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"Interest Rate Shocks and the Composition of Sovereign Debt"

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Abstract

There has been a growing concern about the vulnerability of emerging countries to fluctuations in international interest rates. Empirical evidence shows that these countries suffer significant output drops when developed countries raise their interest rates. In this paper, I document that an important determinant of the magnitude of this effect is the ability of countries to issue sovereign debt domestically, rather than to external creditors. Moreover, I find that the level of financial development of domestic markets is positively related to the share of total public debt that is domestically held. I build a model that integrates a domestic banking sector into a sovereign default model where governments can issue domestic and external debt and decide whether to default on debt selectively. Due to financial frictions, issuing domestic debt crowds out investment in capital. As financial markets develop, crowding-out costs decrease, and banks demand lower interest rates on domestic bonds. Both effects reduce the relative cost to the government of borrowing domestically, leading to a higher share of domestic debt. The results of the quantitative solution of the model are consistent with the patterns of vulnerability to world interest rates and sovereign debt composition observed in the data. I show that financial development, through a less costly access to domestic debt, decreases the vulnerability of emerging economies to external shocks.

Keywords: Sovereign debt, Interest rates, International spillovers, Financial development
JEL codes: E44, F34, F42

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1 Introduction

Recent empirical evidence shows that developing countries suffer significant output drops when international interest rates increase. This has motivated substantial policy debate regarding the vulnerability of emerging markets to changes in the monetary policies of developed economies.[1] For example, Rey (2015), and Miranda-Agrippino and Rey (2015) document the existence of a global financial cycle and show that fluctuations in emerging markets are partially driven by the monetary conditions in the United States.

In this paper, I document that an important determinant for the magnitude of these spillover effects is the ease with which developing countries can issue sovereign debt to domestic creditors, rather than to external creditors. Intuitively, when world interest rates rise, it becomes more expensive for governments in developing countries to use external credit. Then, if they can easily substitute away from foreign debt and into domestic debt, the negative effects of external shocks on their output are reduced. I show that this intuition holds in the data: countries that have a high fraction of their sovereign debt held by domestic residents are less exposed to external shocks than countries whose sovereign debt is mainly composed of debt held by foreign creditors. This evidence suggests that understanding the incentives of the government to borrow domestically as opposed to from external creditors is crucial to assessing the consequences that monetary policies in developed countries have on emerging countries.

The obvious question is if issuing mostly domestic debt rather than external debt makes an emerging economy less vulnerable to fluctuations in world interest rates why don't all emerging market economies issue primarily domestic debt? One feature of the data that is relevant for answering this question is that countries with less developed financial markets tend to issue relatively little domestic debt relative to external debt and that as these financial markets develop the ratio of their domestic debt to external debt rises. Here, financial development is understood as the ability of transferring resources from borrowers to lenders, so a measure of liquidity in the country is used. This feature of the data leads me to construct a model in which, although issuing domestic debt is desirable for insulating a country from world interest rate fluctuations, there are other costs to doing so which are particularly high when the domestic economy has less developed financial markets. Moreover, it suggests that as the financial markets in a country develop the costs of issuing domestic debt fall and so that government optimally chooses to increase its share of domestic debt in total debt.

To formalize such an idea I develop a framework where financial intermediation plays a crucial role for determining the share of total public debt that is held by residents of the country. To also capture the link between vulnerability and default I embed financial intermediation into a sovereign

[1] See, for instance, Neumeyer and Perri (2005), Canova (2005), Uribe and Yue (2006), Maćkowiak (2007), Banerjee et al. (2016), Dedola et al. (2017), Iacoviello and Navarro (2019), and for papers that study the effects of increases in the U.S. interest rates on other developed countries and on emerging countries. See Rajan (2015) and Bernanke (2017) as examples of policy debates around this topic.

default model with domestic and external debt and fluctuations in the world interest rate. In the model, banks are the financial intermediaries in the economy. They lend to domestic firms to invest in capital and they hold domestic government bonds. The government chooses how much debt to sell domestically and how much debt to sell externally.

A key ingredient of this financial intermediation is that domestic banks are collateral constrained. I model these constraints in the tradition of Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) in that banks have limited access to households' savings due to an agency problem. I assume that the level of these frictions, captured by a parameter in the collateral constraint reflecting the enforceability of contracts, represents the financial development of the country. The idea is that in less financially developed countries, the ability to enforce contracts is weak in that banks suffer only a small punishment when they break financial contracts such as repaying their depositors. Hence, in such countries consumers are willing to lend to banks relatively small amounts of resources, the ratio of deposits to output is relatively low and the banks are able to fund relatively small amounts of investment. As countries become more developed in their financial markets, these costs are lowered, which translates into an increase in the amount of resources that banks can borrow. Banks then use these resources to invest in capital and in government bonds.

Financial frictions in the model affect the decision of the government regarding what type of debt to issue. The main trade-off for the government for issuing domestic debt is given by the relative benefit of domestic debt, given by the ex-post incentives of the government to default on external and domestic debt, and the relative cost of domestic debt, a *crowding out* cost. Given that governments can default selectively between domestic and foreign creditors, differences in the costs of default between these types of debt affect the relative likelihood of default and cost of debt.

The benefit of issuing domestic debt relative to external debt comes from the different incentives of the government to default in each type of debt. In the model, the costs of default are a combination of the standard exogenous costs of default, adopted from the sovereign default literature and, critically, the endogenous of cost of defaulting on domestic debt in a model with financial intermediation. These exogenous costs are that upon default on one type of debt, countries experience an output loss and enter in an autarky state in which they do not have access to that type of debt market for a random number of periods. To focus attention on the differential endogenous cost of defaulting on domestic and external debt these exogenous costs are assumed equal across the two types of default. This differential endogenous cost arises because when the government defaults on domestic debt, it is defaulting on its own citizens rather than on foreigners. In particular, a default on domestic debt reduces the net worth of domestic banks and, hence, the amount of resources that they have for investment, which then reduces future output in the economy. This endogenously larger ex post cost for domestic default, in turn, leads domestic agents to expect that, for the same amounts of domestic and external debt, the government has less of an incentive to default on domestic debt. Therefore, all else equal, this endogenous force tends to lower expected default rates and thus the premium on domestic debt over the world rate relative to that on foreign debt. [2]

In terms of the cost to issue the domestic debt relative to external debt, there is also an endogenous differential incentive to do so arising from the way funds are intermediated. Since banks have limited resources to invest in capital and government bonds, increasing the amount of domestic debt in the economy diverts some of these resources to government bonds and thus crowds out the investment in capital by banks. This crowding out cost reduces future output, and therefore makes domestic debt costlier than external debt for the government.[3]. Therefore, the interaction between ex-post default incentives, which make domestic debt more attractive due to lower default probabilities, and ex-ante incentives to issue debt, which make domestic debt less attractive from the point of view of the government because it crowds out capital investment in the economy, determines the equilibrium share of domestic debt in a country.

I turn next on how changes in the world interest rate affect output in emerging countries. In the model, the government needs to finance its expenditures using domestic and external debt, together with taxes on labor income. After an increase in the world interest rate, the cost of borrowing externally increases, which reduces the ability of the government to finance its expenditures using external debt. This implies that the government needs to raise taxes and/or issue more domestic debt which have a negative impact on output: increasing taxes decreases the amount of labor in the economy, and increasing domestic debt, due to its crowding out effect, decreases the amount of capital in the economy. Hence, higher external borrowing costs translates into a decrease in total output.

Then, I use the model to quantitatively assess the role of domestic debt and financial development in mitigating shocks to international interest rates. Specifically, I assume that external creditors have access to an international risk free asset, the return on which evolves stochastically, and that is calibrated to match the features of the U.S. Federal funds rate. Critically, the model is able to generate the main features of the data in emerging countries in terms of the characteristics of sovereign debt and default in these countries, and its relation with their level of financial development. When there is an unexpected increase in the international risk free rate, the model generates a drop in output after a shock that increases the world interest rate similar to what we observe in the data. How does domestic debt mitigate the drop in output? First, I show that in a counterfactual economy where only external debt is allowed, output decreases almost 0.2 percentage points more after an increase in world interest rates than in the baseline economy where the government has access to both, domestic and external debt. This is so because the government responds to the interest rate shock by increasing the share of domestic debt. In the absence of domestic debt, the government needs to raise taxes further in order to meet its payments. Because labor income taxes

[2] The decrease in net worth and private lending from banks after default is observed in the data as shown in Gennaioli et al. (2018) and Baskaya and Kalemli-Ozcan (2016), which provide evidence that after a domestic default, banks holding government debt experience a large decrease in their net worth and aggregate lending.

[3] This mechanism is in line with empirical evidence that shows the relation between domestic debt held by banks and a crowding out effect on corporate lending from these banks. See for instance Becker and Ivashina (2018)

are distortionary, it pushes output to decrease even more. Second, the model predicts that more financially developed economies suffer less from external shocks. I model a country's increase in financial development as an increase in its ability to enforce contracts as captured by a parameter in the collateral constraint. As a country's ability to enforce contracts increases, the balance of the relative benefits and relative costs of domestic debt shifts, and the government endogenously chooses to issue a higher share of domestic debt. The quantitative model captures then the same patterns as in the data: more financially developed countries tend to have higher shares of domestic debt.

Moreover, the model mechanisms and quantitative predictions are robust to the introduction of real exchange rates. In the data, domestic debt is considered as debt issued under domestic jurisdiction and external debt debt that issued under foreign jurisdiction. Typically, this definition is correlated with a definition based on the denomination of currency, that is, domestic-law debt tends to be denominated in local currency, and foreign-law debt, tends to be denominated in foreign currency. That is why the decision on the type of debt to issue might also be influenced by shocks to the real exchange rate, as this would affect the cost of borrowing externally. Moreover, as shown for instance in Eichenbaum and Evans (1995), shocks to the U.S. interest rate might involve changes in the real exchange rate, and so the effect on output in emerging countries after such a shock depends on the evolution of the real exchange rate. To assess the role of real exchange rates both in the decision of the government about what type of debt to issue, and on the effect of an increase in the international interest rate, I extend the model to incorporate an exogenous process for real exchange rate, possibly correlated to the process for the international interest rate. I use the data to estimate these processes, and show that, once those are incorporated in the model, the main mechanisms hold and are quantitatively similar to the baseline model.

Interestingly the model has three additional implications that are consistent with evidence in the data that it was not explicitly designed to address. In a sense this consistency can be thought of as external validation of the mechanism. The first feature is that the ratio of domestic to external debt is countercyclical in the data and the model. This occurs because, on the margin, banks must be indifferent between investing a unit of their resources in domestic debt and investing a unit in physical capital by lending it to firms. When domestic productivity is high so is the return on capital and, hence, governments must pay relatively high return on their domestic debt. The second feature is related to the frequency of the different types of default. In the data we observe that most of the times governments default only on external debt, sometimes in both domestic and external, and almost never they default only on domestic debt. The quantitative model is able to reproduce these patterns: due to the endogenously different cost of default, default only on external debt are more frequent than default on both types of debt, and default only on domestic debt does not happen in equilibrium.[4] The third feature is a pattern of discriminatory default in the data, that I refer to as the *pecking order of default*: in moderate recessions countries tend to default only on external debt and only in severe recessions do they default on both domestic and external debt. That the model also generates this feature is connected to the model's implied countercyclicality of the domestic debt share. If a country starts in a relatively productive state it tends to have a relatively high share of external debt. If following such a state the economy experiences a drop in productivity, given that defaulting on domestic debt is more costly than on external, the government chooses to default only on external debt. If instead the adverse shock happens during a period when the economy was already experiencing low to moderate productivity, the government tends to have a much higher share of domestic debt. Hence, even if it defaults on external debt it does not generate much revenue and hence it chooses to default on both types of debt.

Related Literature

This paper combines elements of the sovereign default and the financial intermediation literature to study the government decision on whether to borrow domestically or externally in an economy that is subject to international interest rate shocks. It contributes to the sovereign default literature by introducing two types of debt, external and domestic, on which the government can selectively default. Standard models of sovereign default, such as Aguiar and Gopinath (2007) and Arellano (2008), focus only on external debt. I include domestic debt motivated by the evidence in Reinhart and Rogoff (2011). They construct a historical series of domestic debt for a large sample of countries and they find that domestic debt represents a large fraction of total sovereign debt in most countries.

The model in this paper is related to Gennaioli et al. (2014), Sosa-Padilla (2018), and Bocola (2016). They incorporate financial intermediation and domestic debt to analyze the effect of sovereign default on domestic banks' balance sheets. However, they assume either that there is only domestic debt, or that default is non-discriminatory. I argue, based on the evidence in Reinhart and Rogoff (2011), Erce et al. (2022), and other literature that focuses on the legal aspects of sovereign default, such as Gelpern and Setser (2003), that governments can and actually do discriminate between domestic and foreign creditors. More similar to this paper are Mallucci (2022) and Perez (2015) which include both domestic and external debt in the decision of the government. However, they assume that governments cannot selectively default on domestic and external debt, which is against what we observe in the data. Therefore, this paper contributes to the sovereign default literature by introducing a new framework where governments can issue both domestic and external debt and can default selectively. I show that allowing selective default as in the data is key in explaining the trade-offs the government faces when deciding between domestic and external debt. This is due to the different costs of default between each type of debt that arise endogenously in the model, which will affect the price of debt.

[4] Reinhart and Rogoff (2011) examine more than 300 historical defaults including those involving only external debt, and overt defaults, that is, those involving both domestic and external debt. They find that since 1800, in about 80% of the cases the government defaulted only on external debt, over 19% of the cases on both external and domestic debt and almost never on only domestic debt.

This paper also contributes to the growing literature on the spillover effects that monetary policies in developed countries have on the rest of the world. Rey (2015), Miranda-Agrippino and Rey (2015), and Bruno and Shin (2015) provide evidence on the existence of a global financial cycle and argue that this cycle is largely driven by monetary policies in the United States, which is unrelated with the economic conditions in developing countries. Other papers that find a strong response of emerging countries to interest rate shocks are Dedola et al. (2017), and Maćkowiak (2007). Here, I show that the spillover effects in emerging countries are related to their level of financial development. My results are in line with the empirical literature that indicates that an important mechanism of transmission of international shocks is the financial channel (see e.g. Canova (2005) and Georgiadis (2016)), and that countries differ in their response depending on how vulnerable they are to external conditions. In this regard, Iacoviello and Navarro (2019) define a vulnerability index that includes measures such as foreign reserves, current account, and external debt, and show that the differences in the response to external shocks observed across countries are largely explained by this vulnerability index. I add to this empirical literature by providing a new mechanism of transmission that relates to the level of financial development of the country and the borrowing decisions of its government. In my framework, these two factors capture endogenously the level of vulnerability of countries to external shocks. Banerjee et al. (2016) also associate financial intermediation to the response of countries to external shocks. However, they ignore the role of the government and focus mostly on the transactions of domestic banks with international banks.

The effect of international interest rate on emerging countries is studied in Neumeyer and Perri (2005). In relation to this literature, recent papers have also explored the role of international interest rate shocks in emerging countries through its effect o sovereign debt. Almeida et al. (2019) study the impact of changes in the international rate in the default probability and renegotiation costs in emerging countries. Similarly, Johri et al. (2022) also introduces fluctuations in the international interest rate is a sovereign default model, which in addition features an economy with stochastic volatility. However, these papers only include external debt, and therefore abstract from the decision of governments between issuing domestic and external debt, and the role of domestic debt to mitigate such fluctuations in the international interest rate.

Finally, my paper complements the literature that studies the implications of an increasing use of domestic debt in developing countries. Bua et al. (2014) documents an increasing trend of domestic debt in low income countries in recent years, and that this increase has been associated with a decrease in their borrowing costs. Panizza (2008) finds similar trends, and studies the potential trade-offs that this switch to domestic debt may have in their economies. I contribute to this literature by providing a new framework to analyze the costs and the benefits of domestic debt, and to understand the incentives of governments that lead them to issue more domestic debt over the last years.

The paper is organized as follows. Section 2 contains the empirical evidence on the relationship between financial development and domestic debt, and the effects on emerging countries output of

Table 1: Descriptive Statistics

	1969-1996				1960-2007			
	Liquid liabilities	Domestic debt share	Total defaults	External defaults	Liquid liabilities	Domestic debt share	Total defaults	External defaults
Argentina	0.172	0.449	2	0	0.184	0.306	3	0
Brazil	0.172	0.848	2	0	0.275	0.787	4	2
Chile	0.267	0.489	1	1	0.340	0.583	4	4
China	0.636	0.359	0	0	0.849	0.443	0	0
Colombia	0.189	0.398	0	0	0.189	0.406	0	0
Ecuador	0.177	0.418	1	1	0.194	0.219	2	1
India	0.297	0.761	2	2	0.389	0.797	2	2
Indonesia	0.194	0.034	1	1	0.261	0.126	4	4
Malaysia	0.632	0.762	0	0	0.868	0.759	0	0
Mexico	0.222	0.562	1	0	0.223	0.460	2	1
Peru	0.186	0.186	6	5	0.245	0.179	6	5
South Africa	0.514	0.958	3	3	0.483	0.937	3	3
Thailand	0.474	0.752	0	0	0.665	0.773	0	0
Turkey	0.195	0.526	2	2	0.239	0.553	2	2
Total	0.312	0.540	22	16	0.370	0.581	31	23

Sources: World Bank Financial Structure and Development, and Reinhart and Rogoff (2011).
Notes: Last row shows the average liquid liabilities to GDP and domestic debt share for the countries in the sample. *Total defaults* refers to the number of years a given country defaulted on either type of debt, and *External defaults* refers to the number of years a country defaulted only on external debt.

an increase in the international interest rate. In Section 3, the model is explained, and in Section 4 I elaborate on the main mechanisms of the model. The main quantitative analysis of the model is done in Section 5, which contains the analysis of both the role of financial development in determining the share of domestic debt, and the quantitative implications of an external shock. It also presents the model quantitative implications of selective default and the resulting pecking order of default. Then, I discuss the main assumptions and main mechanisms of the model in Section 6, and conclude in the last section of the paper.

2 Empirical Evidence

In this section, I provide the evidence that motivates this paper: a shock that increases the U.S. interest rate has a negative effect in the output of emerging countries. Then, I show that this effect is bigger for less financially developed countries.

2.1 Data sources

The main data analysis focuses attention on 14 developing countries during the years 1969 to 2007. The choice of countries is given by availability of data. I drop any country in the dataset for which any of the main variables of interest is not available, namely, real GDP, a measure of financial development which is described below, and domestic debt. In the main analysis, I restrict attention to the period 1969-1996. This is because identification of the interest rate shock is known to be consistent for this period. However, all results are robust to extending the period to 1960-2007. Next, the sources for the main data variables used in this paper are discussed.

Domestic debt. There are different definitions that can be used for domestic debt. In the model, domestic debt refers to debt held by residents of the country as opposed to foreigners. However, there is no long time series data available for this definition. I use data on domestic debt from Reinhart and Rogoff (2011) which uses the definition of domestic debt based on the market where it is issued: under the own country's jurisdiction, or under foreign jurisdiction. In general, in developing countries, debt issued in domestic debt has been held by residents of the country, and debt issued abroad by foreigners. Moreover, it is usually the case that domestic markets issue debt denominated in local currency, whereas when it is issued abroad, it is denominated in foreign currency, which makes it more likely for these two definitions of domestic debt to be positively correlated. The World Bank and IMF (see Arslanalp and Tsuda (2014)) have recently released new data on domestic debt where they can differentiate between debt based on whether holders are residents or foreigners. This time series is too short for being used in my analysis. However, by comparing it with the definition by market of issuance, we can see that for developing countries they exhibit similar levels and trends.[5]

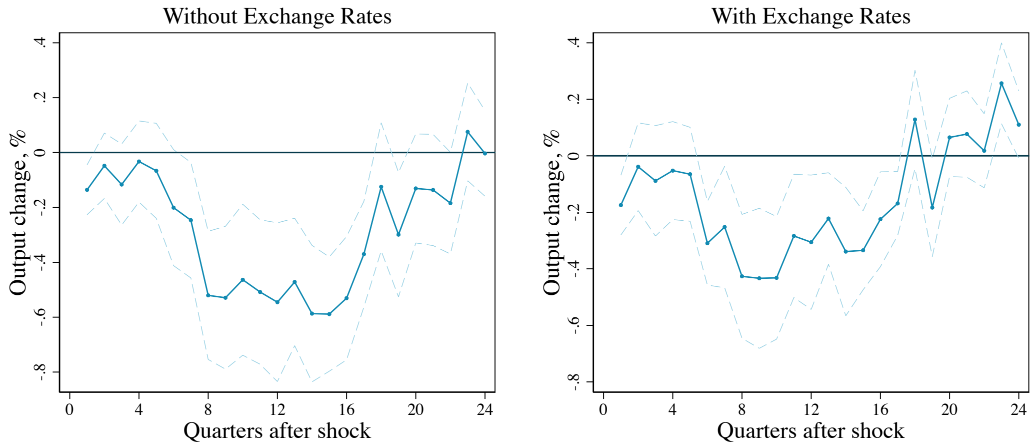
Default events. The list of historical default events across developing countries is also taken from Reinhart and Rogoff (2011). Moreover, I use their classification between defaults that involve only external debt, and those that involve both, domestic and external debt.

Financial development. I use data on liquid liabilities to GDP from the World Bank Financial Structure and Development Dataset as a measure of financial development. In particular, liquid liabilities consists of a broad definition of money including demand and interest-bearing liabilities, such as deposits, at domestic financial institutions. This has been one of the main measures of financial development in the literature (see for example, King and Levine (1993)). This variable measures the size of the financial sector relative to economic activity, which is known as financial depth. Intuitively, when liquidity is high, it is easier to trade among agents in the economy. Low liquidity may indicate the presence of financial frictions that prevent agents to transform their assets, or that prevent resources to flow between savers and borrowers.

Table 1 shows descriptive statistics for each country on the sample. On average liquid liabilities

[5] Appendix E.1 shows a comparison of these series for the time period where there is data on both.

Figure 1: Output Response to an Increase in US Interest Rates



Notes: This figure shows the coefficient β_h from regression (1). The left-panel corresponds to the coefficient when exchange rates are not included as regressors in (1), and the right-panel includes exchange rates. Dashed lines are 68% confident intervals. Standard errors are computed using Driscoll-Kraay method.

are about 30 percent of GDP and domestic debt is 54 percent of total debt. We see large variation across countries: Malaysia and China have the highest level of financial development, with a ratio of liquidity to GDP around 0.6. On the other end, many countries have low levels of financial development, below 0.2, and countries like Peru and Indonesia have shares of domestic debt below 0.10. Table 1 also shows the number of defaults that each country had in the baseline time period and how many of those were only on external debt. If we pool all countries together, these data indicates that countries default on average more than 4% of times per year and 73% of defaults were only in external debt[6].

Other variables. The main analysis also uses data on real GDP in each country. For this, I used data from Iacoviello and Navarro (2019) which extend annual data from the World Bank's World Development Indicators to quarterly data using interpolation methods. Other variables used in the analysis are U.S. interest rates, which is taken as the Fed Funds Rate, and the bilateral real exchange rates, for which I use data from the U.S. Department of Agriculture.

2.2 Effect of interest rate shocks on emerging countries

In this section I study how shocks to world interest rates affect economic outcomes in developing countries. First, I show that after a shock that increases the U.S. interest rate, emerging countries experience a drop in their real GDP. Second, I show how this drop depends crucially on the level of financial development of these countries, where financial development measured by the amount of liquid liabilities in the country.

[6]In the database none of the defaults are labeled as "only domestic debt" defaults. Therefore, those defaults that are not external debt-only are assumed to be defaults on both external and domestic debt.

Baseline specification. In the baseline specification, shocks to the U.S. interest rates are taken from Romer and Romer (2004) on their original sample which covers 1969 to 1996. They identify monetary policy shocks using a narrative approach. This identification strategy has been used in the most recent literature, and is known for capturing well the main features of responses to monetary policy shocks (see Ramey (2016) for a discussion on these methods). Then, to see the effect of these shocks on the output of emerging countries, I use the local projection method proposed in Jordà (2005). In particular, consider the following set of regressions:

$$y_{it+h} = \beta_h u_t + \sum_{j=1}^{4} \gamma_{1ijh} y_{it-j} + \gamma_{2ih} e_{it-1} + \gamma_{3ih} e_{it+h} + \rho_{ih} R^*_{t-1} + \delta^1_{ih} t_i + \delta^2_{ih} t_i^2 + \alpha_i + \varepsilon_{it+h} \quad (1)$$

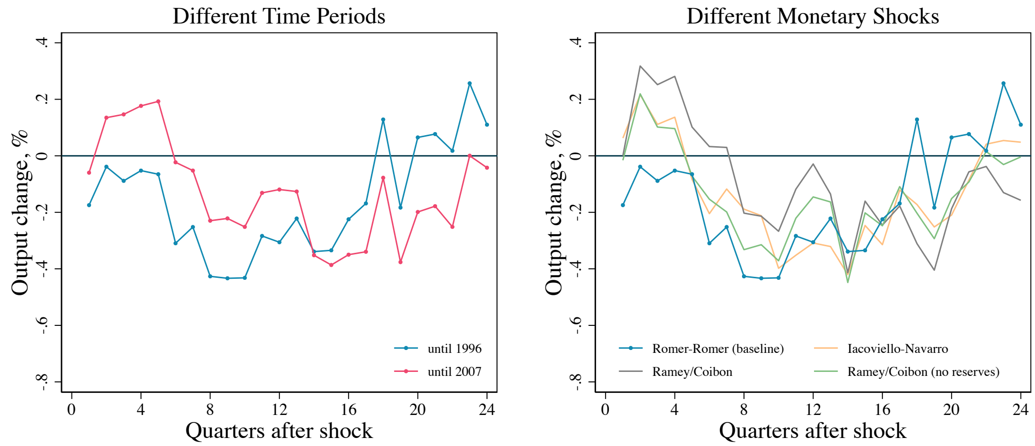
for $h = \{0, ..., H\}$, where, y_{it+h} is the real GDP in country i in quarter $t + h$ and u_t is the Romer-Romer monetary policy shock. The parameter of interest in this regression is β which estimates the effect of a monetary policy shock that increases the U.S. interest rate on the GDP of emerging countries. This specification also controls for the effect that real exchange rates of the emerging country with respect to the U.S. in the periods before the shock, $e_{i,t}$, has on output growth, as well as output in previous quarters. Parameters δ_j capture a linear and quadratic time trend. I allow these trends to be country-specific, as the different countries in my sample experienced different growth trends. Other controls included in the regression are lagged values of GDP, lagged value of the level of interest rate in the United States, R^*_{t-1}, as well as a country fixed effect captured by α_i.

Figure 1 shows the estimated coefficient $\widehat{\beta}_h$ for each quarter after the shock. The left panel shows the specification in (1) without real exchange rates and the right panel the same specification but adding exchange rates as a control. Dotted lines represent the confidence interval of one standard deviation, computed using the Driscoll and Kraay (1998) estimation that allows to control for heteroskedastic, autocorrelated and possibly correlated errors across countries. The drop in output in emerging countries after a shock that increases interest rates by 100 basis points is about 0.6 percent when exchange rates are not considered and 0.4 percent once we include real exchange rates in the estimation. The peak effect happens 8 quarters after the shock. The delay in the response to this type of shocks is standard in the literature. Note that the specification without exchange rates (left panel) shows an even larger delay in the response, possibly due to a delayed transmission on exchange rates themselves.[7]

Alternative specifications. The original series of monetary shocks developed by Romer and Romer (2004) goes up to 1996. This is the series that we use in the baseline specifications. More recently, Wieland and Yang (2020) extends this series to more recent dates using the same methodology. The left panel of Figure 2 compares results using the two series, where I consider periods up to 2007 to avoid the Great Recession period where interest rates where at the zero lower bound.

[7]Other papers in the literature have analyzed the spillover effects of U.S. monetary policy using different methods. See for instance: Banerjee et al. (2016), Canova (2005), Dedola et al. (2017), Iacoviello and Navarro (2019), and Maćkowiak (2007). The results shown here on the effect on output of an external shock align with those reported in the literature.

Figure 2: Output Response to US Interest Rates: Alternative Specifications



Notes: The left-panel of this figure shows the coefficient β_h from regression (1) computed for two different time periods: baseline (blue line) and extended time period until 2007 (red line). The right-panel compares the baseline (blue line) with alternative specifications as explained in the main text.

Results are very similar: it shows a similar fall in output of around 0.4%.

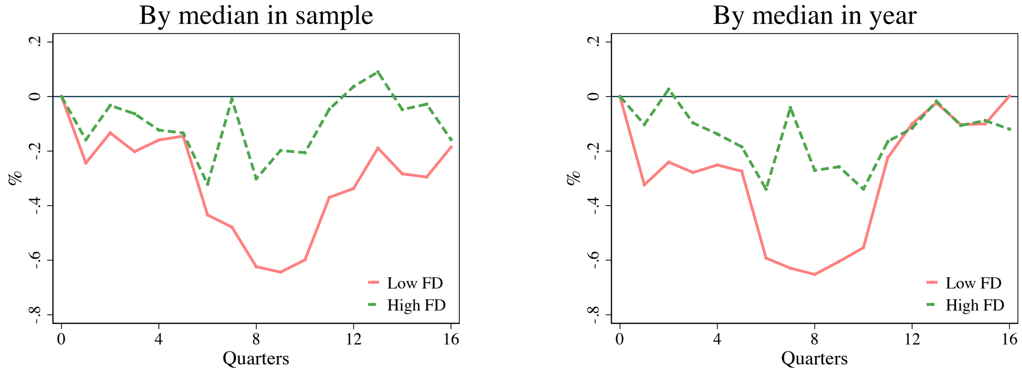
The right panel of Figure 2 compares the results of the baseline specification with those that result from using different monetary policy shocks. I assume that the US interest rate depends on output, inflation, and other real and nominal variables from the US economy, as in a Taylor rule specification, and consider the residuals from a regression on these variables the unexplained variation in the US interest rate, that is, a monetary policy shock. In particular, I estimate by OLS the following regression

$$r_t^{US} = \sum_{j=1}^{4} \beta_i^r r_{t-j}^{US} + \sum_{j=1}^{4} \beta_i^y y_{t-j}^{US} + \sum_{j=1}^{4} \beta_i^\pi \pi_{t-j}^{US} + \gamma X_{t-1} + u_t,$$

and consider $\hat{u}_t$ as the monetary policy shock that I then use in equation (1). The right panel of Figure 2 shows the results of using these shocks with different control variables included in X_t. Following Iacoviello and Navarro (2019), one of the specifications includes as controls corporate spreads in the US and a measure of the world GDP. I also consider the specification in Ramey (2016) and Coibion (2012) which includes as controls the unemployment rate, commodity prices, money and reserves. Finally, I also show results with the Ramey/Coibon set up excluding reserves from the regression. The baseline specification is similar to what one would obtain if using other shocks. Output response of emerging countries to a Romer and Romer monetary policy shocks lies in between of the response obtained by monetary shocks obtained from different Taylor rules specifications.

Other robustness exercises are provided in Appendix E.2, which includes robustness on the sample of countries considered (Latin American or East Asian countries). I also show that the drop

Figure 3: Output Response by Level of Financial Development



Notes: This figure shows the coefficient β_h from regression (1) computed for two different samples: observations for which the level of financial development is above the median (dashed green line) and those below the median (solid red line). The median used as threshold to divide observations is computed in the whole sample in the left-panel, and year by year in the right-panel.

in output is not driven by the Volcker period which was a time in which both the interest rates in the United States were high and many emerging countries experienced years of severe recessions (what is known as the *lost decade* in Latin America).

External vulnerability and financial development. The magnitude of the output drop after an increase in the U.S. interest rate varies with the level of financial development in the country. To see this, first I show the results of running the same regressions as in (1) but for two separate samples of observations: *high* and *low* financially developed. Another way of providing evidence on the difference in response by financial development is to add an interaction term in (1) between the monetary policy shock and the level of financial development. Both methods show the negative relationship between the level of financial development and vulnerability to external shocks.

First, observations are divided into two groups depending on their level of financial development. Here, I consider two possible classifications: 1) a country-year observation is high financial development if its level is above the median level in the sample, and low financial development otherwise, and 2) a country-year observation is high financial development if its level is above the median level in that year, and low financial development otherwise. Note that with these definitions a country might be low-financially developed is some years, but switch to high-financially developed in other years. The second definition takes into account that the level of financial development changes over time. Then, regression (1) is run separately in each of these groups, so that we obtain the response of output for high, $\widehat{\beta}^{\text{high}}$, and for low financially developed, $\widehat{\beta}^{\text{low}}$. Results are shown in Figure 3. When the country is low financially developed, output drops by more than 0.6 percent, but high financially developed ones are barely affected, with a drop in output of about 0.2 percent.

To further analyze the role of financial development, consider now the same local projections as in (1), but adding an interaction between the monetary policy shock and the financial development

Table 2: Output Response and Financial Development

	Interaction coefficient, γ_h					
Quarters after shock:	4	6	8	10	12	16
	0.008	0.012	0.018*	0.020**	0.022**	0.000
	(0.006)	(0.008)	(0.010)	(0.009)	(0.010)	(0.008)

Notes: Driscoll-Kraay standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01.

measure, that is,

$$
\begin{aligned}
y_{it+h} =& \beta_h u_t + \gamma_h u_t \times \mathrm{FD}_{it-1} + \sum_{j=1}^{4} \gamma_{1ijh} y_{it-j} + \gamma_{2ih} e_{it-1} + \gamma_{3ih} e_{it+h} + \rho_{ih} R^*_{t-1} \\
&+ \delta^1_{ih} t_i + \delta^2_{ih} t_i^2 + \alpha_i + \varepsilon_{it+h}, \qquad (2)
\end{aligned}
$$

where, FD_{it-1} is our measure of financial development. Therefore, our object of interest is the estimate $\hat{\gamma}_h$. If positive, it represents by how much an increase in the level of financial development mitigates the drop in output from an external monetary policy shock.

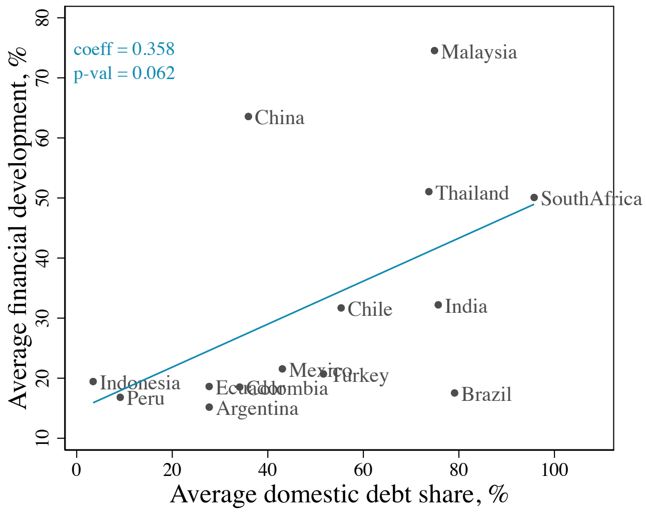
Table 2 shows the estimates for the coefficient on the interaction between financial development and the U.S. monetary policy shock, $\hat{\gamma}$. The coefficient is estimated to be positive and significantly different from zero. This implies that higher financial development decreases the output drop after an expansionary monetary policy shock in the United States. Appendix E.3 show that this finding is robust to the use of different samples, both relative to the countries and to the time periods considered in the analysis.

2.3 Financial development and sovereign debt composition

What makes less financially developed countries more vulnerable to interest rate shocks? I argue that it is their exposition to external debt that makes them more vulnerable, and here I show that, in fact, there is a strong positive relationship between the level of financial development of a country and its share of domestic debt. Figure 4 shows the relationship between average financial development and share of domestic debt across countries. There is a strong positive relationship between these variables, that is, countries with higher level of financial development tend to have on average higher shares of domestic debt. This positive relationship between financial development and domestic debt might be driven by many factors, such as level of income per capita or total amount of debt that these countries are able to issue. To control for these factors, I consider the following regression:

$$
\text{Domestic Debt}_{it} = \alpha_i + \delta_t + \beta \mathrm{FD}_{it-1} + \Gamma X_{it-1} + \varepsilon_{it} \qquad (3)
$$

Figure 4: Average Domestic Debt and Financial Development



where the dependent variable is the share of domestic debt in country i at time t, and the regressors include our main variable of interest, financial development measured as the ratio of liquid liabilities to GDP, lagged by one period to avoid endogeneity, and other regressors including the total amount of public debt and log GDP are also included in X_{it-1}. In this regression, I also allow for country and time fixed effects. Results are reported in Table 3 for countries in our sample. On average, an increase of 10 points in the ratio of liquid liabilities to GDP, that is, the measure of financial development, is associated with an increase in the share of domestic debt of around 4 percentage points. Moreover, this positive relationship is statistically significant.

As a summary, the main empirical finding of the paper is then that emerging countries suffer large output loses from international interest rate shocks, but especially so if they are less financially developed. Moreover, it is precisely the less financially developed countries the ones that tend to have higher shares of their government debt held by foreign creditors rather than domestic creditors. In the following section, I present a general equilibrium model that captures the main empirical findings, and is then used to analyze the decision of governments on their sovereign debt composition as well as the effect of a shock to international interest rates.

3 Model

I consider a small open economy model with infinitely lived consumers. The model incorporates a banking sector along the lines of Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) into a sovereign default model with discriminatory default on domestic and foreign debt. The economy is composed by a representative household whose members switch randomly between being workers and bankers, a representative firm, international creditors, and a government. Households

Table 3: Financial Development and Domestic Debt: Data

	(1)	(2)	(3)
Financial development	0.466***	0.487***	0.389***
	(0.070)	(0.078)	(0.088)
Total debt to GDP	-0.250***	-0.297***	-0.263***
	(0.059)	(0.035)	(0.043)
Log GDP per capita	0.754	-31.573***	-16.273***
	(1.581)	(3.399)	(5.956)
Country Effects	No	Yes	Yes
Year Effects	No	No	Yes
Observations	365	365	365

Notes: Driscoll-Kraay standard errors in parentheses.
*p<0.1, **p<0.05, ***p<0.01.

consume, and save by holding deposits at banks. Banks are the financial intermediaries in the economy: they use deposits from households to invest in capital and government domestic bonds, but they are constrained on how much they can invest. Firms use capital supplied by banks, and labor supplied by workers to produce a single good, and are subject to an aggregate productivity shock. The government finances a constant amount of public expenditures using taxes on labor income, and issuing domestic bonds that are bought by banks, and external bonds that are bought by international creditors. The government can decide whether to default on each type of debt separately.

Households. There is a representative household composed of a measure 1 of workers and a measure 1 of bankers. Households maximize their utility function over consumption, C_t, and labor L_t, and discount the future at rate β. Their preferences are

$$\sum_{t=0}^{\infty} \beta^t \left[C_t - v(L_t)\right]. \tag{4}$$

They can only save by using deposits at banks at price q_t^D, that is, they deposit $q_t^D D_{t+1}$ units today and get back D_{t+1} units tomorrow. A measure $1-\sigma$ of workers randomly become bankers every period. The household transfers $\bar{n}$ to these new bankers so that they can start their activity at the bank. Households receive dividends, X_t from existing banks, and maximize their utility by choosing how much to consume, C_t, how much to save in deposits, D_{t+1}, and how many hours to work, L_{t+1}, at wage w_t, subject to their budget constraint

$$C_t + q_t^D D_{t+1} \leq (1-\tau_t) w_t L_t + D_t + X_t - (1-\sigma)\bar{n}, \tag{5}$$

where τ_t is the labor income tax.

In order for the household to be willing to supply deposits to the bank it has to be that the price of deposits is at least as large as the rate at which they discount the future, so that, in equilibrium, it must be that $q_t^D = \beta$.[8] Moreover, households choose their supply of labor such that the following condition holds

$$v'(L_t) = (1 - \tau_t)w_t. \tag{6}$$

Banks. At the beginning of the period the aggregate productivity shock, z_t, is realized, and bankers collect returns from their last period investments. At this time, banks also receive a shock such that with probability $1-\sigma$ the banker will not continue its activity in the next period, and will return to the household as a worker, and with probability σ bankers continue their activity. When bankers receives the shock $1 - \sigma$, they will transfer all its net worth to the household. Notice that $1 - \sigma < 1$ is required because otherwise banks would build up enough net worth to make financial constraints not binding, and therefore, irrelevant. Every period, a measure $1 - \sigma$ of new bankers replace the exiting banks.

Bankers that survive, decide on their new investments by choosing investment in capital, k_{t+1}, with return R_{t+1}^K, and government bonds b_{t+1} at price q_t. Government bonds are long-term bonds, and it is assumed that payments on debt decay at a geomerical rate: a bank that buys b units of debt today will receive, in case of no default, λ units tomorrow, $\lambda(1 - \lambda)$ in two periods, $\lambda(1 - \lambda)^2$ in three periods, and so on. This follows the way of modeling long term debt as in Hatchondo and Martinez (2009), which keeps tractability as it does not require to keep track of the whole sequence of debt issued in each period: a bank that had b_t amounts of debt from previous period, today receives λb_t and buys $b_{t+1} - (1 - \lambda)b_t$ units, so that it starts period $t + 1$ with a claim on b_{t+1} units. The government can default in its debt, in which case it returns nothing to the bank. Let the government repayment decision on domestic debt be denoted by δ_t, which takes value 1 if it repays and 0 otherwise.

Let the value of an existing bank be denoted by $V_t^b(n_t)$, where n_t is the bank's current net worth, $n_t = R_t^K k_t + \delta_t \left[\lambda + (1 - \lambda)q_t\right] b_t - d_t$. Hence, current net worth is the sum of the returns on capital and the returns from government bonds, net of the payments to the household from their deposits, d_t. When a banker returns to the household, it transfers its current net worth to the household. Then, the objective of a bank is to maximize the value that it will transfer to the household. We can write the value of a bank as

$$V_t^b(n_t) = \max_{\{b_{s+1},k_{s+1},d_{s+1},x_s\}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t+1} \left[\sigma^{s-t} x_{t+s} + \sigma^{s-t}(1 - \sigma)n_{t+s}\right], \tag{7}$$

where x_t are the dividends that surviving banks can transfer to households every period. In equilibrium we can show that $x_t = 0$ in every period, so from now on we impose this equilibrium outcome.

[8] Here, I assume that households have linear utility in consumption for tractability. As it will be clear below, the incentives of the government to smooth consumption are given by its incentives to smooth tax distortions that affect the amount of labor supplied.

Surviving banks choose their capital investment, bond purchases, and how much to borrow from households using deposits, d_{t+1}, subject to their budget constraint

$$k_{t+1} + q_t b_{t+1} - q_t^D d_{t+1} \leq n_t. \tag{8}$$

The key financial constraint is a collateral constraint. Banks are constrained on how much they can borrow using deposits from households. In particular, they can not borrow more than a fraction θ of their current net worth, that is

$$q_t^D d_{t+1} \leq \theta n_t. \tag{9}$$

This constraint arises endogenously from an agency problem between banks and households, in which bankers can divert a fraction of its assets. Assume that the bank, after receiving the deposits from households can run away with a fraction $1/(1+\theta)$ of its total assets at that point, $n_t + q_t^D d_{t+1}$, which will return to its household, and start as a new banker with that given new net worth. In order for the banker to not have incentives to divert, it must be the case that $V_t^b(n_t) \geq V_t^b\left(\frac{1}{1+\theta}(n_t + q_t^D d_{t+1})\right)$. Given monotonicity of V_t^b, this implies $n_t \geq \frac{1}{1+\theta}(n_t + q_t^D d_{t+1})$, which gives rise to collateral constraint (9).

The problem for the bank in recursive formulation is then

$$V_t^b(n_t) = \max_{b_{t+1}, k_{t+1}, d_{t+1}} \mathbb{E}_t \beta \left[\sigma V_{t+1}^b(n_{t+1}) + (1-\sigma) n_t\right], \tag{10}$$

subject to the evolution of net worth,

$$n_{t+1} = R_{t+1}^K k_{t+1} + \delta_{t+1}\left[\lambda + (1-\lambda) q_t\right] b_{t+1} - d_{t+1}, \tag{11}$$

the budget constraint (8), and the collateral constraint (9).

Firms. Firms rent capital from banks at rate $R_{K,t}$, and demand labor from workers at price w_t. Following Neumeyer and Perri (2005), we assume that, within a period, firms need to borrow to pay for a fraction κ of workers wage, that is, they need to borrow working capital. Then, the problem of the firm is

$$\max_{K_t, L_t} z_t F(K_t, L_t) - R_{K,t} K_t - w_t L_t - r_t^* \kappa w_t L_t,$$

so the first order conditions are

$$R_{K,t} = z_t F_{K,t}(K_t, L_t)$$

$$w_t\left(1 + r_t^* \kappa\right) = z_t F_{L,t}(K_t, L_t).$$

I assume that the intra-period borrowing market is frictionless, and firms always repay at the end of the period. Moreover, the rate at which they borrow is given by the international interest rate, r_t^*. This assumption allows the model to capture a way in which the private sector is also directly affected by changes in the world interest rate, not only indirectly through its effect on the cost of borrowing of the government.[9]

International creditors. The government borrows from risk neutral international creditors whose one-period risk free rate is r_t^*. There are external shocks that can affect the interest rate on the world risk free asset, which is characterized by the following stochastic process:

$$r_t^* = (1-\rho_r)\mu_r + \rho_r r_{t-1}^* + \epsilon_{r,t} \qquad \text{where} \quad \epsilon_{rt} \sim \mathcal{N}(0,\sigma_r). \tag{12}$$

The problem of international creditors is to maximize their expected stream of discounted consumption, $\mathbb{E}_t \sum_{s=0}^{\infty} \beta^{t+s} c_{t+s}^*$ subject to

$$c_t^* + \frac{1}{R_t^*} a_{t+1}^* + q_t(b_{t+1}^* - (1-\lambda)b_t^*) = y + a_t^* + \lambda b_t^*,$$

where y is their income, a^* is the one-period international asset which is bought at price $1/R_t^*$ and returns one unit in the next period, where $R_t^* = 1 + r_t^*$ denotes the gross interest rate. It is is that the endowment y is large enough to cover all possible supply of bonds, that is, international creditors are assumed to have *deep pockets*.

In equilibrium, international creditors make zero profits. Therefore, the expected return on bonds has to be equal to the return on the international asset, that is:

$$\frac{\mathbb{E}_t\left[\delta_{t+1}^*(\lambda + (1-\lambda)q_{t+1}^*)\right]}{q_t^*} = R_t^*. \tag{13}$$

Government. The government starts each period with a given amount of outstanding external and domestic debt, $\{B^*, B\}$, on which it owes a fraction λ in current coupon payments. It can decide whether to repay each type of debt or to default on it, and it can do so in a discriminatory way. The difference between defaulting on domestic debt and defaulting on external debt comes from the fact that domestic debt is held by residents of the country: when the government defaults on domestic debt, it defaults on its own citizens. In order to emphasize this feature, I assume that all exogenous costs of defaulting on debt are identical between defaulting on domestic and external debt. The only difference comes from the endogenous effect that defaulting on domestic debt has on the economy. In particular, domestic default affects banks' investment decisions because it decreases their net worth, and therefore, it will affect total output in the country.

Defaulting on either debt implies the immediate exclusion from that credit market. Once the government is excluded from a given market, it can only regain access to it with probability γ every period. I refer to these periods as autarky periods, and, given that the government can

[9] In Section 6, I show that the main results hold when there is no working capital in the model, and therefore firms are not directly affected by fluctuations in the world interest rate.

default separately on domestic and external debt, there are three possible autarky states in which a country can be: domestic autarky, when it defaults on domestic debt, and has access only to external debt, external autarky, when it defaults on external debt, and has only access to domestic debt, and autarky in both markets, that is, when the government has defaulted on both debts, and has no access to borrowing. In all these autarky periods, the economy experiences an exogenous productivity loss, such that productivity in these periods is $h(z) \leq z$.

The government has to provide a constant amount of public goods G every period t, and it chooses labor income taxes, τ_t, and new debt to issue (if it has access to credit). Therefore, the government budget constraint when the country is not in autarky is

$$G + \delta_t \lambda B_t + \delta_t^* \lambda B_t^* = \tau_t w_t L_t + \delta_t q_t \left(B_{t+1} + (1-\lambda) B_t\right) + \delta_t^* q_{t+1} \left(B_{t+1}^* + (1-\lambda) B_t^*\right), \tag{14}$$

where, δ_t and δ_t^* are the current period default decisions on domestic and external debt respectively. When the country is in one of the three autarky states defined before, the budget constraint is similarly defined, but it does not include the market to which the country does not have access to.

The country-level budget constraint for the economy in normal times, defined before government default decisions, is

$$\begin{aligned} C_t + G_t + K_{t+1} - (1-\delta_K) K_t + \delta_t^* \left(\lambda B_t^* - q_{t+1} \left(B_{t+1}^* + (1-\lambda) B_t^*\right)\right) \\ = \quad \delta_t^* \delta_t z_t F(K_t, L_t) + (1 - \delta_t^* \delta_t)\, h(z_t) F(K_t, L_t) - \frac{r_t^*}{1+r_t^*} \kappa z_t F_L(K_t, L_t) L_t \end{aligned} \tag{15}$$

This constraint aggregates the budget constraint of households, banks, and the government, such that aggregate consumption in private and public goods and investment, plus net exports—measured as, payments to foreigners minus transfers from foreigners—must be equal to the production in the economy.[10] If the government defaults on either debt, production is affected by the default productivity cost, $h(z)$.

In this model the government has incentives to issue debt to smooth taxes over the cycle. When productivity is low, labor is reduced, and therefore, the tax revenues that government can get from taxing labor income at a given tax rate are low. That is, if there was no debt, the government would have to raise taxes significantly during downturns in order to finance its expenditures G. Given that taxes are distortionary, the government wants to avoid sharp increases in taxes, and thus, when productivity is low it prefers to issue debt instead, which it will repay during booms.

Competitive equilibrium

Let $S = (B^*, B, K, D, z, a, R^*)$ denote the aggregate state of the economy, where a is an indicator for the current financial state of the country, that is, $a = \{n, d, e, b\}$ indicates non-autarky,

[10] See Appendix B for the derivation of the country-level budget constraint.

domestic market autarky, external market autarky, and autarky in both markets, respectively. Given a government policy $\pi(S) = (\delta^*, \delta, B^{*\prime}, B', \tau)$, a competitive equilibrium is an allocation $Y(S, \pi) = (C, L, B^{*\prime}, B', K', D')$, households and banks' value function $V^h(d; S)$, $V^b(n; S)$, and pricing functions $P(S, \pi) = \left(q, q^*, q^D, R_K, w\right)$, such that

i. given prices and government policy, households' allocations, (C, l, d'), and value function, $V^h(d; S)$, solve the household problem,

ii. given prices and government policy, banks' allocations, (b', k', d'), and value function, $V^b(n; S)$, solve the bank problem,

iii. given prices and government policy, demand for capital, and labor, solve the firm problem,

iv. international lenders break-even condition is satisfied,

v. government policy satisfies the government budget constraint,

vi. allocation is feasible: it satisfies the country-level budget constraint.

Lemma 1: Characterization of the bank's problem

Banks value function is linear in net worth

$$V^b(n; S) = \nu(S)n$$

where

$$\nu(S) = \beta\mathbb{E}\left\{\left[1 - \sigma + \sigma\nu(S')\right]\left[(1+\theta)R_K(S') - \theta/q^D\right]\right\} \tag{16}$$

Moreover, banks prefer not to pay dividends, $x = 0$ if they continue as bankers. They only transfer their net worth to the household when they have to switch back to being workers. The proof for this lemma can be found in Appendix A and follows Gertler and Kiyotaki (2010). Intuitively, all the choices for banks enter linearly in the problem, due to linearity of the budget constraint and the collateral constraint in n. An implication of this lemma is that the aggregate state S does not need to include the measure over individual banks state variables.

The function $\nu(S)$ is then the marginal value of an additional unit of net worth at the bank. The intuition is the following: if the constraint binds, an extra unit of net worth increases deposits by θ/q^D and investment by $1+\theta$. The net return on this investment is then $R_K(S')(1+\theta) - \theta/q^D$, which is the second term in brackets in (16). When banks collect their returns from last period investment, with probability $1-\sigma$ they have to return to the household, and they give to their household their entire net worth. With probability σ they continue as bankers, and their value per unit of net worth is $\nu(S')$. Then, the effective discount rate of banks is $m(S') \equiv \beta\mathbb{E}\left(1 - \sigma + \sigma\nu(S')\right)$, which is the first term in brackets in equation (16).

I now characterize the set of allocations that constitute a competitive equilibrium. Define the productivity in the economy as a function of the current autarky state of the economy as $\tilde{z}(S) = z$ if $\delta(S) = \delta^*(S) = 1$ and $a = n$, that is, normal times, and $\tilde{z} = h(z)$ otherwise. Also, for notation convenience, let $\delta(\cdot, a = \{d, b\}) = 0$ and $\delta^*(\cdot, a = \{e, b\}) = 0$, which just indicates that there is no repayment of debt if the government is already in an autarky situation for that type of market.

From the bank's first order condition, and substituting the R_K from the firm problem, the schedule of prices that the government offers to the bank must be such that for any choices $A' \equiv (B^{*\prime}, B', K', D')$ and given current productivity, z, and autarky state, a, banks' expected value of the return on bonds must be equal to the expected value of the marginal product of capital:

$$\frac{\mathbb{E}\left[m(S')\delta(S')(\lambda + (1-\lambda)q(A''; S'))\big|S\right]}{q(A'; S)} = \mathbb{E}\left[m(S')R^K(S')\big|S\right] \tag{17}$$

where $m(S') = \beta\mathbb{E}\left(1 - \sigma + \sigma\nu(S')\right)$, and $R^K(S) = \tilde{z}(S)F_K(S) + 1 - \delta_K$.

That is, for banks to be willing to hold government debt they have to be indifferent between investing in bonds and in capital. Notice from this condition that the interest rate that the government has to offer to banks is positively related with the returns that they get from investing in capital. Therefore, in periods when returns on capital are high, it is more costly for the government to borrow from banks.

Given that the value of a unit of net worth at the bank is always higher than the value of that unit for the households, banks always borrow to the maximum from households, that is, $q^D D' = \theta N$. Then, aggregating budget constraints of newborn and continuing banks, and substituting the binding collateral constraint, we get that the aggregate budget constraint of the bank is:

$$K' + \delta(S)q(S)B' = (1+\theta)\left[\sigma\left(\tilde{z}(S)F_K(S)K + (1-\delta_K)K + \delta(S)B - D\right) + (1-\sigma)\overline{n}\right] \tag{18}$$

International creditors break-even condition implies that the bond price schedule that the government offers is such that

$$\frac{\mathbb{E}\left[\delta^*(S')\left(\lambda + (1-\lambda)q^*(A''; S')\right)\big|S\right]}{q^*(A'; S)} = R^* \tag{19}$$

Finally, from the labor supply condition of workers, we can write total tax revenues of the government as $T(S) = \left(\tilde{z}(S)F_L(S) - v'(L)\right)L$. Therefore, substituting this condition in the government budget constraint we get:

$$\begin{aligned}&\delta(S)q(S)(B' - (1-\lambda)B) + \delta^*(S)q^*(S)(B^{*\prime} - (1-\lambda)B)\\ &\quad= G + \delta(S)\lambda B + \delta^*(S)\lambda B^* - \left(\tilde{z}(S)F_L(S) - v'(L)\right)L\end{aligned} \tag{20}$$

We refer to the resource constraint (15) together with constraints (17)—(20) as the implementability constraints.

Lemma 2: Characterization of competitive equilibrium

An allocation $Y = (C, L, B^{*\prime}, B', K', D')$ constitute a competitive equilibrium if and only if it satisfies the implementability constraints.

Given that the implementability constraints were derived using the equilibrium conditions of banks, households, and firms, and that they satisfy the government, bank, and country-level budget constraints, it is immediate that if Y is a competitive equilibrium then it has to satisfy the implementability constraints. To proof sufficiency we can construct taxes such that $\tau = 1 - v'(L)/zF_L$, and prices, $w = zF_L$, $R_K = zF_K + 1 - \delta_K$, $q_D = \beta$, so if Y satisfies the implementability constraints, then Y is part of the competitive equilibrium for these prices and tax rate.

Markov equilibrium

A recursive Markov equilibrium is policy functions $\pi(S; a) = (\delta, \delta^*, B^{*\prime}, B', \tau)$, a set of allocation rules $Y(S, \pi; a) = (C, L, B^{*\prime}, B', K', D')$, and pricing functions $q(S, \pi; a)$, $q^*(S, \pi; a)$ such that

i. the associated outcomes constitute a competitive equilibrium for all S and π, and autarky state a,

ii. given S, and taking as given future policy functions, allocation rules, and pricing rules, the current policy $\pi(S; a)$ is optimal for the government

Let $V(S)$ be the value function of the government when the country is not in autarky, and let $W_a(S_a)$ be the value when it is in one of the three possible autarky states, $a = \{d, e, b\}$. The *primal Markov problem* is to choose current allocations $Y = (C, L, B^{*\prime}, B', K', D')$, and current policies δ, δ^*, taking as given future policy functions $\delta(S')$,$\delta^*(S')$, pricing functions $q(S')$, value function of the bank, $\nu(S')$, and value functions of the government, $V(S'), W_a(S'_a)$, with the objective of maximizing utility of the representative household. That is, the value of the government in normal times is

$$V(S) = \max_{Y,\delta,\delta^*} \Big\{ C + v(L) + \beta \mathbb{E}\left[\delta\delta^* V(S') + \delta(1-\delta^*)W_e(S') + (1-\delta)\delta^* W_d(S') + (1-\delta)(1-\delta^*)W_b(S')\right] \Big\} \tag{21}$$

subject to the implementability constraints (15), (17)–(20) conditional on $a = n$.[11] When the country is in domestic or external autarky it can only issue and default on one type of debt. Let δ_a denote the relevant default decision for each type of autarky state. Then, the value of the

[11]To solve the model computationally, it is assumed that the government receives every period idiosyncratic preference shocks on the amount of borrowing $(B^{*\prime}, B')$ that it chooses. This assumption is standard in the sovereign debt with long term bonds literature as is made in order to facilitate the convergence and computation of the model. For simplicity of exposition, here I present the model without such shocks. The details of the model with preference shocks can be found in Appendix D.

government in either external autarky or domestic autarky, $a = \{d, e\}$, is

$$W_a(S) = \max_{Y,\delta_a} \Big\{ C + v(L) \tag{22}$$

$$+ \beta \mathbb{E} \left[\delta_a \left(\gamma V(S') + (1-\gamma) W_a(S') \right) + (1-\delta_a) W_b(S') \right] \Big\} \tag{23}$$

subject to the implementability constraints, where, γ is the probability of exiting the autarky state. Finally, when the government is in complete autarky, there are no default or debt issuing decisions, so the problem for the government is

$$W_b(S) = \max_{Y,\delta_a} \Big\{ C + v(L) + \beta \mathbb{E} \left[\gamma V(S') + (1-\gamma) W_b(S') \right] \Big\} \tag{24}$$

subject to the implementability constraints.

4 Model forces

Before turning to the quantitative results, it is useful to explain here the main forces in the model that determine the composition of sovereign debt, and the effect on output of an increase in the international interest rate.

4.1 Sovereign debt composition

In the decision of what type of debt to issue, the government balances the costs and benefits of domestic debt relative to external debt. On one hand, the main cost of issuing domestic debt is that it crowds out investment in capital. On the other hand, the relative benefit of domestic debt is that, due to lower ex-post default incentives, it becomes relatively cheaper than external debt, especially in bad times. This generates a trade-off for the government between domestic and external debt, which I illustrate in this section using the government first-order conditions.

When choosing how much to borrow, the government equates the revenues of issuing an additional unit of each type of debt to the costs. As in standard models of external sovereign debt, the benefit of an additional unit of debt is that it increases the revenues for the government by $\partial(q^* B^{*\prime})/\partial B^{*\prime}$ units, and thus relaxes its budget constraint. The cost of issuing an additional unit of debt is that it has to be repaid in the future, and therefore tightens the future government budget constraint. In addition to these standard effects of borrowing, in this model there are two factors that must be taken into account. First, an increase in one type of debt affects the price of the alternative debt. That is, increasing external debt results in a higher external default probability and so decreases its price, but it also generally increases the probability of defaulting on domestic debt, so it also decreases the price of domestic debt. Therefore, there is a *cross-price effect* given by $\partial q/\partial B^{*\prime}$, in the case of external borrowing. Using a similar logic, an increase in domestic debt changes the price of external debt by $\partial q^*/\partial B'$. The second additional factor that has to be taken into account, is that because in this economy there are domestic financial intermediaries holding government bonds, changes in borrowing will affect the investment decisions in capital. In the case of domestic debt, these investment decisions will be directly affected, generating a crowding out effect, and indirectly in the case of external borrowing, through the cross-price effect $\partial q/\partial B^{*\prime}$.

To simplify the exposition of the government first order conditions, the case with one-period debt, $\lambda = 1$, full capital depreciation, $\delta_K = 1$, and no working capital, $\kappa = 0$, is considered here. Consider the problem of the government when it is not in autarky as in (21),

$$V^R(S) = \max zF(K, L) + q^* B^{*\prime} - G - K' - B^* + v(L) + \beta\mathbb{E}\left\{\tilde{\delta}(S')V^R(S') + \Gamma^D(S')\right\}$$

subject to

$$\begin{aligned} \mu: &\quad G + B + B^* - qB' - q^*B^{*\prime} - \hat{T}(L)L \leq 0 \\ \rho: &\quad K' + qB' - \sigma\left(zF_K K + B - D\right) - \beta D' - (1-\sigma)\bar{n} \leq 0 \\ \eta: &\quad \beta D' - \theta\sigma\left(zF_K K + B - D\right) - \theta(1-\sigma)\bar{n} \leq 0 \end{aligned}$$

and the pricing equations, where $\hat{T} = F_L - v'(L)$ is the tax revenue per unit of labor. Let μ, ρ, and η be the Lagrange multipliers with respect to the government budget constraint, the banks budget constraint, and the banks collateral constraint, respectively, where the aggregate net worth of the banks is substituted. Assuming that the price functions, q and q^*, are differentiable, and letting $\tilde{\delta}=\delta\delta^*$ denote the joint repayment of both types of debt, the first-order conditions of the government with respect to external and domestic borrowing are

$$\underbrace{\mu\left[q^* + \frac{\partial q^*}{\partial B^{*\prime}}B^{*\prime} + \frac{\partial q}{\partial B^{*\prime}}B'\right] + q^* + \frac{\partial q^*}{\partial B^{*\prime}}B^{*\prime}}_{\text{revenue effect}} = \underbrace{\beta\mathbb{E}\left[\tilde{\delta}'\left(\mu'+1\right)\right]}_{\text{repayment effect}} + \underbrace{\rho\frac{\partial q}{\partial B^{*\prime}}B'}_{\text{investment effect}} + X^* \tag{25}$$

$$\underbrace{\mu\left[q + \frac{\partial q}{\partial B'}B' + \frac{\partial q^*}{\partial B'}B^{*\prime}\right] + \frac{\partial q^*}{\partial B'}B^{*\prime}}_{\text{revenue effect}} = \underbrace{\beta\mathbb{E}\left[\tilde{\delta}'\left(\mu - \sigma\left(\rho' + \theta\eta'\right)\right)\right]}_{\text{repayment effect}} + \underbrace{\rho\left(q + \frac{\partial q}{\partial B'}B'\right)}_{\text{investment effect}} + X \tag{26}$$

where X^* and X capture additional terms corresponding to the non-repayment continuation value for the government.[12]

We can classify the terms in both of the first-order conditions in three groups: a revenue effect, a repayment effect, and an investment effect of increasing borrowing. On the left hand side, there is the revenue effect from borrowing today, which comes from increasing a relaxation of the budget constraint, μ, and an increase in consumption. The first term reflects that each additional unit of borrowing increases resources by $\partial(qB'+q^*B^{*\prime})/\partial B^{*\prime}$ if external, and $\partial(qB'+q^*B^{*\prime})/\partial B'$ if domestic borrowing, and so the government budget constraint is relaxed, as captured by the term multiplying

[12]Details about the derivation of this problem and the equations that solve μ, ρ, and η can be found in Appendix C.

μ. Thus, lower taxes are possible, which in turn have a positive effect on today's output. In the case of external debt, issuing debt has a direct positive effect on consumption due to additional external resources, $\partial(q^*B^{*\prime})/\partial B^{*\prime}$, coming into the economy from abroad, whereas this effect is only indirect through the change in external prices from increasing domestic debt $\partial(q^*B^{*\prime})/\partial B'$. This is captured by the second terms outside the brackets on the revenue effect.

Then, the government equates this marginal revenue from borrowing to the marginal cost from repaying tomorrow and from a change in the investment in capital, that is, the right hand side of equations (25) and (26). Both, repayment of external and domestic debt, suppose a tightening on tomorrow's government budget constraint, μ'. Moreover, external debt is repaid to external creditors, and therefore implies a direct decrease in consumption due to resources flowing out of the economy, whereas domestic debt is repaid to domestic banks, which increases their net worth. These terms correspond to what is labeled as repayment effect. Finally, increasing borrowing has an investment effect, which is captured by the term $\rho\frac{\partial q}{\partial B^{*\prime}}B'$ in the case of external debt, and $\rho\left(q + \frac{\partial q}{\partial B'}B'\right)$ in the case of domestic debt. This corresponds to an important distinction between external and domestic debt, that will be analyzed below.

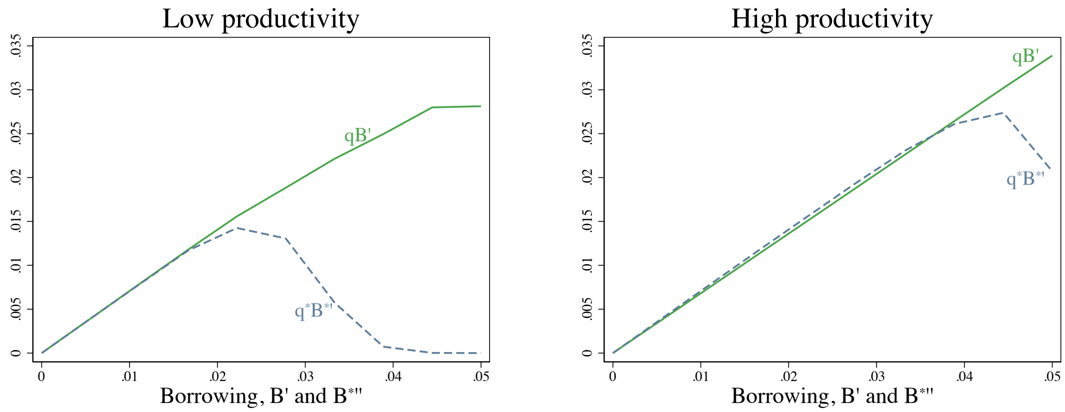
There are two main differences in the first order conditions (25) and (26) that affect the composition of debt. First, the sensitivity of prices to an increase in debt, $\partial q^*/\partial B^{*\prime}$ and $\partial q/\partial B'$, is in general higher for external debt than for domestic debt. This corresponds to the relative benefit of domestic debt. Second, the effect on capital from increasing debt is positive for external borrowing and negative for domestic borrowing. This represents the relative costs of domestic debt. Importantly, these differences depend on the business cycle, as they are affected by the current productivity in the economy. I analyze these differences in detail in what follows.

Benefit of domestic debt. Consider first the sensitivity of each debt price to changes in the amount of borrowing. This effect is mainly captured by changes in the default probability on that debt. When the government defaults on external debt, the only costs that it faces are the exogenous decrease in productivity and autarky from external markets for an exogenous amount of time. When the government defaults on domestic debt, it faces an additional cost because it defaults on its own domestic banks. In particular, aggregate banks net worth is given by

$$N = \sigma\left[zF_K(K,L) + \delta B - D\right] + (1-\sigma)\bar{n}, \tag{27}$$

so, upon default, net worth decreases by σ, which is the survival rate of banks. This additional endogenous effect is not present when defaulting in external debt, and thus makes the government more reluctant to default on domestic than on external debt, which in turn makes the price of domestic debt less sensitive than the external debt price for the same amount of debt. This implies that for similar levels of prices, q and q^*, the increase in available resources from an increase in domestic debt is in general bigger than from an increase in external debt. This effect can be seen in Figure 5, which plots the total resources obtained qB' and $q^*B^{*\prime}$ from borrowing B' and $B^{*\prime}$ units

Figure 5: Laffer Curve for Borrowing



Notes: This figure plots qB' (solid green line) and $q^*B^{*\prime}$ from the numerical solution of the model explained in Section 5. The values q and q^* are for a chosen asset state space, $(B^{*\prime}, B', K', D')$, the interest rate R^* is set to 1, and productivity z is set to be below the mean in the left-panel, and above the mean in the right-panel.

of bonds respectively, that is, the Laffer curve for borrowing on each type of debt. This figure uses the numerical results obtained in the quantitative analysis of the model that will be shown below. As external borrowing increases, $q^*B^{*\prime}$ quickly decreases, especially in periods of low productivity, z (left panel). But, the decrease in total resources obtained from borrowing domestically, qB' decreases at a much lower rate when domestic borrowing increases.

These differences between domestic and external borrowing are captured in the first order conditions by the first term in the revenue effect in (25) and (26). In particular, the relative marginal revenue of external debt can be written as

$$\text{Relative marginal revenue} = \frac{\mu\left(q^* + \frac{\partial q^*}{\partial B^{*\prime}}B^{*\prime} + \frac{\partial q}{\partial B^{*\prime}}B'\right) + \frac{\partial q^*}{\partial B^{*\prime}}B^{*\prime} + q^*}{\mu\left(q + \frac{\partial q}{\partial B'}B' + \frac{\partial q^*}{\partial B'}B^{*\prime}\right) + \frac{\partial q^*}{\partial B'}B^{*\prime}}. \tag{28}$$

Due to the higher sensitivity of external debt prices to increases in debt, the increase in the amount of resources, $q^* + \partial q^*/\partial B^{*\prime}$, is lower for external than for domestic debt, and so the relative marginal gain decreases for high levels of external debt.

Cost of domestic debt. The second main difference between the decision of domestic and external borrowing comes from the *investment effect*: domestic debt crowds out investment, and external debt has, in general, a positive effect on investment. Both of these effects can be understood from the aggregate banks budget constraint:

$$K' = (1+\theta)N - qB'. \tag{29}$$

Domestic debt is held by domestic banks, so increasing B' directly decreases the resources available to the bank to invest in capital. The effect of external borrowing on investment is given through the cross-price effect: increasing external debt generally decreases the price of domestic bonds, $\partial q/\partial B^{*\prime} < 0$, due to a higher probability of defaulting. Therefore, for a given amount of domestic debt, it increases the resources available to the bank to invest in capital.

In the first order conditions (25) and (26) these effects are captured by the term $\rho \frac{\partial q}{\partial B^{*\prime}} B'$ for external borrowing, and $\rho \left(q + \frac{\partial q}{\partial B'} B' \right)$ for domestic borrowing, where ρ is the multiplier on the banks budget constraint. Then, ρ captures the positive effect of capital investment in the economy, and mainly represents the increase in output in future periods due to an increase in future capital.[13] Importantly, the sign of these effects are different for external and domestic debt: an increase in external borrowing increases investment in capital by $-\frac{\partial q}{\partial B^{*\prime}} B'$, which in general is positive, reflecting that more external debt tends to increase the default probability on both types of debt. In the case of domestic borrowing it changes investment by $-q - \frac{\partial q}{\partial B'} B'$, which is negative, that is, it crowds out investment in capital.

Cyclicality of domestic debt. Another important factor that determines the composition of debt is the current productivity level in the economy: when productivity is low, the share of domestic debt increases. This is because when productivity is low expected returns to capital, R_K, are also low. Therefore, first, the price of domestic debt (aside from default risk) is higher as banks incentives to invest in capital decrease, and second, the cost of crowding out capital is lower, as the increase in output from using capital is lower when productivity is low, making then domestic debt more attractive. Moreover, in low productivity periods the incentives to default in external debt increase (relatively more than for domestic debt) which decreases, therefore, the price of external debt. These two factors, more incentives to issue domestic debt and higher default risk on external debt during periods of low productivity, is what makes the share of domestic debt to be countercyclical.

4.2 The effects of a shock to the interest rate

An increase in the international interest rate, increases the cost of borrowing externally. Here, I provide intuition on how the increase in the cost of borrowing translates into a decrease in output, and how the government substitutes the relatively costlier external debt with higher taxes or higher domestic debt to mitigate the drop in output.

Consider the case where the government only has access to external debt and bonds are one-period bonds. Intuitively, the increase in interest rates increases the cost of borrowing externally. To cover its expenditures, the government must then increase taxes which has a negative impact on today's output and banks net worth. The negative effect on banks net worth makes the output drop persistent. To see this, notice that the government budget constraint under repayment is given by $g + B^* - q^* B^{*\prime} = T(L)$, where $T(L) = (zF_L - v'(L))L$ are total tax revenues. Suppose first that after the increase in R^* the government decides not to change its external borrowing $B^{*\prime}$. Then,

[13] In particular, $\rho = \frac{\partial q^*}{\partial K'} B^{*\prime} - 1 + \beta \mathbb{E} \left[z' F'_K + \mu' \hat{T}'_K L' + [\rho' + \theta \eta'] \, \sigma z' \left(F'_{KK} K' + F'_K \right) \right] + \mu \left(\frac{\partial q^*}{\partial K'} B^{*\prime} + \frac{\partial q}{\partial K'} B' \right)$, where $\hat{T}$ are tax revenues per unit of labor.

an increase in the international interest rate implies that for the same amount of debt issued, the government gets a lower amount of resources $q^* B^{*\prime}$, and therefore has to increase tax revenues in order to make its payments $g + B^*$. The total effect on labor is then,

$$\frac{\partial L}{\partial R^*} = -\frac{\partial q^*}{\partial R^*} B^{*\prime} \left[\left(zF_{LL} - v''(L) \right) L + T(L)/L \right]^{-1} < 0. \tag{30}$$

The first term $\partial q^* / \partial R^* B^{*\prime}$ represents the change in total external resources from increasing R^*. As can be seen from the external creditors pricing equation (13), the change in prices due to an increase in the interest rate captures both, the direct decrease in q^* from the better outside option of external creditors, and from a change in the probability of default. The second term in square brackets represents how much total tax revenues decrease given an increase in labor, $\partial T / \partial L < 0$.

Then the effect on output after an increase in R^* is given by $zF_L \partial L / \partial R^*$. After the initial impact on output, the effect carries on to future periods through the net worth of banks. This is because the decrease in labor affects negatively the returns on capital, and hence decreases the total net worth of banks. This implies that banks have fewer resources to invest in capital, so capital available to produce in future periods decreases, and so does output. This example illustrates how the increase in interest rates is propagated to output in emerging countries, but it is an extreme case where the government does not optimally change its decision on how much to borrow externally, so $B^{*\prime}$ is fixed. In equilibrium, the government will prefer to lower the amount of external debt due to its higher costs, up to the point where it equates the marginal gain of external debt to its marginal cost of repaying it.

In fact, domestic debt can mitigate the drop in output after an increase in external interest rates. To avoid the output cost of increasing taxes as seen in equation (30), the government can substitute external debt for domestic debt if the crowding out cost of domestic debt is not larger than the higher costs of borrowing externally. This can be seen from the relative marginal gain of issuing external debt in equation (28). In equilibrium, the government equates the relative marginal gain of external debt to the relative marginal cost of repayment net of the effect on capital, that is, the right hand side of (25) relative to the right hand side of (26). These forces are analyzed quantitatively in the following section.

5 Quantitative Analysis

This section presents the numerical solution of the model in which data on a sample of emerging countries is used to set the parameters of the model. The numerical solution is then used to evaluate the predictions of the model regarding the effects of shocks to the international interest rate on emerging countries, the role of sovereign debt composition, and the patterns of default. Appendix D contains the details on the computational algorithm used to solve the equilibrium.

Table 4: Parameter Values

Assigned parameters		Source
Average world risk free rate	$\mu_R = 0.017$	Average US interest rate (quarterly rate)
Risk free rate autocorrelation	$\rho_R = 0.955$	AR(1) on US interest rate
Risk free rate standard dev.	$\sigma_R = 0.003$	AR(1) on US interest rate
Productivity autocorrelation	$\rho_z = 0.95$	Neumeyer and Perri (2005)
Capital share	$\alpha = 0.3$	Standard capital share
Capital depreciation	$\delta_K = 0.05$	Standard capital depreciation
Debt decay rate	$\lambda = 0.05$	Average maturity
Autarky duration	$\gamma = 0.063$	Gelos et al. (2011)
Inverse Frisch elasticity	$\phi = 0.5$	Keane and Rogerson (2012)
Working capital	$\kappa = 0.26$	Neumeyer and Perri (2005)

Parameters from matching moments		Moment matched
Discount factor	$\beta = 0.986$	Default probability
Banks survival rate	$\sigma = 0.92$	Deposits to GDP
Collateral constraint	$\theta = 0.46$	Share of domestic debt
Banks initial net worth	$\bar{n} = 0.70$	Returns on equity
Gov. expenditures	$G = 0.035$	Government expenditures to GDP
Disutility of working	$\xi = 2.15$	Hours worked
Productivity standard dev.	$\sigma_z = 0.009$	Volatility of GDP
Productivity cost of default	$\zeta_0 = -0.182$	Debt to GDP
Productivity cost of default	$\zeta_1 = 0.195$	Mean spread

5.1 Parameterization

A period in the model is one quarter. I assume that the disutility of working for households takes the following form: $v(L) = \xi \frac{L^{1+\phi}}{1+\phi}$, where ϕ is the inverse of the Frisch elasticity, and the production function is Cobb-Douglas, $F(K, L) = K^\alpha L^{1-\alpha}$ where α is the capital share of production. When the economy is in autarky, productivity becomes $h(z) < z$. As standard in the literature literature on sovereign defaults, I assume that this productivity cost is nonlinear and is higher for high realizations of z. Specifically, following Chatterjee and Eyigungor (2012), I assume $h(z) = z - \max\{\zeta_0 z + \zeta_1 z^2, 0\}$, with $\zeta_0 < 0$ and $\zeta_1 > 0$, which implies that defaulting is relatively more costly at higher levels of productivity.

Assigned parameters. The parameters used in the baseline model are reported in Table 4. Some parameters, $\Theta_1 = \{\mu_R, \rho_R, \sigma_R, \rho_z, \alpha, \delta_K, \lambda, \gamma, \phi, \kappa\}$ are taken directly from the data or from the literature, and the rest of parameters are set using a moment matching procedure so that the model is able to reproduce crucial targets in the data. Most of the parameters assigned from the data or literature are standard. For the parameters regarding the international interest rate process (12) I estimate an AR(1) process using data on the U.S. Federal Funds rate. The process is persistent, with an autocorrelation $\rho_R = 0.955$, and standard deviation of the error term is $\sigma_R = 0.003$. As for the productivity process, I follow the same strategy as in Neumeyer and Perri (2005). Due to lack of available data, it is not possible to construct a reliable series of productivity from Solow residual. Then, fix the autocorrelation parameter ρ_z to 0.95 as in the U.S. data, and choose σ_z so as to match the average volatility of the HP-filtered log output in the countries in the sample, which is 3.08%. Regarding the production technology of firms, the capital share is set to 0.3 and the depreciation rate of capital to 0.05. The parameter λ refers to the debt decay rate, which is set to match an average maturity of 4 years. This is in line with the standard maturity used in the literature (see Chatterjee and Eyigungor, 2012). The period of autarky after default is assumed to last on average almost 4 years, to match the estimates in Gelos et al. (2011). Finally, The Frisch elasticity is set equal to 2, so $\phi = 0.5$, which is in the range of the macroeconomic estimates (see for instance Keane and Rogerson, 2012).

Parameters from moment matching. The remaining eight parameters from the model, $\Theta_2 = \{\beta, \sigma, \theta, \bar{n}, G, \xi, \sigma_z, \zeta\}$, are set to match eight moments from the data. Some of them are standard in the sovereign default literature: average default probability, total debt to GDP, and average spread on external debt.[14] To assign the value of government expenditures, G, I target the average government expenditures to GDP in the data, and for the disutility of working, ξ, I target the average total hours worked. Three parameters are left that are related to the banks problem, $\theta, \sigma, \bar{n}$. The fraction of net worth that the banks can borrow from households, θ, is directly related to the amount of deposits or, more broadly liquidity, in the economy. For this reason, I use the average ratio of liquid liabilities to GDP as a target. The remaining two parameters are the survival rate of banks, σ, and the net worth transferred from households to newborn banks, $\bar{n}$. To set these parameters, I use two moments: the share of domestic debt over total debt, and the average return on equity for banks. Intuitively, the average duration of banks affects the decision of the government on how much domestic debt to issue, as repayment of the debt will last for longer at the bank, and will allow for higher accumulation of capital. The initial net worth at the bank, $\bar{n}$, affects the overall resources of banks and therefore the total capital in the economy, which in turn affects the returns to capital. With this calibration, the value of θ is then set to 0.46, which means that, if the bank were to run away with the deposits of the households, it will get a fraction of 0.68 of its current net worth, that is, $1/(1+\theta)$. The value of σ is set to 0.92, that is, banks survive on average 12.5 years.

Results in the baseline economy. Table 5 compares the targeted moments in the data and in the model. Overall the model can reproduce the main features of the data.

Next, I show the trade-off of the government between the benefit of domestic debt, that is, its lower default risk, and the cost of domestic debt, that is its crowding out effect on investment,

[14] The average default probability is computed using the default events documented in Reinhart and Rogoff (2011). I compute average default probability for each country in the sample (including countries that never defaulted), and take the average across developing countries.

Table 5: Model Fit

	Data	Model
Default probability, annual %	4.51	1.05
Debt to GDP, %	32.5	30.9
Deposits to GDP	0.32	0.33
Share of domestic debt	0.54	0.52
Return on equity, %	12.5	16.5
Government expenditures to GDP	0.14	0.13
Hours worked	0.22	0.22
Output volatility	3.08	3.11
Mean spread	2.45	1.55

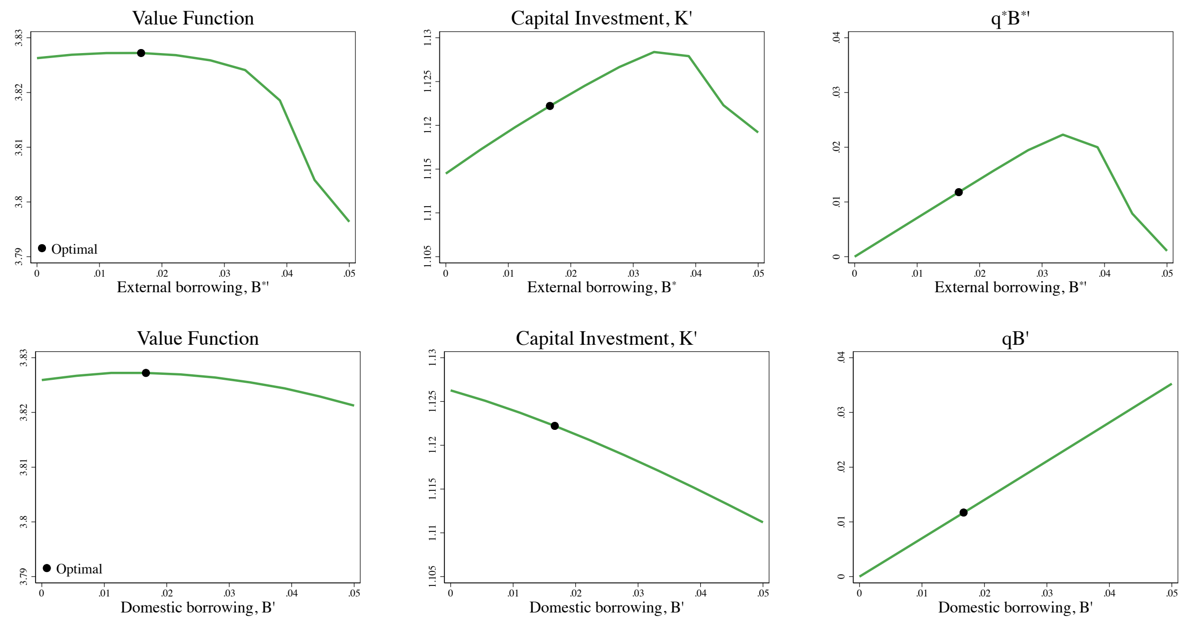
in the calibrated model. Let the value for the government of choosing a given combination of external and domestic borrowing $(B^{*\prime}, B^{\prime})$ be denoted by $\tilde{V}(S; B^{*\prime}, B^{\prime})$, such that, the problem for the government is $V(S; B^{*\prime}, B^{\prime}) = \max_{B^{*\prime}, B^{\prime}} \tilde{V}(S; B^{*\prime}, B^{\prime})$. Figure 6 shows these values as a function of $B^{*\prime}$ (top panels), and $B^{\prime}$ (bottom panels) together with the implied capital investment in the economy, and total resources from debt that the government obtains from borrowing such quantities. The optimal decision is indicated in the plots with a black dot. For the chosen level of the state of the economy, S, the optimal amount of domestic and external borrowing is the same, such that, $B^{\prime} = B^{*\prime} = 0.016$.

The crowding out cost of domestic debt can be seen in the middle panels of Figure 6: as the government increases domestic debt the amount of capital available for next period $K^{\prime}$ decreases. This is the opposite in the case of external debt: increasing external borrowing increases future capital, except for too high values of debt which are never optimal for the government.[15] This is why the value for the government of issuing more domestic debt sharply decreases for high amounts of domestic debt even if $qB^{\prime}$, that is, the revenue from borrowing more, does not decrease. On the other hand, the relative benefit of domestic debt can be seen precisely from the difference in the total amount of resources that the government gets from borrowing domestically, qB, and externally, $q^{*}B^{*\prime}$. External prices are more sensitive to an increase in borrowing than domestic borrowing, as default risk increases more rapidly. As a consequence, the slope of $q^{*}B^{*\prime}$ starts decreasing for low amounts of external borrowing. This contrasts with the slope of $qB^{\prime}$, which is always increasing in the amount of domestic borrowing. Therefore, as the amount of external borrowing increases the relative marginal revenue defined in equation (28) starts decreasing.

To explain the difference in the sensitivity of prices to changes in borrowing, Figure 7 plots the default decisions of the government as a function of (B, B^{*}). Defaulting on domestic involves an additional endogenous cost because it directly decreases the net worth of domestic banks, as can

[15] Note that the government will never optimally choose to borrow on the decreasing side of the Laffer curve of $q^{*}B^{*\prime}$, as it can get the same amount of resources by borrowing less, as shown in Arellano (2008).

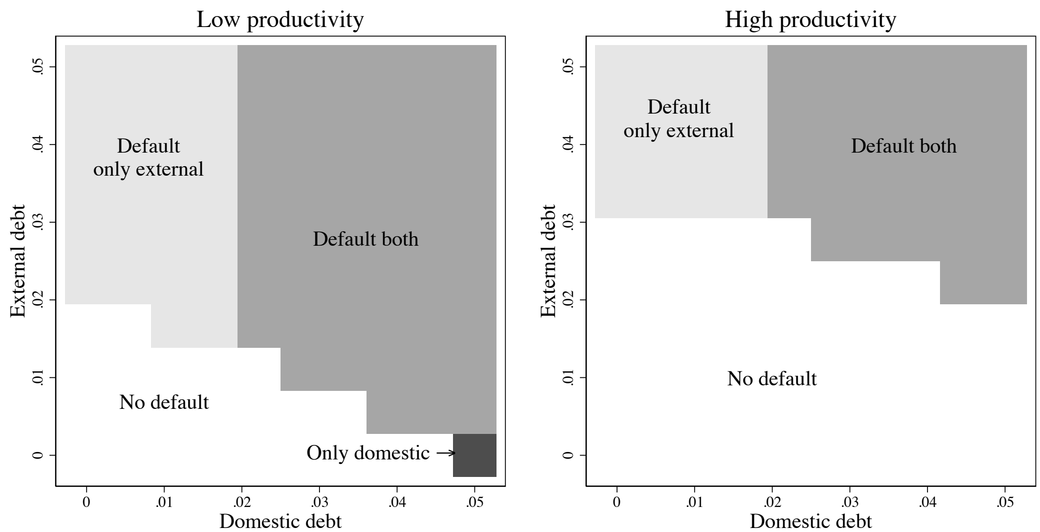
Figure 6: Government Borrowing Decisions



Notes: The upper panels of this figure shows the implied value function for the government (right-panel), new capital (middle-panel), and external resources obtain from borrowing $q^* B^{*\prime}$ as a function of new external borrowing $B^{*\prime}$. This is computed for a given state space (B, B^*, K, D, z, R) and for a given amount of domestic borrowing B', which is set to be the optimal one. The black dot in each figure indicates the optimal amount of external borrowing $B^{*\prime}$, that is, the one that maximizes the value function. The bottom panels show the equivalent plots as a function of new domestic borrowing B'.

be seen in equation (27). This implies that, for the same amount of debt, the government will have more incentives to default on external than on domestic debt. When domestic debt is relatively low, government will default only on external debt when B^* is high enough. Similarly, when external debt is very low, the government defaults only on domestic debt when domestic debt, B, is very large. However, it is clear from the graph that the government is more tolerant to domestic debt: the region of only external default is larger both in terms of the minimum B^* for which it defaults, and because it requires a higher B for defaulting on both. As debt becomes larger for both types of debt, the government have more incentives to default on both. As productivity increases the default set shrink and the repayment area becomes larger, as can be seen in the right panel of Figure 7. Moreover, when productivity is high, there is no region (B, B^*) on which the government defaults only on domestic debt. In this case, the incentives of the government to repay domestic debt increase because, by repaying, it increases the total net worth of the banks, which then can use to invest in high productivity capital. Section 5.5 elaborates on the patterns of default and the differences between the conditions under which the government chooses to default on domestic or on external debt. Moreover, it shows that these patterns are consistent with what we observe in the data.

Figure 7: Ex-post Default Decisions

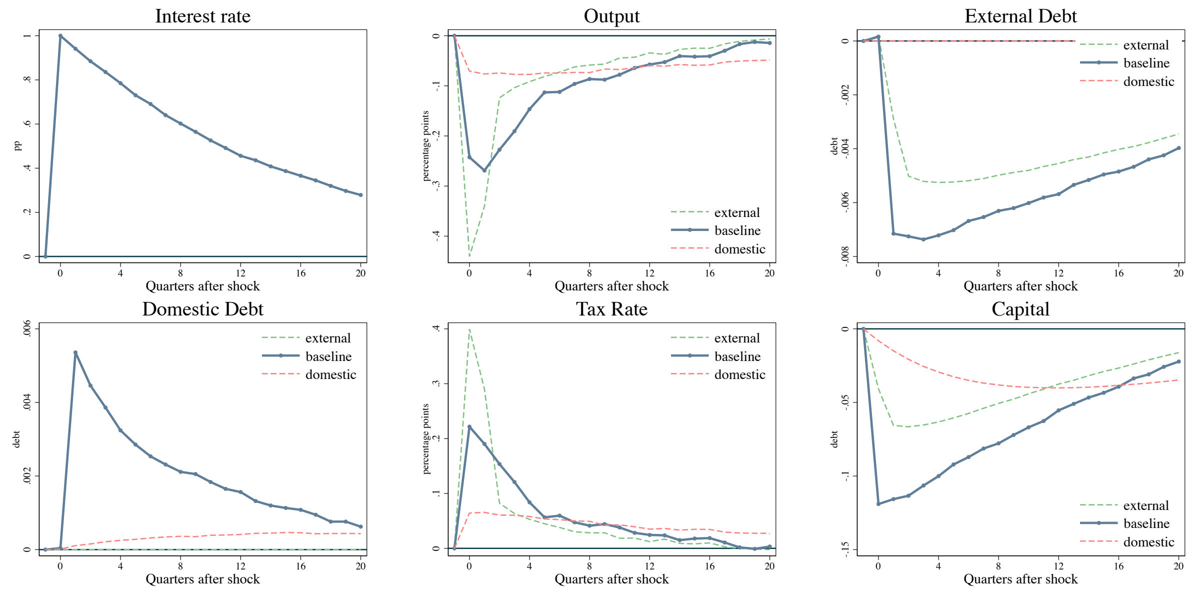


5.2 Vulnerability to external shocks

This section shows the effects of an increase in the international interest rate in output, and how the decisions of the government change after such a shock. In the model, international interest rates are assumed to follow an stochastic process as in equation (12). Figure 8 plots the response to a shock that increases the international interest rate by 100 annual basis points. Output in the baseline economy (solid blue line) drops about 0.3 percentage points, close to what we observe in the data which is around 0.4 percentage points. The drop in output after an increase in interest rates is a consequence of higher costs of external borrowing. Given higher interest rates, it is now more costly for the government to finance its expenditures, especially if it finances it using external debt. As shown in Figure 8, in order to balance the higher cost of external debt, the government chooses to decrease its external borrowing and increase domestic debt. In addition, it also needs to increase tax rates to compensate for the decrease in external borrowing. Higher taxes, through its distortionary nature, and higher domestic debt, through its crowding out effect, will decrease both labor and capital in this economy, and thus output drops.

Domestic debt helps mitigating the drop in output. To see this, consider the case where there is only external debt in the economy. In this exercise, I keep the same parameters as in the baseline economy and solve the equilibrium of the model where I constrain the government to no domestic debt. The output response in the economy with only external debt is shown in Figure 8 represented by the dashed green lines. In this case output drops more than in the baseline economy where the government has access to both types of debt. When the government does not have access to domestic debt, most of the substitution of external debt after the increase in the interest rates is done via an increase in taxes. Therefore, even though capital does not decrease as much as with

Figure 8: Response to a Positive Interest Rate Shock



Notes: The solid blue lines in this figure show the response of each of the variables in the baseline economy, that is, when the government has access to both domestic and external borrowing. The dashed green lines show the case when the government can only borrow externally, and the dashed red lines show the case when the government can only borrow domestically.

domestic debt, because there is no crowding out effect, the increase in taxes implies a significant decrease in labor. This causes the larger decrease in output in the economy with only external debt. The effect of an increase in interest rates in the economy with only domestic debt comes only from the working capital mechanism, as in this case the cost of borrowing is not directly affected by international prices. Therefore, the drop in output is relatively small in this case.

5.3 Financial development and domestic debt

Now, I analyze how the share of domestic debt and the vulnerability to interest rate shocks depend on the level of financial development of the economy. In the model, the level of financial development of a country is controlled by the parameter θ in the collateral constraint (9). The higher θ is the lower the frictions in the financial sector. Specifically, higher θ is associated with a lower fraction of assets that banks can divert. This can be interpreted as improving the monitoring technology that depositors have over banks' behavior, which is linked to the level of development of domestic financial markets.

To see the implications of the model regarding the level of financial development, I perform the following quantitative exercise. First, I divide countries between low and high financial development depending on whether their average level of financial development is above or below the median level in the sample. Then, I vary the parameter θ so as to match the average level of deposits to GDP in each of the groups: low and high financial development. Importantly, in this exercise the

Table 6: Financial Development and Domestic Debt

	Data		Model	
	Low θ	High θ	Low θ	High θ
Deposits to GDP	0.20	0.45	0.22	0.42
Domestic debt share	0.36	0.68	0.18	0.71

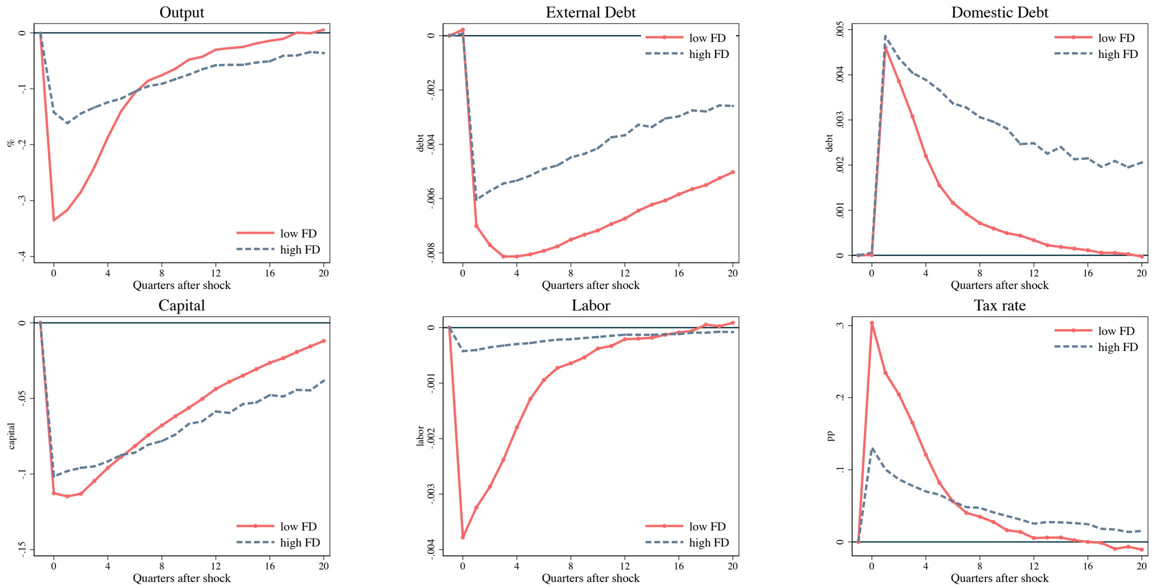
only parameter changing is the value of θ and the rest of parameters are kept fixed at their level as in Table 4. The average share of domestic debt for countries that are less financially developed in the data is 0.36, whereas in countries that are more financially developed this share is 0.68. Moreover, the difference in the means across these two groups is significantly different from zero. The re-calibrated parameter θ is 0.36 for low financially developed and 0.65 for high financially developed (in the baseline economy it is 0.46).

Table 6 compares the levels of financial development and shares of domestic debt in the data and the ones generated by the model. The model captures the differences in the share of domestic debt between high and low financially developed countries. In particular, it captures quantitatively well the higher share of domestic debt in relatively high financially developed economies, and the drop in domestic debt in lower financially developed economies, although it overstates such drop relative to the data. Note that none of the domestic shares in this exercise are targeted moments. There are two main mechanisms in the model that generate this result. First, when banks face lower constraints, that is, countries are more financially developed, the interest rate that the government has to pay on domestic debt decreases. Lower constraints imply lower returns to capital due to lower marginal product of capital, and thus lower interests on domestic debt. Similarly, when constraints are more relaxed, the crowding out cost from issuing domestic debt is lower. Therefore, domestic debt becomes more attractive relative to the case where financial constraints are tighter, and governments issue more domestic debt.

The response to a shock that increases the interest rate for the low and high financially developed economies are shown in Figure 9. After the shock, in both economies there is a decrease in external debt, due to its increase in cost, an increase in domestic debt, and an increase in taxes, to substitute for the decrease in external debt. However, the magnitude of these changes are different for low and high financially developed economies, which in turn affects the magnitude of the drop in total output.

The main difference between the two economies is that when low financially developed, the government mostly substitutes external debt for higher taxes, and when high financially developed, it does so using higher domestic debt instead of taxes. To understand these decisions, it is useful to consider the effect of each of these policies on capital through the banks aggregate budget constraint when the collateral constraint is binding, that is, $K' = (1 + \theta)N - qB'$. An increase in domestic debt, B', has a direct negative effect on capital that depends on the price of domestic debt. In

Figure 9: Response to a Positive Interest Rate Shock: Model



Notes: The dashed blue lines in this figure show the response of each of the variables for the economy with high level of financial development (high θ). The solid red lines show the case when the economy is low financially developed (low θ).

particular, the effect of increasing debt on capital is given by $\frac{\partial q}{\partial B'}B' + q$. For a given amount of debt, this effect is lower for high financially developed economies. On the other hand, increasing taxes has an effect on today's banks aggregate net worth, N. An increase in taxes translates into a decrease in total labor, which in turn decreases the return on capital and therefore, bank's net worth. The effect on capital is then, $(1+\theta)\sigma\frac{\partial R_K}{\partial \tau}$. Notice that, for a given $\frac{\partial R_K}{\partial \tau}$, this effect will be larger the higher θ is, that is, the more financially developed the economy is. The reason is that higher financial development implies that a higher fraction of banks net worth can be invested in capital.

5.4 The role of real exchange rates

A large literature has explored the effects of monetary policy on exchange rates. This literature finds that a shock that increases the U.S. interest rate is associated with a significant appreciation of the U.S. dollar.[16] The decision of the government between domestic and external is affected by changes in the exchange rate. Usually, external credit is issued in foreign currency, so an appreciation of the dollar makes the repayment of dollar denominated debt more expensive. Moreover, if changes in the international interest rate are associated with changes in the real exchange rate not, then the vulnerability of emerging countries to an increase in the international interest rate will also be affected by the change in the exchange rate.

To explore the role of exchange rates both in determining the share of domestic and external

[16]See, for instance, Eichenbaum and Evans (1995), Faust and Rogers (2003).

Table 7: Parameters and Moments to Match: Model With Exchange Rates

Parameter		Moment	Data	Model
Discount factor	$\beta = 0.979$	Default probability	4.51	0.96
Banks survival rate	$\sigma = 0.93$	Deposits to GDP	0.32	0.33
Collateral constraint	$\theta = 0.485$	Share of domestic debt	0.54	0.53
Banks initial net worth	$\bar{n} = 0.70$	Returns on equity	12.5	16.9
Gov. expenditures	$G = 0.036$	Government expenditures to GDP	0.14	0.11
Disutility of working	$\xi = 2.30$	Hours worked	0.22	0.22
Productivity standard dev.	$\sigma_z = 0.009$	Volatility of GDP	3.08	3.24
Productivity cost of default	$\zeta_0 = -0.178$	Debt to GDP	32.5	29.9
Productivity cost of default	$\zeta_1 = 0.188$	Mean spread	2.45	1.67

debt, and in the effects of an increase in the international interest rate, I introduce real exchange rates in the model. Let e_t be the real exchange rate that expresses units of local goods in terms of units of foreign goods. Then, the government budget constraint when the economy is in non-autarky times is

$$G + \delta_t \lambda B_t + \delta_t^* \lambda e_t B_t^* = \tau_t w_t L_t + \delta_t q_t \left(B_{t+1} + (1-\lambda) B_t\right) + \delta_t^* e_t q_{t+1}^* \left(B_{t+1}^* + (1-\lambda) B_t^*\right). \quad (31)$$

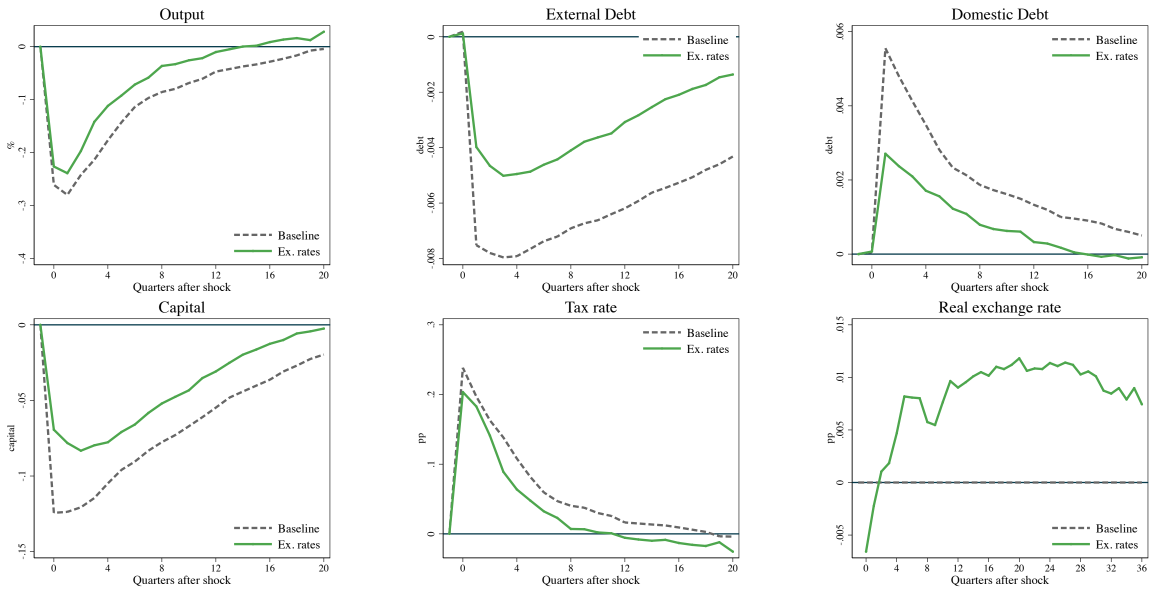
An increase in the real exchange rate, e_t, implies that the cost of repaying the debt increases, as more units of local goods are required to repay a given amount of foreign goods. This can be seen in the left hand side of the government budget constraint (31). In periods of high exchange rates, then, keeping everything else the same, the government will have more incentives to issue domestic debt relative to external debt.

Exchange rates are affected by shocks to the exchange rate, ϵ_t^e, but also by shocks to the international interest rate, ϵ_t^r. This allows to capture the idea that the exchange rate will be affected by a shock increase in the international interest rate. In particular, the joint stochastic process for international interest rates and the exchange rate is

$$\begin{bmatrix} r_{t+1}^* \\ e_{t+1} \end{bmatrix} = A + B \begin{bmatrix} r_t^* \\ e_t \end{bmatrix} + \Sigma \begin{bmatrix} \epsilon_{t+1}^r \\ \epsilon_{t+1}^e \end{bmatrix}, \quad (32)$$

where Σ is the variance-covariance matrix, and A and B are matrices containing the constants and the auto-regressive coefficients of the system. I estimate this system of equations using the data for the countries in the sample, and solve the model using by discretizing the vector of interest rates and exchange rates, following the methodology proposed in Terry and Knotek II (2011). This allows to capture the joint process for r_t^* and e_t. Then, the parameters of the model are set using the same strategy as in the baseline economy without exchange rates. Appendix E.5 show the details of the estimation and the corresponding results. The estimation shows that on impact after an shock that increases the international interest rate, there is a decrease of around 0.8% in the real exchange rate

Figure 10: Response to a Positive Interest Rate Shock: Model With Exchange Rates



Notes: The solid green lines in this figure show the response of each of the variables for the economy that includes real exchange rate fluctuations, and the dashed lines correspond to the baseline economy without real exchange rate fluctuations.

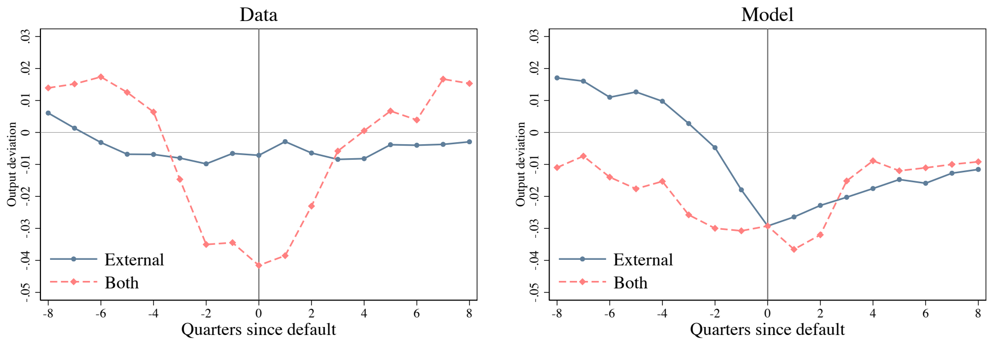
of the emerging countries relative to the United States. However, after the initial negative impact, relative exchange rates increase up to 2%.

Next, I show that the effect of an increase in the international rates—which now has also a direct effect on the real exchange rates— is similar to the economy in which there are no fluctuations in the real exchange rate. The model with exchange rates is then calibrated to match the same moments as in the baseline economy. The parameters used and the model fit are shown in Table 7, and Figure 10 shows the response to an increase in the interest rate of 1 percentage point annualized. In this case, real exchange rate also respond to the shock to interest rate, as specified by the estimated equation (32). The patterns are the same as in the baseline, with a similar decrease in output. To compensate for the higher cost of borrowing externally, the government substitutes external debt by increasing taxes and labor. External debt in Figure 10 is expressed in international goods units. Therefore, the increase in the real exchange rate makes external debt in local goods units to decrease even further.

5.5 Patterns of discriminatory default

When do governments default on external debt and when in domestic debt? There are three main points regarding the patterns of discriminatory default in the data. First, governments tend to default more often only on external debt. Second, the output drop after a default only on external debt is lower than after a default on both types of debt. And third, before defaulting the patterns of output are already different between defaults only on external debt and defaults on both types

Figure 11: Output Deviation at the Time of Default: Data and Model



of debt. This section analyzes the predictions of the calibrated model regarding these patterns of default, and shows that it aligns well with what is observed in the data.

First, regarding the frequency of each type of default, note that one crucial assumption in the model is that governments can discriminate when they default between external and domestic creditors. This is consistent with what we observe in the data. Reinhart and Rogoff (2011) catalogue all default episodes between those involving external debt only, and overt defaults that involved both domestic and external defaults. Their classification of overt defaults includes cases where the government forced conversions of deposits, bank deposits were frozen, imposed lower coupon rates, there was a unilateral reduction of principal, or suspension of payments. They find that in most cases countries default only on external debt: 250 external debt defaults and 68 cases of overt default. I take this as evidence that governments can actually default in a discriminatory way. In the sample of countries considered in this paper the same patterns hold: out of a total of 30 default events in the sample, 23 of them are only on external debt, and the rest are on both domestic and external debt.

Another important aspect of discriminatory default that we see in the data is that the circumstances under which governments default only on external debt and when they default on both, domestic and external, are very different. The left panel of Figure 11 shows the average evolution of real GDP around the time of default across all the events of default in the data, distinguishing between cases where countries defaulted only on its external debt, and where they defaulted on both types of debt. Output deviation is measured as deviations from its HP filtered series. In both cases, output was below its trend at the time of default. However, we can see that when governments default only on external debt output decreases by less than 1%, but when they defaulted on both it drops by more than 4%. I refer to this pattern as *pecking order of default*: in moderate recessions, countries tend to default only on their external debt, and it is only when the recession is severe enough that they default on both, domestic and external debt. Moreover, it is important to notice that the output path before the time of default was also different. In particular, we see that output in the year before was already declining below trend, but only slightly so, whereas the year before

Table 8: Pecking Order of Default

	Data		Model	
Output deviation from trend:	External only	Both	External only	Both
Before default	-0.8%	-1.9%	-0.3%	-2.5%
Default period	-0.7%	-4.2%	-2.9%	-2.9%
After default	-0.6%	-2.2%	-2.3%	-3.4%
Frequency of default	74%	26%	67%	33%

Note: the periods before and after default correspond to the average over the previous and following year of default, respectively.

defaulting on both output was already 2% below trend.

The model is able to generate the same patterns that we observe in the data. The right panel of Figure 11 shows the average across default events from simulating the model over a large number of periods and Table 8 summarizes these results and includes the frequency of each type of default. As in the data, the model generates a higher frequency of discriminatory default, and both in the period of default and the period prior to default output is much lower when the country defaults on both debts than when it only defaults on external debt. Next, I explain the mechanisms in the model that give these results.

In order to understand why the model generates these patterns it is important to see what are the cyclical properties of domestic debt. In the model, higher productivity today increases the expected returns to capital, and therefore, given that the price of debt must be such that banks are indifferent between investing in bonds or in capital, the interest rates that the government has to offer are higher when productivity is high. Moreover, higher productivity implies that the costs from the crowding effect of issuing debt are larger, because high z today implies a high expected marginal product of capital tomorrow, so that an additional unit of investment would be turned into relatively high output, and therefore consumption, tomorrow. These two effects, that is, relatively higher interest rates on domestic debt, and higher costs from issuing domestic debt, makes this type of debt less attractive to the government when productivity is high. This results into a countercyclical share of domestic debt, which is consistent with what we see in the data, as shown in Section 6.

The countercyclicality of domestic debt explains the pecking order of default. When productivity is not too low, like in the period before defaulting on external debt (see Figure 11), the government has incentives to issue more external debt than domestic because it is relatively cheaper and it does not crowd out capital at a time where investment in capital is very valuable. Then, a drop in productivity will induce defaulting only on external debt because defaulting on domestic debt is more costly, and the share of domestic debt is low.

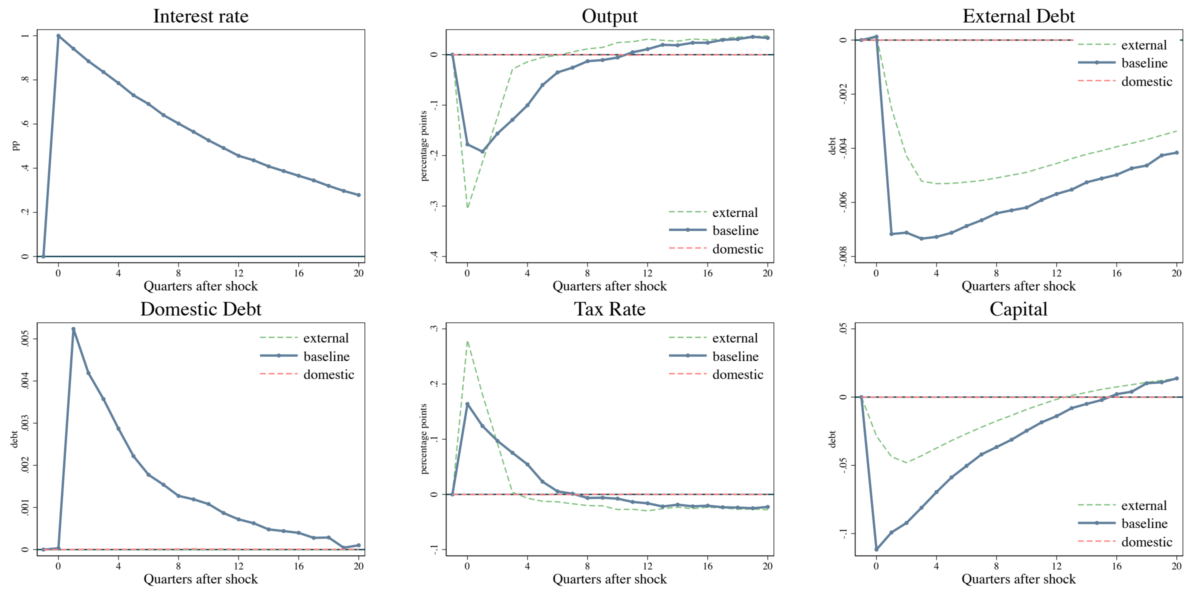
On the other hand, if productivity is already very low, like in the period before defaulting on both domestic and external debt, the price of external debt becomes more expensive due to a relatively higher probability of defaulting on external than on domestic debt. Moreover, both the crowding cost and the interest rates from issuing domestic debt are lower than when productivity is high. Therefore, the government starts issuing a higher share of domestic debt. Then, when there is a sharp decrease in productivity the government has to default on both types of debt, because, given the low shares of external debt, defaulting on foreign creditors is not enough to solve the financing problems of the government.

6 Discussion of assumptions and model mechanisms

Here, the main assumptions regarding the model and quantitative results are discussed. Households are assumed to have linear utility in consumption, and convex disutility of supplying of labor. Linear utility in consumption is assumed to preserve tractability of the computation of the equilibrium, and to simplify the exposition of the model forces. The introduction of risk aversion would not change the main mechanisms of the model, namely, the crowding out effect of domestic debt, the relative lower default incentives on domestic debt than on external debt, and a negative effect on output after an increase in interest rates due to changes in the composition of debt and taxes. In this model, the government decision to borrow is given by a desire to smooth taxes, due to its distortionary effects on labor, and convex disutility of supplying labor by consumers.

Another assumption in the model is that the only holders of domestic debt are domestic banks, and in a similar way the only holders of external debt are foreign creditors. In the data, this is generally the case. Domestic debt in the data is defined to be debt issued under domestic law which is highly correlated with the debt held by domestic creditors (see Appendix E). Moreover, using data from Arslanalp and Tsuda (2014), banks holdings of domestic debt account for more than 35% of all domestic debt. In the model, this assumption is made to understand the rile of financial development. One of the key elements in the model is the need of financial intermediaries to capture the concept of financial development and how changes in financial development in a given country can affect the government decisions regarding the denomination of debt. That is why in this economy all domestic financial transactions are intermediated through domestic banks and households are purposely left out of the domestic debt market. On the other hand, the model also assumes that domestic banks do not have access to external resources to finance their investment. In that sense, all the external resources have to come in through the government. One way to rationalize this is to assume that foreign creditors do not trust enough private domestic banks to lend them resources, probably due to their inability to properly monitor their activities. Following this argument, relaxing the assumption and allowing banks to borrow externally would require the inclusion of an additional collateral constraint on the resources that they can get from abroad (similar to the collateral constraint on domestic deposits). Therefore, in this alternative scenario the banks would still be constrained on how much they can borrow—so, the crowding out effect would still be in place—, and changes in the international interest rate will now directly affect them,

Figure 12: Response to a Positive Interest Rate Shock: No Working Capital



Notes: The solid blue lines in this figure show the response of each of the variables in the baseline economy, that is, when the government has access to both domestic and external borrowing. The dashed green lines show the case when the government can only borrow externally, and the dashed red lines show the case when the government can only borrow domestically.

and thus, the effect of a shock to interest rate will prevail or could even be amplified.

Finally, the model assumes that the international interest rate has not only an effect through changes in the cost of borrowing for the government, but it assumes that firms working capital is paid using international frictionless intra-period borrowing. This is so to introduce a direct effect on private agents in the domestic economy. However, dropping this assumption by setting the amount of working capital to zero, that is, $\kappa = 0$ implies no change in the mechanisms of the model. Figure 12 shows the response to an increase in the international interest rate in such case. All parameters are kept the same as in the baseline calibration except for κ which is set to zero. This figure shows the same patterns as Figure 8, although the drop in output after the increase in interest rate is naturally smaller than in the case with working capital. Similarly to the baseline case, domestic debt mitigates the drop in output.

Empirical evidence on main mechanisms. There are three main mechanisms in the model that explain the patterns observed in the data. First, the model assumes that default in domestic debt implies an endogenous cost arising from a decrease in domestic banks net worth. Second, domestic debt crowds out investment in the private sector trough the collateral constraint affecting banks investment decisions. And, third, issuing domestic debt is relatively more desirable during low productivity periods than during high productivity periods, that is, the share of domestic debt is countercyclical. Here, I discuss and provide evidence on these mechanisms.

Table 9: Private Credit From Banks and Domestic Debt

	(1)	(2)	(3)
Domestic debt to GDP	-0.140***	-0.145***	-0.156***
	(0.026)	(0.041)	(0.043)
Total debt to GDP	-0.122***	-0.053***	-0.073***
	(0.031)	(0.029)	(0.033)
Financial development	1.083***	0.636***	0.666***
	(0.038)	(0.075)	(0.078)
Log GDP per capita	5.259***	20.990***	8.092
	(0.853)	(4.351)	(5.586)
Country Effects	No	Yes	Yes
Year Effects	No	No	Yes
Observations	272	272	272

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

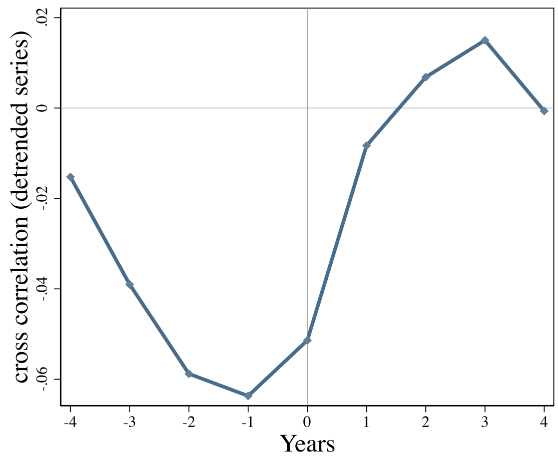
The model allows for selective default on domestic and external debt following. Moreover, upon default, as standard in the literature on sovereign defaults, an exogenous drop in productivity will prevail for a given amount of periods. This exogenous cost is modeled as exactly the same for domestic and external defaults. However, the model also features an additional endogenous default cost when defaulting on domestic debt, that is not present when defaulting on external debt. This happens because domestic banks net worth depend on repayment of such debt, and therefore default would imply a decrease on banks net worth. Empirically, we observe such effect. Gennaioli et al. (2018) use a panel of data on banks for different European countries to analyze the relationship between government default risk, banks holding of domestic debt, and their loan to assets ratio. Baskaya and Kalemli-Ozcan (2016) estimate the impact of default risk on domestic banks holding government debt using a natural experiment in Turkey. They find that increases in default risk imply a significant reduction on bank credit supply and in net worth.

The second important mechanism in the model is the crowding out effect of domestic debt. Becker and Ivashina (2018) show, for the Eurozone countries, that increases in banks government bond holdings were associated with a decrease in their corporate lending. I show a similar result using aggregate data on the sample of emerging countries studied here. Using data on total private credit from banks, and total domestic government debt in a given country, consider the following regression

$$\frac{\text{Private Credit}_{it}}{GDP_{it}} = \beta \frac{\text{Domestic Debt}_{it}}{GDP_{it}} + \Gamma X_{it} + \alpha_i + \delta_t \varepsilon_{it}, \tag{33}$$

where the coefficient β is an indicator of the *crowding out effect* that domestic debt has on the amount of credit that banks are able to provide. The controls included in X in this regression are log GDP per capita, level of financial development, and total debt. Table 9 reports the results and shows that when there is a high domestic debt to GDP ratio, the amount of private credit from

Figure 13: Correlation GDP_{t+h} and Domestic Debt_t



domestic banks tend to significantly decrease, indicating a crowding out effect of domestic debt.

Finally, the model implies that domestic debt is preferable when productivity is low. The price of domestic debt depends negatively on the marginal product of capital, as can be seen from the pricing condition (17). Moreover, the default probability on domestic debt is in general lower than on external debt, and that external default probabilities increase substantially in bad times. This makes external debt relatively more expensive than domestic debt, especially in bad times, and so the government tends to prefer domestic over external. The quantitative exercise confirms this, and shows a countercyclical share of domestic debt. In the data, the same patterns hold. Figure 13 shows the cross-correlation between the detrended series of GDP and of the share of domestic debt.

7 Conclusions

The key motivation in this paper is the evidence that the aggregate fluctuations and default rates in emerging market economies are not driven solely by internal shocks, as is typically assumed, but also by external shocks, such as movements in world interest rates. I argue that a serious omission in the existing literature is the link between financial development, the share of domestic debt, and the vulnerability of developing economies to fluctuations in world interest rates.

I have shown that empirically, countries that are less financially developed, as measured by their deposit to output ratio, have low shares of domestic government debt to externally issued government debt. Such countries are also more vulnerable to fluctuations in world interest rates.

I developed a model consistent with all these features. By embedding a financial intermediation sector into an otherwise standard model of sovereign default, I have a way to naturally model financial development as a strengthening of the ability of enforce contracts as measured by a parameter governing the tightness of the resulting collateral constraint. As this ability to enforce contracts increase so does the share of domestic debt and, through the equilibrium, the vulnerability to external shocks decreases. The model naturally also produces other key features of the data: the pecking order of default and the countercyclicality of the domestic debt share.

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Appendix A Banks problem

A.1 Proof of Lemma 1

Consider the recursive formulation of the bank problem. To write the problem of the bank it is sufficient to have as an individual state variable its net worth, n, at the beginning of the period. Then, the value of a bank is

$$V^b(n;S) = \beta \max_{k',b',d'} \mathbb{E}\left[\sigma V^b(n';S') + (1-\sigma)n'\right] \tag{34}$$

subject to the budget constraint

$$k' + q(S)b' - q^D(S)d' \leq n \tag{35}$$

collateral constraint,

$$q^D(S)d' \leq \theta n \tag{36}$$

and, evolution of net worth

$$n' = R_K(S')k' + \delta(S')\left[\lambda + (1-\lambda)q(S')\right]b' - d' \tag{37}$$

We can rewrite the banks problem (34) by substituting in the evolution of net worth (37)

$$\begin{aligned} V^b(n;S) = \max_{k',b',d'} \quad & \beta\sigma\mathbb{E}\left\{V^b(R^K(S')k' + \delta(S')\left[\lambda + (1-\lambda)q(S')\right]b' - d';S')\right\} \\ & + \beta(1-\sigma)\mathbb{E}\left\{R^K(S')k' + \delta(S')\left[\lambda + (1-\lambda)q(S')\right]b' - d'\right\} \end{aligned}$$

subject to

$$k' + q(S)b' - q^D(S)d' \leq n$$

$$q^D(S)d' \leq \theta n$$

Let $\rho(S)$ be the Lagrange multiplier on the budget constraint (35), and let $\mu(S)$ be the Lagrange multiplier on the collateral constraint (36). Then,

$$\text{FOC}(k'): \qquad \beta\mathbb{E}\left\{\left[1-\sigma+\sigma V^b_n(n';S')\right]R_K(S')\right\} - \rho(S) = 0 \tag{38}$$

$$\text{FOC}(b'): \qquad \beta\mathbb{E}\left\{\left[1-\sigma+\sigma V^b_n(n';S')\right]\delta(S')\left[\lambda+(1-\lambda)q(S')\right]\right\} - q(S)\rho(S) = 0 \tag{39}$$

$$\text{FOC}(d'): \qquad -\beta\mathbb{E}\left[1-\sigma+\sigma V_n^b(n';S')\right]+q^D(S)\rho(S)-q^D(S)\mu(S)=0, \tag{40}$$

where, V_n^b denotes the derivative of the value function with respect to net worth, n.

Now, we guess that the value function is linear in net worth, that is, $V^b(n;S)=n\nu(S)$. Then, optimality conditions are

$$\text{FOC}(k'): \qquad \rho(S)=\beta\mathbb{E}\left\{\left[1-\sigma+\sigma\nu(S')\right]R^K(S')\right\} \tag{41}$$

$$\text{FOC}(b'): \qquad q(S)\rho(S)=\beta\mathbb{E}\left\{\left[1-\sigma+\sigma\nu(S')\right]\left[\lambda+(1-\lambda)q(S')\right]\delta(S')\right\} \tag{42}$$

$$\text{FOC}(d'): \qquad q^D(S)\left[\rho(S)-\mu(S)\right]=\beta\mathbb{E}\left\{1-\sigma+\sigma\nu(S')\right\}, \tag{43}$$

Substituting the guess into the value function, we get

$$\begin{aligned}n\nu(S)=&\beta\mathbb{E}\left\{\left[1-\sigma+\sigma\nu(S')\right]R^K(S')\right\}k'+\beta\mathbb{E}\left\{\left[1-\sigma+\sigma\nu(S')\right]\left[\lambda+(1-\lambda)q(S')\right]\delta(S')\right\}b'\\&-\beta\mathbb{E}\left[1-\sigma+\sigma\nu(S')\right]d',\end{aligned}$$

and, using optimality conditions (41)-(43), we can rewrite it as

$$\begin{aligned}n\nu(S)=&\rho(S)\left[k'+q(S)b'-q^D(S)d'\right]+\mu(S)q^D(S)d'\\=&\rho(S)n+\mu(S)q^D(S)d'\end{aligned} \tag{44}$$

Then the guess is verified: if the constraint binds, $q^D(S)d'=\theta n$, so

$$\nu(S)=\rho(S)+\theta\mu(S), \tag{45}$$

where, $\rho(S)=\beta\mathbb{E}\left\{\left[1-\sigma+\sigma n'\nu(S')\right]R^K(S')\right\}$, and

$$\mu(S)=\beta\mathbb{E}\left\{\left[1-\sigma+\sigma\nu(S')\right]\left[R^K(S')-\frac{1}{q^D(S)}\right]\right\}, \tag{46}$$

so,

$$\nu(S)=\mathbb{E}\left\{\beta\left[1-\sigma+\sigma\nu(S')\right]\left[(1+\theta)R_K(S')-\theta/q^D\right]\right\}. \tag{47}$$

If the constraint does not bind, $\mu(S)=0$, and $\nu(S)=\rho(S)$.

Moreover, from the first order condition we get the pricing equation for domestic bonds. Combining (41) and (42):

$$q(A';S)=\frac{\mathbb{E}\left\{\left[1-\sigma+\sigma\nu'\right]\left[\lambda+(1-\lambda)q(A'';S)\right]\right\}}{\mathbb{E}\left\{\left[1-\sigma+\sigma\nu'\right]R_K'\right\}} \tag{48}$$

Appendix B Aggregate budget constraint

Here we derive the country-level budget constraint under the case where the government repays its debt and thus, it is in the no autarky state. Derivation of the autarky states country-level budget constraint follow the same steps. To get the country's aggregate budget constraint (15) we start with the households budget constraint:

$$C + q^D D' + \sigma \bar{n} = (1-\tau)wL + D + X. \tag{49}$$

From the firm's first order condition, we can substitute $w = zF_L(K, L)$. Moreover, from the banks net worth, the dividends that are transferred to the households are this period returns for the fraction σ of bankers that do not survive to next period, so $X = \sigma \left[R^K K + (\lambda + (1-\lambda)q)\, B - D\right]$, which we can write in terms of N using the aggregate net worth definition as, $X = \frac{\sigma}{1-\sigma} N - \frac{\sigma^2}{1-\sigma}\bar{n}$. So, substituting w and X into (49) we get

$$C + q^D D' + \frac{\sigma}{1-\sigma}\bar{n} = (1-\tau)zF_L(K, L)L + D + \frac{\sigma}{1-\sigma}N. \tag{50}$$

Now, using banks aggregate net worth definition,

$$N = (1-\sigma)\left[R^K K + (\lambda + (1-\lambda)q)B - D\right] + \sigma\bar{n}, \tag{51}$$

we can substitute for D in (50), so

$$C + q^D D' = zF(K, L)L - T + R^K K + (\lambda + (1-\lambda)q)\, B - N, \tag{52}$$

where $T = \tau wL$, and substituting $R^K = zF_K(K, L) + 1 - \delta_K$ from firms first order condition, we get,

$$C + q^D D' = zF(K, L) - T + (\lambda + (1-\lambda)q)\, B - N, \tag{53}$$

where we used the fact that $zF(K, L) = zF_L(K, L)L + zF_K(K, L)K$.

Now, from the government budget constraint under repayment we have,

$$G + \lambda B + \lambda B^* = T + q\left(B' - (1-\lambda)B\right) + q\left(B^{*\prime} - (1-\lambda)B^*\right),$$

so we can substitute T into (53),

$$C + N + q^D D' = zF(K, L) + (1-\delta^K)K - G - \lambda B^* + qB' + q\left(B^{*\prime} - (1-\lambda)B^*\right). \tag{54}$$

Finally, using the aggregate bank budget constraint,

$$N + q^D D' = K' + qB',$$

so, substituting $N + q^D D'$ into (54) we get

$$C + K' - (1 - \delta_K)K + G + \lambda B^* = zF(K, L) + q\left(B^{*\prime} - (1 - \lambda)B^*\right), \tag{55}$$

which is equation (15).

Appendix C Government problem

Consider the government of the problem deciding between domestic and external debt in the simpler case with one-period bonds, no working capital, no capital adjustment costs, and no stochastic international interest rate. Let the aggregate state of the economy be $S_t = (A_t; z_t)$, and A_t denote the assets, that is, $A_t = (K_t, D_t, B_t, B_t^*)$. The problem of the government if it repays its debt this period is:

$$V^R(S) = \max_{B', B'^*, L, C, K_{t+1}} C + v(L) + \beta \mathbb{E} \left\{ \tilde{\delta}(S') V^R(S') + \Gamma^D(S') \right\} \tag{56}$$

where, Γ^D are the collected continuation values for the government in terms of default, and $\tilde{\delta}(S_t) = \delta(S_t)\delta^*(S_t)$. The government budget constraint under repayment is

$$q(A', z)B' + q^*(A', z)B^{*\prime} = G + B + B^* - \big(zF_L + v'(L)\big) L \tag{57}$$

the banks budget constraint is

$$K' + q(A', z)B' = (1 + \beta\theta) \left[\sigma \left(zF_K K + B - D\right) + (1 - \sigma)\bar{n}\right], \tag{58}$$

where, F_K is simplified notation for $\partial F(K, L)/\partial K$; the country's resource constraint is

$$C + G + K' + B^* = zF(K, L) + q(A', z)B^{*\prime}; \tag{59}$$

and, the pricing equations are

$$q^*(A', z) = \frac{\mathbb{E}\delta^*(S')}{R^*}, \tag{60}$$

for the external debt, and,

$$q(A', z) = \frac{\mathbb{E}\left[m(S')\delta(S')\right]}{\mathbb{E}\left[m(S')z' F_K(S')\right]}, \tag{61}$$

for domestic debt, where $m(S) = \beta \mathbb{E}(1 - \sigma + \sigma\nu(S'))$ and ν is the marginal value of net worth at the bank, defined in (16).

Then, the problem of the government is to solve (56) subject to (57)-(61). We can rewrite this problem as

$$\begin{aligned} V^R(S) = \max_{B', B^{*\prime}} & zF(K, L) - B^{*\prime} - G - K'(S, B') + q^*(A', z)B^{*\prime} + v(L) \\ & + \beta \mathbb{E} \left\{ \tilde{\delta}(S') V^R(S') + \Gamma^D(S') \right\} \end{aligned} \tag{62}$$

subject to

$$\mu(S): \qquad G + B + B^* - q(A', z)B' - q^*(A', z)B^{*\prime} - \hat{T}(L; S)L \leq 0 \tag{63}$$

$$\rho(S): \quad K' + q(A', z)B' - \sigma\left(zF_K(K, L)K + B - D\right) - \beta D' - (1-\sigma)\bar{n} \leq 0 \tag{64}$$

$$\eta(S): \quad \beta D' - \theta\sigma\left(zF_K(K, L)K + B - D\right) - \theta(1-\sigma)\bar{n} \leq 0 \tag{65}$$

and, to the pricing equations, where the function $K'(S, B')$ is defined by the banks budget constraint, and the function $\hat{T}(S)$ is the tax revenues per unit of labor. Let $\mu(S)$ be the Lagrange multiplier on the government budget constraint, $\rho(S)$ on the aggregate bank budget constraint, and $\eta(S)$ on the aggregate bank collateral constraint. Then, taking first order condition with respect to external borrowing we get:

$$\begin{aligned} q^* + \frac{\partial q^*}{\partial B^{*\prime}} B^{*\prime} + \mu(S)\left(q^* + \frac{\partial q^*}{\partial B^{*\prime}} B^{*\prime} + \frac{\partial q}{\partial B^{*\prime}} B'\right) - \rho(S)\frac{\partial q}{\partial B^{*\prime}} B' \\ = -\beta \frac{\partial \mathbb{E}\left\{\tilde{\delta}(S')V^R(S')\right\}}{\partial B^{*\prime}} + \Delta^*(S). \end{aligned} \tag{66}$$

To simplify the exposition of the model forces, we focus on the continuation value under repayment, so that we can ignore the extra terms involving default, Γ^D, or changes in default probability, which we collect with the variable, $\Delta^*(S)$, and set to 0. Now, taking first order condition with respect to domestic debt we get:

$$\begin{aligned} \frac{\partial q^*}{\partial B'} B^{*\prime} + \mu(S)\left(q + \frac{\partial q}{\partial B'} B' + \frac{\partial q^*}{\partial B'} B^{*\prime}\right) - \rho(S)\left(q + \frac{\partial q}{\partial B'} B'\right) \\ = -\beta \frac{\partial \mathbb{E}\left\{\tilde{\delta}(S')V^R(S')\right\}}{\partial B'} + \Delta(S), \end{aligned} \tag{67}$$

where, similarly to equation (66), $\Delta(S)$ captures the terms involving changes in default probability and the default continuation values, after a change in B_{t+1}. We can further derive (66) and (67), to obtain

$$q^* + \frac{\partial q^*}{\partial B^{*\prime}} B^{*\prime} + \mu(S)\left(q^* + \frac{\partial q^*}{\partial B^{*\prime}} B^{*\prime} + \frac{\partial q}{\partial B^{*\prime}} B'\right) = \beta \mathbb{E}\left[\tilde{\delta}(S')\left(1 + \mu(S')\right)\right] + \rho(S)\frac{\partial q}{\partial B^{*\prime}} B' \tag{68}$$

$$\begin{aligned} \frac{\partial q^*}{\partial B'} B^{*\prime} + \mu(S)\left(q + \frac{\partial q}{\partial B'} B' + \frac{\partial q^*}{\partial B'} B^{*\prime}\right) \\ = \beta \mathbb{E}\left[\tilde{\delta}(S')\left(\mu(S') - \rho(S')\,\sigma - \eta(S')\theta\sigma\right] + \rho(S)\left(q + \frac{\partial q}{\partial B'} B'\right). \end{aligned} \tag{69}$$

To complete the problem of the government we need to specify the first order conditions with respect to labor, L, capital, K', and deposits D', which give us three additional conditions:

$$\mu(S) = \frac{\left(\rho(S) + \theta\eta(S)\right)\sigma z F_{KL} K + \hat{T}(L; S)}{\hat{T}_L(L; S)L - \hat{T}(L; S)}, \tag{70}$$

$$
\begin{aligned}
\rho(S)+\eta(S)=&\sigma\mathbb{E}\left[\big(\rho(S')+\theta\eta(S')\big)-\mu(S')\hat{T}_K(L';S')L'\right] \\
&-\frac{1}{\beta}\left[\frac{\partial q^*}{\partial D'}B^{*\prime}-\mu(S)\left(\frac{\partial q^*}{\partial D'}B^{*\prime}+\frac{\partial q}{\partial D'}B'\right)\right],
\end{aligned} \tag{71}
$$

and,

$$
\begin{aligned}
\rho(S)=&\frac{\partial q^*}{\partial K'}B^{*\prime}-1+\mu(S)\left(\frac{\partial q^*}{\partial K'}B^{*\prime}+\frac{\partial q}{\partial K'}B'\right) \\
&+\beta\mathbb{E}\left[z'F'_K+\mu(S')\hat{T}_K(L';S')L'+\big[\rho(S')+\theta\eta(S')\big]\,\sigma z'\left(F'_{KK}K'+F'_K\right)\right]
\end{aligned} \tag{72}
$$

Appendix D Computational Algorithm

The model is solved as the limit of a finite horizon model with a large enough number of periods, T. Starting from the last period T, I solve the model backwards taking as given the value functions and bond prices one period ahead until convergence. I use a grid search method to find the optimal amount of borrowing $B', B^{*\prime}$ over a grid $\mathcal{B}$ of a total of 100 points. Moreover, in order to smooth the decision of the government, which is necessary computationally in the case of long-term debt, I follow Dvorkin et al. (2021) and introduce i.i.d. shocks distributed as Extreme Value Type I into the government decision on borrowing.

Notation. Aggregate state is $S = (B^*, B, K, D, z, R^*, a)$. Define for each autarky state:

- Normal times: $S^n = (B^*, B, K, D, z, R^*)$
- Domestic autarky: $S^d = (B^*, K, D, z, R^*)$
- External autarky: $S^e = (B, K, D, z, R^*)$
- Autarky in both markets: $S^b = (K, D, z)$

Let $V^{a,R}(S^a)$ be the value of repaying in autarky state $a = \{n, d, e\}$, that is, normal times, domestic autarky, and external autarky respectively; and $V^b(S^b)$ the value when in autarky in both (no repayment decision)

Discretize space state. The state space is discretized as follows:

- Aggregate endogenous state variables: B^*, B, K, D
- Productivity, z, process: AR1 discretized using Tauchen (1986) method
- International interest rate, R^*, process: AR1 discretized using Tauchen (1986) method

Solve problem in the last period $t = T$

Here, I show how to solve the value functions and price functions in the last period. I assume that in the last period there is no new borrowing and no investment in capital. First, I show how to compute the repayment values in each of the autarky states: no-autarky, domestic autarky, external autarky, and full autarky. Given the repayment values, we can compute the default decisions, and therefore the prices.

Repayment values.

1. Enter the last period in no-autarky state (normal times). The value of repaying both debts is

$$V_T^{n,R}(S^n) = zK^\alpha L(S^n)^{1-\alpha} + (1-\delta_K)K - G - B^* + \psi\frac{L(S^n)^{1+\phi}}{1+\phi}$$

where, $L(S^n)$ solves

$$G + B + B^* = z(1-\alpha)K^\alpha L(S^n)^{1-\alpha} + \psi L(S^n)^{1+\phi}$$

2. Enter the last period in domestic autarky state. The value of repaying external debt is

$$V_T^{d,R}(S^d) = zK^\alpha L(S^d)^{1-\alpha} + (1-\delta_K)K - G - B^* + \psi\frac{L(S^d)^{1+\phi}}{1+\phi}$$

where, $L(S^d)$ solves

$$G + B^* = h(z)(1-\alpha)K^\alpha L(S^d)^{1-\alpha} + \psi L(S^d)^{1+\phi}$$

3. Enter the last period in external autarky state. The value of repaying domestic debt is

$$V_T^{e,R}(S^e) = zK^\alpha L(S^e)^{1-\alpha} + (1-\delta_K)K - G + \psi\frac{L(S^e)^{1+\phi}}{1+\phi}$$

where, $L(S^e)$ solves

$$G + B = h(z)(1-\alpha)K^\alpha L(S^e)^{1-\alpha} + \psi L(S^e)^{1+\phi}$$

4. Enter the last period in autarky in both markets. The value of full autarky is

$$V_T^b(S^b) = zK^\alpha L(S^b)^{1-\alpha} + (1-\delta)K - G + \psi\frac{L(S^b)^{1+\phi}}{1+\phi}$$

where, $L(S^b)$ solves

$$G = h(z)(1-\alpha)K^\alpha L(S^b)^{1-\alpha} + \psi L(S^b)^{1+\phi} - \xi^b$$

where ξ^b is a fixed cost of defaulting on both. Note that this is only included in the last period because absent this cost the government always wants to default on both rather than defaulting only on domestic or external.

Default decisions and value function.

1. If currently in normal times:

   (a) Default on external only if $V_T^{e,R}(S^e) > V_T^{n,R}(S^n)$, and then $\delta_T(S^n) = 1$, $\delta_T^*(S^n) = 0$

(b) Default on domestic only if $V_T^{d,R}(S^d) > V_T^{n,R}(S^n)$, and then $\delta_T(S^n) = 0$, $\delta_T^*(S^n) = 1$

(c) Default on both if $V_T^b(S^b) > V_T^{n,R}(S^n)$, and then $\delta_T(S^n) = 0$, $\delta_T^*(S^n) = 0$

(d) Otherwise, and then $\delta_T(S^n) = 1$, $\delta_T^*(S^n) = 1$

and therefore value is $V_T(S^n) = \max\{V_T^{n,R}(S^n), V_T^{d,R}(S^d), V_T^{e,R}(S^e), V_T^b(S^b)\}$

2. If currently in domestic autarky default if $V_T^b(S^b) > V_T^{d,R}(S^d)$, and then $\delta_{d,T}(S^d) = 0$; otherwise $\delta_{d,T}(S^d) = 1$

   and therefore value is $V_T^d(S^d) = \max\{V_T^{d,R}(S^d), V_T^b(S^b)\}$

3. If currently in external autarky default if $V_T^b(S^b) > V_T^{e,R}(S^e)$, and then $\delta_{e,T}^*(S^e) = 0$; otherwise $\delta_{e,T}^*(S^e) = 1$

   and therefore value is $V_T^e(S^e) = \max\{V_T^{e,R}(S^e), V_T^b(S^b)\}$

Bond prices. Given repayment decisions, $(\delta_T^*, \delta_T, \delta_{e,T}^*, \delta_{d,T})$, compute prices that creditors will offer to the government at $t = T - 1$

$$q_T^*(B^{*\prime}, B', K', D'; z, R^*) = \frac{\mathbb{E}_{z',R^{*\prime}}\left(\delta_T^*(B^{*\prime}, B', K', D', z', R^{*\prime})\Big| z, R^*\right)}{R^*}$$

$$q_{d,T}^*(B^{*\prime}, K', D'; z, R^*) = \frac{\mathbb{E}_{z',R^{*\prime}}\left(\gamma\delta_T^*(B^{*\prime}, 0, K', D', z', R^{*\prime}) + (1-\gamma)\delta_{e,T}^*(B^{*\prime}, K', D', z', R^{*\prime})\Big| z, R^*\right)}{R^*}$$

$$q_T(B^{*\prime}, B', K', D'; z, R^*) = \frac{\mathbb{E}_{z',R^{*\prime}}\left(\delta_T(B^{*\prime}, B', K', D', z', R^{*\prime})\Big| z, R^*\right)}{\mathbb{E}_{z',R^{*\prime}}\left(F_K(B^{*\prime}, B', K', D', z', R^{*\prime})\Big| z, R^*)\right)}$$

$$q_{e,T}(B^{*\prime}, K', D'; z, R^*) = \frac{\mathbb{E}_{z',R^{*\prime}}\left(\gamma\delta_T(0, B', K', D', z', R^{*\prime}) + (1-\gamma)\delta_{d,T}(B', K', D', z', R^{*\prime})\Big| z, R^*\right)}{\mathbb{E}_{z',R^{*\prime}}\left(\gamma F_K(0, B', K', D', z', R^{*\prime}) + (1-\gamma)\gamma F_K^d(B', K', D', z', R^{*\prime})\Big| z, R^*)\right)}$$

where, $F_K(S^n) = z\alpha K^{\alpha-1}L(S^n)^{1-\alpha}$ and $F_K^d(S^d) = h(z)\alpha K^{\alpha-1}L(S^d)^{1-\alpha}$. I set the marginal value of a unit in the bank in the last period, ν_T, to be 1, as it is immediately transfer to the household.

Iterate backwards: $t = T - 1$

Taking as given the value functions and price functions from last period, T, we can iterate backwards to compute the value functions and price functions at $t = T - 1$.

Value functions under repayment.

1. **Normal times** (access to both credit markets)

Let $\tilde{V}_t^{n,R}(B^{*\prime}, B'; S^n)$ be the value of repaying existing debt and issuing new debt $(B^{*\prime}, B')$:

$$
\begin{aligned}
\tilde{V}_t^{n,R}(B^{*\prime}, B'; S^n) =& zK^\alpha L(B^{*\prime}, B'; S^n)^{1-\alpha} - K'(B^{*\prime}, B'; S^n) + (1-\delta_K)K - G \\
&+ q^*_{n,t+1}(B^{*\prime}, B'; S^n)\left[B^{*\prime} - (1-\lambda)B^*\right] - \lambda B^* \\
&- \frac{\kappa r^*}{1+r^*} z(1-\alpha)K^\alpha L(B^{*\prime}, B'; S^n)^{1-\alpha} + \psi \frac{L(B^{*\prime}, B'; S^n)^{1+\phi}}{1+\phi} \\
&+ \beta \mathbb{E}_{z', R^{*\prime}}\left[V_{t+1}\left(B^{*\prime}, B', K'(B^{*\prime}, B'; S^n), D'(B^{*\prime}, B'; S^n), z', R^{*\prime}\right)|z, R^*\right]
\end{aligned}
$$

where functions $L(B^{*\prime}, B'; S^n), K'(B^{*\prime}, B'; S^n), D'(B^{*\prime}, B'; S^n)$ solve the competitive equilibrium conditions for given values $(B^{*\prime}, B'; S^n)$. That is, these functions solve the following system of equations.

- Collateral constraint

$$\beta D'(B^{*\prime}, B'; S^n) = \theta N$$

  where aggregate net worth N is defined as

$$N = \sigma\left[\alpha z K^\alpha L(B^{*\prime}, B'; S^n)^{1-\alpha} + (1-\delta_K)K + B(\lambda + (1-\lambda)B) - D\right] + (1-\sigma)\bar{n}$$

- Bank aggregate budget constraint

$$K'(B^{*\prime}, B'; S^n) = (1+\theta)N - \hat{q}_{n,t+1}(B^{*\prime}, B'; S^n)B'$$

- Government budget constraint

$$G + \lambda B + \lambda B^* = T + \hat{q}(B^{*\prime}, B'; S^n)\left[B' - (1-\lambda)B\right] + \hat{q}^*_{n,t+1}(B^{*\prime}, B'; S^n)\left[B^{*\prime} - (1-\lambda)B^*\right]$$

  where T are tax revenues

$$T = z(1-\alpha)K^\alpha L(B^{*\prime}, B'; S^n)^{1-\alpha} + \psi L(B^{*\prime}, B'; S^n)^{1+\phi}$$

Solution method: Nelder-Mead algorithm to find (L, K', D') that solve

$$
\begin{cases}
K'(B^{*\prime}, B'; S^n) - (1+\theta)N - \hat{q}_{n,t+1}(B^{*\prime}, B'; S^n)B' & = 0 \\
G + \lambda B + \lambda B^* - T - \hat{q}(B^{*\prime}, B'; S^n)\left[B' - (1-\lambda)B\right] - \hat{q}^*_{n,t+1}(B^{*\prime}, B'; S^n)\left[B^{*\prime} - (1-\lambda)B^*\right] & = 0 \\
\beta D'(B^{*\prime}, B'; S^n) - \theta\left\{\sigma\left[\alpha z K^\alpha L(B^{*\prime}, B'; S^n)^{1-\alpha} + (1-\delta)K + B(\lambda + (1-\lambda)B) - D\right] + (1-\sigma)\bar{n}\right\} & = 0
\end{cases}
$$

where, $\hat{q}_{n,T}(B^{*\prime}, B'; S^n)$ is the value q_T piecewise linearly interpolated at the points (K', D'), and similarly for $q^*_{n,T}$.

Then, value of repaying both debts is

$$
\begin{aligned}
V_t^{n,R}(S^n) =& \mathbb{E}\max\left\{\tilde{V}_t^{n,R}(B^{*\prime},B^{\prime};S^n)+\xi_B\right\} \\
=& \eta\log\sum_{(B^{\prime},B^{*\prime})\in\mathcal{B}}\exp\left(\tilde{V}_t^{n,R}(B^{*\prime},B^{\prime};S^n)\right)^{1/\eta}
\end{aligned}
$$

where η is the scale parameter of the Extreme Value Type I shocks, ξ_B, which I assume is equal to 0.0001. Note also that given the assumed distribution for the borrowing shocks, we can compute the probability of the government choosing a bond portfolio of $(B^{*\prime},B^{\prime})$ as

$$
\pi(B^{*\prime},B^{\prime};S^n)=\frac{\exp\left(\tilde{V}_t^{n,R}(B^{*\prime},B^{\prime};S^n)\right)^{1/\eta}}{\sum_{\hat{B}^{*\prime},\hat{B}^{\prime}}\exp\left(\tilde{V}_t^{n,R}(\hat{B}^{*\prime},\hat{B}^{\prime};S^n)\right)^{1/\eta}}
$$

2. **Domestic autarky** (no access to domestic borrowing)

Let $\tilde{V}_t^{d,R}(B^{*\prime};S^d)$ be the value of repaying existing debt and issuing new debt $B^{*\prime}$:

$$
\begin{aligned}
\tilde{V}_t^{d,R}(B^{*\prime};S^d) =& h(z)K^{\alpha}L(B^{*\prime};S^d)^{1-\alpha}-K^{\prime}(B^{*\prime};S^d)+(1-\delta_K)K-G+\psi\frac{L(B^{*\prime};S^d)^{1+\phi}}{1+\phi} \\
&+q^*_{d,t+1}(B^{*\prime};S^d)\left[B^{*\prime}-(1-\lambda)B^*\right]-\lambda B^* \\
&+\beta\mathbb{E}_{z^{\prime},R^{*\prime}}\Big\{\gamma V_{t+1}\left(B^{*\prime},0,K^{\prime}(B^{*\prime};S^d),D^{\prime}(B^{*\prime};S^d),z^{\prime},R^{*\prime}\right)+ \\
&+(1-\gamma)V_{t+1}^d\left(B^{*\prime},K^{\prime}(B^{*\prime};S^d),D^{\prime}(B^{*\prime};S^d),z^{\prime},R^{*\prime}\right)\Big|z,R^*\Big\},
\end{aligned}
$$

where functions $L(B^{*\prime};S^d),K^{\prime}(B^{*\prime};S^d),D^{\prime}(B^{*\prime};S^d)$ solve the competitive equilibrium conditions for given $\left(B^{*\prime};S^d\right)$, that is summarize by the following system of equations:

– Collateral constraint

$$
\beta D^{\prime}(B^{*\prime};S^d)=\theta N
$$

where aggregate net worth N is defined as

$$
N=\sigma\left[\alpha h(z)K^{\alpha}L(B^{*\prime};S^d)^{1-\alpha}+(1-\delta_K)K-D\right]+(1-\sigma)\bar{n}
$$

– Bank aggregate budget constraint

$$
K^{\prime}(B^{*\prime};S^d)=(1+\theta)N
$$

– Government budget constraint

$$
G+\lambda B^*=T+\hat{q}^*_{d,t+1}(B^{*\prime};S^d)\left[B^{*\prime}-(1-\lambda)B^*\right]
$$

where T are tax revenues

$$T = h(z)(1-\alpha)K^{\alpha}L(B^{*\prime};S^d)^{1-\alpha} + \psi L(B^{*\prime};S^d)^{1+\phi}$$

Solution method: Nelder-Mead algorithm to find (L', K') that solve

$$\begin{cases} K'(B^{*\prime};S^d) - (1+\theta)\left\{\sigma\left[\alpha h(z)K^{\alpha}L(B^{*\prime};S^d)^{1-\alpha} + (1-\delta_K)K - D\right] + (1-\sigma)\bar{n}\right\} & = 0 \\ G + \lambda B^* - T - \hat{q}^*_{d,t+1}(B^{*\prime};S^d)\left[B^{*\prime} - (1-\lambda)B^*\right] & = 0 \end{cases}$$

where, $q^*_{d,t+1}(B^{*\prime}, S^d)$ is the value of $q^*_{d,T}$ piecewise linearly interpolated at the points (K', D') and

$$D' = \frac{\theta}{\beta}\left\{\sigma\left[\alpha h(z)K^{\alpha}L(B^{*\prime};S^d)^{1-\alpha} + (1-\delta_K)K - D\right] + (1-\sigma)\bar{n}\right\}$$

Then, value of repayment is

$$\begin{aligned} V_t^{d,R}(S^d) =& \mathbb{E}\max\left\{\tilde{V}_t^{d,R}(B^{*\prime};S^d) + \xi_B\right\} \\ =& \eta \log \sum_{B^{*\prime}\in\mathcal{B}^d} \exp\left(\tilde{V}_t^{d,R}(B^{*\prime};S^d)\right)^{1/\eta} \end{aligned}$$

3. **External autarky** (no access to external borrowing)

Let $\tilde{V}_t^{e,R}(B';S^e)$ be the value of repaying existing debt and issuing new debt B':

$$\begin{aligned} \tilde{V}_t^{e,R}(B';S^e) =& h(z)K^{\alpha}L(B';S^e)^{1-\alpha} - K'(B';S^e) + (1-\delta)K - G \\ &+ \psi\frac{L(B';S^e)^{1+\phi}}{1+\phi} \\ &+ \beta\mathbb{E}_{z',R^{*\prime}}\Big\{\gamma V_{t+1}\left(0, B^{*\prime}, K'(B';S^e), D'(B';S^e), z', R^{*\prime}\right) \\ &+ (1-\gamma)V^e_{t+1}\left(B', K'(B';S^e), D'(B';S^e), z', R^{*\prime}\right)\big|z, R^*\Big\} \end{aligned}$$

where functions $L(B';S^e), K'(B';S^e), D'(B';S^e)$ solve the competitive equilibrium conditions for given$(B';S^e)$, that is summarize by the following system of equations:

- Collateral constraint

$$\beta D'(B^{e\prime};S^e) = \theta N$$

where aggregate net worth N is defined as

$$N = \sigma\left[\alpha h(z)K^{\alpha}L(B';S^e)^{1-\alpha} + (1-\delta_K)K + B(\lambda + (1-\lambda)B) - D\right] + (1-\sigma)\bar{n}$$

– Bank aggregate budget constraint

$$K'(B^{e\prime}; S^e) = (1+\theta)N + \hat{q}_{e,t+1}(B'; S^e)B'$$

– Government budget constraint

$$G + \lambda B = T + \hat{q}_{e,t+1}(B'; S^e)\left[B' - (1-\lambda)B\right]$$

where T are tax revenues

$$T = h(z)(1-\alpha)K^\alpha L(B'; S^e)^{1-\alpha} + \psi L(B'; S^e)^{1+\phi}$$

Solution method: Nelder-Mead algorithm to find (L, K') that solve

$$\begin{cases} K'(B'; S^e) - (1+\theta)N - \hat{q}_{e,t+1}(B'; S^e)B' & = 0 \\ G + \lambda B - T - \hat{q}(B'; S^e)\left[B' - (1-\lambda)B\right] & = 0 \\ \beta D'(B'; S^e) - \theta\left\{\sigma\left[\alpha h(z)K^\alpha L(B'; S^e)^{1-\alpha} + (1-\delta_K)K + B(\lambda + (1-\lambda)B) - D\right] + (1-\sigma)\bar{n}\right\} & = 0 \end{cases}$$

where, $\hat{q}_{e,t+1}(B'; S^n)B'$ is the value $q_{e,T}$ piecewise linearly interpolated at the points (K', D'); and

$$D' = \theta\left\{\sigma\left[\alpha h(z)K^\alpha L^{1-\alpha} + (1-\delta_K)K + B - D\right] + (1-\sigma)\bar{n}\right\}$$

Then, value of repayment is

$$\begin{aligned} V_t^{e,R}(S^e) =& \mathbb{E}\max\left\{\tilde{V}_t^{e,R}(B'; S^e) + \xi_B\right\} \\ =& \eta \log \sum_{(B')\in\mathcal{B}^\rceil} \exp\left(\tilde{V}_t^{e,R}(B'; S^e)\right)^{1/\eta} \end{aligned}$$

4. **Autarky in both markets**: no debt issuance or default decision

$$\begin{aligned} V_t^b(S^b) =& h(z)K^\alpha L(S^b)^{1-\alpha} - K'(S^b) + (1-\delta)K - G \\ &+ \psi\frac{L(S^b)^{1+\phi}}{1+\phi} \\ &+ \beta\mathbb{E}_{z',R^{*\prime}}\left\{\gamma V_{t+1}\left(0, 0, K'(S^b), D'(S^b), z', R^{*\prime}\right) + \right. \\ &\left. + (1-\gamma)V_{t+1}^b\left(K'(S^b), D'(S^b), z', R^{*\prime}\right) \middle| z, R^*\right\} \end{aligned}$$

where functions $L(S^b), K'(S^b), D'(S^b)$ solve the competitive equilibrium conditions for givenS^b, that is summarize by the following system of equations:

– Collateral constraint

$$\beta D'(S^b) = \theta N$$

where aggregate net worth N is defined as

$$N = \sigma \Big[\alpha z K^{\alpha} L(S^b)^{1-\alpha} + (1-\delta_K)K - D\Big] + (1-\sigma)\bar{n}$$

– Bank aggregate budget constraint

$$K'(S^b) = (1+\theta)N$$

– Government budget constraint

$$G = h(z)(1-\alpha)K^{\alpha}L(S^b)^{1-\alpha} + \psi L(S^b)^{1+\phi}$$

Default decisions and value function.

1. If currently in normal times:

   (a) Default on external only if $V_t^{e,R}(S^e) > V_t^{n,R}(S^n)$, and then $\delta_t(S^n) = 1$, $\delta_t^*(S^n) = 0$

   (b) Default on domestic only if $V_t^{d,R}(S^d) > V_t^{n,T}(S^n)$, and then $\delta_t(S^n) = 0$, $\delta_t^*(S^n) = 1$

   (c) Default on both if $V_t^b(S^b) > V_t^{n,R}(S^n)$, and then $\delta_t(S^n) = 0$, $\delta_t^*(S^n) = 0$

   (d) Otherwise, , and then $\delta_t(S^n) = 1$, $\delta_t^*(S^n) = 1$

   and therefore value is $V_t(S^n) = \max\{V_t^{n,R}(S^n), V_t^{d,R}(S^d), V_t^{e,R}(S^e), V_t^b(S^b)\}$

2. If currently in domestic autarky default if $V_t^b(S^b) > V_t^{d,R}(S^d)$, and then $\delta_{d,t}(S^d) = 0$; otherwise $\delta_{d,t}(S^d) = 1$

   and therefore value is $V_t^d(S^d) = \max\{V_T^{d,R}(S^d), V_T^b(S^b)\}$

3. If currently in external autarky default if $V_t^b(S^b) > V_t^{e,R}(S^e)$, and then $\delta_{e,t}^*(S^e) = 0$; otherwise $\delta_{e,t}^*(S^e) = 1$

   and therefore value is $V_t^e(S^e) = \max\{V_t^{e,R}(S^e), V_t^b(S^b)\}$

Bond prices. Given repayment decisions, $(\delta_t^*, \delta_t, \delta_{e,t}^*, \delta_{d,t})$, compute prices that creditors will offer to the government at $t = T-1$

$$q_t^*(B^{*\prime}, B', K', D'; z, R^*) = \frac{1}{R_t^*}\mathbb{E}_{z',R^{*\prime}}\left\{\delta_t^*(B^{*\prime}, B', K', D', z', R^{*\prime})\left[\lambda + (1-\lambda)q_T^*(S')\right]\Big| z, R^*\right\}$$

$$q^*_{d,t}(B^{*\prime},K',D';z,R^*)=\frac{1}{R^*_t}\mathbb{E}_{z',R^{*\prime}}\Big(\gamma\delta^*_t(B^{*\prime},0,K',D',z',R^{*\prime})\left[\lambda+(1-\lambda)q^*_T(S')\right]$$
$$+(1-\gamma)\delta^*_{e,t}(B^{*\prime},K',D',z',R^{*\prime})\left[\lambda+(1-\lambda)q^*_{d,T}(S')\right]\Big|z,R^*\Big)$$

$$q_t(B^{*\prime},B',K',D';z,R^*)=\frac{\mathbb{E}_{z',R^{*\prime}}\Big(\nu_T(S')\delta_T(S')\left[\lambda+(1-\lambda)q_T(S')\right]\Big|z,R^*\Big)}{\mathbb{E}_{z',R^{*\prime}}\Big(\nu_T(S')F_K(B^{*\prime},B',K',D',z',R^{*\prime})\Big|z,R^*\Big)}$$

$$q_{e,t}(B^{*\prime},K',D';z,R^*)=\frac{1}{\mathbb{E}_{z',R^{*\prime}}\left(\gamma\nu_T(S')F_K(0,B',K',D',z',R^{*\prime})+(1-\gamma)\nu_{e,T}(S')F^d_K(S^{e\prime})\right)}$$
$$\times\Big\{\mathbb{E}_{z',R^{*\prime}}\Big(\gamma\nu_T(S')\delta_t(0,B',K',D',z',R^{*\prime})\left[\lambda+(1-\lambda)q_T(S')\right]$$
$$+(1-\gamma)\nu_{e,T}(S')\delta_{d,t}(B',K',D',z',R^{*\prime})\left[\lambda+(1-\lambda)q_{d,T}(S')\right]\Big|z,R^*\Big)\Big\}$$

where, $F_K(S^n)=z\alpha K^{\alpha-1}L(S^n)^{1-\alpha}$ and $F^d_K(S^d)=h(z)\alpha K^{\alpha-1}L(S^d)^{1-\alpha}$.

Value of the bank. Finally, we need to compute the marginal value of a unit in the bank ν, which is given by (16). In particular,

$$\nu_t(S)=\beta\mathbb{E}_{z',R^{*\prime}}\sum_{(B^{*\prime},B')\in\mathcal{B}}\pi(B^{*\prime},B';S)\Big[F_K(B^{*\prime},B',K',D',z',R^{*\prime})$$
$$+\theta\nu_T(B^{*\prime},B',K',D',z',R^{*\prime})\Big|z,R^*\Big],$$

and similarly for the other autarky states.

Iterate backwards and check convergence

Check value function convergence: $d=\max\left\{|V_t-V_{t-1}|,|V^e_t-V^e_{t-1}|,|V^d_t-V^d_{t-1}|,|V^b_t-V^b_{t-1}|\right\}$, and bond price schedule convergence, $d^q=\max\Big\{|q_t-q_{t-1}|,|q_{e,t}-q_{e,t-1}|,|q^*_t-q^*_{t-1}|,|q^*_{d,t}-q^*_{d,t-1}|\Big\}$, update them and iterate until convergence.

Simulate equilibrium results

1. Start from a given initial state $S_0=(B^*_0,B_0,K_0,D_0,z_0,R^*_0,a_0)$
2. Using value functions, policy functions in equilibrium, and extreme value shocks for the determination of borrowing, find new assets, $A_1\equiv(B^*_1,B_1,K_1,D_1)$; given repayment decision $\delta(S_0),\delta^*(S_0)$, update (intra-period) autarky state
3. Realization of new shocks: productivity, z_1, international interest rate, R^*_1, and, if intra-period autarky-state $\tilde{a}=\{d,e,b\}$, re-enter credit markets with probability γ, and updated autarky state, a_1 correspondingly.

4. Start with new state $S_1 = (B_1^*, B_1, K_1, D_1, z_1, R_1^*, a_1)$, and iterate for $T = 50000$ periods.

Appendix E Additional empirical evidence

E.1 Domestic debt definition

The definition used in the empirical evidence for domestic vs. external debt is by the jurisdiction where the debt is issued. This data is taken from Reinhart and Rogoff (2011). The definition in the model is based on who holds the debt: domestic vs. foreign investors. However, in the data the two definitions align in most cases. Using data from Arslanalp and Tsuda (2014), I compare these two definitions for the years in which we have information on both series and for the countries in the sample (for most countries, this time period is 1999-2010). Figure 14 compares the share of domestic debt using each definition, and it can be seen that the correlation is high for the two series. Moreover, Table 10 compares the main statistics of the series for the overlapping periods, and we can see that they are remarkably similar.

Figure 14: Domestic debt share by definition

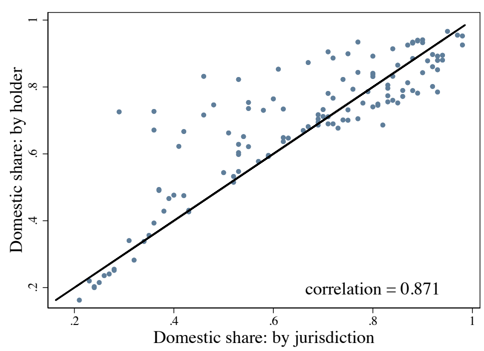


Table 10: Domestic debt definition

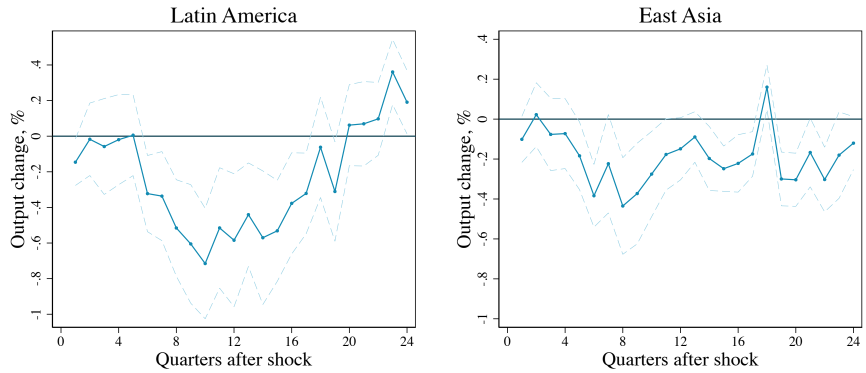
	By holder	By jurisdiction
Mean	0.547	0.549
Median	0.577	0.570
P25	0.341	0.360
P75	0.752	0.780

E.2 Effect of interest rates on emerging countries: robustness exercises

Sample of countries. In the baseline sample there are 7 countries from Latin America and 4 East Asian, as well as Turkey and South Africa. Here, I show that the negative output response after a shock to the U.S. interest rates is present regardless of the sub-sample of countries that we consider. The left panel of Figure 15 shows the estimated response of real GDP when only countries in Latin America are considered in equation (1), and the right panel shows the response for East Asian countries. Real GDP drops around 0.6 percent in Latin America, and around 0.4 percent in

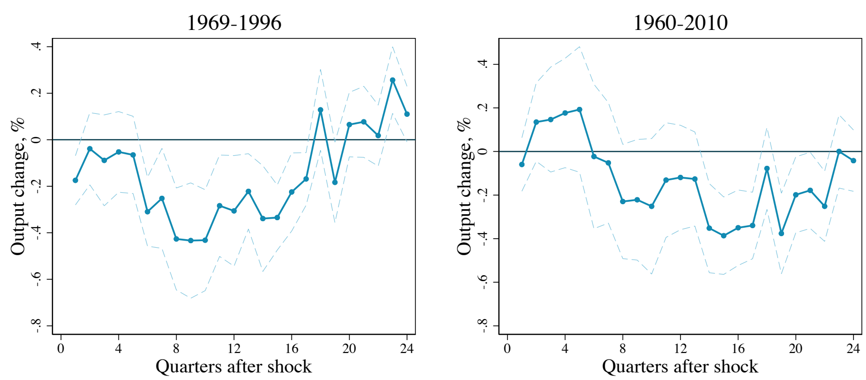
East Asia.

Figure 15: Output response by sample of countries



Volcker periods. Another potential concern about the results on the effect of interest rate shocks on emerging countries is whether results are partially driven by the Volcker shock. The beginning of 1980s was a period characterized by large increases in the U.S. interest rates which was followed by several crisis in developing countries. To see the effect of this period in the main results, I run regression (1) taking out the years of the Volcker shock: 1980-1985. Figure 16 shows the results for the two sample periods considered in the paper. The results do not change if we exclude the Volcker shock years.

Figure 16: Output response excluding Volcker shock periods



E.3 Financial development and external shocks: Robustness

In this section, I show robustness exercises regarding the results on the difference in the vulnerability of emerging countries to interest rate shocks by their level of financial development. To this end, regression (2) is estimated in a number of different sub-samples including different time period, countries, and excluding the Volcker shock periods. Table 11 shows the results for all sub-samples. The main result prevails: the coefficient γ_h is positive and significantly so for many quarters after the shock. This indicates that a higher level of financial development, measured as liquid liabilities to GDP, mitigates the drop in output in emerging countries from a shock that increases U.S. interest rates.

Table 11: Output response and financial development: Robustness

	Interaction coefficient, γ_h					
Quarters after shock:	4	6	8	10	12	16
All countries 1960-2007	0.015***	0.026***	0.023**	0.019	0.010	-0.004
	(0.006)	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)
Latin America 1969-1996	0.024	0.037	0.055	0.082*	0.095*	-0.008
	(0.036)	(0.033)	(0.041)	(0.047)	(0.051)	(0.043)
Latin America 1960-2007	0.051	0.102***	0.117***	0.101**	0.065**	0.007
	(0.034)	(0.035)	(0.042)	(0.041)	(0.044)	(0.041)
East Asia 1969-1996	0.010	0.014*	0.020*	0.013	0.021*	-0.001
	(0.007)	(0.008)	(0.011)	(0.010)	(0.011)	(0.008)
East Asia 1960-2007	0.019***	0.030***	0.024**	0.014	0.009	-0.009
	(0.007)	(0.011)	(0.012)	(0.010)	(0.011)	(0.011)
All countries 1969-1996	0.008	0.015	0.030*	0.024	0.036*	-0.006
excluding Volcker shock	(0.012)	(0.013)	(0.017)	(0.018)	(0.021)	(0.013)
All countries 1960-2007	0.015*	0.027***	0.031**	0.020	0.013	0.002
excluding Volcker shock	(0.009)	(0.010)	(0.011)	(0.013)	(0.012)	(0.013)

Driscoll-Kraay standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

E.4 Financial development and domestic debt: 1960-2007

Here, I consider the same regression as in (3) but focus on the broader sample period from 1960 to 2007. Results are reported in Table 12, which shows that higher financial development is associated with a larger share of domestic debt. The magnitudes are also similar to the baseline sample 1969-1996.

Table 12: Domestic debt and financial development

	(1)	(2)	(3)
Financial development	0.332***	0.420***	0.189***
	(0.045)	(0.070)	(0.076)
Total debt to GDP	-0.156***	-0.168***	-0.103***
	(0.046)	(0.032)	(0.035)
Log GDP per capita	0.432*	-16.497***	-1.409
	(1.316)	(3.236)	(5.130)
Country Effects	No	Yes	Yes
Year Effects	No	No	Yes
Observations	516	516	516

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

E.5 U.S. interest rate and real exchange rate

Here I show the results for the estimation of the bivariate process for the U.S. interest rate and the real exchange rate between the United States and each of the emerging countries considered in the sample, as specified in equation (32). I estimate the process for each country separately and then take averages of each of the coefficients. The estimation is done using the average quarterly U.S. Federal funds rate, and the average quarterly log real exchange rates. The estimated coefficients are

$$\begin{bmatrix} r^*_{t+1} \\ e_{t+1} \end{bmatrix} = \begin{bmatrix} 0.0011 \\ -0.0198 \end{bmatrix} + \begin{bmatrix} 0.933 & 0.000 \\ 1.237 & 0.967 \end{bmatrix} \begin{bmatrix} r^*_t \\ e_t \end{bmatrix} + \begin{bmatrix} 0.00001 & 0.00000 \\ -0.00002 & 0.01076 \end{bmatrix} \begin{bmatrix} \epsilon^r_{t+1} \\ \epsilon^e_{t+1} \end{bmatrix}. \quad (73)$$

Figure 17 plots the resulting impulse response of a shock that increases the annualized interest rate by 100 basis points.

Figure 17: Bivariate VAR process for r^* and e