Capital Flow Management with Multiple Instruments

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Emerging markets (EMs) are affected by a global financial cycle originating in developed economies (Rey, 2013). An increase in risk appetite of developed economies, perhaps spurred by easy monetary policy, leads to a surge in capital flows to EMs. These foreign capital flows, especially foreign portfolio investments (FPI) in debt and equity markets (as against foreign direct equity investments or FDI), can reverse quickly, thus leading to a sudden stop and a sharp macroeconomic slowdown. Managing this capital flow cycle is a central concern for EM governments (as discussed by De Gregorio, 2010; and Ostry and others, 2010) and is the focus of this paper.

These points are evident in events of the last 10 years. Figure 1 plots, as an example, FDI and FPI flows into India over the period 2004 to 2017. FPI flows (in dashed grey) drop sharply in the global financial crisis before rising in the post-crisis period, when developed economy interest rates are low. They reverse again in the taper tantrum of 2013,

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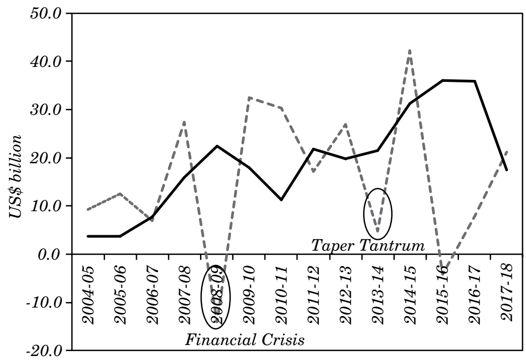
when investors feared that the Federal Reserve may tighten monetary policy (see Krishnamurthy and Vissing-Jorgensen, 2013). When these fears ease in 2014, capital flows resume before falling again in late 2015 as the Fed indeed raises rates. The figure also plots FDI flows, which are far more stable (black line).

The capital flow reversal in the taper tantrum episode led to a sharp depreciation of the Indian rupee (INR). Figure 2 plots the exchange rate (black line) from 2004 to 2017, with the shaded region indicating the taper tantrum period. The rupee depreciated by over 30 percent against the U.S. dollar in the summer of 2013, more so than other EMs on average (grey line in graph).

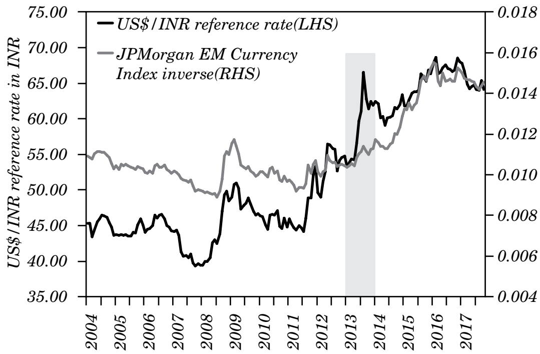
In response to such capital flow volatility and attendant consequences on exchange rates, EMs have adopted two main strategies: hoard foreign reserves and impose capital controls. Reserves can act as a buffer against a sudden stop. See Obstfeld and others (2010)'s discussion of the intellectual history and underpinnings of the role of foreign reserves as a buffer against sudden stops. Capital controls that reduce external debt limit the vulnerability of an EM to sudden stops. The IMF study by Ostry and others (2010) provides a comprehensive examination of the motivation behind capital controls as well as the effectiveness of such controls in practice.

Figure 1. Volatility of FPI and FDI Flows



Source: Reserve Bank of India (RBI). Data for 2017-18 updated until October 2017.
Note: Net Foreign Direct Investment (FDI) in black and Net Foreign Portfolio Investment (FPI) in dash grey.

Figure 2. Exchange Rate and 2013 Taper Tantrum



Sources: Bloomberg, DBIE, and RBI.

This paper revisits the topic of capital flow management, and particularly the interaction between two commonly deployed instruments to achieve it, *viz.*, foreign reserves policies and capital controls. In practice as well as in much of the literature on capital flow management, capital controls and reserves management are cast as *alternative* instruments which can both reduce sudden-stop vulnerability. Our principal theoretical result is that these policies interact and should be seen by central banks as *complementary* instruments. Better capital controls enable more effective reserve management. Likewise, a higher level of foreign reserves dictates stronger capital controls.

Jeanne (2016) is another study that examines the complementarity between these instruments in a somewhat different setting than ours.

The intuition for our key result is simply stated. One way of interpreting the sudden stop is as a state of the world in which foreign creditors refuse to rollover both external (foreign currency) short-term debt and domestic (local currency) short-term debt. This can trigger both a currency crisis and a rollover/banking crisis. Borrowers with external debt will fire-sale domestic assets to convert to foreign currency to repay foreign creditors. Foreign holders of domestic debt will convert repayments from this debt into foreign currency. The liquidation of domestic assets for foreign currency triggers a currency crisis. The rollover problem triggers defaults and a banking crisis. Consequently, our model embeds the twin-crisis nature of sudden stops in EMs (Kaminsky and Reinhart, 1999). The crisis is worsened if the aggregate amount of external and domestic short-term debt is higher, as this results in more fire-sales. On the other side, in the *extremis*, central bank reserves can be used to reduce currency depreciation as well as borrower defaults. Therefore, reserves reduce the magnitude of the fire-sale discount in prices. But *ex ante*, they induce greater undertaking of short-term liabilities by borrowers, a form of moral hazard from the insurance effect of reserves in case of sudden stops: the greater the reserves, the lower the anticipated fire-sale discount in prices, and in turn, the greater the undertaking of short-term liabilities. Hence, unless the build-up of reserves is coincident with capital controls on the growth of short-term liabilities, the insurance effect of reserves is undone by the private choice of short-term liabilities. In other words, reserves and capital controls are complementary measures in the regulatory toolkit.

With capital flows into both foreign-currency and domestic-currency-denominated assets, there arises a further complementarity result. If capital controls can only be introduced on one margin, say foreign-currency debt, then they cannot be too tight. Otherwise, there is the prospect of arbitrage of capital controls between the two markets: borrowing short-term will switch to domestic-currency assets, even if domestic borrowing is costlier in a spread sense as it enjoys weaker capital controls. We show that with an additional instrument, say capital controls on domestic-currency debt, capital controls as a whole can be more effective, which then makes reserve polices also more effective. We show that the design of capital controls in such a setting where the emerging-market currency is internationalized to some extent requires careful weighing of the gains from attracting capital flows, typically in the form of lower cost of borrowing abroad relative to domestically, against the cost of sudden stops and the cross-market regulatory arbitrage of capital controls. Moreover, our main finding continues to hold in this case: Central banks should make reserve management and capital control policy choices understanding that they are complements rather than substitutes.

Our paper contributes to the large literature on the role of reserves and capital controls in managing sudden stops. Ostry and others (2010) provide a comprehensive examination of the motivation behind capital controls, as well as the effectiveness of such controls in practice. Obstfeld and others (2010) discuss the intellectual history and underpinnings of the role of foreign reserves as a buffer against sudden stops. Aizenman and Marion (2003) rationalize the build-up of reserves in Asia as a response to precautionary motives. Jeanne and Ranciere (2011) provide a quantitative analysis regarding how much reserves a central bank should hold, shedding light on the well-known Greenspan-Guidotti rule (Greenspan, 1999). In this literature, typically both reserves and capital controls are viewed as precautionary tools to buffer against sudden stops (for example, Aizenman, 2011). Thus, the literature typically takes the perspective that these tools are substitutes, whereas our main result is that they are complements. Our paper is also related to the classic analysis of Poole (1970) studying the optimal choice of instruments. The principal difference between our analysis and Poole's is that in his model the instruments are substitutes, while in our case they are complements. We discuss this further in the conclusion.

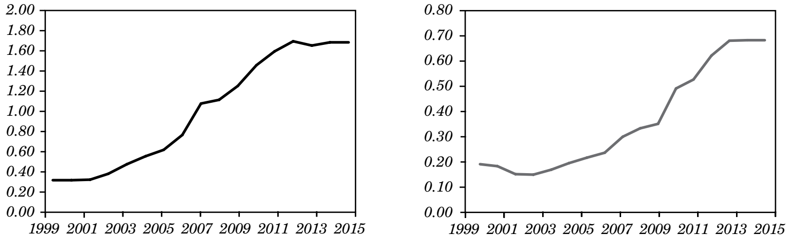
Section 1 presents empirical evidence suggestive of the complementarity perspective. Section 2 builds a model to analyze reserves and capital controls jointly. Finally, as a case study for the analysis, in section 3 we discuss how capital controls have been used in India and how they map into the model's economic forces and implications.

1. EM Liquidity: Empirical Evidence

The left panel of figure 3 plots the total foreign reserves held by central banks in a sample of EMs over the period 1999 to 2015.[1] There is a dramatic increase in foreign reserves after the global financial crisis. From 2006 to 2015, reserves increase from \$0.78 trillion to just over \$1.7 trillion. Indeed, many policy-makers and academics have described the reserve accumulation as a proactive capital flow management strategy. Carstens (2016) documents the dramatic increase in the volatility of capital flows after 2006 (chart 3 of his paper). He notes that the accumulation of international reserves is the primary policy tool EMs have used to manage this capital flow volatility.

1. The countries are: Argentina, Brazil, Colombia, Egypt, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Sri Lanka, Thailand, Turkey, and Venezuela. Note that we exclude China in this calculation, primarily because the movement in China's reserve holdings are so large relative to the rest of the EMs. China's foreign reserves rise by about \$2.4 trillion from 2006 to 2015.

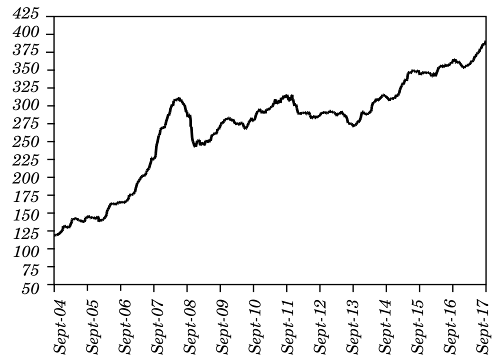
Figure 3. The Left Panel Graphs the Aggregate Foreign Reserves, in Trillions of USD, Across a Sample of Emerging Markets, from 1999 to 2015. The Right Panel Graphs the Aggregate External Short-Term Debt (<1 Year) of These Countries.



Source: International Monetary Fund.

The right panel of figure 3 graphs the aggregate external short-term debt of these EMs. As is well understood in the literature, reserves can act as a buffer against withdrawals of these flows in the event of a sudden stop. External creditors may choose not to rollover their short-term debt, which indicates a liquidity need for the country that is partially covered with foreign reserves. The Greenspan-Guidotti rule, already mentioned above, is a prescription that EMs hold reserves equal to external debt less than one year in maturity. It is apparent that, as foreign reserves have grown, short-term debt has also grown.

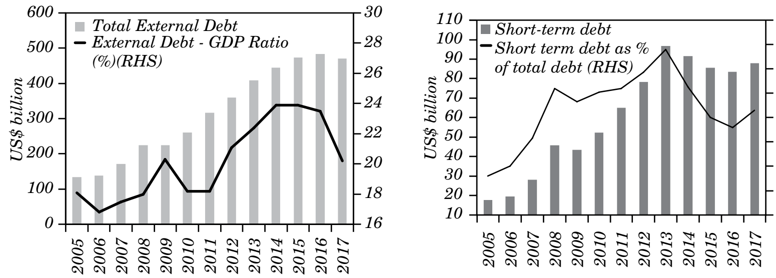
Figure 4. Foreign Exchange Reserves for India (US$ billion)



Source: RBI.

Figure 5. India Total and Short-Term External Debt

A. India Total External Debt *B. Short-term External Debt*



Source: India's External Debt, a Status Report, 2016-17 by Government of India.

Figure 4 below graphs India's forex reserves, showing that they rose steadily after the global financial crisis and until 2011, dipping slightly by 2012 and then remaining relatively flat until the taper tantrum. In an absolute sense, India's reserves had accumulated by the 2013 taper tantrum to exceed the level in the crisis of 2008 levels, thus suggesting greater external sector resilience. However, the net capital outflow after the Federal Reserve's taper announcement led to a sharp depreciation in the exchange rate, as evident from figure 2. The culprit is short-term debt: the diagnosis of resilience is reversed if one accounts for the build-up of external debt in India.

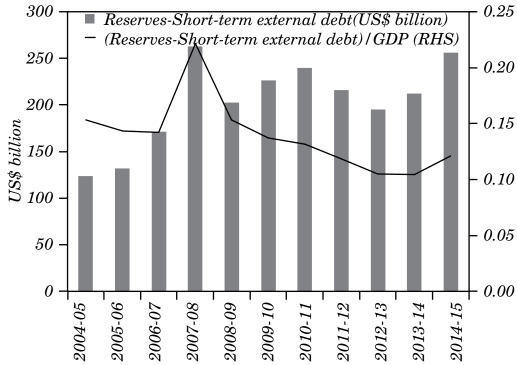
Figure 5, panel A, plots the time series of India's external debt, which rose steadily and was at close to 25 percent relative to GDP around the taper tantrum. Equally important, the short-term component of this debt (with residual maturity less than one year) is seen in figure 5, panel B, to have also risen steadily (to around 20 percent short-term debt) by the 2013 taper tantrum.

Let us define liquidity (or external-sector resilience) metric at the country level:

$$\text{Liquidity}_{i,t} = \frac{\text{Reserves}_{i,t}\text{-ST Debt}_{i,t}}{\text{GDP}_{i.t}}. \qquad (1)$$

Figure 6 shows that the liquidity measure had been steadily declining for India from a peak of above 20 percent prior to the global financial crisis to a low of below 10 percent by the taper tantrum, thus more accurately capturing the loss of resilience as witnessed during the period from May to August of 2013.

Figure 6. Country Liquidity = $\frac{\text{Reserves-Short-term External Debt}}{\text{GDP}}$



Source: World Bank, RBI, Ministry of Statistics & Program implementation.

To summarize, the case of India in the build-up to the taper tantrum suggests that forex reserves, *per se*, were not adequate in measuring external sector resilience against sudden stops. The model we develop in this paper studies the linkage between reserves and short-term debt. We will argue theoretically that reserve adequacy is contingent upon the quantity and quality of debt and, in particular, the extent of short-term external debt. Our theoretical analysis also points to the mechanism whereby the increase in reserves in part likely drove the rise in short-term external debt, although it is difficult to causally identify this economic force from the data we have presented.

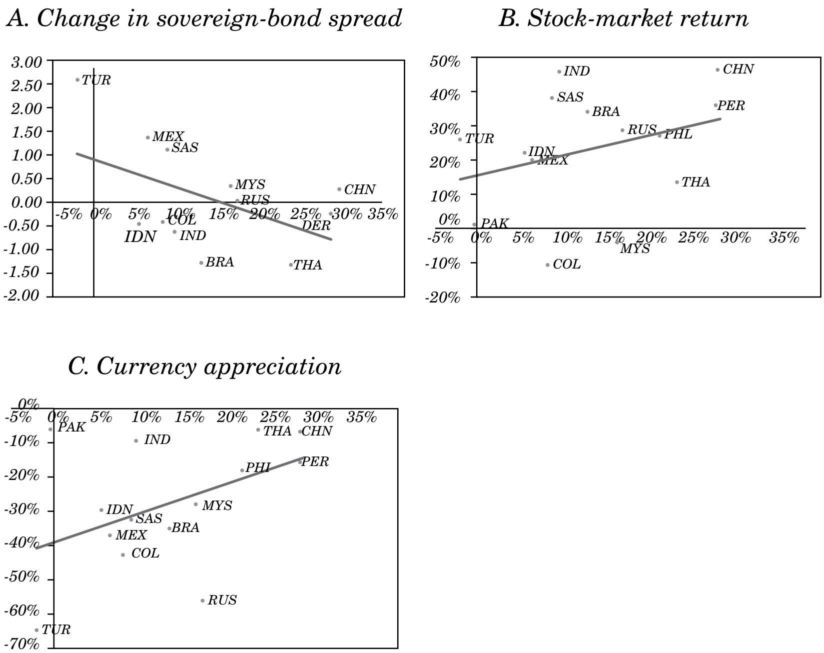
We next investigate the linkage between reserves and short-term debt more broadly across EMs, asking how well the liquidity metric in (1) discriminates among countries in their exposure to the global financial cycle.

Figure 7 plots country liquidity as of 2013, as in (1 with $t = 2013$), against asset price changes, for a group of EMs. We consider asset price changes from June 2013 to October 2017. We begin in June 2013 to include the start of the taper tantrum. Over this period, the global financial cycle turns back towards developed economies, so that, on average, EM currencies depreciate (panel C). The figure reveals that the liquidity metric discriminates between the EMs that are more and less sensitive to the financial cycle. From panel C we see that countries that are more liquid see their currencies depreciate less. Likewise, more liquid countries see sovereign-bond yield spreads rise less (panel A) and experience higher domestic stock-market returns (panel B).

That is, in all cases, higher liquidity is associated with a more favorable EM asset price outcome.

We next turn to high frequency data. The relation in figure 7 reflects a correlation over a long time window, where the global shock is negative for EMs. At a high frequency, we can hope to uncover more shifts in the global cycle and hence better document a relation between liquidity and EM performance. Our approach builds on the literature and particularly Rey (2013), who notes the importance of the VIX for the global cycle. We proxy for the global factor using the VIX multiplied by -1 (i.e., the negative of the VIX). Our normalization is that when the global factor is high we say that capital flows are favorable to EMs. Using the AR(1) innovations to the global factor, we estimate the heterogeneous effect of the global financial cycle on countries with different degrees of liquidity.

Figure 7. Country Liquidity as of 2013 Against Asset Price Changes, for a Group of Emerging Markets



Source: Author's elaboration.
Panel (a) plots liquidity on the x-axis against the change in sovereign-bond yield spreads from June 2013 to October 2017, on the y-axis. Panel (b) plots a similar relation for the country stock-market return. Panel (c) is for the EM currency appreciation against the USD. In all cases, higher liquidity is associated with a more favorable EM asset price outcome.

Table 1 reports the results of panel data regressions. In panel A, the dependent variable is the daily change in the sovereign-bond spread of a given country. The independent variables are the global factor innovations in columns (1) and (2), and the global factor innovations interacted with liquidity, as well as liquidity by itself, in columns (3) and (4). We include country and year fixed effects in all regressions. Columns (2) and (4) restrict the data to observations with large global shocks, defined as those in the 5 percent tails of the distribution of daily global innovations to check for non-linearities. The independent variables have been normalized by dividing by their standard deviation, so that the coefficients can be interpreted as the effect of a one-sigma change.

We see that the global factor innovation comes in with a negative coefficient in all four columns. There is no discernible difference between the cases where we restrict the observations to large shocks, indicating no evidence of non-linearities. The negative coefficients are to be expected as the global factor is defined in terms of good news for EMs (hence, for instance, sovereign-bond spreads fall). The more relevant covariate for our analysis is the second row, which is the global factor innovation interacted with liquidity. Higher liquidity dampens the impact of innovations in the global factor on changes in sovereign-bond spreads. The regression results are consistent with the pattern evident in figure 7.

Panel B reports results for the domestic stock-market return. Stock returns load positively on the global factor. The interaction term has a negative sign, indicating dampening, but the coefficient is not statistically different from zero.

Panel C is for the EM currency appreciation. As expected, the coefficient on the global factor innovation is positive. Again we see evidence of the dampening effect as the coefficient on the interaction is negative and significant.[2]

2. We have experimented with specifications where we include reserves and short-term debt separately in these regressions for Panels A-C. We would expect that the coefficients on these measures will have opposite signs, when interacted with the global factor. However, there is not enough variation in the data to detect this pattern.

Table 1. Liquidity and Shocks to Global Factor

	(1)	*(2)*	*(3)*	*(4)*
	(a) Change in sovereign-bond spread			
	-0.0788	-0.0620	-0.1326	-0.1163
	(3.88)***	(3.47)***		
Liquidity			0.0812	0.0770
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Restrict to large shock	N	Y	N	Y
R^2	0.01	0.04	0.01	0.05
N	21,340	2,047	13,741	1,419
	(b) Stock market return			
Global factor	0.2878	0.2669	0.2775	0.2788
	(6.87)***	(7.07)***	(4.14)***	(4.63)***
Global factor × liquidity			-0.0026	-0.0350
			(0.03)	(0.47)
Liquidity			-0.0029	0.0514
			(0.12)	(0.72)
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Restrict to large shock	N	Y	N	Y
R^2	0.07	0.23	0.07	0.22
N	25,545	2,535	17,549	1,892
	(c) Currency appreciation			
Global factor	0.1496	0.1314	0.2101	0.1860
	(5.08)***	(5.15)***	(3.87)***	(3.91)***
Global factor × liquidity			-0.0937	-0.0860
			(2.27)**	(2.43)**
Liquidity			-0.0020	0.0364
			(0.09)	(0.97)
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Restrict to large shock	N	Y	N	Y
R^2	0.07	0.21	0.08	0.24
N	27,631	2,756	17,837	1,935

Source: Author's elaboration.
** $p < 0.05$; *** $p < 0.01$.

These results from our data analysis indicate that asset price changes in EMs depend on the global shocks, consistent with a number of papers in the literature (Calvo and others, 1996; and Rey, 2013). We also see that the impact of the global factor depends on the liquidity of the EM, which in turn depends on the foreign reserves of the central bank and the external short-term debt of the EM, as we may expect from the literature on international reserves as a buffer against sudden stops. The next section builds on these observations to construct a model to study the management of capital flows when there are multiple policy instruments, *viz.*, reserves management and capital controls.

2. Model of Macroprudential Management of Capital Flows

This section lays out a model of EM firms, more generally, banks or governments, which borrow from foreign investors to fund high return investments. The model is closest to Caballero and Krishnamurthy (2001), and Caballero and Simsek (2016). Foreign investors are "fickle" in the sense of Caballero and Simsek (2016): they may receive a shock that requires them to withdraw funding from the EM. The loss of funding leads to a fire-sale, which depreciates the exchange rate, and creates an external effect for all borrowers as in Caballero and Krishnamurthy (2001). The central bank has foreign reserves that it can use to reduce the fire-sale and stabilize the exchange rate. We study the connections between the central bank's actions and private sector borrowing decisions. We first lay out a model where all borrowing is via an external debt market, i.e., dollar debt. We then introduce foreign lending in domestic-currency debt.

2.1 Model with External Debt Market

The model has three classes of agents: domestic borrowers (B), foreign lenders (FL), and a central bank (CB). There are three dates: $t = 0, 1, 2$. Date 0 is a borrowing and investment date, at date 1 there are shocks, and at date 2 there are final payoffs.

There is a continuum of borrowers with unit mass. Each B has a project that requires capital and own labor. B's utility is:

$$U^B = E[c_2 - l_0 - l_1] \qquad c_2, l_0, l_1 \geq 0, \tag{2}$$

where c_2 is date 2 investment and l_0 and l_1 are disutility from labor at date 0 and date 1.

The borrower has an investment project at date 0. B can create K units of capital by borrowing,

$$L^F = K \tag{3}$$

goods from foreign lenders, and providing labor of $l_0(K)$, with $l_0(\cdot)$ increasing and convex. The project pays $(1+2R)K$ at date 2 and cannot be liquidated early.

FL are the only lenders at date 0. They have a large endowment of goods and are risk neutral. FL's required return in lending to the EM is $1+r$. A period in which developed market interest rates are low corresponds to a period when r is low. Additionally, if risk appetite for EM bonds is high, we can think of r as being low.

Our key assumption is that lenders are fickle. With probability ϕ they may receive a retrenchment shock at date 1, in which case they need to withdraw their funding. We assume that it is not possible to write contracts contingent on this shock. Consequently, the foreign lenders lend via one-period loans that may or may not be rolled over. It is clearest to think of these loans as in units of "dollars."

If a loan is not rolled over, borrowers owe foreign lenders $L^F(1+r)$ dollars. Loans must be repaid; bankruptcy costs are infinite. To repay a loan, the borrower turns to domestic lenders to borrow funds against collateral of K units of the project. We assume these lenders are present at date 1 and are willing to lend against collateral of K at interest rate of r. The borrower raises $(1+r)K$ domestic currency ("rupees"), with promised repayment of $(1+2r)K$, converts this to $e(1+r)K$ dollars, so that the borrower raises a total of $e(1+r)K$. Here e is the exchange rate in units of dollars per rupee. A depreciated rupee corresponds to a low value of e. The shortfall to the borrower, i.e., owed dollar debt minus funds raised from the domestic loan, is $K(1+r)(1-e)$. The borrower makes up this shortfall by working hard and suffering disutility,

$$l_1 = \beta(K(1 + r)(1 - e)), \tag{4}$$

with $\beta(\cdot)$ increasing and convex. By doing so, and with funds from the domestic loan, the borrower repays $(1+r)K$ in full. $\beta(\cdot)$ is modeled as disutility of labor to keep the model concise rather than to reflect realism. We think of $\beta(\cdot)$ as the deadweight cost of bankruptcy. More generally, it can reflect costly adjustments that must be made in order to meet debt payments.

The central bank has total foreign exchange reserves of X^F which it can use to stabilize the exchange rate. We assume that the exchange rate at all dates other than the retrenchment state is one, and can fall to $e<1$ in the retrenchment state. Henceforth, when discussing the exchange rate e, this e refers to the exchange rate in the retrenchment state at date 1.

Given e we can write the borrower's problem. The utility from choosing $K=L^F$ is,

$$U^B = 2(R - r)L^F - l_0(L^F) - \phi\times\beta(L^F(1+r)(1-e)). \tag{5}$$

Define $\Delta \equiv R - r$. The first order condition (FOC) is:

$$l'_0(L^F) = 2\Delta - \phi\times(1-e)(1-r)\beta'(L^F(1+r)(1-e)). \tag{6}$$

Note that Δ matters in the model, more so than the level of R or r. We henceforth set

$$r = 0 \tag{7}$$

to simplify some expressions. The term Δ can be thought of as the carry offered by the EM.

In equilibrium in the retrenchment state, borrowers pledge K units of collateral to raise L^F rupees and exchanges these domestic funds for X^F units of dollar. The exchange rate is then,

$$e = \frac{X^F}{L^F} \tag{8}$$

Throughout out analysis we will assume that parameters are such that $e<1$. The exchange rate expression reflects the fire-sale externality in our model. When a borrower increases date 0 borrowing and investment, he pushes up K, which then implies that the date 1 retrenchment exchange rate is more depreciated, thus increasing the debt burden ($L^F(1-e)$) to all borrowers. Substituting from (8) into (5) above we can write the aggregate borrower utility as

$$2\Delta L^F - l_0(L^F) - \phi\times\beta(L^F - X^F).$$

This aggregate corresponds to a welfare function for borrowers who account for the effect of their borrowing (L^F) on the exchange rate and hence the repayment ability of other borrowers. The FOC for the aggregate is,

$$l_0'(K) = 2\Delta - \phi \times \beta'(L^F - X^F) \tag{9}$$

We compare (6) to (9) and see that,

Proposition 1. *(Overborrowing)*

1. *Let* $L^{F,priv}$ *be the solution to the first order condition in (6), and* $L^{F,agg}$ *be the solution to (9). Since* $1 > 1 - e$*, the private solution features overborrowing:*

$L^{F,priv} > L^{F,agg}$.

The private choices of K and L^F *are larger than the coordinated choices.*

2. *Take the case where* β *is linear, or not too convex.*[3] *Then, since e is increasing in* X^F*, the private sector overborrowing (gap between private and coordinated solution) increases in* X^F*. Central bank reserves are a form of bailout fund. The larger the bailout fund, the greater the private sector borrowing.*[4]

How can borrowers implement the coordinated optimum? In our model there are at least two solutions. A planner can set a borrowing limit on L^F which directly implements the optimum. Or, the planner can set a tax rate on external borrowing, τ^F, so that a borrower who raises L^F pays $\tau^F L^F$ to the planner, who then rebates the funds to the borrowers. With this tax, the borrower would maximize:

$$2\Delta L^F - l_0(L^F) - \phi \times \beta(L^F(1 - e)) - \tau^F L^F + T. \tag{10}$$

where $\tau^F L^F$ is the borrowing tax and T is the lump sum rebated to the borrower. The optimal tax is set so that the private FOC is equal to the social FOC. It is straightforward to see that,

$$\tau^F = \phi \times \beta'(L^F(1 - e)). \tag{11}$$

3. The caveat is necessary because if reserves are large enough that e approaches one, then the cost of bankruptcy goes to zero.

4. If we do not assume $r = 0$, which we have for simplicity, then it can be shown that as r falls and hence Δ rises, K and L^F rise. Since $\beta(\cdot)$ is convex, the term $\beta'(L^F - X^F)$ is increasing in K (and L^F). Thus a lower world interest rate, or increase in foreign investors' risk appetite, exacerbates the overborrowing problem. If bankruptcies create spillovers to un-modeled sectors, via bank losses for example, that are increasing in the amount of bankruptcy, then β is increasing in K, and the problem is reinforced.

The tax is increasing in the probability of the foreign run state, ϕ. It is also increasing in the expected marginal deadweight cost of the retrenchment state, $e \times \beta'(L^F(1-e))$, which we note is itself increasing in L^F. Our result that capital flow taxes on EM borrowers can beneficially correct an overborrowing problem is similar to Caballero and Krishnamurthy (2004), and Jeanne and Korinek (2010).

2.2 Optimal Reserve Holdings and Taxes

We next study the central bank's holdings of reserves and consider how reserve holdings affect welfare. Suppose that holding reserves for the central bank comes at a cost $\kappa(X^F)$, where κ is an increasing and convex function of X^F. We take this cost in reduced form. We can think there are other forms of capital flows, say FDI or equity, which the central bank uses to accumulate foreign reserves. In this case, κ is the opportunity cost of the alternative activity. Then, consider the following welfare function:

$$W(L^F, X^F) \equiv 2\Delta L^F - l_0(L^F) - \phi \times \beta(L^F - X^F) - \kappa(X^F) \tag{12}$$

How much X^F would a central bank choose knowing that the choice of X^F affects L^F? We optimize over X^F given that $L^F(X^F)$. The FOC is,

$$L^{F'}(X^F)\,\{2\Delta - l_0'(L^F) - \phi \times \beta'(L^F - X^F)\} + \phi\beta'(L^F - X^F) - \kappa'(X^F) = 0.$$

The term in brackets $\{\cdot\}$ can be simplified using the private FOC, (6). We find:

$$-L^{F'}(X^F) \times \phi \times e\beta'(L^F - X^F) + \phi \times \beta'(L^F - X^F) - \kappa'(X^F) = 0$$

so that,

$$\phi\beta'\left(L^F - X^F\right) = \frac{\kappa'(X^F)}{\left(1 - eL^{F'}(X^F)\right)}. \tag{13}$$

It is instructive to compare this expression to the case where the central bank can directly choose L^F. In that case, the term in the brackets {} goes to zero so that the FOC is

$$\phi\beta'(L^F - X^F) = \kappa'(X^F). \tag{14}$$

In this latter case, the intuition for the choice of X^F is clear. The marginal cost of reserves is increasing in κ' and the marginal benefit of holding reserves is the reduction in expected default cost $\phi\beta'(L^F - X^F)$. The optimal holding of reserves equates these two margins.

In the former case, when the private sector chooses L^F, the cost of reserves is higher. Algebraically we can see it is higher since $1 - eL^{F'}(X^F) < 1$ as $e > 0$ and $L^{F'}(X^F) > 0$. Intuitively, the private sector chooses a higher L^F in response to a higher X^F. Therefore, the effective cost of reserves is increased from κ' to $\frac{\kappa'}{1 - eL^{F'}(X^F)}$. The central bank recognizes that increasing X^F provides beneficial insurance, but that the private sector will undo some of this beneficial insurance by overborrowing and increasing L^F. The central bank cuts back on its optimal reserve holdings as a result.

To summarize:

Proposition 2. *(Complementarity between policy instruments I)*

• *If the central bank can directly choose L^F via a borrowing limit or external-borrowing tax, then it chooses X^F to solve (14). Call this maximized value X^F_{**}.*

• *If the central bank does not have instruments to directly affect L^F, then it chooses X^F to solve (13). Call this maximized value X^F_{*}. We then have that,*

$X^F_{**} > X^F_{*}$.

• *With two instruments, taxes and reserves, the central bank can do strictly better than with only one instrument. The two instruments are complements in the sense that taxing ability allows for more reserve holdings; likewise, more reserve holdings dictate higher taxes.*[5]

2.3 Heterogeneity among Borrowers

We extend the model to allow for heterogeneity. Suppose that in a retrenchment shock some firms are more exposed than others. In particular suppose that the probability a given firm will suffer loss of funding in the retrenchment shock is p_i where i indices borrowers. We can think of p_i as capturing the relative safety of a firm. We may expect that larger, more stable, or more export-oriented firms will be less exposed to the retrenchment shock.

5. This complementarity result is derived in a somewhat different setting by Jeanne (2016).

Borrower-*i*'s problem is to maximize,

$$U^{B,i} = 2\Delta L^{F,i} - l_0(L^{F,i}) - \phi p_i \times \beta(L^{F,i}(1-e)) - \tau^{F,i} L^{F,i} + T \tag{15}$$

where we have allowed the tax rate to be borrower-specific, $\tau^{F,i}$. The FOC is,

$$l'_0(L^{F,i}) = 2\Delta - \phi p_i \times (1-e)\, \beta'(L^{F,i}(1-e)) - \tau^{F,i}$$

Aggregating across all borrowers, accounting for the likelihood of retrenchment for borrower i given loan amount $L^{F,i}$, the equilibrium exchange rate is,

$$e = \frac{X^F}{\overline{L}^F} \text{ where } \overline{L}^F = \int_i p_i L^{F,i}\, di. \tag{16}$$

Next, consider the coordinated solution where we use an equal-weighting welfare function:

$$\overline{U}^B = \int_i U^{B,i} di. \tag{17}$$

By differentiating with respect to an increase in borrower-*i*'s loan amount, accounting for the effect on all other *j* through the exchange rate, we have that:

$$\frac{\partial \overline{U}^B}{\partial L^{F,i}} = \left(2\Delta - l'_0\left(L^{F,i}\right) - \phi pi \times (1-e)\beta'\left(L^{F,i}(1-e)\right)\right) \\ -\phi p_i \int_j \left(p_j e \beta'(L^{F,j}\ (1-e)) \frac{L^{F,j}}{\overline{L}^F} \right) dj. \tag{18}$$

The second term on the right-hand side is the externality term. Increased borrowing by i puts pressure on the exchange rate in proportion to the borrower's retrenchment exposure p_i.

The optimal tax rate is chosen to equate the social and private margins. It is straightforward to derive that:

Proposition 3. *(Borrowing taxes)*

The optimal tax on borrower-i is,

$$\tau^{F,i} = \phi p^i \int_j \left(p_j e \beta'(L^{F,j}\ (1-e)) \frac{L^{F,j}}{\overline{L}^F} \right) dj. \tag{19}$$

Note that the term in the integral (19) is common across all borrowers. So if we compare the optimal tax rate for two borrowers, i and i', we find

$$\frac{\tau^{F,i}}{\tau^{F,i'}} = \frac{p^i}{p^{i'}}.$$

Finally, the tax rate expression (19) simplifies substantially for the special case of the model where the bankruptcy cost is linear, $\beta(z) = B \times z$. In this case,

$$\int_j \left(p_j e \beta'(L^{F,j} \ (1 - e)) \frac{L^{F,j}}{\overline{L}^F} \right) dj = \overline{p} e B$$

so that,

$$\tau^{F,i} = \phi p^i \times \overline{p} e B$$

which can be readily compared to (11) for the homogeneous borrower case. The optimal tax is proportional to the pressure caused by borrower-i times the increase in expected bankruptcy cost caused by the additional borrowing.

The central implication of this analysis is that, in general, capital flow taxes should be borrower-specific and depend on the fire-sale externality imposed by a given borrower. In many cases, such contingency is hard to implement. But it is nevertheless the implication of the theory. Indeed, our analysis implies that, if taxes are set positive but uncontingent on borrower type, an across-firm distortion rises. High p^i borrowers will over-borrow, while low p^i borrowers will underborrow, all relative to the social optimum.

2.4 Domestic Loan Market

We return to the homogeneous borrower case but extend the model to introduce a domestic (rupee) loan/bond market at date 0. The market is for borrowing in local currency from either domestic or foreign lenders. Given our focus on foreign lending, we suppress domestic lenders, or alternatively can think of our modeling as net of the loans from domestic lenders. The date 0 cost of borrowing on domestic loans is $r^D > r$. The higher rate stems from the possibility of a currency depreciation, weaker legal protection in the domestic market, higher information requirements to ensure sound collateral, and so on. As noted earlier, we fix the currency to be worth one at date 0 and in the non-retrenchment state. It may depreciate to $e < 1$ in the retrenchment state. Additionally, the cost for a foreign lender to participate in the local market is s, covering the collateral issues mentioned. Thus, the return to an external lender in the domestic bond market is,

$$(1 - \phi)\,(1 + r^D) + \phi(1 + r^D)e - s.$$

Since foreign lenders can either buy domestic bonds or foreign bonds by paying r, the domestic interest rate must satisfy:

$$r^D - r \approx s + \phi\,(1 - e). \tag{20}$$

The domestic spread reflects the cost of lending in the local market, s, and the loss to foreign lenders due to the exchange rate depreciation in the sudden-stop state. As noted, we set $r = 0$ so that the required return on domestic borrowing simplifies to, $r^D = s + \phi\,(1 - e)$. A borrower who agrees to repay L^D at date 1 raises $\frac{L^D}{1 + s + \phi(1 - e)}$ at date 0.

We have described the rate r^D on borrowing at date 0. Next, consider date 1. We assume that in the rollover market at date 1, the cost of domestic borrowing is r rather than r^D. Although asymmetric, this latter assumption serves to simplify some algebraic expressions.

Foreign lenders can lend domestically or externally, and run at date 1 against either type of debt with probability ϕ. Define total borrowing as

$$K = L^F + \frac{L^D}{(1 + s + \phi(1 - e))} \tag{21}$$

where L^F is external loans from foreign lenders and L^D is domestic loans from foreign lenders.

At date 1, if there is retrenchment shock, borrowers have to come up with L^F dollars to repay external debt. They raise $L^F(1 - e)$ via domestic loans, and pay for the shortfall via the bankruptcy/adjustment costs of $\beta(\cdot)$.

In the domestic loan market, the retrenchment shock also leads to a need for funding. We assume (symmetrically with the case of external debt) that other domestic lenders are able to step in and rollover the borrower's debts. However, the foreign lenders receive their local funds of L^D and convert them into dollars since they need to retrench into dollars. This potentially depreciates the exchange rate:

$$e = \frac{X^F}{L^F + L^F} \text{ for } e < 1. \tag{22}$$

A larger outflow triggers a greater depreciation; and, the central bank can intervene to reduce the depreciation by using foreign reserves of X^F. Note our symmetric treatment of foreign and domestic loans. Our model captures a sudden stop as a "twin crisis" in the sense of Kaminsky and Reinhart (1999), and Chang and Velasco (2001). A domestic debt crisis triggers an outflow of capital which adds to a currency crisis.

Given e, the borrowers choose their investment and funding at date 0. They maximize,

$$U^B = 2\Delta L^F + \left(2\Delta - r^D\right)\frac{L^D}{(1+r^D)} - l_0(K) - \phi \times \beta\left(L^F(1-e)\right).$$

The second term here reflects that when $r^D > 0$ domestic borrowing results in less profits than foreign borrowing.

For the analysis of this section we assume that that the bankruptcy cost is linear in its argument, that is, $\beta(x) = Bx$. Then,

$$U^B\left(L^F, L^D, e\right) = 2\Delta\left(L^F + \frac{L^D}{(1+r^D)}\right) - l_0\left(L^F + \frac{L^D}{(1+r^D)}\right)$$
$$-\phi \times B \times L^F(1-e) - (s + \phi(1-e))\frac{L^D}{(1+r^D)}.$$

This expression highlights the key difference between domestic and foreign borrowing. External borrowing brings a potential bankruptcy cost of $B \times L^F(1-e)$. The *borrower* bears the retrenchment cost ex-post and accounts for it when making the ex-ante borrowing decision. Domestic borrowing avoids this cost but requires the higher ex-ante spread of $r^D = s + \phi(1-e)$. The *lender* bears the retrenchment cost ex-post, and charges for it ex-ante by increasing the domestic spread. Next consider the central bank's objective.

$$W\left(L^F, L^D, X^F\right) = 2\Delta\left(L^F + \frac{L^D}{1+r^D}\right) - l_0\left(L^F + \frac{L^D}{1+r^D}\right) - \tag{23}$$
$$\phi \times \mathrm{B} \times L^F(1 - e) - (s + \phi(1 - e)) - \kappa(X^F).$$

We simplify this expression and the following algebra by assuming that r^D is relatively small so that we can take $\frac{1}{1+r^D} \approx 1$. In this case, we rewrite the objective as

$$W(L^F, L^D, X^F) \approx 2\Delta(L^F + L^D) - l_0(L^F + L^D) \\ -\phi \times B \times L^F(1-e) - (s + \phi(1-e))L^D - \kappa(X^F) \tag{24}$$

The central bank chooses (L^F, L^D, X^F) to maximize $W(\cdot)$. Differentiating, we have that,

$$\frac{\partial W}{\partial L^F} = 2\Delta - l_0'(K) - \phi(1-e)B + \phi(L^D + BL^F)\frac{\partial e}{\partial L^F}$$

and,

$$\frac{\partial W}{\partial L^D} = 2\Delta - l_0'(K) - (s + \phi(1-e)) + \phi(L^D + BL^F)\frac{\partial e}{\partial L^D}.$$

These two expressions give the marginal value of more domestic loans and foreign loans. Notice from (22) that $\frac{\partial e}{\partial L^D} = \frac{\partial e}{\partial L^F}$. That is, an extra unit of either domestic or foreign loans results in the same pressure on the exchange rate and hence has the same fire-sale externality. This is because in the case of an extra unit of foreign loans, the borrower worsens the fire-sale with the extra unit of loans. In the case of domestic loans, the lender worsens the fire-sale with the extra unit of domestic loans. But the marginal fire-sale impact does not depend on the denomination of the loan.[6] Then, the difference in these marginal values is,

$$\frac{\partial W}{\partial L^F} - \frac{\partial W}{\partial L^D} = s + \phi(1-e) - \phi(1-e)B.$$

Foreign borrowing is socially preferable if the domestic spread s is high and the bankruptcy costs B are low, otherwise domestic borrowing is preferred.

6. In our formulation L^F and L^D appear symmetrically in equation (22). But it is also plausible that a unit of external borrowing applies more pressure on the exchange rate in the sudden-stop state. In this case, the external borrowing carries a higher externality than the domestic borrowing, analogous to our study of heterogeneity among borrowers. We set this effect aside because it is not central to our conclusions. For an analysis of the issue, see Caballero and Krishnamurthy (2003).

Next consider implementation of the optimum. Suppose that the spread s is high so that foreign borrowing is preferred to domestic borrowing. How can the central bank implement the optimum via taxes? This case superficially appears similar to our early analysis. However, there is a key difference. Increasing taxes on foreign borrowing decreases aggregate borrowing, but also *shifts borrowing to domestic markets*. To see this, let us write the borrower's objective with the foreign debt tax:

$$U^B(L^F, L^D, e) = 2\Delta(L^F + L^D) - l_0(L^F + L^D) \\ - \phi \times B \times L^F(1 - e) - (s + \phi(1 - e))L^D - \tau^F L^F. \tag{25}$$

The derivative of U^B with respect to the two forms of borrowing are:

$$\frac{\partial U^B}{\partial L^F} = 2\Delta - l_0'(K) - \phi(1 - e)B - \tau^F$$

and,

$$\frac{\partial U^B}{\partial L^D} = 2\Delta - l_0'(K) - (s + \phi(1 - e)).$$

As taxes, τ^F, increase, the borrower optimally chooses lower foreign borrowings L^F. However, if

$$\phi(1 - e)B + \tau^F > s + \phi(1 - e)$$

the borrower takes no external loans and shifts fully to domestic borrowing. At this point, the tax policy is completely ineffective.

We account for this substitution effect by placing an additional constraint on the central bank. The central bank maximizes (24) subject to a constraint on taxes:

$$\tau^F \leq s + \phi(1 - e) - \phi(1 - e)B. \tag{26}$$

The final result of the analysis is that the tax constraint can be relaxed. Suppose that the central bank can also tax domestic borrowing. Then, the tax constraint becomes

$$\tau^F \leq \tau^D + s + \phi(1 - e) - \phi(1 - e)B. \tag{27}$$

We highlight this result as:

Proposition 4. *(Complementarity between policy instruments II) Domestic-borrowing taxes, external-borrowing taxes, and holdings of foreign reserves are complimentary policy tools. With the ability to level a tax on domestic borrowing, the central bank can decrease aggregate borrowing without distorting the balance between foreign and domestic borrowing, which results in a higher welfare for the economy.*

3. Macroprudential Measures Deployed in India

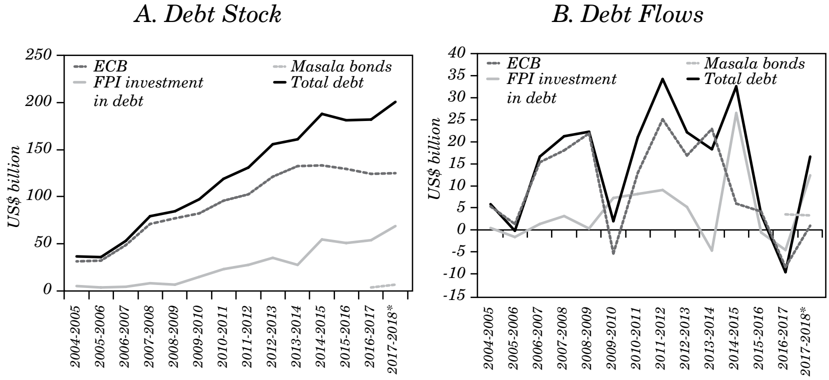
India has deployed a range of macroprudential measures to contain the impact of sudden stops and reversals of foreign capital flows, and the concomitant shocks to the financial and real sector. Many of these measures had been in place prior to the taper tantrum; however, the taper tantrum led to a further revision of their nature, as explained below. In this section, we discuss these measures through the lens of our theoretical model of optimal capital controls.

India has three principal kinds of external debt once various forms of government debt from multilateral agencies, as well as non-resident Indian deposits, are excluded (the latter have usually been a source of stability for India during stress episodes): FPI in domestic debt (in both Government of India securities at center and state level, as well as corporate bonds); external commercial borrowings (ECB), which are typically loans to Indian corporations, quasi-government entities or private firms, denominated in foreign currency; and, introduced most recently, the rupee-denominated bonds (RDB) or "Masala bonds" issued overseas, again by quasi-government entities or private firms, typically listed on the London Stock Exchange.

Net investments (stock in panel A, flow in panel B) in these various segments of external debt are plotted over time in figure 8. The ECB contributed to the bulk of such external debt flows until the taper tantrum, after which time the FPI debt flows have overtaken as the most significant component. It is also worth pointing out the growth in the Masala Bond in 2017 as ECB borrowings fall. This switch in the nature of external debt is also reflected in table 2 which shows that the foreign-currency-denominated external debt has steadily declined since 2014 while the INR-denominated component has grown. We will discuss this substitution pattern in terms of proposition 4.

Macroprudential capital controls with regard to these different forms of external debt are briefly explained below, placing the various controls into broad categories so as to interpret them in terms of our model's normative implications:

Figure 8. Debt Stocks and Flows



Sources: RBI, NSDL, and SEBI.

Table 2. Currency Composition of External Debt (%), End-of-March

Currency	*Year*						
	2011	*2012*	*2013*	*2014*	*2015*	*2016 (PR)*	*2017 (QE)*
1 U.S. dollar	55.3	56.9	59.1	61.1	58.3	57.1	52.1
2 Indian rupee	18.8	20.5	22.9	21.8	27.8	28.9	33.6
3 SDR	9.4	8.3	7.2	6.8	5.8	5.8	5.8
4 Japanese yen	10.9	8.7	6.1	5.0	4.0	4.4	4.6
5 Euro	3.6	3.7	3.4	3.3	2.3	2.5	2.9
6 Pound sterling	1.6	0.9	0.7	1.1	0.9	0.8	0.6
7 Others	0.4	1.0	0.6	0.9	0.9	0.5	0.4
Total (1 to 7)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sources: Based on data from RBI, CAAA, SEBI, and Ministry of Defence.
PR: Partially revised. QE: Quick Estimate.

3.1 Caps on Exposure to Global Shocks

These are presently in the form of absolute size limits on (i) total FPI in domestic securities by asset class, with separate limits for Government of India securities (G-secs), State Development Loans (SDL), and corporate bonds, amounting to around US$39 billion, US$6 billion, and US$36 billion, respectively, or a total of about US$80 billion across the three asset categories; and on (ii) ECBs and Masala bonds together, amounting to a total of about US$130 billion.

From the standpoint of our model, the aggregate short-term external liability that cannot be rolled over relative to the forex reserves of the country is what matters for macroeconomic outcomes in the sudden-stop state. Moreover, the complementarity perspective of our model indicates that borrowing limits should be closely tied to the central bank's holdings of foreign reserves.

In practice, the limits discussed have either been set as a percentage of the underlying market size (as in the case of the G-sec and SDL limits), or set as an absolute number (as in the case of corporate debt limits). In both cases, roll-out of the limits has been calibrated over quarters, i.e., gradually, presumably based on considerations outside of our model such as implications of capital inflows on the exchange rate. Our analysis suggests that optimal limits should depend on *stocks* of debt rather than *flows*. They should also be contingent on central bank reserve holdings.

That being said, there are several aspects to these limits which conform to the model's implications. In particular, there are limits by investor and by borrower- or issuer-type, as well as restrictions on nature of the debt. These aspects have evolved over time given India's experience with external sector vulnerability. We discuss these aspects next.

Table 3. FPI Limits (US$ billion)

	Central government securities			*State development loans*			*Corporate bonds*		
Effective for quarter	*General*	*Long term*	*Total*	*General*	*Long term*	*Total*	*General*	*Long term FPIs Inf.*	*Total*
2017-18 Q3	29.29	9.31	38.60	4.63	1.44	6.07	33.64	1.47	35.10

Sources: RBI, and DBIE.

3.2 Restrictions on Investors by their Horizon of Investment

Within FPI limits for G-sec, SDLs and corporate bonds, there are sub-limits by investor type as shown in table 3, in particular, for *Long Term* versus *General* investors, where long term includes insurance firms, endowments and pension funds, sovereign wealth funds, central banks, and multilateral agencies; whereas general covers all other qualified institutional investors. The long term category has been added to the corporate bonds limit only since October 2017. Prior to July 2017, the unutilized portion of the long term category was transferred to the general category, a feature that has since been removed.

These investor-specific investment restrictions can be understood in terms of proposition 3. We showed that limits should be type-dependent, where type referred to borrower. By extension, it follows that limits should optimally depend on investor horizon to the extent that the immediacy demanded by short-term investors (typically carry traders) creates a fire-sale externality in the sudden-stop state. There is no obvious rationale within our model, however, for the transfer of unutilized long-term limits to short-term investors, as this would over time increase the short-term investor limit towards the overall limit, as indeed has been the case for India.

Interestingly, FPI restrictions in the past also included sub-limits for 100 percent debt funds as against minimum 70:30 equity-debt investment ratio funds. In addition, there were minimum lock-in periods of up to three years on investors once they purchased Indian debt securities. While such restrictions would also find support under our model as ways to limit the type of short-term external debt, these have over time been replaced entirely by investor categories based on horizon (long term vs general) and minimum maturity restrictions (which we explain below).

Counter to our theoretical analysis, long-term investors such as pension funds, insurance companies and sovereign wealth funds were not allowed by India to be eligible lenders in ECBs until 2015. There is, however, an indirect policy attempt to ensure that the sudden-stop risk does not directly affect the domestic banks (who have significant deposit liabilities), a feature that our model would support. This is achieved by disallowing the refinancing of ECBs by Indian banks as well as preventing the underlying ECB exposure to be guaranteed by Indian banks, financial institutions, or non-bank financial companies (NBFCs).[7]

3.3 Restrictions on Maturity of the Underlying Investment

Presently, FPIs are disallowed altogether from investing in liquid short-term money-market debt instruments such as Treasury bills or commercial paper (CP). Prior to the taper tantrum however (November 2013 to be precise), there was a carve-out for FPI investments in Treasury bills and CP, as shown in table 4. Since the taper tantrum, India has introduced even tighter restrictions in the form of residual maturity restrictions of investments by FPIs in debt holdings to be of minimum three years of maturity at origination or purchase. If one assumes that the arrival of the sudden-stop state is exogenous, as in our model, then these restrictions are potentially effective ways of limiting short-term external debt in case such a state materializes.[8]

Table 4. Debt Investment Restrictions

Type of securities	*April-2013 US$ bn*	*Jun-2013 US$ bn*	*Nov-2013 US$ bn*
1. Government debt	25	30	30
a. T-bills within overall limit	5.5	5.5	5.5
b. Carved out limit for SWFs & other LT FIIs	-	5	5
2. Corporate bond	51	51	51
a. CPs within overall limit	3.5	3.5	3.5
b. Credit enhancement bonds within overall limit	-	-	5
3. Total limit (1+2)	76	81	81

Sources: DBIE, and RBI.

7. These restrictions on domestic financial institutions were in part also to avoid the ever-greening of non-performing loans.

8. Another possible rationale for requiring FPIs to hold longer-dated instruments is that it exposes them to greater interest-rate risk, which could deter excessive presence of short-term investors looking for "carry" by arbitraging interest-rate differentials with an early exit.

A similar rationale for limiting the maturity of underlying external debt also exists for ECBs. Following the taper tantrum, policies were revised in November 2015 to require that a borrower could undertake an ECB of up to US$50 million (foreign-currency-denominated under the so-called Track-I of ECB, or INR-denominated under Track-III of ECB) with minimum average maturity of 3 years; or up to US$50 million if the maturity is 5 years. In contrast, no borrowing limit within the overall ECB limit is imposed for borrowings meeting a minimum average maturity of 10 years (for foreign-currency-denominated borrowing under Track-II of ECB). These maturity restrictions were not as onerous prior to the taper tantrum.

3.4 Restricting High Liquidity Demanders

Our model suggests a Pigouvian form of taxation, wherein borrowers who contribute more to the fire-sale externality in the sudden-stop state are charged a greater tax for taking on short-term external debt (proposition 3). Indian capital controls ensure that only relatively high credit quality borrowers tap into ECBs by (i) imposing coupon ceilings by debt issue, (ii) carving out sub-limits on investments in risky instruments such as unlisted corporate bonds and security receipts (a form of distressed asset resolution instrument), and (iii) ruling out excessive correlated liquidations by having investment sub-limits by sector. These restrictions limit ECBs to high-rated borrowers, as suggested by our model. However, this form of differential taxation does not exist for domestic debt issuances purchased by the FPIs, except to the extent that the current market-practice in the domestic corporate debt market is to fund only relatively high-rated investment-grade borrowers.

Closest to the model are the all-in-cost (AIC) issuance cost ceilings for ECBs, which prescribe that borrowers in the 3- to 5-year range cannot issue ECBs at a coupon of 6-month Libor + ceiling as indicated in table 5. A higher ceiling applies for issuances greater than 5-year maturity. These ceilings have evolved over time in a somewhat countercyclical manner relative to the evolution of 6-month Libor (figure 9): as global interest rates eased post the global financial crisis, the coupon ceilings were raised, and with global rates tightening since 2015, the ceilings were lowered.

Table 5. Evolution of AIC spread (in bp) over Libor-6 month/ Swap

Minimum average maturity	*3 year to 5 year*	*More than 5 year*
2004-05	200 bps	350
2007-08	150	250
2008-09	200	350
2009-10	300	500
2011-12	350	500
2015-16	300	450

Sources: DBIE, and RBI.

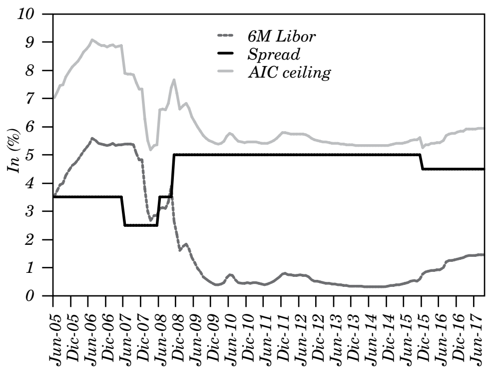
3.5 Regulatory arbitrage between domestic and overseas external debt

India permitted ECB borrowings denominated in rupees (Track III) in September 2014. For macroprudential reasons and as ECBs were envisioned as bilateral loan arrangements, they faced various tenor and all-in-cost constraints, end-use requirements, eligibility requirements on borrowers and lenders, and the like, as explained above. Borrowings under Track III were, however, not subject to cost caps that applied to other ECBs, as the borrowing was considered as not subject to exchange rate risk. It is unclear as per our model if this is necessarily the correct distinction since there is still the sudden-stop risk on rollover of rupee-denominated ECBs. Nevertheless, the scope of eligible borrowers and lenders remained similarly restrictive as for U.S. dollar ECBs.

To widen the international investor base for corporates, an additional route of RDB, or Masala bonds, was introduced in September 2015. Since these were intended to be bonds issued under market discipline, they were subject to a more relaxed regulatory regime. Most important of these is the much wider scope of eligible borrowers (any corporate or body corporate including real estate investment trusts, or REITs, and infrastructure investment trusts, or InvITs), eligible investors (any investor from FATF-compliant jurisdictions), and end-use (no restrictions except for a small negative list). Masala bonds also had an advantage *vis*-à-*vis* the FPI route in domestic bonds insofar as investors in Masala bonds did not have to register in India and the bonds were issued in international finance centers such as London with well-established financial and legal infrastructure. Further, there was no listing requirement for Masala bonds. FPI investments were subsequently allowed in unlisted instruments, but were subjected to a cap.

As noted, at the inception of this market, Masala bonds were viewed by regulators as bond-market borrowings similar to other FPI investments. They received a liberal regulatory treatment under the presumption that these bonds would have transparent pricing and other forms of market discipline. In actual practice, many Masala bond issuances were essentially bilateral loans issued as bonds, often to related entities. Coupon rates in many instances had no linkage with market-borrowing rates and varied from extremely low rates (related party transactions to circumvent ECB and FDI restrictions) to high rates (to circumvent the all-in-cost ceilings under the ECB route). Complicated structures using Masala bonds were also used to by-pass ECB cost caps. The overall evidence from issuances suggested that many entities were exploiting the relaxed regulatory treatment of Masala bonds to bypass ECB norms on bilateral funding arrangements.

Figure 9. All-in-Cost for ECBs with 5-year Minimum Maturity



Source: RBI.

Recognizing this regulatory arbitrage between ECB and Masala bonds, and recognizing that both were vulnerable to sudden stops because the source of capital was foreign creditors, India chose to harmonize their regulations. In June 2017, the RBI prescribed cost caps (Treasury yield + 300 bp) as well as minimum maturity period for Masala bonds (3 or 5 years, depending on the issue size). The minimum maturity period also harmonized the Masala bond investments by foreign creditors to the restrictions on FPI in domestically issued debt. Masala bonds were also not allowed to be issued to related entities. Such harmonization, and the observed regulatory arbitrage by issuers and investors in the pre-harmonization period, reinforces the importance of setting capital flow management policy based on the entirety of an EM's tools.

4. Conclusion

We have analyzed the macroprudential use of reserves and capital controls to manage sudden stops in EMs. Our principal conclusion is that these tools are complements. Hoarding reserves is beneficial against sudden stops, but creates incentives for the private sector to undo the insurance offered by reserve holdings. In this context, limits on borrowing increase the efficacy of reserve holdings. Our complementarity perspective also implies that the optimal holding of reserves depends on the set of policy instruments available to affect private borrowings. Optimal reserve holdings are increasing in the efficacy of such instruments.

In his classic analysis of policy instruments, Poole (1970) studies the use of the money supply and interest rate as instruments to stabilize output. In his baseline, both money supply and interest rate are equally effective instruments: they are substitutes. This leads to the result that either can be used as instrument. He then considers the case where there is some slippage in the transmission mechanism that varies across the instruments. In this case, he shows that the low-slippage instrument should be used more, while the high-slippage instrument should be used less, to stabilize output.

The complementarity logic for managing capital flows turns this result around. We show that the efficacy of one instrument (reserves) depends on the use of the other (capital flow taxes). Then, as the slippage in one instrument falls, both instruments should be used more, rather than just the low-slippage instrument.

Where does this end? We have studied three instruments, but what if there were 50 instruments available to the central bank, some of which were more effective than others? Should the central bank use all 50 of these instruments? Should it use some more than others? Suppose that the central bank is only able to use three out of the 50 instruments; either implementation challenges or slippage issues in the other instruments render them unusable. Our perspective implies that it should use less of the three instruments than in the case where all instruments are used. Complementarity implies that the marginal effectiveness of an instrument is increasing in the use of others. This is the main lesson from our analysis.

References

Aizenman, J. and N. Marion. 2003. "The High Demand for International Reserves in the Far East: What is Going on?" *Journal of the Japanese and International Economies*, 17(3):370–400.

Aizenman, J. 2011. "Hoarding International Reserves versus a Pigovian Tax-cum-subsidy Scheme: Reflections on the Deleveraging Crisis of 2008–2009, and a Cost Benefit Analysis." *Journal of Economic Dynamics and Control* 35(9): 1502–13.

Caballero, R.J. and A. Krishnamurthy. 2001. "International and Domestic Collateral Constraints in a Model of Emerging Market Crises." *Journal of Monetary Economics* 48(3): 513–48.

————. 2003. "Excessive Dollar Debt: Financial Development and Underinsurance." *Journal of Finance* 58(2): 867–93.

————. 2004. "Smoothing Sudden Stops." *Journal of Economic Theory* 119(1): 104–27.

Caballero, R.J. and A. Simsek. 2016. "A Model of Fickle Capital Flows and Retrenchment." Technical Report, National Bureau of Economic Research.

Calvo, G.A., L. Leiderman, and C.M. Reinhart. 1996. "Inflows of Capital to Developing Countries in the 1990s." *Journal of Economic Perspectives* 10(2): 123–39.

Carstens, A. 2016. "Overview Panel: The Case for Emerging Market Economies." *Proceedings, Economic Policy Symposium, Jackson Hole*, pages 1–65.

Chang, R. and A. Velasco. 2001. "A Model of Financial Crises in Emerging Markets." *Quarterly Journal of Economics* 116(2): 489–517.

De Gregorio, J. 2010. "Tackling the Capital Inflow Challenge." Economic policy papers. Central Bank of Chile.

Greenspan, A. 1999. "Currency Reserves and Debt." *Federal Reserve System*.

Jeanne, J. and A. Korinek. 2010. "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach." *American Economic Review* 100(2): 403–07.

Jeanne, O. and R. Rancière. 2011. "The Optimal Level of International Reserves for Emerging Market Countries: a New Formula and Some Applications." *Economic Journal* 121(555): 905–30.

Jeanne, O. 2016. "The Macroprudential Role of International Reserves." *American Economic Review* 106(5): 570–73.

Kaminsky, G.L. and C.M. Reinhart. 1999. "The Twin Crises: the Causes of Banking and Balance-of-Payments Problems." *American Economic Review*, pages 473–500.

Krishnamurthy, A. and A. Vissing-Jorgensen. 2013. "The Ins and Outs of LSAPs." *Proceedings, Economic Policy Symposium, Jackson Hole*.

Obstfeld, M., J.C. Shambaugh, and A.M. Taylor. 2010. "Financial Stability, the Trilemma, and International Reserves." *American Economic Journal: Macroeconomics* 2(2): 57–94.

Ostry, J.D., A.R. Ghosh, K.F. Habermeier, M. Chamon, M.S. Qureshi, and D.B.S. Reinhardt. 2010. "Capital Inflows; the Role of Controls." IMF Staff Position Notes 2010/04. International Monetary Fund.

Poole, W. 1970. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model." *Quarterly Journal of Economics* 84(2): 197–216.

Rey, H. 2013. "Dilemma not Trilemma: the Global Cycle and Monetary Policy Independence." *Proceedings, Economic Policy Symposium, Jackson Hole*, pages 1–2.