

Uncertainty, Capital Flows, and Maturity Mismatch

JOB MARKET PAPER

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Abstract

Output growth in emerging markets is significantly more volatile than in advanced economies, due in large part to fluctuations in total factor productivity (TFP). This paper shows that where maturity mismatch is widespread, as in emerging markets, capital flow volatility amplifies the volatility of both output and TFP. I build a model of a small open economy in which financial frictions force firms to fund long-term projects with short-term debt. Greater uncertainty regarding the future availability of foreign borrowing causes firms to cut long-term investment. This depresses aggregate investment and generates an endogenous drop in aggregate productivity. Conversely, a fall in uncertainty increases investment, output, and TFP. Shocks to capital flow volatility will therefore amplify the volatility of output and TFP in emerging markets where maturity mismatch is pervasive, but not in advanced economies. Using data from a panel of major emerging markets, I show that the volatility of portfolio debt flows negatively affects output by dampening investment, while the volatility of equity flows, which do not generate maturity mismatch, has no effect. Moreover I find that the negative impact of volatility is mitigated by financial market development, which I use as a proxy for the extent of maturity mismatch in the economy. These empirical results suggest that maturity mismatch acts as an important channel through which uncertainty shocks affect the real economy.

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Keywords: Capital Flows, Emerging Markets, Maturity Mismatch, Financial Volatility, Uncertainty, Capital Allocation

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1 Introduction

When comparing the growth performance of emerging markets to that of advanced economies, two major differences are evident. First, output is significantly more volatile in emerging markets.¹ Second, growth rates in emerging markets are more negatively skewed, exhibiting periodic sharp contractions without correspondingly large growth surges.² Recent work has showed that fluctuations in aggregate total factor productivity (TFP) are the key driver of both the volatility of growth and its skewed distribution.³ These findings raise the question of why the efficiency with which capital and labor are employed appears to fluctuate more substantially over time in some economies than in others. Is the elevated macroeconomic volatility observed in emerging markets simply a result of these economies being hit by larger fundamental shocks? Or does some feature of emerging markets cause them to respond differently when hit by shocks that affect all economies?

In this paper I show that when maturity mismatch is widespread, as is the case in emerging markets, capital flow volatility contributes to the volatility of output and TFP and to the skewed distribution of growth rates. When financial frictions force firms to rely on short-term debt, long-term investments entail rollover risk. Greater uncertainty about the future availability of foreign borrowing increases rollover risk and causes firms to cut back on long-term investment, depressing both aggregate investment and TFP. As a result, capital flow volatility amplifies macroeconomic fluctuations in emerging markets, but not in advanced economies where firms can finance long-term projects without engaging in maturity mismatch. The interaction of uncertainty and maturity mismatch increases the negative effects of sudden stops and dampens the positive investment response to surges in capital inflows, contributing to the skewed distribution of growth rates.

¹Numerous studies have found that the volatility of GDP in emerging markets averages twice that of a typical advanced economy. Lucas (1988) comments on the greater volatility of growth rates in low income countries. Neumeyer & Perri (2005) and Aguiar & Gopinath (2007) systematically document the higher macroeconomic volatility of emerging markets in recent decades using quarterly frequency data. The greater volatility of developing and emerging economies over longer periods is documented by García-Cicco et al. (2010) and Koren & Tenreyro (2012) using annual data.

²Growth rates in advanced economies are also negatively skewed, but to a much lesser extent than in emerging markets. For emerging markets, the average skewness of annual rates from 1960 to 2010 was -1.25, while for small advanced economies skewness averaged around -0.4. Rodrik (1999), Raddatz (2007), and Mendoza (2010) provide evidence of the asymmetric distribution of growth rates in emerging markets.

³Bergoeing et al. (2002) show that this is the case for Mexico and Chile in the 1980s. Mendoza (2006) examines the role of TFP in the downturn and recovery that followed 1994 Mexican crisis. Evidence on the role of TFP in Argentina's volatile economic performance can be found in Kydland & Zarazaga (2007) and Kehoe (2007). Whereas these studies employ annual data, Aguiar & Gopinath (2007) use quarterly data to analyze the behavior of TFP in 13 emerging markets and 13 advanced economies. Meza & Quintin (2007) study the role of TFP in Indonesia, Korea, and Thailand during the Asian financial crisis

I begin by documenting two new empirical facts regarding fluctuations in capital flow volatility over the business cycle. First, I show that capital flow volatility in a set of 15 emerging markets is significantly countercyclical and leads the business cycle. By contrast, in a group of six small advanced economies capital flow volatility is weakly procyclical. The difference in cyclicity motivates my focus on capital flow volatility as an explanation for the differing behavior of output.

I then separate the debt and equity components of portfolio capital flows and show that the negative relationship between volatility and output is much more pronounced for debt flows than for equity. This second empirical fact leads me to concentrate on the distinctive properties of portfolio debt flows. Unlike equity issuance, short-term debt can generate maturity mismatch on a firm's balance sheet if the firm's assets have a longer maturity. While maturity mismatch is a fundamental feature of banks, as in the canonical Diamond & Dybvig (1983) model, nonfinancial firms also incur maturity mismatch if they issue short-term debt to finance long-term investment projects.

To study the impact of capital flow volatility on output in the presence of maturity mismatch, I model firms' borrowing and investment decisions in a small open economy. Domestic firms owned by risk neutral entrepreneurs take on short-term foreign debt to finance investment in a portfolio of short- and long-term projects. The long-term technology is more productive but takes two periods to produce a return, so that long-term investments cause maturity mismatch. I incorporate capital flow volatility into the model by introducing uncertainty regarding the availability of borrowing during the intermediate period. If foreign borrowing is sufficiently scarce, firms will prematurely liquidate their long-term projects. Thus the combination of firms' inability to borrow long term and their uncertainty about future borrowing means that firms face rollover risk.

The presence of rollover risk means that firms face a trade-off when deciding how much to borrow and invest in long-term projects. Higher leverage increases their return on equity when borrowing is abundant during the life of the long-term project. If external funds are scarce, however, greater debt-financed long-term investment means that the firm must liquidate a larger share of the project, lowering the return. Moreover, the firm must take into account that its higher debt also increases the probability that it will be forced to liquidate.

To analyze the impact of the fluctuations in capital flow volatility that I observe in the data, I examine how investment decisions change in response to an increase in uncertainty regarding the future availability of foreign lending. The uncertainty shock induces entrepreneurs to scale back their investments in long-term projects, and output falls even if external fi-

nancing remains plentiful. This happens for two reasons. First, greater uncertainty increases the probability that firms will be forced to liquidate their projects. Second, a rise in uncertainty reduces the expected return on the long-term project in states of the world in which liquidation occurs. As a result, greater uncertainty reduces the optimal level of long-term investment. Uncertainty has no impact on the optimal level of investment in short-term projects, since these do not incur maturity mismatch.

The mechanism in my model increases the volatility of output and TFP observed in emerging markets and contributes to the skewed distribution of their growth rates. Because volatility shocks alter long-term investment while leaving short-term investment unchanged, they generate fluctuations in aggregate investment. For the same reason, volatility shocks alter the share of investment allocated to more productive long-term projects, leading to endogenous changes in aggregate TFP. This is in contrast to the existing literature on emerging market business cycles, which treats more volatile TFP as exogenous (e.g. Neumeyer & Perri 2005, Aguiar & Gopinath 2007). Since a jump in uncertainty both depresses investment and reduces TFP, output falls as well. Conversely, a reduction in uncertainty boosts investment, productivity, and output. Therefore when maturity mismatch is a feature of the macroeconomy, shocks to capital flow volatility constitute an additional source of variation in investment, productivity, and output, increasing their volatility.

My model implies that output and TFP are more volatile in emerging markets than in advanced economies because uncertainty shocks affect investment only where maturity mismatch is present. Where firms can easily issue long-term debt and equity, as in advanced economies, variations in capital flow volatility have little or no impact on investment, productivity, and output. Other models in which uncertainty shocks affect investment rely on either risk aversion (Fernández-Villaverde et al. 2011) or irreversible investment (Dixit & Pindyck 1994, Bloom 2009) to generate a response. However, since neither the degree of risk aversion nor the extent of irreversibility are different in emerging markets as compared to advanced economies, those models are not helpful in explaining why output volatility differs between the two groups of countries. Thus the maturity mismatch channel of transmission for volatility shocks that I introduce in this paper is not only novel, but particularly suited to explain the greater volatility of output and TFP in emerging markets.

The model presented here also provides an explanation for the negatively skewed distribution of growth rates in emerging markets. A sudden cutoff in capital inflows raises uncertainty about the future availability of foreign borrowing, depressing investment in addition to the negative effects of the shock itself. On the other hand, while a large jump in inflows will increase the capital available to fund investment, it will also generate uncertainty, thereby

dampening the positive response. This asymmetric amplification means that the interaction of capital flow volatility and maturity mismatch contributes to the skewed pattern of output growth in emerging markets.

I then turn to the data and show that the empirical evidence on the relationship between capital flow volatility and investment from a panel of 15 major emerging markets is consistent with the model's implications. I measure uncertainty regarding the future availability of external financing using the realized volatility of portfolio capital flows. To capture the variation in uncertainty over time, I collect monthly capital flows data directly from central banks and capital market regulators. This allows me to construct a quarterly frequency measure of capital flow volatility.

I first verify that the volatility of portfolio capital flows dampens growth by reducing investment, while the level of portfolio flows is positively related to output and investment. This result explains the common empirical finding that foreign direct investment (FDI) benefits growth while portfolio flows have no effect or even reduce growth (Calderón & Schmidt-Hebbel 2003, Mody & Murshid 2005, Aizenman & Sushko 2011). Once I condition on the volatility of portfolio flows, they too are beneficial.

Next I separate portfolio capital flows into equity and debt. I find that the volatility of debt flows dampens investment, while the volatility of equity inflows has no significant impact. This is consistent with the model because short-term debt flows can generate maturity mismatch, while equity flows do not.

The data are also consistent with a role for capital flow volatility in generating a skewed distribution of growth rates in emerging markets. When I interact the level of portfolio debt flows with their volatility, I find that greater capital flow volatility will dampen the positive effects of higher portfolio debt inflows and amplify the negative impact of a drop in inflows.

Finally, I compare the effects of capital flow volatility on investment in economies with different levels of maturity mismatch. Recent empirical work has shown that the extent of maturity mismatch in an economy is highly correlated with widely used measures of financial development (Schmukler & Vesperoni 2006, Fan et al. 2012). I therefore use a common measure of financial development, equity market capitalization as a share of GDP, as a proxy for maturity mismatch. I find that the negative impact of capital flow volatility is greater where financial markets are less developed. My empirical findings are thus indicative of a role for maturity mismatch as a channel through which shocks to capital flow volatility affect investment and output.

The paper proceeds as follows. In the next section, I motivate my focus on the role of

capital flow volatility by documenting its business cycle properties. In Section 3, I model the interaction between capital flow volatility and maturity mismatch in a small open economy. Section 4 presents my empirical findings on the relationship between capital flows, their volatility, and economic performance and discusses the extent to which these are consistent with a role for maturity mismatch in transmitting shocks to capital flow volatility. Section 5 concludes and discusses directions for further research.

1.1 Related Literature

This paper contributes to several areas of literature. First, it relates to the growing body of work analyzing the distinctive properties of business cycles in emerging markets. From this perspective, the greater output volatility in emerging markets is the result of these economies being hit by different, more volatile shocks than advanced economies. The shocks in emerging market RBC models include not only productivity shocks (Aguiar & Gopinath 2007) but also shocks to the level (Neumeyer & Perri 2005) and volatility (Fernández-Villaverde et al. 2011) of interest rates. My approach differs from this literature in two important respects. First, in my model emerging markets respond differently when hit by the same shocks as advanced economies, rather than being hit by different shocks. The difference in response is due to the presence of realistic financial market imperfections in my model. Second, whereas the emerging market RBC literature treats the higher TFP as exogenous, in my model the greater volatility of TFP in emerging markets is generated endogenously by the interaction of volatility shocks and maturity mismatch.

Whereas much existing work has documented the prevalence of maturity mismatch in emerging markets and studied its causes, I analyze its implications for the transmission of uncertainty shocks. Although the average maturity of emerging market debt has lengthened somewhat in the last decade (Burger et al. 2010), the median share of short-term debt in the total debt of nonfinancial corporations remains 64 percent in emerging markets, compared with 39 percent in advanced economies (Fan et al. 2012).⁴ Motivated by this fact, many authors have explored how information frictions and agency problems can render it optimal for firms to borrow short-term to finance long-term investments in these economies (Chang & Velasco 2000, Tirole 2003, Jeanne 2009, Broner et al. 2011, Bengui 2011, Farhi & Tirole 2012). In this paper, I highlight a previously unexplored consequence of the maturity mismatch for which others have provided empirical evidence and microfoundations.

⁴The IMF's 2005 Global Financial Stability Report provides an overview of the evidence on maturity mismatch in emerging markets.

Second, this paper contributes to the extensive literature on sudden stops, episodes in which rapid shifts from current account deficit to surplus are accompanied by large drops in output. Caballero & Krishnamurthy (2001, and subsequent work) show how maturity mismatch can amplify the effects of an exogenous drop in the availability of foreign capital. The mechanism in my model amplifies such negative shocks, but also dampens the effects of surges in capital inflows. It therefore helps explain the skewed growth patterns discussed above.

More recent work on sudden stops has focused on how fractional borrowing constraints amplify exogenous shocks via Fisherian debt deflation (Mendoza 2010, Jeanne & Korinek 2010, Bianchi 2011). This class of models has had notable success in explaining not only the volatility of output in emerging economies, but also the volatility of TFP and the skewed distribution of growth rates. A key difference between these papers and my own approach is that whereas they employ a fractional borrowing constraint as a shorthand for a variety of credit market imperfections, the maturity mismatch present in my model is a directly observable feature of emerging market economies. I also show that in addition to the direct impact of sudden stops analyzed in the existing literature, the uncertainty generated by the possibility that a sudden stop will occur also has macroeconomic implications. Moreover, the uncertainty affects output, investment, and productivity not only during crisis episodes but also during tranquil times.

Several other studies seek to explain the empirical facts motivating this paper. Rancière et al. (2008) set out to understand the skewed distribution of emerging market growth rates and show that while high levels of investment in risky projects render the economy vulnerable to occasional crises, the net effect of this behavior is growth enhancing. However, they explain long-run growth rather than the business cycle fluctuations that are the focus of this paper.

In attempting to explain high volatility in emerging markets, my modeling approach is similar to that of Aghion et al. (2010), who demonstrate that maturity mismatch amplifies the effects of productivity shocks in the presence of a fractional borrowing constraint (due to their impact on net worth). The source of shocks in the models differs, however, in that I analyze the effects of variations in the volatility of borrowing constraints, rather than in the level of productivity.

Also studying the sources of volatility in developing and emerging economies, Koren & Tenreyro (2007, 2012) decompose aggregate output volatility into country-level, sector-level, and idiosyncratic volatility and build an endogenous growth model that explains the empirical facts they document. The model presented here proposes an additional source of cross-country differences in output volatility. In particular, investment and output in sectors

with longer project durations will be more volatile in countries with less developed financial systems. My model also provides an explanation for the negative relationship between firm size and age, on the one hand, and output volatility, on the other, that Koren & Tenreyro observe in a broad sample of countries. Older firms are less reliant on the short-term debt, and therefore engage in less of the maturity mismatch that boosts output volatility in my model.

My paper also contributes to the large literature on the costs and benefits of capital account liberalization (for a survey, see Henry 2007). Research comparing the relative benefits of different types of international capital flows has consistently found that FDI boosts growth while portfolio flows have no effect or even dampen growth (Calderón & Schmidt-Hebbel 2003, Mody & Murshid 2005, Aizenman & Sushko 2011). These and other papers often cite the volatility of portfolio capital flows as an explanation for their findings, but the relationship between capital flow volatility and economic performances has remained relatively unexplored. Papers that do explicitly analyze the relationship use annual capital flow data (Alfaro et al. 2007, Broner & Rigobon 2011, Knill 2005, Lensink & Morrissey 2006, Rancière et al. 2008). Consequently their measures of capital flow volatility describe ten- or twenty-year periods and capture relatively little of the variation in capital flow volatility over time. By obtaining monthly balance of payments data directly from central banks, I am able to measure capital flow volatility on a quarterly basis.

2 Capital Flow Volatility and the Business Cycle

In this section, I examine the business cycle properties of capital flow volatility. My findings focus on the role of volatility shocks and maturity mismatch in amplifying output fluctuations in emerging markets. I begin by introducing a novel monthly frequency data set on portfolio capital flows to 15 major emerging markets and six small open advanced economies. I analyze portfolio flows rather than FDI in part due to data availability, but primarily because of the extensive evidence that the portfolio flows are significantly more volatile (Montiel & Reinhart 1999, Albuquerque 2003, Alfaro et al. 2007).

I then document two new empirical facts. First, I show that the volatility of portfolio capital inflows to emerging markets is countercyclical and leads the business cycle. In small open advanced economies, however, that volatility is acyclical or weakly procyclical. The difference in comovement suggests a role for capital flow volatility in explaining the distinctive patterns of output growth in emerging markets. Second, I find that the countercyclicality of portfolio

capital flow volatility is driven by the volatility of short-term debt flows rather than equity. As a result, I focus my analysis on properties specific to such debt flows.

2.1 Data Description

To capture fluctuations in capital flow volatility over time, I use monthly frequency data on capital flows to emerging markets. Where possible, I collected monthly balance of payments data directly from central banks.⁵ In five cases, the data were supplemented with data on the purchases and sales of equities and bonds by foreigners. I obtained this data from financial markets and regulatory agencies in the emerging markets.⁶ Appendix A provides details of the data sources for each country in the sample.

In supplementing balance of payments data with financial market data, I strike a balance between covering a wide sample of countries and capturing all capital flows to each country. My use of financial market data is in line with its increasing use in studies of international capital flows (e.g. Henry 2003, Bekaert et al. 2005, Gupta & Yuan 2009). Several recent studies have also made use of data on transactions by mutual funds, which are available for a larger group of countries than are included in my sample (e.g. Hau & Rey 2008, Raddatz & Schmukler 2011, Jotikasthira et al. 2011, Fratzscher 2011). However, the mutual fund data capture only around 15 percent of the capital flows in the balance of payments (Lambert et al. 2011). By contrast, the financial data I collect account for between 74 and 100 percent of the flows in the IMF’s quarterly balance of payments data.⁷ Thus while using balance of payments data narrows my sample, it ensures that the data fully capture capital flows to the countries in my data set.

This paper does not analyze capital flows initiated by domestic residents. Although so-called capital flight has in many cases contributed to large outflows in times of crisis, the vast majority of sudden stop episodes are driven by the actions of foreign investors rather than domestic residents (Calderón & Kubota 2011, Rothenberg & Warnock 2011). Moreover, the disruption in terms of growth, consumption, and investment associated with capital flow driven by foreign investors is generally larger than that following outflows driven primarily by residents (Rothenberg & Warnock 2011).

⁵Specifically, the data on portfolio capital flows come from the line “portfolio investment, liabilities” of the financial account, as defined in the fifth edition of the IMF Balance of Payments Manual (BPM5).

⁶Financial market data were used for Colombia, India, Indonesia, Mexico, and South Africa.

⁷Appendix A includes a discussion of the relationship between the monthly data in my sample and quarterly balance of payments data

Having compiled monthly data on capital flows to these 15 emerging markets, I measure their realized volatility by calculating a trailing 12-month standard deviation each month. I then normalize by trend quarterly GDP so that my measure captures the magnitude of capital flow volatility relative to the size of the economy. Thus capital flow volatility in country i month t ($Vol_{i,t}$) is defined as:

$$Vol_{i,t} = \frac{\sqrt{\frac{1}{12} \sum_{j=0}^{11} (flow_{i,t-j} - \overline{flow}_{i,t})^2}}{Trend\ GDP_{i,t}} \text{ where } \overline{flow}_{i,t} = \frac{1}{12} \sum_{j=0}^{11} flow_{i,t-j}$$

Where $flow_{i,t}$ is the level of capital inflows in country i in month t and $\overline{flow}_{i,t}$ is the mean level of capital inflow over the previous 12 months. Alternative measures of capital flow volatility are discussed in Appendix A.

Table 1: Capital Flow Volatility: Descriptive Statistics

	Coverage		Portfolio Equity Inflows ¹			Portfolio Debt Inflows ¹		
	Start	End	Mean	Min	Max	Mean	Min	Max
Turkey	Dec-92	Apr-11	0.0023	0.0004	0.0057	0.0106	0.0035	0.0257
S.Africa	Jun-98	May-11	0.0084	0.0025	0.0163	0.0106	0.0046	0.0225
Brazil	Dec-95	May-11	0.0046	0.0010	0.0105	0.0072	0.0026	0.0264
Chile	Feb-02	May-11	0.0072	0.0013	0.0264	0.0105	0.0002	0.0215
Colombia	May-99	May-11	0.0025	0.0002	0.0067	0.0015	0.0000	0.0051
Mexico	Dec-91	Dec-05	0.0392	0.0113	0.0810	0.0061	0.0007	0.0195
India	Apr-97	May-11	0.0032	0.0006	0.0099	0.0009	0.0001	0.0023
Indonesia	Dec-01	May-11	0.0026	0.0009	0.0100	—	—	—
Korea	Dec-90	May-11	0.0066	0.0004	0.0195	0.0068	0.0019	0.0208
Philippines	Dec-99	Mar-11	0.0041	0.0004	0.0119	0.0175	0.0092	0.0299
Thailand	Dec-93	Apr-11	0.0061	0.0008	0.0158	0.0056	0.0002	0.0216
Bulgaria	Dec-98	Apr-11	0.0021	0.0003	0.0104	0.0116	0.0022	0.0513
Czech Rep	Dec-03	Apr-11	0.0054	0.0019	0.0093	0.0134	0.0030	0.0267
Hungary	Dec-95	Feb-05	0.0026	0.0009	0.0100	—	—	—
Poland	Dec-98	Apr-11	0.0031	0.0011	0.0059	0.0124	0.0041	0.0198

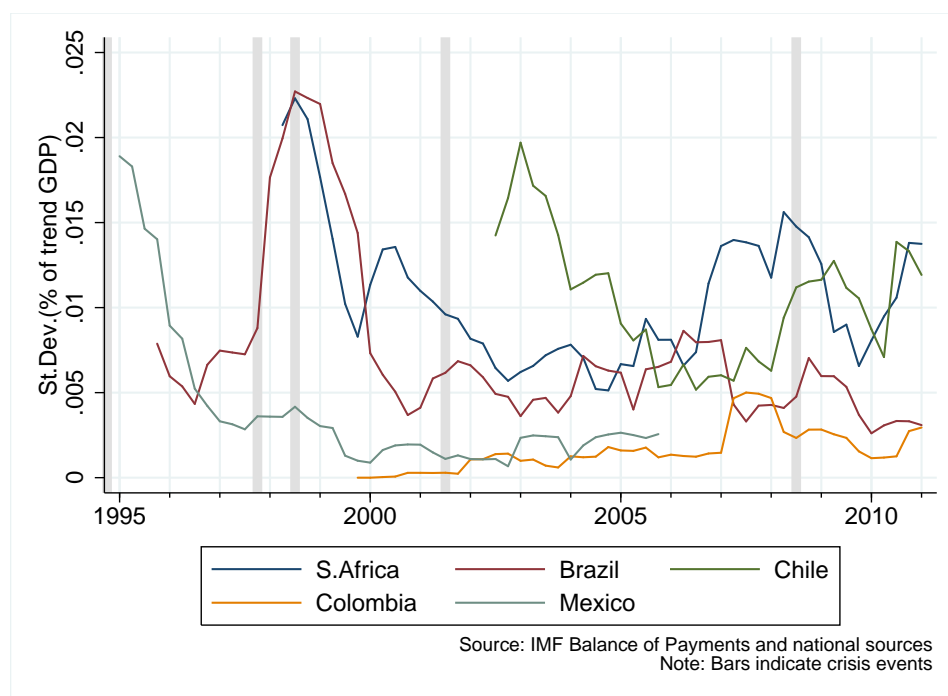
¹ Percent of trend GDP.

Source: IFS, national sources

Table 1 presents descriptive statistics on the resulting data on capital flow volatility. The data cover 15 emerging market economies for periods ranging from 7 years to more than 20 years. All regions containing emerging markets are represented. The sample includes 12 of the 32 countries that make up the JPMorgan Emerging Markets Bond Index-Global (EMBI-G). These 12 account for 65 percent of the combined GDP of the EMBI-G economies.⁸ Also included are India, Korea, and the Czech Republic. The data therefore provide a meaningful view of emerging market economies.

⁸Published by JPMorgan, the EMBI-G a widely used index of the yield on debt issued by low- and middle-income countries.

Figure 1: Portfolio Capital Flow Volatility: Latin America and S.Africa



In all but four countries, monthly debt flows are on average more volatile than equity. The volatility of equity flows relative to the size of the economy is largest in Mexico in late 1994 and early 1995, at eight percent of trend GDP. The maximum debt flow volatility is 5 percent of GDP and occurs in Bulgaria in 2004. The minimum values of volatility as a share of GDP both occur in Colombia in the early 2000s, a time when the country had capital controls in place.

Figures 1, 2, and 3 plot the standard deviation of monthly capital flows as a percentage of annual GDP for Latin America and Africa, Eastern Europe, and Asia, respectively. The figures make clear that capital flow volatility varies substantially across countries and over time. Volatility is generally high during crisis episodes, including the 1994 Mexican crisis, the 1997 Asian crisis, the 1998 Russian crisis, and the 2008 global financial crisis. At the same time, there is substantial variation in relatively tranquil periods such as the mid-2000s.

2.2 Stylized Facts on Capital Flows and their Volatility

The figures in the previous section made clear that the volatility of portfolio capital flows varies over time. To get a sense of how changes in volatility relate to the business cycle

Figure 2: Portfolio Capital Flow Volatility: Eastern Europe

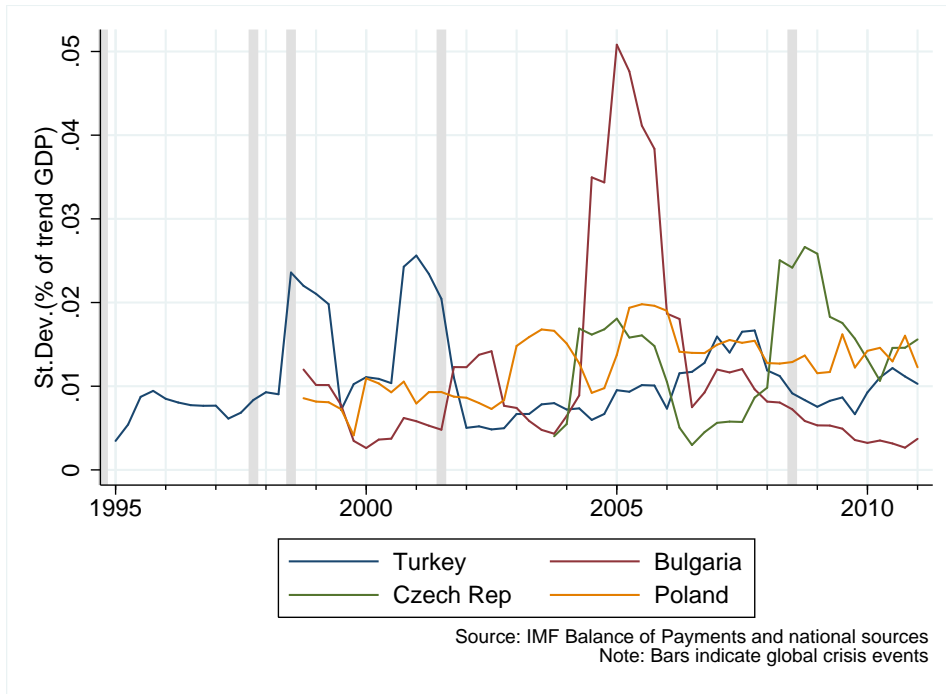
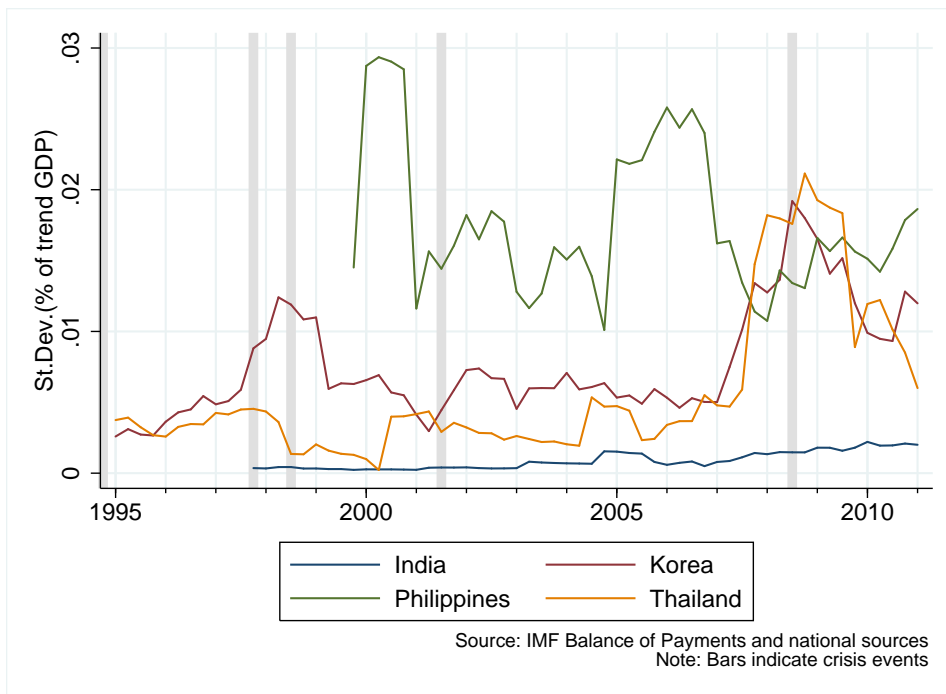
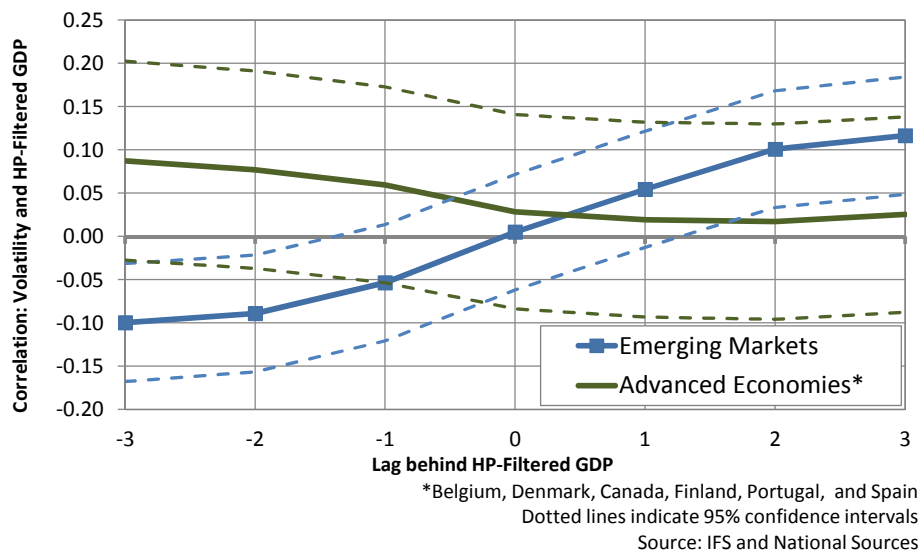


Figure 3: Portfolio Capital Flow Volatility: Asia



in these economies, I examine their comovements with real GDP.⁹ Figure 4 presents the correlation between capital flow volatility and output at different lags. Volatility leads the business cycle by three quarters and is significantly countercyclical. This pattern, evident for these economies as a whole, is the same in 8 of the 13 individual countries for which data are available, and capital flow volatility is never significantly procyclical (see Section A4 of Appendix A for data on the cyclical properties of capital flows in individual countries). In contrast, capital flow volatility is not significantly correlated with output at any lag in a set of six small open advanced economies for which monthly capital flows data were available.¹⁰ Volatility is leading significantly countercyclical in Portugal, but this is not the pattern in any of the other advanced economies. This difference in the cyclical properties of capital flow volatility motivates my focus on capital flow volatility as a potential factor explaining the distinctive features of the growth performance in emerging markets.

Figure 4: Correlations of Capital Flow Volatility (%GDP) with Real GDP (SA and HP-Filtered)



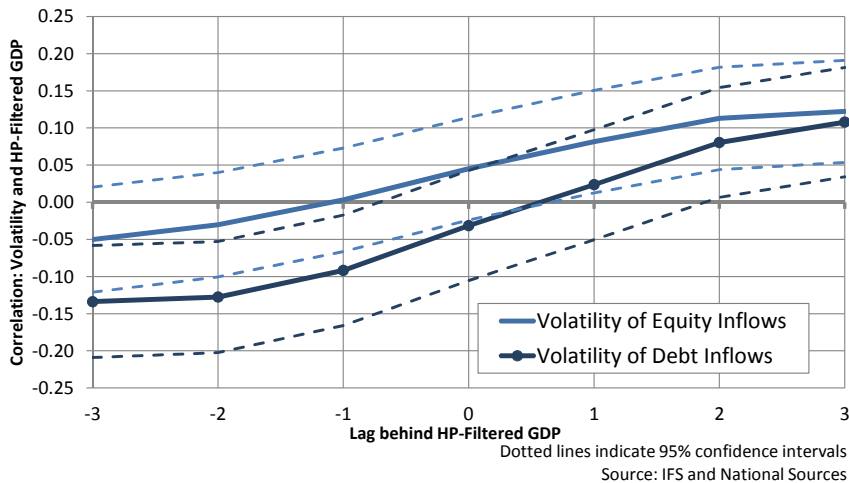
In Figure 5, I disaggregate portfolio capital inflows into their two component parts. Overall, portfolio debt flow volatility leads the business cycle and is countercyclical, to a statistically significant extent. This pattern also holds for the majority of individual countries. By contrast, portfolio equity flow volatility does not significantly lead the business cycle and is procyclical at lags of one quarter and longer. The contemporaneous correlation between the

⁹In particular, quarterly real GDP data were seasonally adjusted using the TRAMO-SEATS algorithm implemented in the Demetra+ software available from Eurostat. Detrending was done using a Hodrick-Prescott filter. Results were nearly identical when deviations from a quadratic trend were used.

¹⁰These are Belgium, Denmark, Canada, Finland, Portugal, and Spain.

volatility of equity and output is positive in 13 of the 15 emerging markets in the dataset (significantly so in six of these) and is never significantly countercyclical. This difference in cyclicality, with the volatility of debt flows countercyclical and the volatility of equity flows acyclical or procyclical, leads me to focus on the specific properties of short-term debt flows, in particular, their potential to generate maturity mismatch.

Figure 5: Correlations of Capital Flow Volatility (%GDP) with Real GDP (SA and HP-Filtered)



The two novel empirical facts discussed in this section motivate my focus on capital flow volatility and maturity mismatch. In emerging markets portfolio capital flow volatility leads the business cycle in a countercyclical manner, while in advanced economies volatility is uncorrelated with output. This leads me to focus on changes in the volatility of portfolio capital flows as a potential contributor to business cycle fluctuations in emerging economies. The data presented also indicate that portfolio debt flows are more volatile than equity, and that their volatility is more countercyclical. Because a key difference between equity and short-term debt financing is that only the latter generates maturity mismatch, I look to such mismatch as a potential channel through which capital flow volatility impacts the growth performance of emerging markets.

3 Model

In this section I develop a model that captures key features of emerging market economies. Entrepreneurs borrow from abroad to finance domestic investment. In particular, they have

the opportunity to invest in high-yielding long-term projects that can be prematurely terminated, but such liquidation yields a net return of at most zero. Credit markets are imperfect in two respects. First, agents' borrowing is restricted to one-period riskless bonds, so that firms cannot issue equity or long-term debt. This reflects the well-documented fact that financial markets in emerging economies are underdeveloped, forcing firms to rely disproportionately on short-term debt (IMF 2005, Schmukler & Vesperoni 2006, Fan et al. 2012).

Second, firms are subject to an exogenously determined borrowing constraint. The borrowing constraint is stochastic, so that entrepreneurs are uncertain about how much they will be able to borrow in the future. This uncertainty corresponds to the capital flow volatility documented in the previous section. The exogenous constraint is realistic in light of substantial recent work showing that so-called push factors in the advanced economies play a far greater role than pull factors in recipient countries in determining the pattern of international capital flows.¹¹

In the remainder of this section, I first develop a model in which entrepreneurs may only invest in a long-term, linear technology. The simplified model makes clear the mechanism by which increased uncertainty about the availability of financing depresses long-term investment. I then introduce a richer version of the model, in which firms invest in a portfolio of long- and short-term projects with standard concave production functions. In this full model, increases in capital flow volatility will not only reduce aggregate investment but also shift the composition of investment away from long-term projects and towards short-term projects, resulting in lower aggregate TFP.

3.1 A Model of Long-Term Investment

I consider a small open economy populated by identical risk-neutral entrepreneurs who live for three periods. In the initial period ($t = 0$), entrepreneurs have the opportunity to invest in projects which yield gross return R after two periods (time-to-build). In the intermediate period ($t = 1$), entrepreneurs can choose to liquidate a portion L_1 of the long-term investment, with capital goods converted back into consumption goods one-for-one, so that investment is fully reversible.¹² Firms finance these investments using an exogenous endowment y_0 and

¹¹The evidence comes not only from research on the macro-level determinants of capital flows (González-Rozada & Levy-Yeyati 2008, Forbes & Warnock 2012, Fratzscher 2011), but also from empirical finance research on the portfolio allocations of institutional investors holding assets in emerging markets Didier et al. (2010), Jotikasthira et al. (2011).

¹²Introducing partial irreversibility is straightforward and increases the impact of uncertainty shocks in the model.

by issuing a quantity D_1 of non-state-contingent, one-period bonds on international capital markets at an exogenously determined interest rate (r). The return on domestic projects is sufficiently high that financing investment with debt is profitable if the project reaches maturity ($R > (1+r)^2$). Again, the divergence in the maturity of firms' projects and their liabilities captures the pervasive maturity mismatch in emerging markets. In these economies, long-term debt and equity financing are prohibitively expensive for most firms.

In what follows I abstract from any interest rate uncertainty. The full model presented in Section 3.2 is virtually identical to a model in which firms are initially uncertain about the interest rate on borrowing at $t = 1$.¹³ In the latter case, firms would partially liquidate their long-term projects when the cost of new borrowing in the intermediate period exceeded the long-term projects' marginal product of capital. The mechanism emphasized in this section remains the same, in that firms' borrowing and investment in long-term projects determines their exposure to rollover risk.

When deciding how much to borrow and invest at time $t = 0$, entrepreneurs face uncertainty regarding κ_2 , the quantity of credit that will be available at time $t = 1$. This stochastic borrowing constraint has distribution $\kappa_2 \sim F(\kappa)$. As a result of this uncertainty, when the entrepreneur borrows in order to invest in the long-term technology he runs the risk that he will be unable to roll over his debts, forcing him to partially liquidate the project.

Entrepreneurs thus maximize the discounted sum of dividends:

$$\max_{I_0, D_1, D_2, L_1} d_0 + \beta d_1 + \beta^2 d_2 \quad (1)$$

where

$$d_0 = y_0 + D_1 - I_0 \quad (2)$$

$$d_1 = y_1 + D_2 + L_1 - (1+r)D_1 \quad (3)$$

$$d_2 = y_2 + R(I_0 - L_1) - (1+r)D_2 \quad (4)$$

and y_t are exogenous endowments. In addition to the borrowing constraint ($D_2 \leq \kappa_2$), the firm is subject to a non-negativity constraint on dividends ($d_t \geq 0 \forall t = \{0, 1, 2\}$). This means that the firm cannot issue equity—a realistic assumption in the context of emerging economies. The firm's choice of liquidation must be feasible, so that it cannot be greater than the total quantity invested ($L_1 \leq I_0$). Nor can liquidation be negative ($L_1 \leq I_0$), which

¹³Chari et al. (2005) make a similar point regarding the mapping between interest rate fluctuations and quantity constraints in the context of DSGE models of small open economies.

means the firm cannot expand the scale of projects once they have been initiated.

I abstract from default risk and assume that creditors will never lend the entrepreneur more than he can feasibly pay back. Thus the entrepreneur's borrowing is also subject to two solvency constraints, which I discuss in detail in the Mathematical Appendix. Importantly, the solvency constraints are not so tight as to prevent the entrepreneur from borrowing an amount large enough that he risks being forced to prematurely liquidate part of his long-term project. Moreover, for realistic values for the world interest rate and for the return on long-term projects, these solvency constraints will not bind in the neighborhood of the solution to the entrepreneur's problem.

The entrepreneur will choose investment to equate the shadow value of resources in the initial period ($1 + \lambda_0$, where λ_t is the Lagrange multiplier on the non-negativity constraint on dividends) with the discounted return on the long-term project,

$$1 + \lambda_0 = \beta^2 RE_0[1 + \lambda_2] + \beta E[\zeta_1^{(2)}], \quad (5)$$

where $\zeta_1^{(2)}$ is the Lagrange multiplier on the upper bound on liquidation ($L_1 \leq I_0$). The second term on the right-hand side of (5) captures the fact that resources used for long-term investment can also be accessed in the intermediate period through liquidation. Optimal borrowing is set according to an Euler equation, subject to the borrowing constraint in the second period, with μ_1 the multiplier on this constraint:

$$1 + \lambda_0 = \beta(1 + r)E_0[1 + \lambda_1] \quad (6)$$

$$1 + \lambda_1 = \beta(1 + r)(1 + \lambda_2) + \mu_1. \quad (7)$$

The first order condition for the liquidation of long term projects is

$$(1 + \lambda_1) + \zeta_1^{(1)} = \beta R(1 + \lambda_2) + \zeta_1^{(2)} \quad (8)$$

where $\zeta_1^{(1)}$ is the Lagrange multiplier on the non-negativity constraint on liquidation. The non-negativity constraint is binding when entrepreneurs have additional borrowing capacity available after rolling over their debts in the intermediate period. They would like to expand the scale of their long-term projects, which corresponds to negative liquidation, but are unable to do so.

The profitability of long-term projects means that entrepreneurs are better off investing and deferring consumption until those projects mature. Firms will therefore never pay dividends in the first period ($d_0 = 0$). Nor will they issue dividends in the second period, due to the

cost of capital and the presence of the borrowing constraint. Thus firms will pay dividends only in the final period (for a proof of this, see Section B2 of the Mathematical Appendix).

Since long-term projects have a higher return than bonds, it will never be optimal to liquidate when the borrowing constraint does not bind (see the proof of Proposition B2.3 in the Mathematical Appendix). With both dividends and liquidation set to zero, from the budget constraint (3) it is clear that when the borrowing constraint does not bind, the entrepreneur borrows exactly the amount needed to cover his outstanding obligations: $D_2 = (1+r)D_1 - y_1$. In this case, the entrepreneur's final period consumption will be equal to net profits on long-term investment, along with the final-period value of his endowments.

$$C^H = [R - (1+r)^2]D_2 + [Ry_0 + (1+r)y_1 + y_2]. \quad (9)$$

Since uninterrupted projects are profitable ($R > (1+r)^2$), higher initial borrowing translates into greater consumption in states in which the second-period borrowing constraint does not bind. This implies that the borrowing constraint will bind when the borrowing available at $t = 1$ combined with the entrepreneur's $t = 1$ endowment is less than his debt service payments: $\kappa_2 + y_1 \leq (1+r)D_1$.

When the borrowing constraint does bind, it will be the case that $D_2 = \kappa_2$. Since no dividends are paid at $t = 1$, the budget constraint (3) makes clear that the entrepreneur will liquidate a portion $L_1 \in [0, I_0]$ of the long-term project in order to service his debts. In particular, he will liquidate just enough of his investment to repay his first period borrowing: $L_1 = (1+r)D_1 - (y_1 + \kappa_2)$. In this case, final period consumption is given by

$$\begin{aligned} C^L &= R(I_0 - L_1) - (1+r)\kappa_2 + y_2 \\ &= [R - (1+r)]\kappa_2 - rRD_1 + [Ry_0 + Ry_1 + y_2] \end{aligned} \quad (10)$$

The conditions for optimal borrowing (7) and liquidation (8), along with the results discussed above, give

$$\mu_t = \beta(1+r) \left[\frac{R}{1+r} - 1 \right] (1 + \lambda_2).$$

This illustrates that when the borrowing constraint binds ($\mu_t > 0$), firms carry out liquidation that appears inefficient, in that the present value of allowing the project to mature is $R/(1+r) > 1$ while liquidating yields a gross return of one. However, this liquidation is in fact an optimal response to the capital market imperfections present in the economy.

Optimal Borrowing

Once the uncertainty regarding the $t = 2$ borrowing constraint has been resolved, the entrepreneur's decisions are mechanical. The key decision is therefore the choice of initial borrowing, and the entrepreneur's problem reduces to

$$\max_{D_1} [1 - F(\underline{\kappa})] E_0[C^H | \kappa_2 > \underline{\kappa}] + F(\underline{\kappa}) E_0[C^L | \kappa_2 < \underline{\kappa}]$$

where $\underline{\kappa} = (1 + r)D_1 - y_1$ is the level below which the borrowing constraint binds. Thus the probability that the constraint will bind is endogenously determined by the entrepreneur's choice of initial borrowing, because $\underline{\kappa}$ is a function of D_1 . The more he borrows, the more likely it is that he will be unable to roll over the debt in the intermediate period. Substituting using (9) and (10) into the simplified objective function (3.1) gives

$$\begin{aligned} \max_{D_1} [1 - F(\underline{\kappa})] \{ [R - (1 + r)^2] D_1 + [Ry_0 + (1 + r)y_1 + y_2] \} \\ + \int_{-\infty}^{\underline{\kappa}} \{ [R - (1 + r)] \kappa_2 - rRD_1 + [Ry_0 + Ry_1 + y_2] \} dF(\kappa_2) \end{aligned} \quad (11)$$

This expression makes clear that when the borrowing constraint does not bind (on the first line of 11), the more the entrepreneur has borrowed, the larger will be his final-period consumption. When the borrowing constraint binds, greater borrowing reduces consumption by forcing the entrepreneur to liquidate a larger share of the long-term project. The level of the borrowing constraint will affect the return on investment only when it binds (κ_2 appears only in the second line of 11). I show in the next section that this asymmetry, along with endogeneity of the entrepreneur's exposure to rollover risk, means that symmetric changes in the distribution of κ_2 will affect the expected return on long-term investments.

The first order condition for the entrepreneur's borrowing is

$$\begin{aligned} [1 - F(\underline{\kappa})][R - (1 + r)^2] - C^H f(\underline{\kappa}) \frac{\partial \underline{\kappa}}{\partial D_1} \\ = F(\underline{\kappa})rR - C^L f(\underline{\kappa}) \frac{\partial \underline{\kappa}}{\partial D_1} \end{aligned} \quad (12)$$

Intuitively, the entrepreneur chooses the level of debt-financed investment which equalizes the expected marginal returns across the two types of states—those in which the borrowing constraint binds and those in which it does not. Since $C^H = C^L$ when $\kappa_2 = \underline{\kappa}$, the second

terms on each side of this equation cancel. Simplifying gives:

$$F(\underline{\kappa}) = \frac{R - (1 + r)^2}{R(1 + r) - (1 + r)^2} \quad (13)$$

Since $\underline{\kappa} = (1 + r)D_1 - y_1$, this pins down the optimal level of borrowing and thus initial investment.¹⁴ In what follows, I refer to the term on the right-hand side of (13), which will lie between zero and one, as Ψ . As one would expect, optimal investment is increasing in the gross return on long-term investment (R) and decreasing in the cost of capital, the world interest rate r .

Increased Uncertainty

In order to understand the effects of the fluctuations in capital flow volatility that I observed in the data, I now examine how increased uncertainty regarding the value of the second-period borrowing constraint (κ_2) affects initial investment and borrowing. More specifically, I consider a shift in the distribution of borrowing constraints from $F(\kappa)$ to a distribution $G(\kappa)$ which is a mean-preserving spread. In other words, I examine an increase in risk as defined by Rothschild & Stiglitz (1970): $\int_0^t [G(\kappa) - F(\kappa)] dt \geq 0 \forall t$ so that $F(\kappa)$ second-order stochastic dominates $G(\kappa)$. This will isolate the impact of greater uncertainty regarding the borrowing constraint, independent of any changes in the level.

Remembering that $\underline{\kappa}$ is increasing in the amount of initial borrowing, equation (13) makes clear that greater uncertainty will reduce investment when the optimal level of investment lies in a region in which $F(\underline{\kappa}) < G(\underline{\kappa})$. Second-order stochastic dominance ensures that at least one such region exists. For most distributions, to fall in such a region $\underline{\kappa} = (1 + r_1)D_2^* - y_2$ must lie in the left tail of the distribution. This will be the case for realistic parameter values for the return on long-term domestic projects and international interest rates.

When will a mean-preserving spread *increase* initial borrowing and investment? When optimal borrowing is high enough that the greater mass in the right tail of the distribution reduces the probability that the borrowing constraint will bind. This occurs if the spread between the return on long-term projects (R) and the world interest rate ($1 + r$) is so large that the entrepreneur finds it optimal to incur very high rollover risk. In this situation, even

¹⁴This is indeed a maximum, as $\frac{\partial^2 E_0[C^s]}{\partial D_1^2} = f(\underline{\kappa})(1 + r)[(1 + r)^2 - (1 + r)R] < 0$ because I am assuming (i) long-term investment is profitable (ii) investment is partially irreversible and (iii) the world interest rate is non-negative.

Table 2: Parameter Values

Symbol	Parameter	Value	Source
$1 + r$	World interest rate	1.049	Mean real interest rate in emerging markets
R	Return on long-term projects	1.11	Term premium on speculative-grade US corporate debt
$E(\kappa_2)$	Expected Value of borrowing constraint (%GDP)	0.12	Mean portfolio debt liabilities in emerging markets (Lane & Milesi-Ferretti 2007)
$[y_0, y_1, y_2]$	Endowments	$[1,0,0]$	Normalization

though he will most likely be forced to liquidate, the reward in situations where he avoids liquidation is sufficiently large to make high debt the optimal choice.

To illustrate this mechanism, I now assume that the borrowing constraint κ_2 has a lognormal distribution and assign the parameter values given in Table 2. The world interest rate is set to match the average real interest rate on foreign borrowing for my sample of 15 emerging markets.¹⁵ I set the return on long-term projects so that the spread between return on long-term projects and the world interest rate is equal to the average term premium on two-year BB-rated corporate bonds in the United States over the last 15 years. In a perfect capital market, any term premium would correspond to differences in returns on projects of different duration. The US is presumably closest to an ideal financial market. I use the term premium for speculative-grade bonds since it is the rating of the vast majority of corporates in emerging markets.

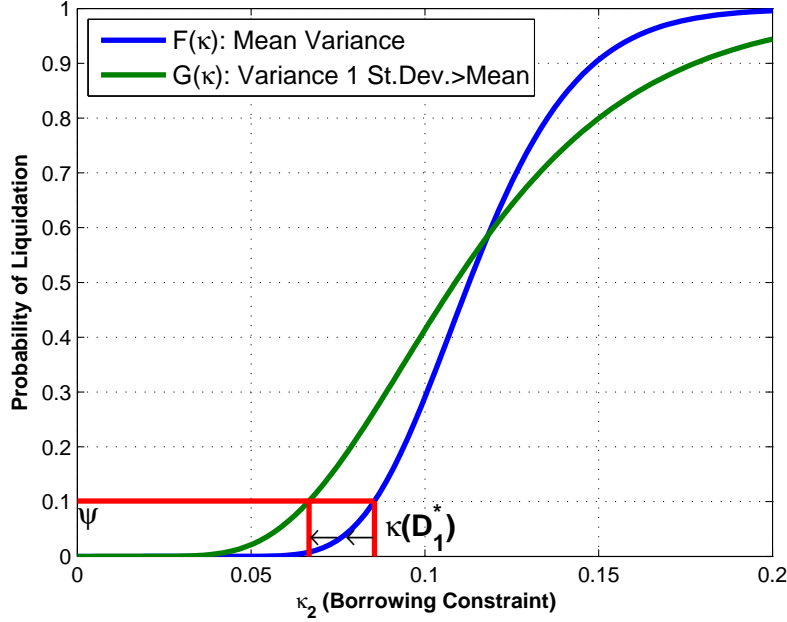
I set the expected value of the borrowing constraint so that average borrowing is equal to the average ratio of net portfolio debt liabilities to GDP in the emerging markets in my sample over the last 15 years, as reported in Lane & Milesi-Ferretti (2007). The parameter values in Table 2 imply that firms liquidate long-term projects seven percent of the time.

In Figure 6 a mean-preserving spread in the distribution of the borrowing constraint (κ_2) increases the variance of foreign borrowing from the observed mean to volatility one standard deviation above the mean. To maintain the equality in condition (13) the entrepreneur must reduce D_1 and thus investment in order to equate $G(\underline{\kappa})$ and Ψ , the optimal probability of liquidation from the solution to the entrepreneur's problem (13).

Intuitively, when agents borrow short-term to finance long-term investments they face a trade-off. On the one hand, greater leverage increases their return on equity if the borrowing

¹⁵Following Neumeyer & Perri (2005), I measure the real interest rate on foreign borrowing as the real US three month T-Bill rate plus the relevant EMBI-G spread. For details on the sample of countries, see Section 2 and Appendix A.

Figure 6: Mean-Preserving Spread



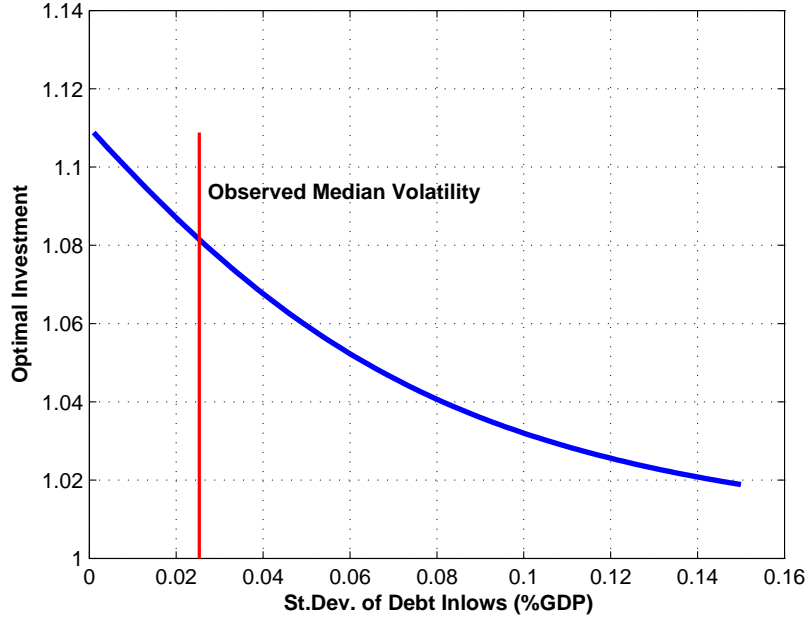
constraint does not bind. On the other hand, the risks associated with greater borrowing are twofold. Most obviously, when the borrowing constraint does bind the rate of return falls since the entrepreneur must liquidate part of the project. The greater the gap between outstanding liabilities and available borrowing, the lower the overall return on the investment.

In addition, higher debt increases the entrepreneur's exposure to rollover risk, boosting the probability that the borrowing constraint will bind in the second period. Figure 6 makes clear that the probability of the borrowing constraint binding, $F(\underline{\kappa})$, depends on D_2 . This introduces concavity into the entrepreneur's objective function, so that even when agents are risk neutral, in the presence of maturity mismatch second-moment shocks have first-order effects, and symmetric changes in the distribution of borrowing constraints affect the entrepreneurs' chosen investments in long-term projects.

Figure 7 graphs optimal investment for the range of portfolio debt flow volatility observed in the sample. A shift from the minimum volatility observed in the data (during the 1990s in India and Colombia) to the observed maximum value (Bulgaria in 2005) reduces investment by around 10 percent of the initial endowment.

Thus, I find that even when the agents making investment decisions are risk neutral, an increase in uncertainty about the future availability of borrowing will dampen investment and slow output growth. If agents were risk averse, this effect would be amplified, since the

Figure 7: Capital Flow Volatility and Optimal Investment



desire to smooth consumption would provide a further motive—above and beyond the need to roll over debt—to borrow in the intermediate period. Here I have abstracted from this effect in order to emphasize the role played by maturity mismatch in transmitting shocks to capital flow volatility. Moreover, in contrast to the literature on real options (Dixit & Pindyck 1994, Bloom 2009), uncertainty affects firms’ investment decisions even in the absence of any irreversibility. Introducing partial irreversibility into the model presented here quantitatively strengthens the effect of uncertainty shocks by reducing the expected profits from debt-financed investment in states in which the borrowing constraint binds.

In order to compare the impact of capital flow volatility in emerging markets with its effects in advanced economies, I now compare the above result to a situation in which the entrepreneur does not face maturity mismatch. This means that in the initial period ($t = 0$), he can issue debt (D_2^L) with the same maturity as his investments, but faces uncertainty regarding the productivity of his investment. In this case, his problem becomes:

$$\max_{D_2^L} E_0[(R - (1 + r^L))D_2^L]$$

Where $1 + r^L$ is the interest rate on long-term bonds issued by the entrepreneur. With no

interest rate uncertainty, this is simply:

$$\max_{D_2^L} [E_0[R] - (1 + r^L)] D_2^L$$

If the expected return on the investment exceeds the cost of capital, the entrepreneur will borrow up to the solvency constraint (B-2). If we assume (as in Rothschild & Stiglitz 1970) that $\kappa_2^{min} = 0$, or that the support of κ_2 is the entire real line, a mean-preserving spread will leave the solvency constraint unaffected and thus have no effect on investment.

The comparison case without maturity mismatch demonstrates why the interaction between this common feature of emerging markets and volatile capital flows can help to explain their greater output volatility. Where firms cannot borrow long-term when financing long-term projects, changes in capital flow volatility will affect the investment and output. Firms in countries with well-developed capital markets can issue long-term debt, and therefore will not alter their investment in response to changes in the uncertainty regarding the future availability of borrowing. By contrast models relying on risk aversion (Fernández-Villaverde et al. 2011) or irreversible investment (Dixit & Pindyck 1994, Bloom 2009) are not capable of generating a different response to uncertainty shocks in emerging markets, since neither risk aversion nor irreversibility is different in these countries as compared to advanced economies.

3.2 Full Model

I now consider a richer specification, in which the entrepreneur has the opportunity to invest in both a standard technology with the production function $y_t^s = f(I_{t-1}^s)$, which takes one period to mature, and a long-term technology with production function $y_2^L = z f(I_0^L - L_1)$, which takes two periods to mature. Long-term projects can be liquidated with a gross return $\phi < 1$, so that investment may be partially irreversible, although the results remain qualitatively the same regardless of any irreversibility. The long-term technology is more productive than the short-term technology, so that $z \geq 1$ (for simplicity I normalize the productivity of the short-term technology to one). For both technologies, $f'() > 0$ and $f''() < 0$.

As before the firm operates for three periods under the management of a risk neutral entrepreneur. Thus, this firm will maximize the discounted sum of dividends:

$$\max_{I_0^L, D_1, D_2, I_0^S, I_1^S, L_1} E_0 \sum_{t=0}^2 \beta^t d_t \tag{14}$$

where dividends are given by

$$\begin{aligned} d_0 &= y_0 + D_1 - I_0^L - I_0^S \\ d_1 &= y_1 + f(I_0^S) + \phi L_1 + D_2 - (1 + r_0)D_1 - I_1^S \\ d_2 &= y_2 + zf(I_0^L - L_1) + f(I_1^S) - C_2 - (1 + r_1)D_2 \end{aligned}$$

and subject to non-negativity constraints ($d_t \geq 0 \forall t = \{0, 1, 2\}$). Now in addition to choosing initial-period borrowing and investment, the firm optimizes over short-term investment in both the first and second periods.

Apart from the different menu of production technologies, the model is the same as in the previous section. The firm's borrowing in the intermediate period is again subject to an exogenous borrowing constraint ($D_2 \leq \kappa_2$), the value of which becomes known at time $t = 1$ and which is drawn from a distribution $F(\kappa)$. Any liquidation carried out while the long-term investment is gestating is subject to a non-negativity constraint ($L_1 \geq 0$) and an upper bound ($L_1 \leq I_0$).

The conditions for optimal borrowing remain (6) and (7), since the financial side of the model is the same as in the simplified model. Although the condition for optimal long-term investment is similar to equation (5), the marginal return on long-term investment now depends on the amount of liquidation that the firm expects to carry out during the project's gestation period:

$$(1 + \lambda_0) = \beta^2 E_0 [zf'(I_0^L - L_1)(1 + \lambda_2)] + E_0[\zeta_1^{(2)}], \quad (15)$$

where the Lagrange multipliers are defined as in the previous section. In this regard, equation (15) differs from the simple model where rollover risk entered the entrepreneur's optimization problem only through the Euler equation and did not affect marginal rates of return.

Apart from the more realistic production technology, the other difference from the model in the previous section is that the firm can also produce using a short-term technology that is less productive. The firm initially chooses short-term investment so that its marginal return equals the cost of capital, as is standard (subject to the feasibility constraints):

$$(1 + r) = \beta f'(I_0^S). \quad (16)$$

If the borrowing constraint binds in the second period the return on short-term projects will exceed the cost of capital, since the firm's investment is limited by the scarcity of external financing. At the same time, the firm will choose short-term investment to equate

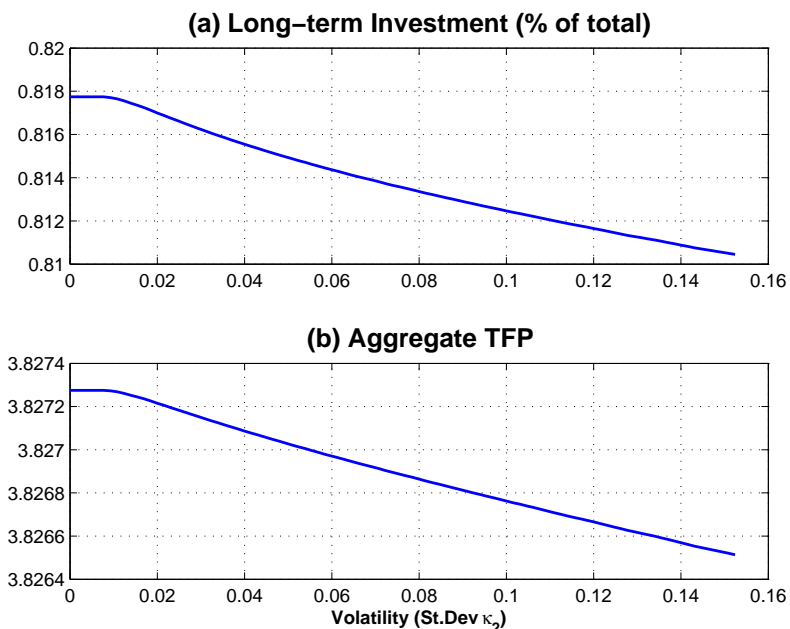
its marginal return with the return on any liquidated long-term investment:

$$\phi f'(I_1^s)(1 + \lambda_2) + \zeta_1^{(1)} = z f'(I_0^L - L_1)(1 + \lambda_2) + \zeta_1^{(2)}. \quad (17)$$

I solve this system numerically using the parameter values in Table 2 and setting the wedge in productivity between short- and long-term projects (z) to 3. I choose the functional form $f(k) = k^\alpha$ and set $\alpha = 0.3$.

As was the case in the simplified model, liquidation and intermediate-period borrowing are functions of initial borrowing and investment, so that in principle I need only solve (15) taking this into account. However, because of the non-linearities in the full model, I cannot do this analytically. Rather, I find the solution to (15) by searching over a grid of values for long-term investment (I_0^L). For each gridpoint, I calculate the optimal levels of liquidation and $t = 1$ short-term investment, then impose the non-negativity constraint on liquidation. For a grid of values for κ_2 approximating the lognormal distribution, I check whether the borrowing constraint will bind. I then recalculate optimal liquidation and short-term investment for states in which the borrowing constraint binds. After calculating the values of the Lagrange multipliers in each state, I evaluate the two sides of (15).

Figure 8: The Composition Effect of Capital Flow Volatility



Changes in uncertainty regarding the future availability of borrowing affect aggregate investment, as was the case in the simplified model, but also the composition of investment

and aggregate TFP. As in the simplified model, uncertainty shocks cause firms to scale back their long-term investments. Short-term investment remains unaffected, however, since it does not generate rollover risk. Aggregate investment will therefore fall, since the reduction in long-term investment is not offset by an increase in short-term investment. At the same time, the share of investment allocated to long-term project falls, as Figure 8(a) makes clear. Figure 8(b) shows that this composition effect will reduce aggregate TFP since long-term projects are more productive than short-term projects.

This mechanism at work in the model offers an explanation for the greater volatility of output and TFP in emerging markets and for the skewed distribution of growth rates. Shocks to capital flow volatility affect both advanced economies and emerging markets; however, those shocks will affect the macroeconomy only when maturity mismatch is widespread. Sudden stops in capital inflows directly affect the economy by reducing the availability of financing in the current period, but also increase agents' uncertainty about the level of financing that will be available in the future. The model that I have presented indicates that the uncertainty shock will amplify the impact of the sudden stop. A spike in the availability of foreign capital will also increase uncertainty. As a result, the direct benefits of more abundant foreign financing will be offset by the negative effect of the accompanying rise in uncertainty. This asymmetric amplification helps to explain the observed asymmetry in growth rates in emerging economies.

4 Empirical Results

The unconditional correlations in Figure 5 indicated that output is negatively related to the volatility of portfolio capital flows. In this section, I examine these relationships in more detail in order to test whether the data are consistent with the mechanism at work in the model.

Recall that the empirical analog of the variance of the borrowing constraint in the model of the previous section is the realized volatility of portfolio capital inflows. Underlying this link are two assumptions. First, as discussed at length at the start of the previous section, the level of financing available to emerging markets is primarily determined by exogenous factors, in particular risk appetite, liquidity, and macroeconomic conditions in advanced economies. The second assumption is that firm managers in emerging markets form beliefs about the variance of capital inflows based on the previous realized volatility of those flows.

I first verify that the relationship between output and capital flow volatility suggested by

the correlations in Section 2 remain when conditioning other determinants of growth. Thus, I begin by estimating the following equation by:

$$y_{i,t} = \beta_1 Flow_{i,t-1} + \beta_2 Vol_{i,t-1} + X'_{i,t}\gamma + \alpha_i + \varepsilon_{i,t} \quad (18)$$

Where $y_{i,t}$ is the deviation of log seasonally adjusted GDP from its quadratic trend, $Flow_{i,t-1}$ is the level of portfolio capital inflows as a percentage of trend GDP, and $Vol_{i,t-1}$ is the realized volatility of portfolio inflows, as discussed in detail in Section 2.¹⁶ $X_{i,t}$ is a vector of control variables. These include not only inflation and aggregate output in the US, EU, and Japan (the G-3) as a measure of global economic conditions, but also the level of FDI and the residual “other investment” flows from the balance of payments (both normalized by trend GDP).¹⁷ The latter category consists primarily of long-term loans, but also includes trade credits.

I include country fixed effects (α_i) to control for unobserved cross-country heterogeneity. Endogeneity is an obvious concern when estimating (18). While the level and volatility of capital flows in an economy may affect aggregate growth and investment, economic performance in part determines capital flows. For this reason I lag potentially endogenous regressors (capital flows, their volatility, and inflation) by one quarter.

The results in column 1 of Table 3 demonstrate that while the capital flows variables—FDI, “other flows,” and portfolio flows—are significantly associated with higher growth, the volatility of portfolio flows is negatively related to growth. Thus, after conditioning on other relevant variables, the relationship between capital flow volatility and output remains. As a first step towards understanding the mechanism through which capital flow volatility affects growth, in column 3, I re-estimate (18) with investment as the dependent variable, and find evidence that the negative impacts of capital flow volatility on growth are due at least in part to a negative relationship with investment, as was the case in the model. The results in columns 2 and 4, in which a level-volatility interaction term has been added, suggest that the negative effects of volatility are smaller when capital inflows are greater.

In the model of Section 3, capital flow volatility affected investment due to the presence of maturity mismatch and had no effect where mismatch was not present. Therefore, I

¹⁶In what follows, GDP, investment, and the CPI were all seasonally adjusted using the TRAMO-SEATS algorithm, as implemented by the Demetra+ software package made available by Eurostat. Since these variables are all non-stationary, the deviations of these variables from their quadratic trends were used in all regressions.

¹⁷I have estimated the model with a much more extensive array of control variables, including trade as a share of GDP, institutional quality, and GDP per capita, but these were not significant.

Table 3: Capital Flow Volatility, Growth, and Investment

Country Fixed-Effects Regressions, Quarterly Frequency				
Dependent Variable:	GDP ¹	GDP ¹	Investment ¹	Investment ¹
	(1)	(2)	(3)	(4)
Portfolio Inflows ²	0.273*** (.038)	0.217*** (.058)	0.644*** (.140)	0.347 (.220)
St.Dev. of Portfolio Inflows ²	-0.287** (.140)	-0.302** (.140)	-0.992* (.520)	-1.076** (.520)
Portfolio flows X St.Dev Interaction		2.490 (1.960)		13.04* (7.410)
Net FDI flows ²	0.162*** (.033)	0.160*** (.033)	0.316** (.130)	0.301** (.130)
Net "other" flows ²	0.256*** (.023)	0.258*** (.023)	0.823*** (.087)	0.832*** (.087)
CPI ¹ (lagged)	-0.0002 (.003)	0.0001 (.003)	-0.0183 (.013)	-0.0165 (.013)
GDP in G-3 ¹	0.371*** (.055)	0.372*** (.055)	0.341 (.210)	0.350* (.210)
Observations	688	688	675	675
R-squared	0.27	0.27	0.15	0.15

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

Notes: ¹ Seasonally adjusted, log deviation from quadratic trend.

²Lagged and measured as % trend GDP.

expect that the volatility of capital flows that do not generate maturity mismatch will not dampen investment. I test this hypothesis in Table 4, where I divide portfolio inflows into its two components—portfolio equity and portfolio debt flows. The results suggest that the negative effects of capital flow volatility are indeed restricted to portfolio debt flows, which are significantly and negatively related to investment. By contrast, the coefficient on equity flow volatility is several times smaller and never significantly different from zero.

When I interact the level and volatility of the disaggregated portfolio flows, I find that greater volatility reduces the marginal benefit of additional portfolio debt inflows. This latter finding suggests that volatility does indeed contribute to the skewed distribution of growth rates in emerging markets. A large, sudden capital outflow (of the kind observed during a sudden stop) is associated with lower investment and growth, but also results in a jump in volatility, amplifying the negative impact. By contrast, a sudden surge in inflows will boost growth, but this effect will be dampened by the volatility channel.

Empirical work by Schukler & Vesperoni (2006) and Fan et al. (2012) demonstrates that the extent of maturity mismatch in the economy is closely related to the overall level of financial development in the economy. With this in mind, I employ a widely used measure

Table 4: Equity and Debt Flow Volatility

Country Fixed-Effects Regressions, Quarterly Frequency				
Dependent Variable:	GDP ¹	GDP ¹	Investment ¹	Investment ¹
	(1)	(2)	(3)	(4)
Portfolio Equity Inflows ²	0.270** (.110)	0.287*** (.110)	0.291 (.400)	0.351 (.400)
Portfolio Debt Inflows ²	0.405*** (.082)	0.511*** (.100)	0.858*** (.310)	1.416*** (.390)
St.Dev. Portfolio Equity Inflows ²	0.226 (.200)	0.188 (.200)	0.764 (.740)	0.991 (.750)
St.Dev. Portfolio Debt Inflows ²	-0.842*** (.240)	-0.649* (.350)	-3.385*** (.900)	-5.445*** (1.320)
Level X volatility, portfolio equity	1.398 (6.770)	0.932 (6.810)	24.100 (25.500)	21.780 (25.600)
Level X volatility, portfolio debt	-9.682** (4.180)	-10.540** (4.360)	-15.890 (15.900)	-30.280* (16.500)
Portfolio debt level X financial dev		-0.002* (.001)		-0.006* (.003)
Portfolio debt volatility X financial dev		-0.004 (.006)		0.047** (.022)
Additional Controls: FDI², Other inflows², Financial Dev., CPI¹, G-3 Output¹				
Observations	688	688	675	675
R-squared	0.28	0.29	0.16	0.17

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

Notes: ¹ Seasonally adjusted, log deviation from quadratic trend. ² Lagged and measured as % trend GDP.

of financial development, equity market capitalization as a share of GDP, as a proxy for the level of maturity mismatch. In particular, I use the quadratic trend of this variable in an attempt to ensure that it captures the underlying structural characteristic that I am interested in, rather than for example a stock price bubble. I also ran these regressions using credit to the private sector as share of GDP, another common financial development measure, and the results were nearly identical.

The results, in column 4, indicate that higher levels of financial development do indeed reduce the negative effects of portfolio debt flow volatility on investment. It thus appears to be the case that the negative impact of portfolio debt flow volatility is less in more financially developed economies—those economies in which maturity mismatch is less severe. These results are consistent with the work of other researchers, including Alfaro et al. (2004) and Eichengreen et al. (2011), who have demonstrated that financial development amplifies the benefits associated with capital inflows. Moreover, this finding is consistent with a role for maturity mismatch in channeling shocks to capital flow volatility through to the real economy.

5 Conclusion

This paper shows that the high output volatility and negatively skewed growth rates observed in emerging markets can be understood as an effect of shocks to capital flow volatility in economies where maturity mismatch is widespread. Small open economies, both advanced and emerging, face uncertainty regarding the future availability of foreign financing. However, the uncertainty will affect investment only where financial markets are not well developed and firms are forced to finance investment in long-term projects with short-term borrowing. An increase in uncertainty about the availability of foreign borrowing increases firms' exposure to rollover risk and reduces the expected return on long-term investment in states of the world in which firms are forced to liquidate long-term projects. As a result, greater uncertainty not only prompts a reduction in the level of aggregate investment, but also shifts its composition away from more productive long-term projects towards short-term projects which do not entail rollover risk. This composition effect generates endogenous fluctuations in aggregate TFP, increasing its volatility.

The interaction between capital flow volatility and maturity mismatch amplifies the impacts of fluctuations in capital inflows in an asymmetric way and thereby contributes to the skewed pattern of growth rates in emerging economies. Sudden stops increase uncertainty about the future availability of foreign capital. Through the mechanism modeled in this paper, that uncertainty amplifies the negative effects of sudden stops. On the other hand, surges in capital inflows also boost uncertainty, which will dampen the positive effects of such surges on investment and growth.

In advanced economies where firms can finance long-term investment by issuing equity or long-term debt, uncertainty shocks will not affect investment because firms do not face rollover risk. Thus changes in capital flow volatility will boost the volatility of investment, output, and aggregate productivity only in emerging markets. Models in which uncertainty affects investment because of risk aversion (Fernández-Villaverde et al. 2011) or the irreversibility of investment (Bloom 2009) are not suited to explaining differences between advanced and emerging economies, since these features do not vary systematically between the two groups.

Data from a panel of 15 emerging markets are consistent with a role for maturity mismatch in transmitting uncertainty shocks to capital flow volatility. The volatility of portfolio debt flows, which can generate maturity mismatch, negatively affects output by dampening investment. By contrast, the volatility of equity flows, which do not generate maturity mismatch, is not significantly related to either output or investment. Moreover, the negative impact of

portfolio debt flow volatility is mitigated by financial market development, one component of which is a longer yield curve and thus less widespread maturity mismatch.

In order to mitigate the risks associated with openness to international capital flows, many governments have imposed capital controls to limit exposure to capital flow volatility. Since in the model developed in this paper firms' investment decisions are constrained efficient, capital controls will reduce welfare. The reduction in volatility comes at the cost of lower investment and output. Moreover, substantial evidence indicates that greater openness to international capital flows promotes financial development (Chinn & Ito 2006, Baltagi et al. 2009, Calderón & Kubota 2009). As a result, capital controls slow the deepening of equity markets and the lengthening of corporate yield curves that reduce the economy's vulnerability to volatility shocks by preventing maturity mismatch.

There is an obvious role for policy in mitigating the underlying financial frictions that prevent firms from financing long-term projects by issuing equity or long-term debt. However, financial market development entails institutional changes that take time to implement. More immediately, governments have sought to self-insure through the accumulation of official reserves. To the extent that the authorities can credibly commit to provide liquidity to firms during sudden stop episodes, and thus mitigate rollover risk, this policy could be welfare enhancing. Such a policy would reduce the uncertainty regarding the future availability of financing and thus limit vulnerability to volatility shocks. However, accumulating reserves reduces the funds available for investment in productive projects, and thus entails a cost. I plan to explore this trade-off in future work.

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