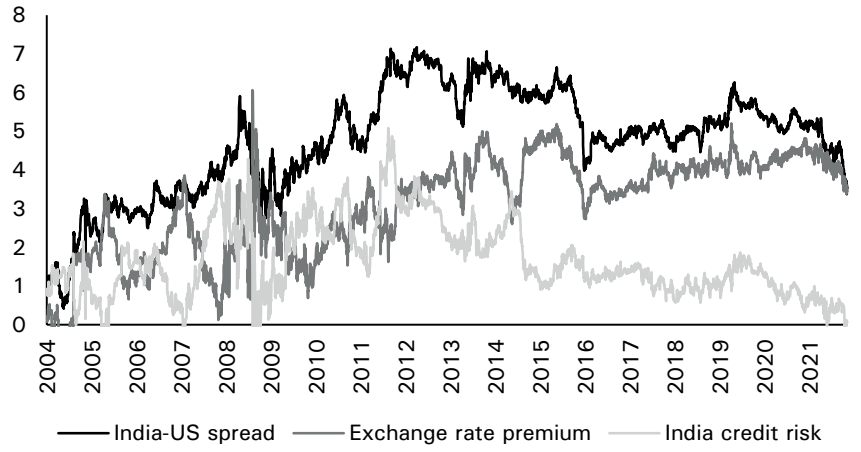
The India-US spread and India-US credit risk are shown in Figure 17. The data series designated India credit risk is the spread between the 10-year G-Sec and the 10-year U.S. treasury in rupees. The cross-currency swap rate for these 10-year bonds converts U.S. dollar returns to risk neutral equivalent bond returns in rupees.

The average 10-year spread for May 2016 to September 2022 was 5.1 percent. Of this, currency risk was 4.0 percent and credit risk was 1.1 percent. This spread is an opportunity cost of holding the stock of reserves. The vast majority of the stock of reserve qualified assets issued by the Government of India is held domestically. The premium on bonds held by private domestic entities is an internal transfer. The net cost equals the spread times the amount of government liabilities held by foreign creditors.

In our analysis, we ask whether adding reserves reduces the spread between India and U.S. 10-year treasuries. If so, then the marginal cost of holding reserves falls below the interest differential. To the extent that higher reserves provide more self-insurance against global shocks and sudden capital outflows, spreads should fall with the reserves to GDP ratio. A higher external debt-to-GDP ratio increases the exposure of the economy to the same shocks, and a higher fraction of external debt denominated in domestic currency may reduce risk exposure and spreads.

Following Devereux and Wu (2022), we use the Du and Schreger (2016) calculations to estimate the effect of reserves as a share of GDP on the 10-year spread, currency risk, and credit risk for India, as in Equation (3). In our regression, we control for global uncertainty shocks using the VIX and the yield on U.S. 10-year treasuries. Domestic controls are the rate of real GDP growth and domestic credit-to-GDP ratio. The amount of government debt held by foreigners is proxied by total external debt denominated in rupees as recorded by the World Bank. Private external borrowing also exposes the economy to global shocks and sudden gross foreign capital outflows. The measure used to capture this exposure is a ratio of private non-guaranteed external debt for both non-financial and financial corporations to GDP in foreign currency. The adoption of inflation targeting may be associated with decreasing exchange rate risk. A dummy for inflation targeting starting in May 2016 is included in the regression.

FIGURE 17. Daily 10-year India-U.S. Treasury Spreads



Source: Du, Im, and Schreger (2018), and authors calculations using data from Bloomberg.

The regression equation for the sovereign bond spread has a conventional linear form given by

$$y_t = \alpha + \beta_1 ln\left(\frac{Reserves}{GDP}\right)_{t-1} + \beta_2 ln\left(\frac{Rupee\ external\ debt}{GDP}\right)_{t-1} + \beta_3 ln\left(\frac{Priv\ external\ debt}{GDP}\right)_{t-1} + \beta_4 IndiaGDPgrowth_{t-1} + \beta_5 ln\left(\frac{Domestic\ credit}{GDP}\right)_{t-1} + \beta_6 ln\, VIX_t + \beta_7 USyield_{t-1} + \beta_7 IT_{t-1} + \varepsilon_t \quad (3)$$

The dependent variable y_t is an interest rate spread expressed in percent, and the financial stock ratios to GDP are in logarithms. The coefficient β_1 gives the semi-elasticity of the spread to the ratio of reserves to GDP. The regressors with the exception of the log of the VIX are lagged, as in the quantile regressions for capital flows. Changes in the VIX affect GOI bond spreads contemporaneously and are unlikely to be endogenous to them.

Our data cover the period from January 2006 through September 2022. This time period was chosen because of the following two data limitations. Data for foreign currency denominated external debt and domestic currency denominated external debt stocks are available beginning in 2006. The basis and interest swap rates used to calculate the dependent variable measuring the currency risk component of bond yields are not reported by Bloomberg past September 2022. We used the calculation proposed by Du and Schreger to replicate and extend the estimation of the cross-currency swap rates using data from Bloomberg. We chose to use 10-year bond spreads because the market for the 10-year G-Sec

is the most liquid market for bonds issued by the Government of India. Data descriptions and sources are given in Appendix A.

The regression results are reported in Table 8. The first column in the table reports the results of the regression when the dependent variable is the India-U.S. 10-year spread in percent. The coefficient estimate for the logarithm of the reserves to GDP ratio is negative and significant. It suggests that an increase of 1 percent in the reserves to GDP ratio reduces the spread by 2.4 basis points. This reduction applies to the entire stock of reserves, so that the marginal cost of a 1 percent increase in foreign reserves is 2.4 percentage points less than the market spread on the 10-year G-Sec over the 10-year U.S. treasury. At the mean spread of 5.1 percent for the full sample, the estimated opportunity cost of accumulating an additional 1 percent of reserves equals 2.7 percent, not 5.1 percent.[29]

The coefficient for the India-U.S. bond spread on private external debt is significant and positive. The coefficient for the reserves-to-GDP ratio on the exchange risk premium is also significant and negative. The exchange risk premium displays a negative and significant coefficient to rupee-denominated external debt. This might be expected as higher local currency debt is often associated with a higher inflationary bias. The coefficient on reserves to GDP on the credit risk for government debt is also significant and negative. The coefficients for private external debt (our proxy for foreign currency debt) and rupee-denominated external debt are significant. While increasing foreign currency debt raises credit risk, rupee-denominated debt reduces it. An interesting finding is that global uncertainty has a positive effect on exchange rate risk and a negative effect on credit risk.

Increasing reserves appears to reduce the overall sovereign bond spread by reducing both currency risk and credit risk using the 10-year bond spread. The effect on currency risk is intuitive, but the effect on credit risk contradicts the panel data findings of Devereux and Wu (2022). Our result might be consistent with the argument of Obstfeld, Shambaugh, and Taylor (2010) that reserves can mitigate the risk of domestic-sourced financial crises because domestic collateral instruments lose value in crises. Rupee-denominated external debt may reduce pure credit risk as it raises currency risk.

The regressions show that inflation targeting is associated with a decrease in the overall 10-year yield spread and in the exchange rate risk premium. A decrease in the exchange rate risk premium is consistent with the experience of many emerging inflation targeting economies. The absence of significance for the inflation targeting dummy variable is also consistent with intuition. Our

29. The robustness of the regression results with respect to changes in the lag length for the ratios of reserves, foreign currency external debt, and rupee external debt was checked. The significance of the estimates is the same for lag lengths of one to at least three months. Point estimates change little. The results reported in Table 8 use three-month lags.

results suggest significant reductions in government borrowing costs due to higher reserves and to inflation targeting separately.[30]

TABLE 8. The Impact of Foreign Reserves on Sovereign Bond Spreads

	India-US Spread (%)	*Exchange-Rate Premium (%)*	*India-Credit Risk (%)*
$ln\left(\frac{Reserves}{GDP}\right)$	-2.408***	-0.710*	-1.698***
	(0.354)	(0.402)	(0.447)
$ln\left(\frac{Rupee\ external\ debt}{GDP}\right)$	0.023	2.458***	-2.435***
	(0.337)	(0.382)	(0.425)
$ln\left(\frac{Private\ external\ debt}{GDP}\right)$	1.320**	0.233	1.088*
	(0.520)	(0.589)	(0.655)
$India\ GDP\ growth\ rate$	0.032	0.173	-0.141
	(0.195)	(0.221)	(0.246)
$\ln VIX$	0.035	0.313**	-0.278*
	(0.123)	(0.139)	(0.155)
$US\ 10year\ bond\ yield$	- 0.714***	-0.173*	-0.541***
	(0.083)	(0.094)	(0.104)
$ln\left(\frac{Domestic\ credit}{GDP}\right)$	0.363	-0.241	0.604
	(1.129)	(1.280)	(1.424)
Inflation target	-0.820***	-0.541**	-0.279
	(0.190)	(0.215)	(0.240)
Constant	10.270*	2.155	8.115
	(5.419)	(6.141)	(6.831)
Number of observations	200	200	200
Adjusted R^2	0.79	0.72	0.54

Source: Data sources are listed in Appendix A.

Note: Standard errors in parentheses. *, **, *** refer to significance at 10, 5, and 1 percent levels, respectively.

6. Conclusion

The holding of large stocks of foreign reserves by India provides resources that the RBI uses to alleviate adverse impacts on the financial and real sectors from global shocks. In part, reserves in the event of foreign capital flow reversals reduce pressures on the exchange rate that can affect both financial stability

30. We introduced interaction terms separating the impact of reserves on bond spreads before and after inflation targeting was adopted in May 2016. The coefficients on the two terms were insignificantly different and nearly identical.

and economic activity through relative price volatility. Intervention by the RBI also directly provides liquidity to financial markets to ease distress in crises or support market efficiencies. The role of reserves is not limited to having on hand the necessary liquidity for the worst events. A stock of reserves can have a deterrence effect on capital flows by signaling a capacity to respond to external shocks and reducing the size of capital flow reversals that may occur. To quantify the impact of reserves on international capital flows over the global financial cycle, we use quantile regressions for India to estimate the marginal effect of reserves as a share of GDP on gross capital flows across the distribution of external and internal shocks given global financial, growth, and monetary policy risks. We focus on (non-resident) gross capital inflows, which matter most for financial stability concerns, and amounted to about 1 percent of GDP in 2023.

Using portfolio capital flows data from 2004-2023 for India, our main result is that we find foreign exchange reserves play a significant role in shifting the empirical distribution of gross flows wherein the probability of large negative flows is substantially reduced. Higher reserves reduce both foreign capital inflows at the right tail of the distribution and outflows at the left tail. We also find a significant and large effect of reserves for reducing negative foreign portfolio flows in the event of shocks to global uncertainty. Additional reserves continue to reduce the magnitude of gross flow reversals during adverse global financial shocks and interest rate shocks. These results suggest that there are positive marginal benefits to accumulating reserves for financial stability functions. Our results are robust across a variety of specifications.

The counterpart of the benefit of reserves for reducing the impact of global shocks or the global financial cycle is the opportunity cost of holding a stock of reserves. The effect of reserves on sovereign spreads should be considered when estimating the cost of reserve hoarding. The estimation of the spread between Government of India and U.S. treasury yields shows that the ratio of reserves to GDP reduces the yield differential. Our regressions test the hypothesis that India's reserves, at the margin, reduce the insurance premium. Thus, the significance of the negative coefficient on the reserves-to-GDP ratio shows that additional reserves reduce currency risk, and that the sovereign interest rate spread over-estimates the marginal cost of reserves in India. We also show that inflation targeting is associated with a decrease in the overall 10-year yield spread and in the exchange rate risk premium.

The decomposition of this spread is conceptually valuable and may be useful for understanding how monetary policy frameworks and reserves affect exchange rate risk in future work.

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Appendix A: Data

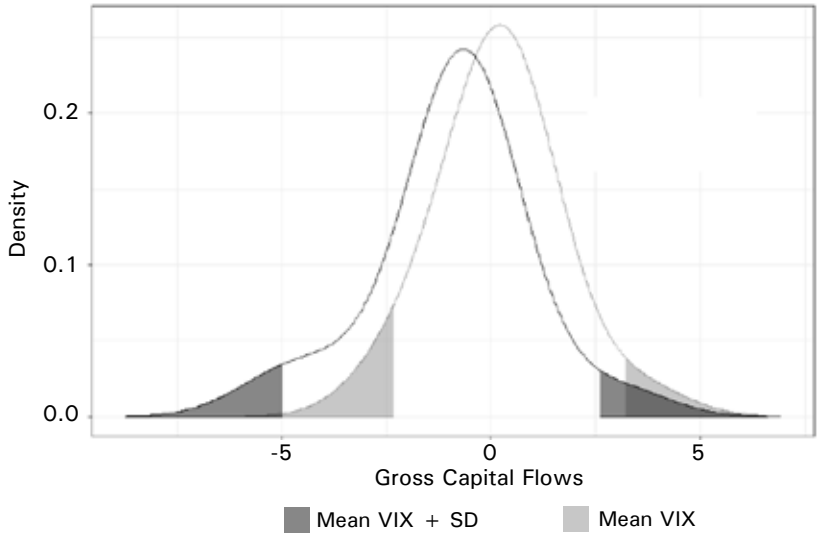
TABLE A.1. Data

Variable	*Definition*	*Frequency*	*Source*
Gross Capital Flows (USD Billions)	Sum of Portfolio Equity and Debt Flows	Monthly	OECD Monthly Capital Flows Dataset
Chicago Board Options Exchange (CBOE) Volatility Index (VIX)	Near term volatility of stock index option prices	Monthly	FRED, St. Louis Fed Database
Weighted Average Call Rate (WACR)	India short term call money rate	Monthly	Reserve Bank of India, Database on Indian Economy
Fed Funds Rate (USFFR)	US Effective Federal Funds Rate (overnight interbank lending)	Monthly	FRED, St. Louis Fed Database
India 10-year bond yield	India long term government bond yields (10 year)	Monthly	Bloomberg
US 10-year bond yield	US long term government bond yields (10 year)	Monthly	FRED, St. Louis Database
India Foreign Exchange Reserves	India Total Foreign Exchange Reserves in USD (FCA, Gold, Reserve Tranche position, SDRs)	Monthly	Reserve Bank of India, Database on India Economy
India GDP	India GDP, Current Rupees	Quarterly; interpolated monthly	IMF, International Financial Statistics
India GDP growth	India Real GDP, domestic currency (growth rate)	Quarterly; interpolated monthly	IMF, International Financial Statistics
US GDP growth (Brave Butters Kelley Index)	Brave Butters Kelly Real GDP Annualised % change monthly	Monthly	FRED, St. Louis Database
India-US 10-year spread	Difference between 10-year India and U.S. treasury bond yields	Daily; averaged to monthly	Du, Wenxin and Jesse Schreger updated calculations using Bloomberg
Exchange rate premium	Cross currency swap rate for 10-year India and U.S. treasury bond yields	Daily; averaged to monthly	Du, Wenxin and Jesse Schreger updated calculations using Bloomberg
India credit risk	India-US spread less cross currency swap rate	Daily; averaged to monthly	Du, Wenxin and Jesse Schreger updated calculations using Bloomberg
Private rupee external debt	Gross external debt position, domestic currency, all sectors, all maturities, domestic currency, USD	Quarterly	World Bank Quarterly External Debt Statistics, SDDS
Domestic credit to GDP	Credit from all sectors to private non-financial sector at market value, domestic currency	Quarterly	Bank for International Settlements

Appendix B: Quantile Regression Results

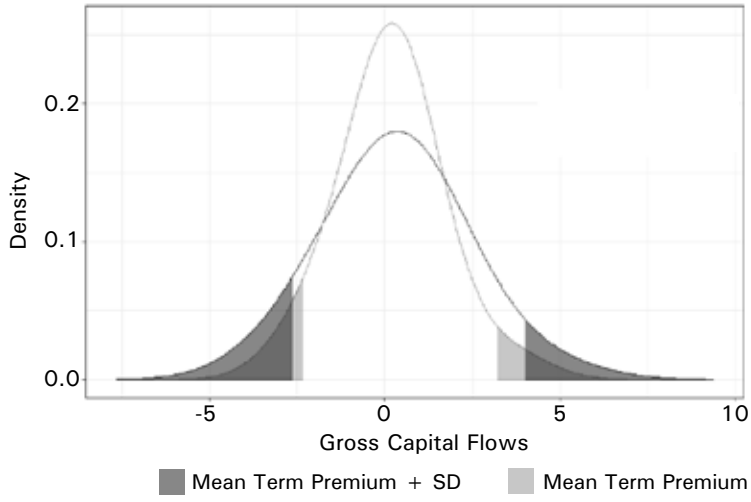
Figures B.1(a)-B.1(d): Pre- and post-probability density functions plots of total flows after a VIX shock, an India term premium shock, an India-US bond spread shock, an India-US growth differential shock, respectively.

FIGURE B.1(a). Impact of VIX Shock on Total Capital Flows



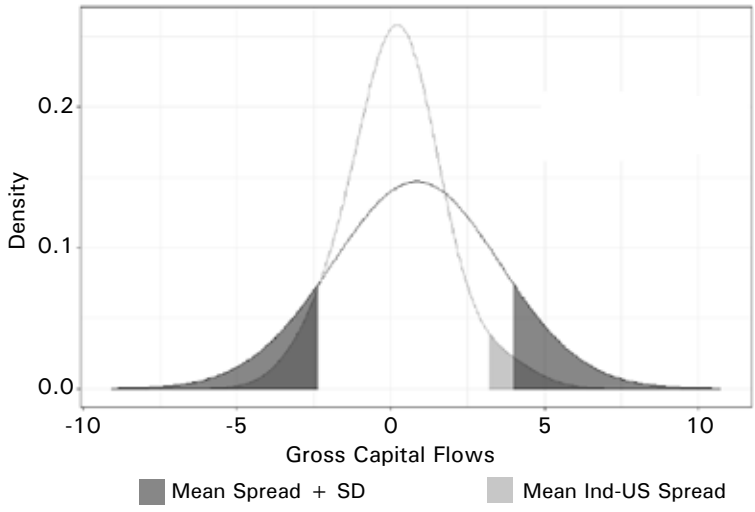
Source: Authors' estimates; data described in Appendix A.

FIGURE B.1(b). Impact of India Term Premium Shock on Total Capital Flows



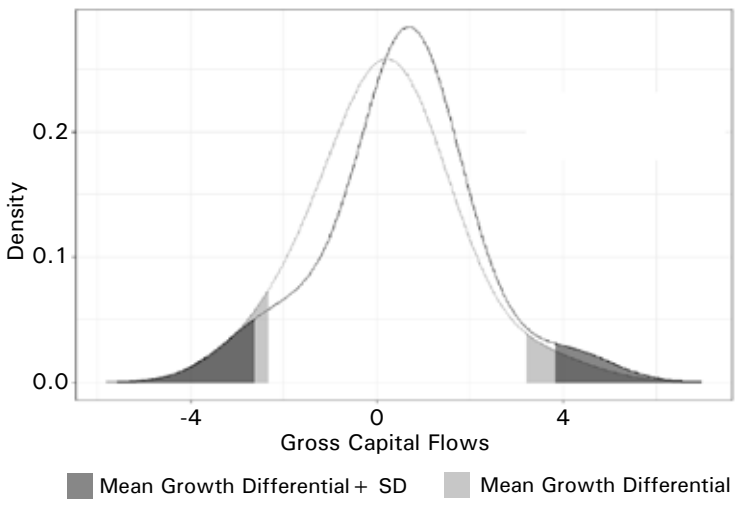
Source: Authors' estimates; data described in Appendix A.

FIGURE B.1(c). Impact of India-US Spread Shock on Total Capital Flows



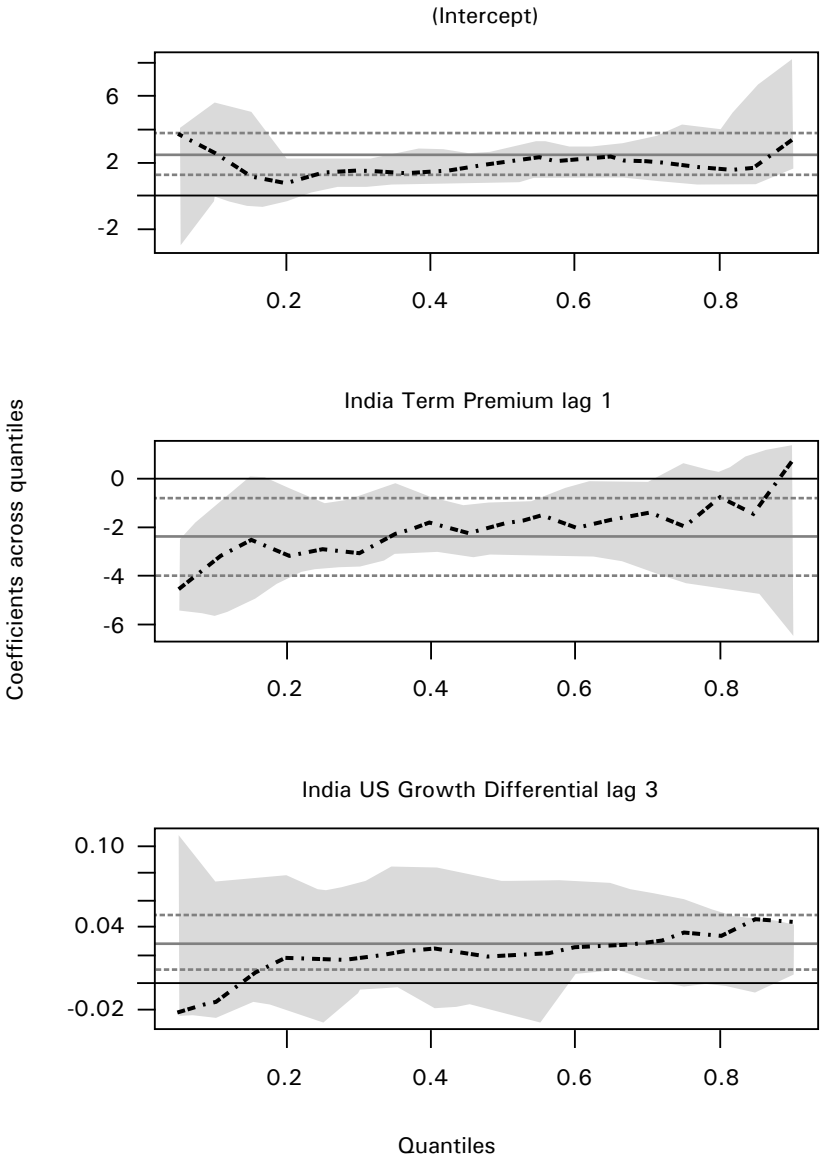
Source: Authors' estimates; data described in Appendix A.

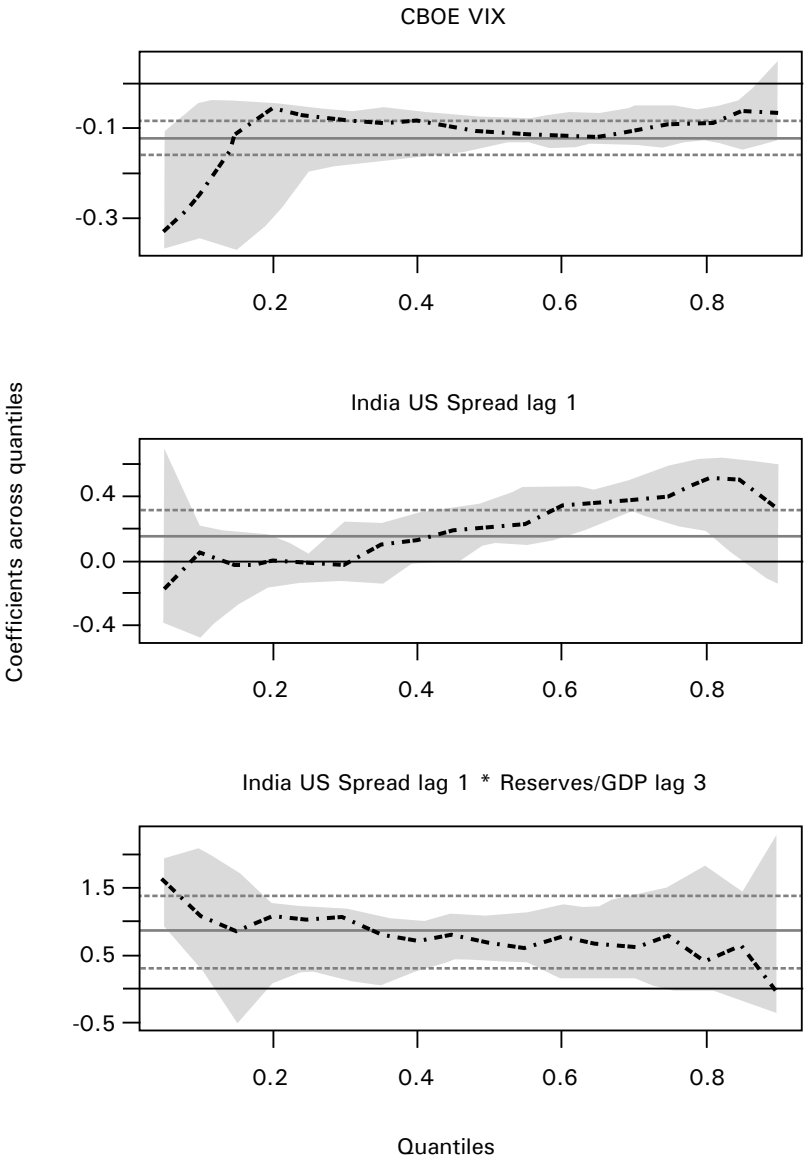
FIGURE B.1(d). Impact of Growth Differential Shock on Total Capital Flows



Source: Authors' estimates; data described in Appendix A.

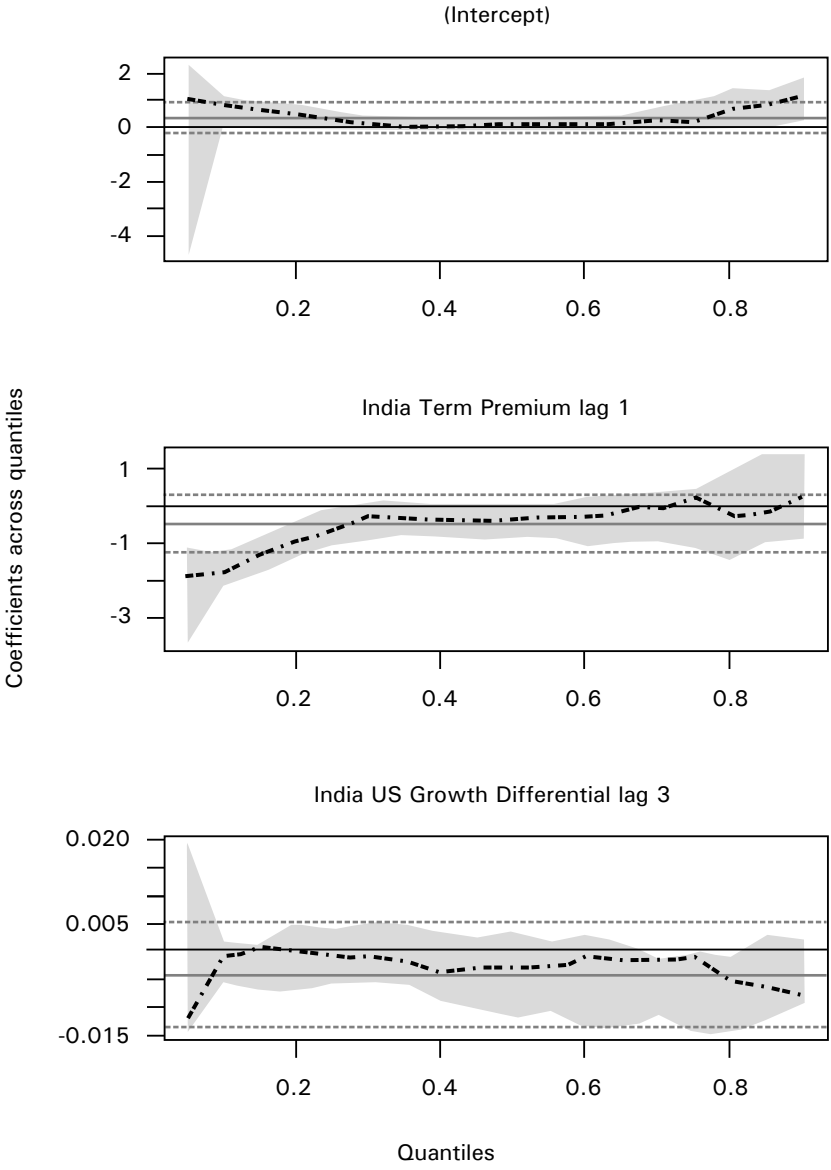
FIGURE B.2(a). Quantile Regression Results - Dependent Variable = Gross Portfolio Flows. Reserves Interacted with India Term Premium

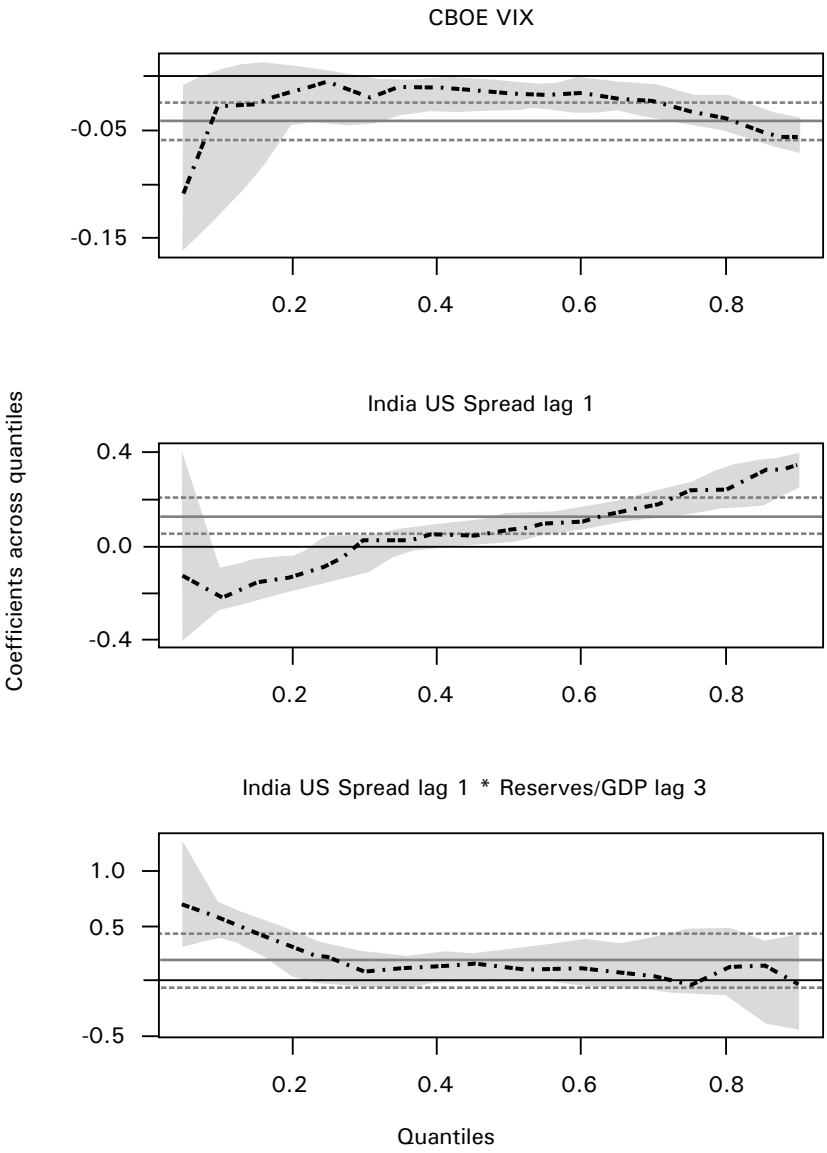




Source: Authors' estimates; data described in Appendix A.

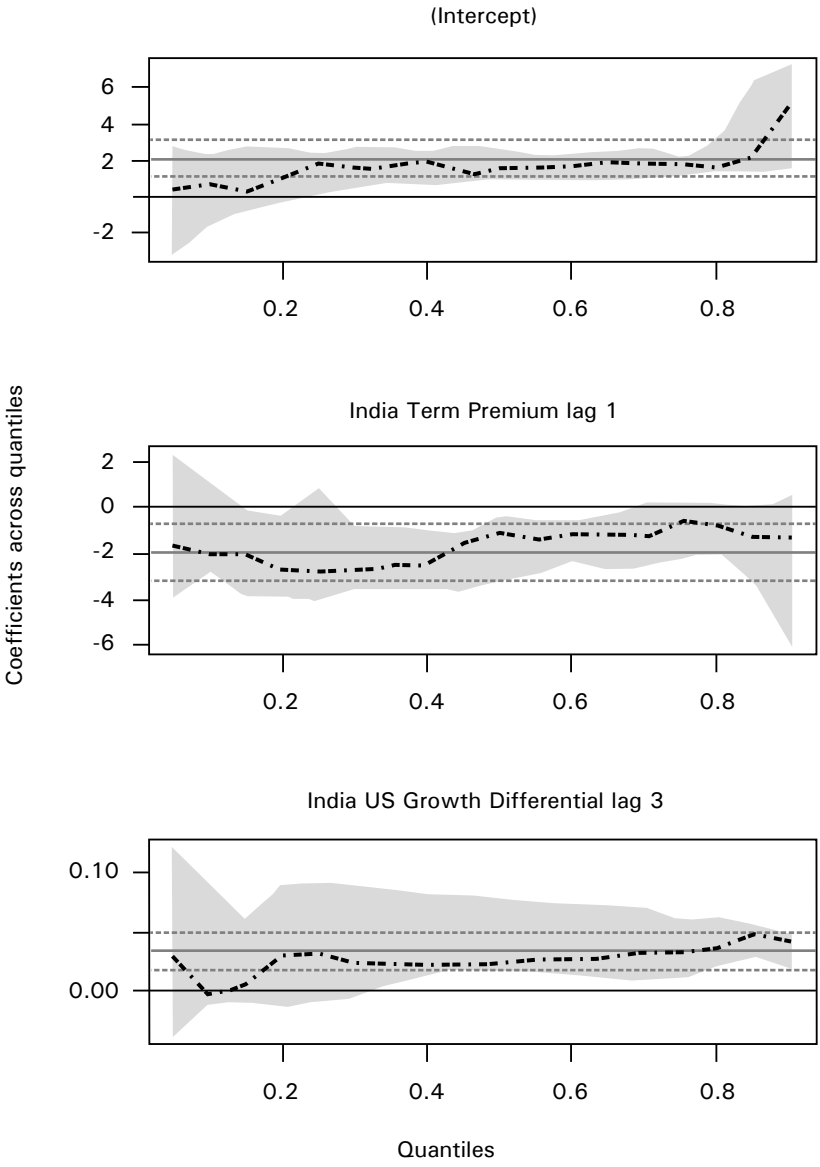
FIGURE B.2(b). Quantile Regression Results - Dependent Variable = Debt Flows. Reserves Interacted with India Term Premium

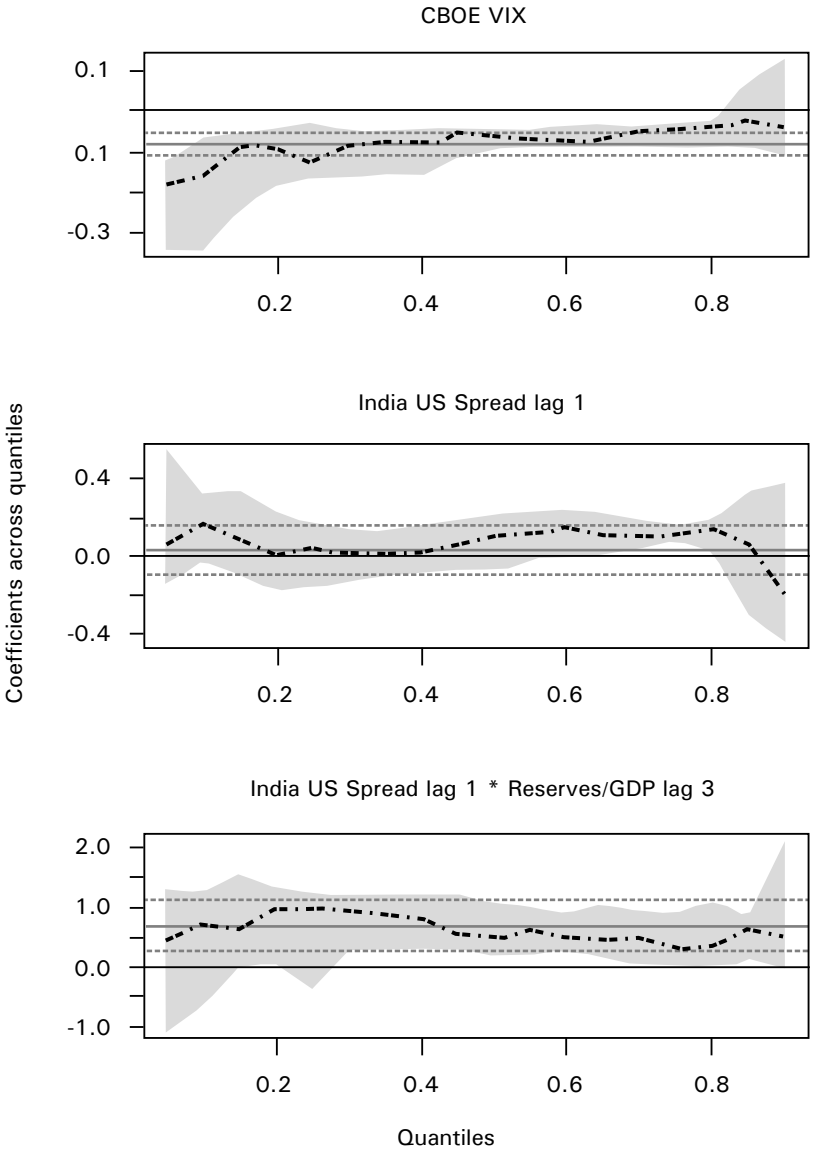




Source: Authors' estimates; data described in Appendix A.

FIGURE B.2(c). Quantile Regression Results - Dependent Variable = Equity Flows. Reserves Interacted with India Term Premium





Source: Authors' estimates; data described in Appendix A.

TABLE B.1. Robustness of Baseline Regression with a 6-month Lag on Reserves to GDP

Dependent variable: Debt and Equity Flows	*.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.315***	-0.124***	-0.153***
	(0.096)	(0.030)	(0.027)
India 10-year term premium	-0.457	0.214	0.064
	(0.328)	(0.201)	(0.182)
India-US policy spread	0.050	0.318***	0.224**
	(0.278)	(0.111)	(0.101)
India-US growth diff	-0.02919	0.034**	0.0223*
	(0.044)	(0.014)	(0.013)
Reserves/GDP	3.353***	1.214	1.727**
	(1.097)	(0.800)	(0.723)
Constant	-5.73486	-1.584	-1.720
	(2.813)	(1.869)	(1.689)
Number of observations = 237		Adj R-squared = 0.128	

Source: Authors' estimates; data described in Appendix A.

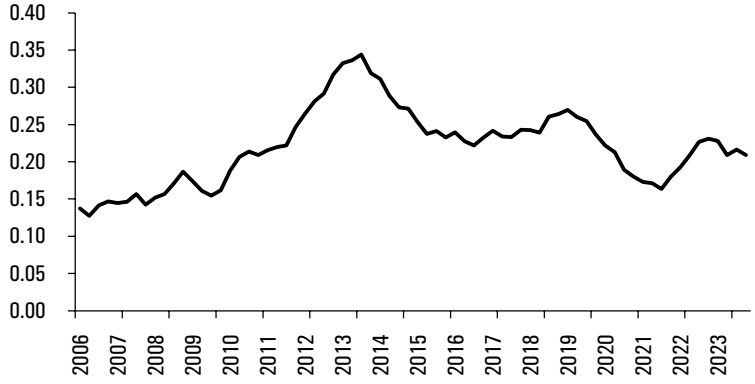
TABLE B.2. Robustness of the Baseline Regression with the Ratio of Reserves to M3 for Reserves to GDP (lagged 3 months)

Dependent Variable: Debt and Equity Flows	*.05 Quantile Regression*	*Median Regression*	*Mean Regression*
VIX	-0.300***	-0.101***	-0.124***
	(0.060)	(0.025)	(0.023)
India 10-year term premium	0.449	0.198	0.209
	(0.336)	(0.190)	(0.179)
India-US policy spread	0.155	0.253**	0.243**
	(0.189)	(0.111)	(0.105)
India-US growth diff	0.018	0.033**	0.031**
	(0.067)	(0.013)	(0.012)
Reserves/M3	0.089***	-0.0041	0.0174
	(0.021)	(0.015)	(0.014)
Constant	-3.108	1.554	1.082
	(2.012)	(1.040)	(0.979)
Number of observations = 237		Adj R-squared = 0.113	

Source: Authors' estimates; data described in Appendix A.

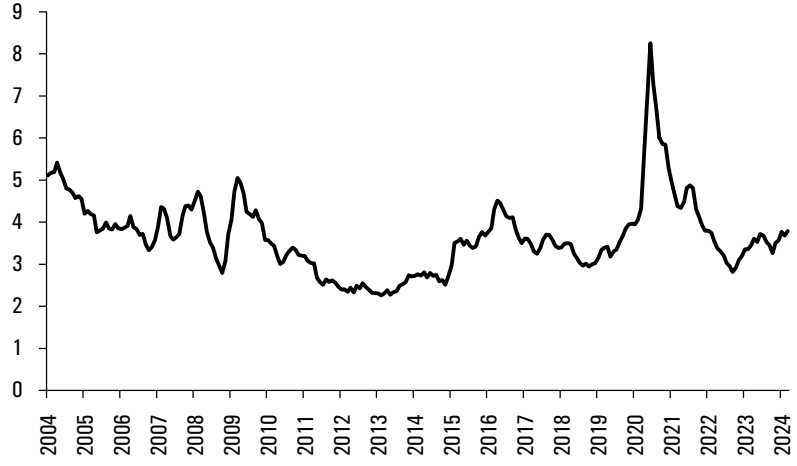
Appendix C: Additional Figures

FIGURE C.1. Short-term External Debt to Reserves (In Percent)



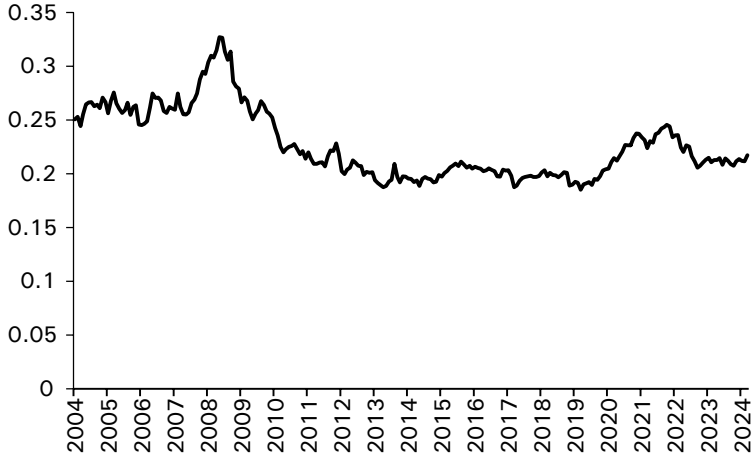
Source: World Bank, Quarterly External Debt Statistics, RBI.

FIGURE C.2. Ratio of Reserves to 3-months Imports in India



Source: IMF International Financial Statistics, RBI.

FIGURE C.3. Ratio of Reserves to Broad Money (M3)



Source: RBI.