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ESSAYS IN DEVELOPMENT MACROECONOMICS

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Essays in Development Macroeconomics

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To Felipe and Pedro: may they someday read this and discover that they can do so much more and so much better;

To Daniela, who gave me the two little monsters;

To Antonio, who still thinks this actually means something;

To my mother, who still thinks I'm smart, regardless of what follows;

And to my father, who, despite the facts and his better judgment, never stopped believing.

Guys, we made it (somehow…)!

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I've spent the better part of my PhD training years at Columbia University in the city of New York. It was there that I completed my two masters degrees – one in Economics and another in Finance – and it was also there that I began the long, painful and, hence, dreaded stroll down dissertation lane. It would, therefore, be an unforgivable lapse not to mention the fantastic advisory work performed by Michael Woodford, who coached me through the first essay of this thesis. Without his remarkable insights and his unrelenting encouragement, this would never have been possible. And I would not have made it to Columbia at all if it were not for two extraordinary individuals: Professors Albert Fishlow and José Alexandre Scheinkman. Their guidance and support was instrumental in my survival as a graduate student in the US.

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ABSTRACT

Developing macroeconomics is less about looking for ways to say that economic rules stemming from research in developed countries don't apply to emerging-markets, than it is about trying to understand the many stages these economies go through in the natural course of their development. There are, of course, exceptions, but economic phenomena tend to have common sources. These are, after all, generated by the incentives, designed or natural, that people face when dealing with their day to day decisions as they go about their everyday lives. In the two essays that follow, we try to stay true to that fundamental belief. Instead of searching for the proverbial "jabuticaba", we strive to understand how countries in different stages of development deal with a fundamental feature of "growing pains": crises, be they imported or locally generated. In the first essay, we look at an entirely novel feature of (some) developing economies: the potential to implement certain countercyclical policies when faced with an external shock. During the financial crisis of 2007-2009, to respond to a sudden stop in capital flows, many central banks in emerging market economies relied on credit policies. We build a quantitative small open economy model to study these credit policies. The main innovation of our setup is the presence of two imperfect credit markets, one domestic and the other international, and of two types of firms. The exporter is assumed to have access to both credit markets, while the wholesale firm can only borrow in the domestic market. During a sudden stop, exporters, faced with higher spreads for international credit lines, repay part of their foreign debt, tap the local market for funds and cause spreads to increase in the domestic market. This increases financing costs for all firms, causes a deterioration of the balance of payments and depresses output. Calibrating the model to match Brazilian data, we assess the effects of two policies implemented by the Central Bank of Brazil: (i) lending to exporters using previously accumulated foreign-exchange reserves and (ii) expanding credit in order to reduce spreads in the domestic market. The model suggests that both policies probably raised GDP, but that the latter may well have decreased welfare. Moreover, had the central bank not been able to use foreign reserves as the source of funding, lending to exporters would also have reduced welfare. In the second essay, we look at less promising situations, when countries are faced with default. In this work, we take a broader view, noticing that some of the salient features of the theoretical literature on sovereign debt, including its prediction that almost all defaults should arise in "Bad Times", are at odds with the data: over 38% of defaults actually occur in "Good Times", as measured by an HP filter. We explore the specific characteristics of both types of default. We first review some definitions of good and bad times, revealing that the resulting classification can differ greatly and have important implications for the overall analysis. Then, we present econometric evidence that failures to repay foreign debt in good times can, usually, be rationalized by three components: (i) changes in the political environment, (ii) hikes in global interest rates and (iii) instances in which good HP times actually take place under quite poor economic conditions. Finally, we present some suggestive indications that the duration of the episodes varies substantially with the type of default that precedes them as well as with the environment in which they occur, drawing some important implications for the understanding of economies' post-default market access.

RESUMO

Diferentemente do que se imagina, a chamada macroeconomia do desenvolvimento tem menos a ver com a tentativa de encontrar justificativas para afirmar que os fundamentos da pesquisa econômica não se aplicam a mercados emergentes, do que, de fato, com o intuito de entender os diversos estágios pelos quais passam essas economias no curso normal de seu desenvolvimento. Existem, é claro, exceções, mas os fenômenos econômicos, em sua maioria, apresentam fatores comuns. Estes decorrem, afinal, dos incentivos, desenhados ou naturais, encontrados pelos agentes nas decisões do dia a dia. Nos dois artigos que seguem, buscamos respeitar essa concepção dos fatos: nos esforçamos para entender como países em diferentes fases de desenvolvimento enfrentam uma característica fundamental do processo de crescimento, as crises – importadas ou geradas localmente. O primeiro ensaio está centrado em uma característica completamente nova de (certos) países em desenvolvimento: a capacidade de implementar certas políticas contracíclicas quando submetidos a choques externos. Durante a crise de 2007-2009, vários bancos centrais de países emergentes reagiram à parada brusca nos fluxos de capitais através de políticas de crédito. Construímos, no artigo, um modelo quantitativo de uma pequena economia aberta para estudar essas políticas de crédito. A principal inovação em nossa estrutura é a presença de dois mercados imperfeitos de crédito, um doméstico e outro internacional, servindo a pelo menos um de dois tipos de firmas. Assume-se que o exportador tem acesso a ambos os mercados, enquanto o atacdista (*wholesale firm*) só toma empréstimos no mercado doméstico. Durante uma parada brusca, os exportadores, face a *spreads* mais elevados para linhas de crédito internacionais, repagam parte da sua dívida externa e usam o mercado doméstico para se financiarem, elevando, dessa forma, os *spreads* no mercado local. O custo de financiamento, portanto, cresce para todas as firmas, deteriorando o balanço de pagamentos e deprimindo o produto. Calibrando o modelo com base nos dados da economia brasileira, analisamos os efeitos de duas políticas implementadas pelo Banco Central do Brasil: (i) empréstimos a exportadores usando reservas internacionais previamente acumuladas, e (ii) expansão do crédito com vistas a reduzir o *spread* no mercado doméstico. O modelo sugere que as duas políticas são capazes de elevar o PIB, porém a segunda provavelmente reduz o nível de bem-estar. Ademais, se o banco central não houvesse usado as reservas como forma de financiar os empréstimos aos exportadores, tal política também teria impactos negativos no bem-estar. No segundo artigo, de cunho empírico, estudamos situações menos promissoras, nas quais os países enfrentam a possibilidade do calote em suas dívidas internacionais. Tomamos um ponto de vista mais amplo, notando que algumas das características fundamentais da literatura teórica sobre dívida externa, incluindo a previsão de que quase todos os defaults deveriam ocorrer em "períodos ruins", não encontram respaldo nos dados: mais de 38% dos calotes ocorrem em "períodos bons", na definição do Filtro HP. Começamos pela revisão de algumas das definições de períodos bons e ruins, mostrando que as classificações podem variar substancialmente, impactando a análise de modo geral. Em seguida, apresentamos algumas evidências econométricas de que calotes na dívida externa durante períodos bons podem ser explicados por três componentes: (i) mudanças no ambiente político, (ii) aumentos nas taxas de juros internacionais, e (iii) instâncias em que o Filtro HP apresenta períodos bons apesar da real situação econômica bastante negativa. Por fim, apresentamos alguns resultados que sugerem que a duração dos episódios de *default* depende do tipo de *default*, assim como do ambiente em que o calote ocorre. Tal resultado abre o caminho para novas pesquisas sobre o acesso de economias aos mercados internacionais de crédito após um *default*.

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1 THE CREDIT DIMENSION OF MONETARY POLICY: LESSONS FROM DEVELOPING ECONOMIES UNDER SUDDEN STOPS[1]

1.1 Introduction

The financial crisis of 2007-2009 pushed monetary authorities far beyond the traditional management of interest rates. Central banks around the world felt the need to supplement their conventional policies with strategies designed to alleviate adverse conditions in credit markets. Emerging market economies, in particular, buffeted as they were by large reversals in foreign credit flows, engaged in a variety of specifically targeted credit policies (see Ishi, Stone, and Yehoue 2009). The case for these types of policies, however, remains contentious among practitioners. And there is even more controversy about the justification, in terms of economic theory, for the exceptional measures undertaken by so many central banks. Here, we aim to contribute to this debate by building a quantitative small open economy model to study the credit policies adopted by developing countries in response to sudden stops in capital inflows.

The main innovation of our model is the presence of two imperfect credit markets, one domestic and the other international. This allows us to capture an important financial market segmentation present in many emerging economies: while most firms can borrow domestically, only some types of firms have access to foreign credit. Moreover, shocks to the foreign supply of credit affect not only international spreads but domestic spreads as well, as firms that previously relied on credit from abroad are forced to tap the local market to a greater extent. The increase in both spreads raises financing costs for all borrowers in the economy and depresses output.

In this economic environment, we use our model to assess the implications of two common types of credit policies that were embraced across emerging market economies, during the crisis. The first was the liquidity provision to the export sector. The fact that in the data, as well as in our model, exporters are the main class of firms that have access to foreign borrowing is crucial in an analysis of this type of measure. The second policy adopted was an

[1] With Guilherme B. Martins. This paper is the job market paper of João Moreira Salles.

expansion of credit by central banks intended to lower domestic spreads across the board. This latter type of intervention was also common in advanced economies. What is special about emerging economies is that the policy was implemented in response to a major tightening in international credit conditions that generated a sudden stop in capital inflows. Acknowledging the link between the external shock and conditions in the domestic credit market turns out to be essential for both policies.

In order to clarify this, we posit an economy populated by households, a financial sector and four types of firms: wholesale, trading companies, retail and capital producing. The key aspects of the model are related to the financing of firms in the wholesale and trading sectors. Wholesale firms combine physical capital and labor to produce home goods. Since they own the physical capital, wholesalers require funds to operate. Trading companies instead specialize in the export market: they acquire goods from domestic producers and sell them abroad, at no additional cost, to foreign consumers. They also require funding because they receive the corresponding payments only with a delay. In the same vein as the financial accelerator literature (Bernanke, Gertler, and Gilchrist 1999), the financial frictions in our model imply that firms rely mostly on debt contracts to adjust their capital structure. The main difference here is that they can, at least in principle, borrow either domestically or from abroad.

In the domestic market, which we model, like Cúrdia and Woodford (2010c) and Good-friend and McCallum (2007), through a costly loan production technology, both firms can borrow at the same rate. However, in the international market, as is common in developing countries, some firms face more favorable foreign credit supply conditions than other firms operating in the same economy. To simplify the model, we assume that only the trading firms have access to foreign credit markets at all.

A variety of observations support our assumption that exporters have access to foreign credit at more favorable terms, at least in emerging market economies[2]. First, in the banking

[2]A number of market participants in Latin America also point out that trade finance offers better terms because the essentiality of international trade shields the repayments of trade-related lines from being blocked by exchange rate centralizations and other heteredox measures. This widespread view is based on the history of past currency crises in Latin America, where local governments always made efforts to guarantee that trade credit obligations were honored. We would like to thank those who took the time to explain to us this aspect and other features of trade finance related products.

literature, Berger, Klapper, and Udell (2001), Stein (2002), Mian (2006), Gormley (2010), among others, show that foreign-owned financial institutions, as well as large banks, tend to finance only the largest and most profitable firms. Combined with the well-established view in the modern trade literature that firms operating in the export-import sector tend to be larger, better organized and more sophisticated (Melitz 2003), these papers suggest that lending to firms engaged in international trade is usually viewed as a safer market, which foreign banks can supply more easily, either directly or through local banks[3].

Second, in our model, trading firms require funding because exports require additional working capital, as foreign customers make payments with a one-period delay. Therefore, in the model, we associate international borrowing with trade finance credit lines. The literature on the topic (for example, Amiti and Weinstein 2009) has emphasized, among other aspects, the higher working capital requirements associated with international transactions. A recent theory of trade finance by Ahn (2010) suggests that, due to screening advantages, foreign lenders of working capital to firms in developing economies should specialize in providing trade finance to exporters[4].

Finally, banks do not take on currency mismatch risk when lending to exporters in emerging economies. This explains the existence, in normal times, of a highly competitive credit market, with many specialized players, in which trade finance becomes a low-risk, low-reward proposition (Korinek, Le Cocguic, and Sourdin 2010).

With asymmetric access to international credit, a sudden stop of capital flows impacts different agents though different channels. The exporters are directly affected as they can no longer obtain the cheap trade finance credit lines from abroad, and hence see a significant deterioration in the terms at which they can borrow. As a consequence, they reduce their activity, decrease their foreign debt, and tap the domestic market for funds. The wholesale firms are indirectly affected, because the additional demand for funds from exporters

[3]Cho, Krishnan, and Nigh (1993), for instance, show that foreign banks operating in the US tend to specialize in trade finance.

[4]In addition, according to the World Bank Global Development Finance Report (2004), "Participation in international trade can help less creditworthy countries and firms expand their access to finance. Banks are more willing to lend when traded goods are available as security." Cetorelli and Goldberg (2010) show the importance of trade finance as a transmission mechanism of the 2007-2009 crisis. For a more complete discussion of bank structuring of trade finance, see Manova (2010).

increases domestic spreads and interest rates. In response to a higher borrowing cost, these firms reduce production and cut back investments. Finally, as exporters repay their foreign debt, the exchange rate depreciates, further reducing domestic consumption and investment.

In light of the importance of these financial channels, credit policies are arguably important tools for central banks dealing with sudden stops. Given that the Central Bank of Brazil has been a prominent example of the use of unconventional policies[5], we calibrate our model using Brazilian data, and offer a (simplified) case study of the recent crisis in this country[6]. We start by establishing that the model's mechanism is able to capture the dynamics of key macroeconomic variables during the crisis of 2008-2009. In particular, the model can replicate the rise in both international and domestic spreads, as observed in the data. Then we perform a series of counterfactual analyses to assess the importance of the credit policies implemented by the Central Bank of Brazil.

Our main findings are the following. First, providing credit to exporters is an effective tool. Our simulations indicate that it reduced spreads and that both GDP and welfare were higher as a result of the credit policy. Essential to this conclusion is the fact that the central bank funded its intervention entirely from previously accumulated foreign reserves. The economic intuition supporting the effectiveness of the policy is, then, straightforward: the credit facility provides a cheaper alternative of foreign credit to the exporters during the crisis. It should be emphasized, however, that in our analysis the central bank provides credit at the prevailing market price. Therefore, any benefits come from the general equilibrium effects on spreads, as exporters reduce the amount of debt contracted with the private sector.

To be able to provide an alternative line of credit, the central bank needs to have foreign-exchange reserves available at the time of the intervention[7]. Had they not been fully-funded

[5]Calvo (2006), for example, suggests that some of these alternative policies, especially the central bank involvement in the credit market for exports first implemented by Brazil in 2002, and then again in 2008-2009, have had significant effects in terms of reducing the economic and social costs of these crises.

[6]As shall be further explained below, we assume away some important aspects of the crisis. In particular, Brazil, as most emerging economies, was also hit by a large terms of trade shock. Abstracting from this shock affects the ability of the model to match some aspects of the crisis, but allows us to focus on the role of credit policies in response to a sudden stop.

[7]To be precise: the central bank has to have access to foreign resources that are not subject to the same spreads available to private agents. Previously accumulated foreign reserves, IMF loans or currency swaps with the US Federal Reserve are examples of funding. In our model, all of these sources of funding would have the same effect.

out of reserves, credit facilities to exporters would reduce welfare in our model. In this case, targeting credit to exporters would still provide them with the incentive to repay their foreign debt. But, without the use of foreign reserves, this movement would also accelerate the exchange rate depreciation and, hence, inflation. When the central bank cares about these variables, as they most likely do – after all, many emerging market economies adopt an inflation targeting regime – the policy ends up reducing welfare.

Second, with respect to the policy aimed at the domestic market more generally, our results are not as favorable. Even though the intervention is effective in reducing domestic spreads due to general equilibrium effects, the impact on welfare can be negative. By reducing domestic spreads, the central bank distorts the incentives of agents in favor of domestic debt. This increases, for instance, the repayment of foreign debt by exporters. Similarly to the case without the use reserves described above, when nominal rigidities are taken into account, the resulting capital outflow can reduce welfare through their effects on the exchange rate and, consequently, on the inflation rate[8].

Finally, we show that, in the absence of domestic financial frictions, the central bank has no reason to implement any credit policy. In this case, the only factor that matters is the use of foreign-exchange reserves. To make this point clear, we compare two policies: one in which extending credit to exporters is fully-funded out of foreign reserves and another in which the central bank sells foreign reserves in the spot market, with the proceeds transferred to households (through a reduction in the government debt or an immediate tax rebate). If we consider an economy with perfect domestic financial markets, the two policies are equivalent. Moreover, even when we assume that domestic spreads are positive, but constant, the two policies have almost identical effects. The intuition is a simple one: without frictions, it does not matter where in the economy the central bank injects resources, because they will always end-up where they are most needed. These results underline that we need to take account of

[8]There are other reasons to intervene in the domestic market, such as releasing liquidity to avoid potential bank runs. These, however, are beyond the scope of our model. The banking literature – as well as the Lehman bankruptcy experience – has illustrated the importance of acting conscientiously in that dimension. Implicitly, we assume that the banking system is not directly impacted by the sudden stop. We understand this can be a strong assumption, but one that allows us to highlight the importance of the credit policies in dealing with sudden stops, regardless of the specific secondary effects of the crisis on domestic financial systems. It is also important to point out that there were no major bankruptcies in developing economies' financial sectors.

key institutional features of the economy, such as the observed increase in domestic spreads during crises, to correctly consider the implementation of credit policies.

These findings suggest two broader lessons for credit policies in emerging economies. The first is that *domestic frictions matter for the design of credit policies*. Although it should be obvious, this is a relevant point to make for the case of emerging markets, where policies were implemented in response to a negative shock to the international borrowing conditions faced by these economies. Furthermore, with few exceptions, most of the literature on sudden stops (see references below) has focused exclusively on this international dimension of credit market frictions and ignored the empirically observed presence of domestic frictions. Our results show that such a narrow focus can be misleading, as one could erroneously conclude that there is no need at all for credit policy and only the use of foreign-exchange reserves matters.

The second broader lesson says that *the mere fact of an increase in credit frictions does not necessarily imply that central bank credit policy will raise welfare.* In fact, our simulations suggest that intervening only in domestic credit markets, or engaging in more general credit policies without the necessary backing of foreign-exchange reserves, is not a good recipe for dealing with sudden stops in capital flows. Note that in both cases, the policies are successful in achieving their goal of reducing credits spreads. Nevertheless, they reduce welfare because of their negative impact on the exchange rate and inflation.

This point is worth emphasizing because policies designed to act exclusively upon the inefficiencies of the domestic financial markets are exactly the ones recommended in most works focused, for example, in the case of the US economy[9]. Cúrdia and Woodford (2010a) show that if the condition that "all investors can purchase arbitrary quantities of the same assets at the same market price" is violated then credit policy can improve welfare. That condition is violated in our model, but still credit interventions to reduce domestic spreads can reduce welfare. What our results show is that those policy recommendations depend further on the details of the financial structure that is assumed. For many developing countries suffering from sudden stops in capital inflows, given the structure of their economies, the

[9]Some examples are Geanakoplos (2010), Gertler and Karadi (2011) and Cúrdia and Woodford (2010a).

most effective credit policies are of a different type. Credit targeted at the more affected sectors in a developing economy – mainly the export-import firms, which use more foreign borrowing to fund their operations – can be quite helpful during a crisis, as long as the central bank funds these loans with reserves hoarded before the crisis.

The remaining sections of the paper are organized as follows. After relating our work to the literature in the final part of this introduction, we review Brazil's crisis experience through the lens of its key macroeconomic variables. Section 1.3 presents the details of the model and its baseline calibration. In Section 1.4, we perform a crisis experiment, first using the baseline calibration and taking as given the credit policies implemented in Brazil. Then, in the same section, we perform a series of experiments, under different assumptions, to discuss the mechanism of the crisis, the importance of the policies and provide two broader lessons for credit policies in emerging markets. Section 1.5 concludes.

1.1.2 Relation to the Literature

Our work contributes to three branches of the literature. First, our approach, which allows financial intermediation to play a fundamental role in the macroeconomy, is part of a renewed effort by monetary economists to integrate the insights of financial economics into their policy evaluation frameworks (Brunnermeier 2009). Until recently, it had become common to consider monetary policy as consisting solely of interest rate policy, and to analyze alternative policies in models that abstracted from the allocative role of financial intermediation. Woordford (2003) stresses that, by the time his manuscript was published, few central banks still used credit controls or other methods to "directly regulate the flow of funds through financial markets and institutions" (p.15). Such controls would, it was believed, distort the relative cost of funds to different parts of the economy in ways that would negatively impact the central banks' overall objectives[10].

Recent events have brought a renewed focus on unconventional monetary policies. This in turn has required renewed attention to credit market imperfections. Cúrdia and Woodford

[10] Cúrdia and Woodford (2010a) discuss conditions under which central bank credit policy would have no useful role to play.

(2010b) raise this point clearly, stating that the usual policy prescriptions, based on concern for stabilization of inflation and real GDP alone, may "be inadequate to circumstances of the kind recently faced". Important recent contributions to this literature include Gertler and Karadi (2011), Gertler and Kiyotaki (2009), Cúrdia and Woodford (2010a, 2010b, 2010c), Reis (2010), Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010), Geanakoplos (2010) and Ashcraft, Garleanu, and Pedersen (2010).

Our results confirm that taking credit frictions into account can be important. Credit interventions seem to have been an effective countercyclical, welfare-improving policy during the financial crisis of 2008-09, in emerging economies. However, our analysis also suggests that some interventions can reduce welfare. Therefore, the implication of our work to this literature is that the desirability or undesirability of credit policies depends crucially on detail of their implementation.

Second, we contribute to the literature on sudden stops in emerging economies. Even though the use of credit policies in the most recent episode can be considered a novelty, sudden stops in international capital flows have been a fixture in the history of developing economies. And, following Calvo (1998), much has been said about how countries handle the existence of such an exogenous shock. However, most of the literature has focused exclusively on the financial frictions related to the foreign financing of economic activity in emerging markets. Some examples are Cook (2004), Céspedes, Chang, and Velasco (2004), Elekdag, Justiniano, and Tchakarov (2006), Devereux, Lane, and Xu (2006), Cúrdia (2008) and Braggion, Christiano, and Roldos (2009). Gertler, Gilchrist, and Natalucci (2007) develop one the few models that incorporates financial frictions in the domestic credit markets. Despite such an extensive body of work, the policy instruments considered for counteracting credit market driven crises have, nevertheless, remained quite restrained, with the interest rate instrument and active management (or not) of exchange rates as the central elements of most analyses.

Moreover, as domestic financial markets in many developing economies deepen and central banks expand their policy options, such a narrow focus on the international dimension of credit markets – arguably, one of the fundamental issues over the 1990's – ends up limiting the usefulness of these models. In particular, few connections have been made between the frictions in both domestic and foreign financial markets and their role as a channel for the

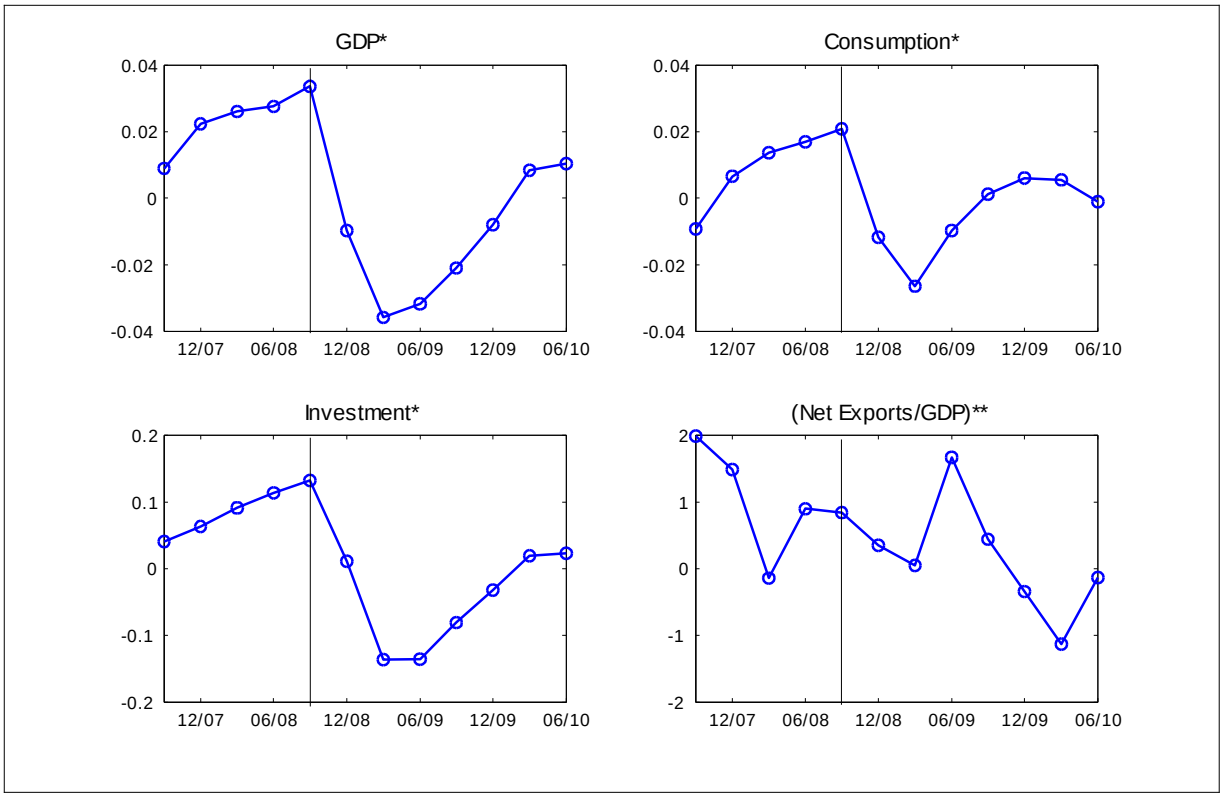
transmission of sudden stops (one important exception is Caballero and Krishnamurthy 2001). Here, we highlight this link.

Finally, we also contribute to the large literature on the accumulation and management of foreign-exchange reserves by developing economies. Some recent examples are Calvo (2006), Jeanne and Ranciere (2006), Aizenman and Lee (2007), Jeanne (2007) and Obstfeld, Shambaugh, and Taylor (2010). To the best of our knowledge, we are the first to show in a quantitative macro model that using foreign reserves to provide credit to exporters during a sudden stop can improve welfare.

1.2 The Crisis in Brazil

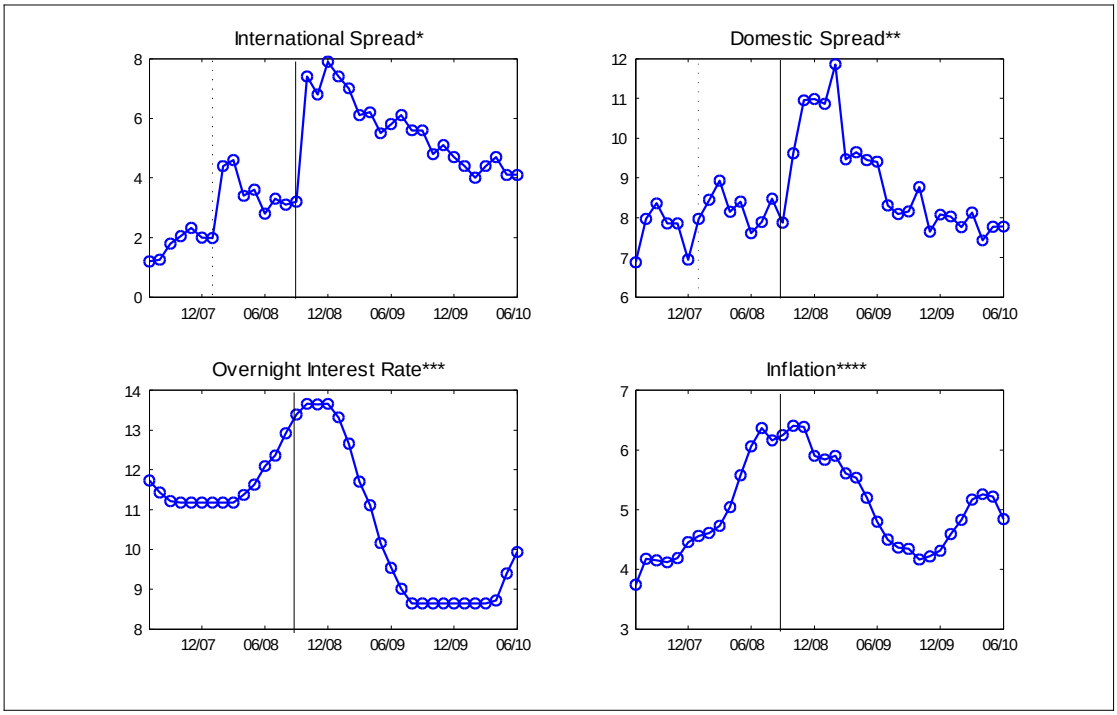
Despite some early signs of tightening in the international capital markets in the first quarter of 2008, reflected in the growing spreads on foreign loans to Brazil, the country continued its course of economic expansion as GDP, investments and consumption growth sustained their fast pace (figure 1). The beginnings of a global meltdown, even with the first few bank failures in the UK and the US, were not enough to change the outlook for the economy, as was emphasized by the Brookings Institution panel on Brazil (2009). Economic decoupling dominated the news. Perhaps even more telling, in hindsight, was the Brazilian Central Bank's decision to keep raising overnight interest rates to control demand-driven inflation (figure 2).

Figure 1- The Financial Crisis of 2008-09 in Brazil
The figure shows the performance of selected variables from 2007 to 2010. The vertical line mark the jump in the international spread faced by Brazilians firms that occurred when Lehman Brothers went bankrupt



* Quarterly data, log scale and detrended. ** Quarterly data.

Figure 2 - The Financial Crisis of 2008-09 in Brazil (continued)
The figure shows the performance of selected variables from 2007 to 2010. The two vertical lines mark two jumps in the international spread faced by Brazilians firms. The second and larger one, occurred when Lehman Brothers went bankrupt



* Monthly average. Trade finance credit lines available to exporters. Spread over libor. ** Monthly average.

The reigning chaos in global financial markets, strengthened by the bankruptcy of Lehman Brothers in September, completely changed the prevailing scenario. Brazil was, once again, coupled with the world. International spreads more than doubled in a single quarter, while the domestic credit spreads increased by 400 basis points over the same period (figure 2). GDP started falling over the fourth quarter, as real investments collapsed and aggregate consumption reversed course[11].

The most common diagnostic suggests that the crisis reached Brazil through two main channels (Pastore and Pinotti 2008, Stone, Walker, and Yasui 2009). The first of these was the negative impact of worldwide financial crisis, which pushed the country towards an unexpected sudden stop on incoming international funding, including trade-related lines of credit. The second conduit was the global recession itself, in particular the slowdown in China, which reduced the demand for commodity exports and, hence, commodity prices. As a

[11]Many emerging market economies went through the same process, as highlighted by Ishi, Stone, and Yehoue (2009), Yehoue (2009) and several references cited therein. Brazil is a very representative member of this group.

consequence, Brazil was subject to a terms-of-trade shock that limited the use of exports as an exit strategy for the crisis.

Faced with the prospect of disruption in the economy, the Brazilian Central Bank aggressively cut the economy's short-term interest rate in response to the declines in activity and inflation. In addition, it elected three main lines of defense, which were established concomitantly and implemented in several steps throughout the duration of the crisis[12].

First, the monetary authority decided to reduce banking reserves' requirements across the board, in order to infuse the domestic banking system with liquidity and reduce the lending rates charged by banks. It also designed some targeted reductions in reserves requirements geared towards small and medium-sized banks. These were carried out through government-incentivized acquisitions of the loan portfolios of smaller banks by the five largest privately-owned financial institutions in the country. In total, these measures[13] amounted to about 142 billion reais (about 75 billion US dollars at the time).

The second line of defense was established to deal with the shortage of external funding. Through the sale of dollars with repurchase agreements starting in late September and auctions of US dollars (USD) against dollar-denominated collateral, which began in October of 2008, the central bank announced the provision of USD 34 billion to the Brazilian firms operating in the international markets. The total amount actually sold was closer to USD 25 billion and involved mainly exporting companies.

The third announced objective of the Brazilian Central Bank was to reduce the volatility of the exchange rate. To achieve this goal, the monetary authority acted directly in the spot market for foreign currency, selling over USD 14.5 billion of its massive stock of foreign-exchange reserves. It also intervened in the derivatives market, announcing the auction of

[12]The Treasury also put into practice a hefty agenda of countercyclical fiscal policies. While these may have been important, we choose not to include them in our experiments in order to better frame our credit policy analysis.

[13]The government-owned banks also aggressively increased their loan portfolios during the crisis. The Brazilian development bank, BNDES, was particularly active, providing long-term lending to the corporate sector. Although in line with the credit policies we study here, proceedings governing the lending decisions by these government-owned banks lack transparency and include some subsidies – especially in the case of the BNDES – that we don't consider in our model, as they do not generalize to other economies.

swaps, in which the central bank took the short position against the dollar, of over USD 50 billion – but actually implementing only around USD 12 billion.

As figures 1 and 2 show, the final toll of the crisis can be viewed as moderate and short lived. The economy presented negative growth rates for two quarters, but GDP, consumption and investment had already begun to recover by the second quarter of 2009. Domestic and international spreads remained high throughout most of the first half of 2009, but below their peak levels. In the second half of that year, the spreads started to decline and, in the domestic case, returned to their previous levels. It is nevertheless important to point out that international spreads remain above their pre-crisis levels.

Overall, the actions of the Brazilian Central Bank were viewed as successful, even if empirically reliable evidence to support this view remains scarce. Our paper contributes to the debate about the impact and importance of some of the policies implemented. However, it is important to highlight that our main focus is to study credit policies and its implications in the general context of an emerging economy facing a sudden stop. Therefore, we abstract from some of the particularities, like the terms-of-trade shock and the intervention in the exchange rate spot and forward markets, and focus on the followings stylized facts of the crisis in Brazil:

a) An exogenous shock reduced the supply of foreign credit and increased international and domestic spreads;
b) Real activity declined and remained below trend for a few quarters following the shock; and
c) The central bank intervened in the trade finance market (the second line of defense above) and in the domestic credit market (part of the first line of defense above).

1.3 Model

1.3.1 Outline of the Model

The core of the model is a standard small open economy with financial frictions and nominal price rigidities along the lines of Cúrdia (2008), Elekdag, Justiniano, and Tchakarov (2006), and Devereux, Lane, and Xu (2006). A key financial friction in these models is that firms can borrow abroad subject to constraints as in Bernanke, Gertler, and Gilchrist (1999) (henceforth, BGG). To deal with the dynamics of the crises of interest and the policy responses, we extend these models in two key dimensions, both related to financial aspects.

First, we allow firms to also contract domestic debt by introducing – through the simple, but effective mechanism of a costly loan production technology – a local financial sector that, by its imperfection, generates credit spreads in the domestic market. The existence of firms with access to both domestic and foreign financial sectors is an important feature of economies in which both credit markets are relevant. In addition, the fact that financial markets are imperfect in emerging economies should not come as a surprise. The data also shows that these frictions become more important during sudden stop episodes. In Section 1.2, we show that the domestic spreads in Brazil increased significantly during the financial crisis of 2008-09. Gertler, Gilchrist, and Natalucci (2007) document similar behavior for South Korea during the Asian crisis of 1997-98. In a qualitative model of collateral constraints, Caballero and Krishnamurthy (2001) focus on the domestic financial frictions during emerging crisis. In the quantitative model presented here, the domestic frictions are essential to understand the design and implications of credit policies, in addition to helping us to match important features of the data.

By considering a single loan production technology in the domestic financial system, we are implicitly assuming that all firms are homogenous from the point of view of a domestic bank. Hence, the domestic spreads are unique and depend only on the total volume of domestic financial intermediation. As a consequence, the demand by firms for domestic and foreign credit depends mostly on the conditions they face in the international markets.

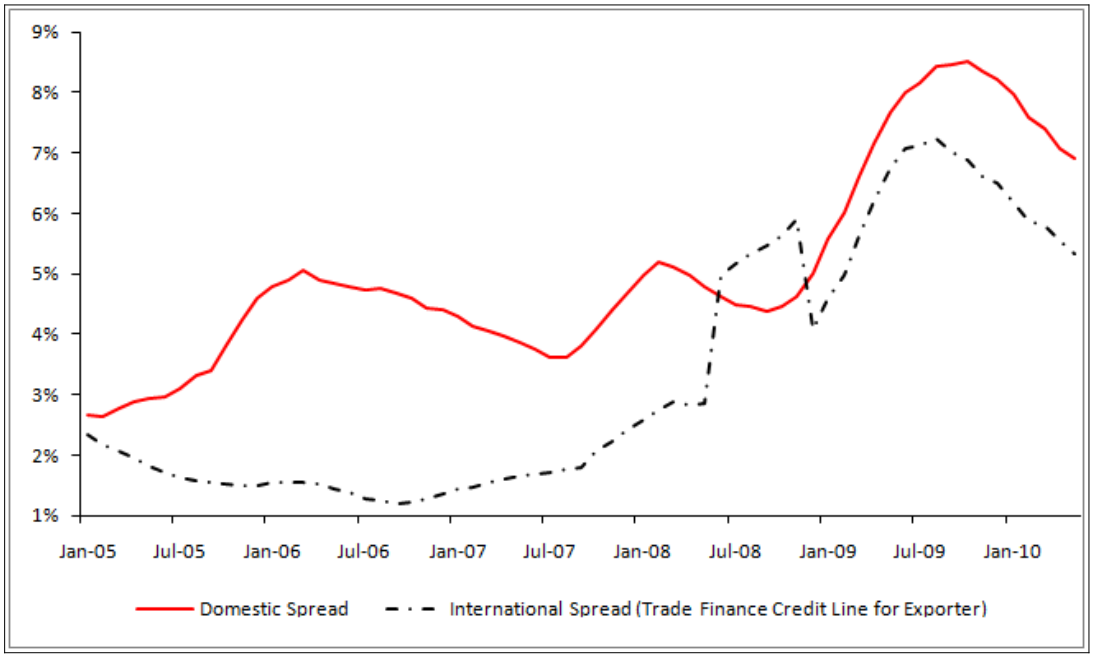
This last observation brings us to the second key innovation in our model: exporters are assumed to obtain loans from abroad at better financial terms than the ones that are available to other firms in the economy. This is a fundamental characteristic of many developing economies. As discussed in the introduction, there are three main reasons as to why exporters might have better access to foreign financial markets. First, international lenders may have a better understanding of the business of exporters, which are usually larger and more transparent companies, than of firms who mostly attend to domestic consumers. Second, foreign lenders may also prefer to specialize in trade finance credit in emerging markets. Finally, the assets of exporters are linked to the foreign currency and since foreign debt in developing economies is almost always denominated in foreign currency, there is a smaller degree of currency risk in lending to exporters.

Moreover, at least in normal times, exporters can obtain better funding abroad than in the domestic credit markets[14]. For instance, Figure 3 shows the actual spreads on loans provided by a number of Brazilian Banks through different lines of credit. Noticeably, in periods of small spreads, the cost of credit to exporters, mostly through trade lines, is considerably lower than the working capital lines available to equivalent companies in non-exporting sectors.

[14]Chapter 5 of the World Bank Global Development Finance Report (2004) shows that, for a set of developing economies in which trade lines can be matched to comparable domestic finance loans, the spreads on trade finance were (marginally) lower than their domestic counterparts. This is consistent with the evidence we obtain from Brazilian banks.

Figure 3 - Trade Finance and Domestic Working Capital Lines

The graph shows the spreads on trade finance (short term and denominated US$) and domestic (short term and denominated in domestic currency) credit lines for top rating firms in Brazil. The data was provided by Brazilian banks.



Annualized spread.

Except for these two points, the underlying framework proposed remains fairly standard. We construct a small open economy with identical households, which are divided between workers and managers, a simple domestic financial sector (or the market for "domestic loans"), a market for loans from abroad (which we also label as the "trade finance" market) and four types of firms: wholesale, retail, trading and capital producing companies. We close the model with a government entity that combines the roles of both Treasury and Central Bank, and the usual resource constraint on home goods. The balance of payments, as always, reflects the budget constraints of all the actors. The details of the economy are spelled-out below.

1.3.1.1 Households

We assume that the households are composed of a constant fraction $(1-f)$ of workers and a fraction f of managers[15]. A worker provides labor to the wholesale firms and returns her wage to the household, while a manager, as the name suggests, manages one of the household's firms and also returns her earnings – ie, the profit of the firm she manages – to the family unit. The managers are further segmented according to the type of firm they oversee. A fraction $f - f_e$ of the individuals within the household, called "wholesalers", is responsible for running the wholesale firms, while a fraction f_e , of "exporters", takes care of the trading companies. Individuals can move between the worker and manager groups. In particular, every period, a random fraction $(1-\theta_w)$ of the wholesalers and a fraction $(1-\theta_e)$ of the exporters become workers. To keep the fractions of each type constant, a number of individuals, also randomly selected, become managers. Note that, even though the manager operates it, the household is the actual owner of all the firms.

Within the household there is perfect insurance and, hence, all consumption decisions are taken at the household level. However, all the professional transactions between a manager and other agents in the economy, including those within the same household, are done at arms-length. In the case of the financial decisions of a firm, the manager is considered an insider, while the household is an outside investor. This approach allows us to include a rich variety of financial frictions in the model while keeping the convenience of having a representative consumer. In particular, the model has two types of firms that rely on debt to fund their activities. The traditional "financial accelerator" approach (ie, BGG) would require three types of individuals, each with different consumption and labor decisions. Here, we also have three agents, but only the household consumes and works.

When an individual becomes a manager, she receives a start-up equity (or net worth) to initialize the operation of the firm. The size of the initial net worth and the fact that a manager has a finite expected life implies that the firms always borrow debt to finance their investments. All of the relevant decisions by the managers, such as the financing decision, the initial equity, the evolution of the firm's net worth, and the aggregate per period net cash flow

[15]Our structure is similar to the one developed in Gertler and Karadi (2011), where the two types are workers and bankers.

payments to the households, shall become clear when we discuss the problem of the wholesale and the trading companies. At this juncture, it suffices to say that a manager, when exiting the group, returns all remaining net worth to the households.

There are two types of consumption goods in the economy: home goods ($C_{H,t}$) and foreign goods ($C_{F,t}$) . Both goods are internationally traded and preferences between them are Cobb-Douglas

$$C_t = \left(\frac{C_{H,t}}{\gamma}\right)^{\gamma}\left(\frac{C_{F,t}}{1-\gamma}\right)^{1-\gamma}. \tag{1}$$

These preferences imply that the aggregate price index P_t , and the demands for domestic and foreign goods are, respectively, given by

$$P_t = P_{H,t}^{\gamma} S_t^{1-\gamma} \tag{2}$$

$$C_{H,t} = \gamma \frac{P_t C_t}{P_{H,t}} \tag{3}$$

$$C_{F,t} = (1-\gamma)\frac{P_t C_t}{S_t} \tag{4}$$

where S_t is the nominal exchange rate, defined as the domestic price of the foreign currency, $P_{H,t}$ is the aggregate domestic price of the home good, and we normalize the foreign price level to 1 .

Besides the wholesale firms and trading companies, the households also own retail firms, capital producers and financial intermediaries. None of these last three types of firms require capital to operate. In addition, households can buy government bonds and make deposits with a financial intermediary. These two financial assets are both risk free and, in equilibrium, perfect substitutes. We aggregate them into a single variable B_t .

The consumption (C_t), bond holdings (B_t) and labor (L_t) decisions are given by maximizing the discounted expected future flow of utility

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\left(C_t - \tilde{L} \frac{L_t^{1+\psi}}{1+\psi} \right)^{1-\sigma} /(1-\sigma) \right] \tag{5}$$

with respect to $\{C_t, L_t, B_t\}$, subject to the budget constraint

$$P_t C_t + P_t B_t \leq W_t L_t + R_{t-1} P_{t-1} B_{t-1} + \Pi_{f,t} - T_t \tag{6}$$

where W_t is the wage, R_t is the interest rate received from holding one period bonds, $\Pi_{f,t}$ is the aggregate net cash flow from all types of firms owned by the household and T_t is a lump sum tax. Following a common practice in the emerging market literature, utility is defined as in Greenwood, Hercowitz, and Huffman (1988). This assumption eliminates the wealth effect on labor supply by making the marginal rate of substitution between consumption and labor independent of consumption.

The Euler equation and labor supply are given by

$$E_t \left[\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{1}{\Pi_{t+1}} R_t \right] = 1 \tag{7}$$

$$\frac{W_t}{P_t} = \tilde{L} L_t^{\psi} \tag{8}$$

where Π_t is the gross inflation rate and

$$\lambda_t = \left(C_t - \tilde{L} \frac{L_t^{1+\psi}}{1+\psi} \right)^{-\sigma} . \tag{9}$$

1.3.1.2 Wholesale Firms

A continuum of identical wholesale firms, indexed by j, hire domestic labor (L_t) and acquire capital (K_t) to produce the home good (Y_t) using a Cobb-Douglas production function

$$Y_t = \left(\frac{L_t}{\alpha}\right)^{\alpha}\left(\frac{K_t}{1-\alpha}\right)^{1-\alpha}. \tag{10}$$

For simplicity, we assume that capital completely depreciates in one period and, hence, that investment at t is equal to the next period level of capital times the price of the capital good: $K_{t+1}P_{K,t}$. Capital is acquired from the capital producers. Their production function and the determination of the price $P_{K,t}$ are described in the subsection 1.3.1.5.

The wholesale firms are owned by the households and operated by the managers within them (the wholesalers). A specific firm has two sources of funds: the internal accumulation of profits and the debt contracted with the domestic financial sector.

Let $N_{w,t}(j)$ be a given net worth level of a wholesale firm j at period t. The balance sheet constraint imposes that

$$P_{K,t}K_{t+1}(j) = P_t N_{w,t}(j) + P_t D_{w,t}(j) \tag{11}$$

where $D_{w,t}(j)$ is the amount of debt contracted specifically by wholesale firm j . For a given net worth, the maximization of the value of the firm described below and an aggregate version of this balance sheet constraint determine the level of capital in the wholesale sector.

The net worth of a previously existing firm is given by

$$P_t N_{w,t}(j) = P_{w,t}Y_t(j) - W_t L_t(j) - R_{b,t-1}P_{t-1}D_{w,t-1}(j) \tag{12}$$

where $P_{w,t}$ is the wholesale price of the home good and $R_{b,t}$ is the gross interest rate available to borrowers in the domestic market.

In any period, the demand for labor is a static decision given by

$$L_t = \frac{\alpha}{(1-\alpha)}\left(\frac{P_{w,t}}{W_t}\right)^{\frac{1}{1-\alpha}} K_t. \tag{13}$$

Substituting this demand curve and the production function (10) into (12), we get

$$P_t N_{w,t}(j) = \left(R_{K,t} - R_{b,t-1}\right)P_{K,t-1}K_t(j) + R_{b,t-1}P_{t-1}N_{w,t-1}(j) \tag{14}$$

where

$$R_{K,t} = \frac{P_{w,t}}{P_{K,t-1}}\left(\frac{W_t}{P_{w,t}}\right)^{-\frac{\alpha}{1-\alpha}} \tag{15}$$

is the return of investing in capital, which depends only on aggregate conditions. This last property implies that the size of the firm does not matter and therefore, from this point forward, we drop the index j.

The wholesaler keeps accumulating assets in the firm until exiting the sector, when all of the remaining net worth returns to the household. Therefore, an operating firm chooses the path $\{K_{t+1}\}$ to maximize the expected terminal net worth. The value of the firm (in real terms) is then given by

$$V_w\left(N_{w,t}\right) = \max_{\{K_{t+1}\}} E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\left[(1-\theta_w)N_{w,t+1} + \theta_w V_w\left(N_{w,t+1}\right)\right]\right\} \tag{16}$$

where $N_{w,t}$ evolves according to (14) and the manager uses the stochastic discount factor of the shareholder of the firm, the household. Note that the value of the firm is a weighted average of the value when the firm ceases to exist, the first term above, and the value if it remains in operation. Moreover, it is straightforward to show that the value of the firm is a linear function of its net worth

$$V_{w,t}\left(N_{w,t}\right) = \eta_{w,t}N_{w,t} \tag{17}$$

where

$$\eta_{w,t} = E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{R_{b,t}}{\Pi_{t+1}}\left((1-\theta_w)+\theta_w\eta_{w,t+1}\right)\right\} \tag{18}$$

The solution to this maximization problem yields one of the two main equations for the wholesale sector. Since the wholesalers take the time paths of the prices $R_{K,t}$ and $R_{b,t}$ as given, in equilibrium, the risk adjusted excess return provided by leverage is zero:

$$E_t\left[\mu_{w,t+1}\frac{1}{\Pi_{t+1}}\left(R_{K,t+1}-R_{b,t}\right)\right]=0 \tag{19}$$

where μ_{t+1} defines the current marginal value, in real terms, of one additional unit of net worth in period t+1

$$\mu_{w,t+1} = \beta\frac{\lambda_{t+1}}{\lambda_t}\left((1-\theta_w)+\theta_w\eta_{w,t+1}\right) \tag{20}$$

The second main equation describes the evolution of the net worth in the wholesaler sector. We make two assumptions. First, a manager who exits the sector returns all the remaining cash to the households. That is, at period t , all of the firm's net worth 14) is paid out as dividends. Second, the household provides a small fraction κ_w of total assets in the sector to the new start-ups. The aggregate evolution of the net worth in the sector is then given by

$$P_t N_{w,t} = \theta_w\left[\left(R_{K,t}-R_{b,t-1}\right)P_{K,t-1}K_t + R_{b,t-1}P_{t-1}N_{w,t-1}\right]+\kappa_w P_{K,t}K_{t+1} \tag{21}$$

Equations (19) (together with the specification of the domestic financial sector) and (21) determine the consolidated debt level and the aggregate evolution of the net worth in the wholesale sector.

1.3.1.3 Retail Firms

A continuum of retail firms, owned by the households, indexed by $i\in[0,1]$, buy the home good from the representative wholesale firm and transform it, with a linear technology and at

no additional cost, into their own variety. Firms operate in a monopolistically competitive environment and prices are sticky à la Calvo. Every period, firms reset their price with probability $(1-\alpha_p)$.

The total aggregate demand for the domestic good is given by

$$Y_{H,t} = C_{H,t} + K_{H,t+1} + C^*_{H,t} + \Xi_{H,t} \tag{22}$$

where $C_{H,t}$ is the demand from the domestic consumers, $K_{H,t+1}$ is the investment demand (determined at t), $C^*_{H,t}$ is the demand from foreign consumers and $\Xi_{H.t}$ is the resource cost, denominated in terms of the home good, of financial intermediation. The demand from foreign consumers is given by

$$C^*_{H,t} = C^* \left(P^*_{H,t}\right)^{-\nu^*} \tag{23}$$

where C^* is an exogenous shifter of the foreign demand for home goods, which here, for simplicity, we assume is constant. The remaining two components of the aggregate demand, $K_{H,t+1}$ and $\Xi_{H,t}$, are described below.

The final home good is assumed to be a composite made of the continuum of differentiated goods, $Y_{H,t}(i)$, produced by the retail firms via the aggregator

$$Y_{H,t} = \left(\int_0^1 Y_{H,t}(i)^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}. \tag{24}$$

The demand for each variety is then given by

$$Y_{H,t}(i) = Y_{H,t} \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\eta}. \tag{25}$$

A firm i that can reset its price at t chooses $\overline{P}_{H,t}(i)$ that solves[16]

$$\underset{\overline{P}_{H,t}(i)}{Max} E_t \sum_{j\geq 0}^{\infty} \alpha_p^j \beta^j \frac{\lambda_{t+i}}{\lambda_t} \frac{P_t}{P_{t+j}} Y_{H,t+T} \left(\frac{\overline{P}_{H,t}(i)}{P_{H,t+j}} \right)^{-\eta} ((1-\tau)\overline{P}_{H,t}(i) - P_{w,t+j}) \tag{26}$$

[16]The term $(1-\tau)$ allows for a subsidy that we set to eliminate the monopoly distortion at the steady state $\left(\frac{\eta}{\eta-1}\frac{1}{1-\tau}=1\right)$

where we use the stochastic discount factor of the household.

The optimal price, which is the same for all firms that reset their price, is given by

$$\overline{P}_{H,t} = \frac{E_t \sum_{j\geq 0} \alpha_p^j \beta^j \frac{\lambda_{t+j}}{P_{t+j}} Y_{H,t+j} P_{H,t+j}^{\eta} P_{w,t+j}}{E_t \sum_{j\geq 0} \alpha_p^j \beta^j \frac{\lambda_{t+j}}{P_{t+j}} Y_{H,t+j} P_{H,t+j}^{\eta}}. \quad (27)$$

Finally, the aggregate domestic price index is given by

$$P_{H,t} = [(1-\alpha_p)(\overline{P}_{H,t})^{1-\eta} + \alpha_p (P_{H,t-1})^{1-\eta}]^{\frac{1}{1-\eta}}. \quad (28)$$

1.3.1.4 Trading Companies

The differentiated retail goods are sold in domestic and international markets. In the case of exports, we assume that the goods take one period to arrive in the customers markets: a good sold and shipped in the current period arrives at its international destination only in the next period. More importantly, foreign consumers pay for the good only when they receive it.

Given this structure, we consider the case in which the trading companies specialize in the export market. In period t, they buy, sell and ship to international markets, at no additional cost, each variety of the home good demanded by foreign consumers. The price of the good they sell is determined at period t and is denominated in foreign currency. Since they receive payments for their sale only at period t+1, trading firms require capital to operate.

To support its activities, a trading firm has access to three sources of funding: internal cash flow, debt in the domestic market and debt from abroad. The most important characteristic of these firms is that they have access to credit from abroad on favorable terms compared with other domestic firms. Here we make the assumption that they are actually the only firms that have access to the international credit markets.

Trading companies are managed by individuals – the exporters – within the household. Let $N_{e,t}$ be a given net worth level of a trading company at period t. Since, as in the case of the wholesale firm, size does not matter, we already omit an index to differentiate each exporter. The balance sheet constraint imposes that

$$P_{H,t}C^*_{H,t} = P_t N_{e,t} + P_t D_{e,t} + S_t D^*_{e,t} \tag{29}$$

where $P^*_{H,t}$ is the aggregate export price, $C^*_{H,t}$ is the aggregate quantity exported, $D^*_{e,t}$ is the foreign debt, which is denominated in foreign currency, contracted by the exporter, $D_{e,t}$ is the domestic debt. For a given net worth, the maximization of the value of the trading company and the aggregate balance sheet determine the demand for $C^*_{H,t}$ (the equivalent to investing in "capital" for the exporter).

The net worth of a previously existing firm is given by[17]

$$P_t N_{e,t} = S_t P^*_{H,t-1} C^*_{H,t-1} - S_t \psi^*_{e,t-1} R^* D^*_{e,t-1} - R_{b,t-1} P_{t-1} D_{e,t-1} \tag{30}$$

where $\psi^*_{e,t}$ is the spread the trading firm pays in international markets and R^* is the world risk free interest rate, which, to simplify the model, is assumed to be constant.

The value of the trading company (in real terms) is then given by

$$V_e\left(N_{e,t}\right) = \max_{\{C^*_{H,t},\, D^*_{e,t},\, D_{e,t}\}} E_t\left\{\beta \frac{\lambda_{t+1}}{\lambda_t}\left[(1-\theta_e)N_{e,t+1} + \theta_e V_e\left(N_{e,t+1}\right)\right]\right\} \tag{31}$$

where the maximization is subject to the balance sheet constraint (29) and the transition equation (30). The value of the trading company is given by an expression equivalent to (17), with the time-varying coefficient on the net worth now given by

$$\eta_{e,t} = E_t\left\{\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{s_{t+1}}{s_t} \psi^*_{e,t} R^*\left((1-\theta_e) + \theta_e \eta_{e,t+1}\right)\right\} \tag{32}$$

where s_t is the real exchange rate.

The setup above results in three main equations for the export sector. First, exporters take prices and the interest rates as given. In the equilibrium we consider here, and in line with our discussion above, they always borrow in the international market. However, they may decide

[17]The trading company buys and sells each variety of the home good. Optimization implies that the return, as given by expression (34), of selling one extra unit is the same for each variety i. Therefore, we already write the profit function in terms of the aggregate variables: $P^*_{H,t}C^*_{H,t} = \int P^*_{H,t}(i)C^*_{H,t}(i)di$ and $P_{H,t}C^*_{H,t} = \int P_{H,t}(i)C^*_{H,t}(i)di$

not to access the domestic market. As a consequence, their optimal borrowing decision implies that

$$E_t\left[\mu_{e,t+1}\frac{1}{\Pi_{t+1}}\frac{S_{t+1}}{S_t}\psi^*_{e,t}R^*\right]\leq E_t\left[\mu_{e,t+1}\frac{1}{\Pi_{t+1}}R_{b,t}\right] \tag{33}$$

where $\mu_{e,t+1}$ is defined as in (20).

The left hand side of the equation above is the risk-adjusted cost of borrowing from abroad, while the right hand side is the correspondent measure for domestic debt. When the cost of domestic debt is too high compared with what the exporter can get abroad, condition (33) holds as an inequality and the domestic debt $D_{e,t}=0$. We consider that this is the "normal" case in the economy. However, during a crisis, when there is a negative shock to the supply of credit from abroad, equation (33) will hold as an equality and the exporter will also borrow domestically.

Second, the leverage decision of the exporter implies that the return, in terms of foreign currency, of selling one extra unit of C^*_{Ht} – the left hand side in the expression below – must equal the borrowing cost:

$$\frac{P^*_{H,t}}{P_{H,t}/S_t}=\psi^*_{e,t}R^*. \tag{34}$$

Finally, as with the wholesalers, we assume that the exporter who exits the sector returns all the remaining cash to the households, who provide a small fraction κ_e of the total "assets" in the sector to the new start-ups. These assumptions imply that the evolution of the aggregate net worth in the trading sector is given by

$$P_tN_{e,t}=\theta_e\left(S_tP^*_{H,t-1}C^*_{H,t-1}-S_t\psi^*_{e,t-1}R^*D^*_{e,t-1}-R_{b,t-1}P_{t-1}D_{e,t-1}\right)+\kappa_eP_{H,t}C^*_{H,t}. \tag{35}$$

1.3.1.5 Capital Producing Firms

Another important characteristic of developing economies is the use of imported (capital and intermediary) goods as essential inputs for production. Capital goods and inputs usually represent a substantial fraction of the overall imports in these economies. Cúrdia (2008) and

Fraga, Goldfajn, and Minella (2003) provide a large amount of evidence and discuss the importance of this characteristic. When we calibrate the model to match the data from Brazil, we allow for the composition of the (composite) consumption goods to be quite different from that of the capital goods, which have a larger share of imported inputs. Hence, changes to the prevailing exchange rate can affect investments much more significantly than overall consumption.

To capture this effect, we follow Gertler, Gilchrist, and Natalucci (2007) and assume that capital goods are produced from domestic and foreign goods using a CES production function:

$$K_{t+1} = \left[(\gamma_k)^{\frac{1}{\rho_k}} \left(K_{H,t+1}\right)^{\frac{\rho_k - 1}{\rho_k}} + (1-\gamma_k)^{\frac{1}{\rho_k}} \left(K_{F,t+1}\right)^{\frac{\rho_k - 1}{\rho_k}} \right]^{\frac{\rho_k}{\rho_k - 1}}. \tag{36}$$

The price index for capital goods and the breakdown into domestic and foreign components are, respectively, given by

$$P_{K,t} = \left[\gamma_k \left(P_{H,t}\right)^{1-\rho_k} + (1-\gamma_k)\left(S_t\right)^{1-\rho_k}\right]^{\frac{1}{1-\rho_k}} \tag{37}$$

$$K_{H,t+1} = \gamma_k K_{t+1} \left(\frac{P_{H,t}}{P_{K,t}} \right)^{-\rho_k} \tag{38}$$

$$K_{F,t+1} = (1-\gamma_k) K_{t+1} \left(\frac{S_t}{P_{K,t}} \right)^{-\rho_k}. \tag{39}$$

1.3.1.6 Financial Intermediation

1.3.1.6.1 International Market

The international credit market is open (only) to exporters. Even though they take prices as given, the premium $\psi^*_{e,t}$ is a function of the overall leverage in the export sector

$$\psi^*_{e,t} = 1 + \tilde{\psi}^*_{e,t} \left(d^*_{e,t}\right)^{\eta_e} \tag{40}$$

where $d^*_{e,t} = S_t D^*_{e,t} / P_{H,t} C^*_{H,t}$ and $\tilde{\psi}^*_{e,t}$ is an exogenous shock.

In a model with asymmetric information between inside and outside investors and costly verification, as in the BGG framework, the optimal decisions would imply a positive relation between leverage and spread as in the equation above. Note also that information frictions, and the heterogeneity in this aspect among sectors, is an essential feature of our discussion about the different access of exporters and other firms to international credit. In Cúrdia (2008), Elekdag, Justiniano, and Tchakarov (2006), and Devereux, Lane, and Xu (2006) the authors follow the BGG approach and include the information frictions explicitly in the model. Here, we simplify along that dimension in order to focus on the sectorial heterogeneity and the interaction between international and domestic credit markets (features that are absent in those works). Therefore we follow a common practice in the real business cycle literature on emerging markets with international financial frictions[18] and directly assume a functional form for the international spread.

1.3.1.6.2 Domestic Market

The role of the domestic financial system is to raise one-period, interest-rate-bearing deposits from households and to make loans to firms that need funding – the trading companies and the wholesale firms. We assume that the market is imperfect and, as a consequence, there is a spread between borrowing and lending rates. Following similar approaches in Cúrdia and Woodford (2010c) and Goodfriend and McCallum (2007), we consider a loan production technology that can capture monitoring and management efforts in the financial sector. In particular, to make a total real amount of loans equal to D_t, banks consume, in the period the loan is originated, $\Xi(D_t)$ units of real resources, measured in consumption goods. The function Ξ represents a specific loan technology and is assumed to be equal to

$$\Xi(D_t) = \tilde{\Xi}(D_t)^{\xi} \tag{41}$$

where $\tilde{\Xi}$ and ξ are parameters.

Note that we are implicitly assuming that all firms are homogenous from the point of view of a domestic bank, and, hence, the domestic spreads are unique and depend only on the total

[18] See, for example, Garcia-Cicco, Pancrazi, and Uribe (2010) and Neumeyer and Perri (2005).

volume of domestic financial intermediation. In our model, the important sectorial heterogeneity is related to information aspects, in particular, in the relation between foreign lenders and domestic firms. Our assumption here is that domestic banks can equally assess the quality of all types of borrowers.

For the households, deposits in the banking system and government bonds are perfect substitutes: one-period, nominal, risk-free bonds. Therefore, the deposit rate equals the rate on government bonds R_t . The real profit of a representative financial intermediary is given by

$$\Pi_{fi,t} = R_{b,t} D_t - R_t D_{h,t} \tag{42}$$

where $R_{b,t}$ is the interest charged to borrowers in the domestic market; $D_t = D_{w,t} + D_{e,t}$ is the total amount of loans made to the wholesale and trading companies; and $D_{h,t}$ is the total amount of deposits raised from the households.

A flow of funds restriction imposes that the value of total deposits has to equal the loan portfolio plus the resource costs associated with the loan origination

$$D_{h,t} = D_t + \Xi_t(D_t). \tag{43}$$

Maximization of equation (42) subject to (43) implies that

$$R_{b,t} = (1 + \Xi_t^{'}) R_t . \tag{44}$$

The structure presented here allows us to incorporate, in a simple manner, a spread between the domestic borrowing and lending rates. Moreover, this spread depends on the volume of financial intermediation. Finally, we also note that the spread is the same for all types of firms. As a consequence, firms with favorable access to external credit lines – the exporters in our model – will prefer to borrow from foreign lenders, while the remaining firms will mostly use the domestic financial system.

1.3.1.7 Government

The government is a single entity composed by the Treasury and the Central Bank. Together, they control five variables in the model: the nominal interest rate (R_t), a lump-sum tax on households (T_t), the supply of domestic government bonds held by households ($B_{g,t}$), the

amount of foreign reserves (FA_t) – held as US Treasury Bonds, for example – and loans made to domestic firms as part of a credit policy ($D_{g,t}$). We include foreign reserves in the model because some of the credit policies implemented by emerging market central banks were coordinated with the management of their holdings of foreign currency reserves.

We impose two restrictions on the government. The first is a standard intertemporal budget constraint

$$T_t = D_{g,t} + S_t FA_t - P_t B_{g,t} + \left(R_{t-1} P_{t-1} B_{g,t-1} - R_{g,t-1} D_{g,t-1} - R^* S_t FA_{t-1}\right) \tag{45}$$

where is $R_{g,t}$ is the interest rate received by the Central Bank on its domestic credit interventions.

The second condition restricts the interventions in the credit and bond markets to be sterilized. That is, any change in the volume held of a specific asset on the consolidated government balance sheet requires an equivalent change in the holdings of another asset or in the amount of government bonds on the liability side:

$$D_{g,t} + S_t FA_t = P_t B_{g,t}. \tag{46}$$

Imposing this last condition allows us to abstract from money in the model. It is also a close description of the actual policies we study in this paper.

Taken together, these restrictions imply that the government has, at least in the case of a flexible exchange rate regime, three independent instruments: R_t , FA_t and $D_{g,t}$.

For the interest rate, we assume that the Central Bank follows a Taylor Rule type of policy

$$\frac{R_t}{R} = \left(\Pi_t\right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y} \tag{47}$$

where R and $\bar{Y}$ are the steady levels of, respectively, the gross domestic interest rate and output. The credit policies and the management of reserves are the topic of Section 1.4.

1.3.1.8 Exogenous Shocks

The only exogenous shock in the model is the $\tilde{\psi}^*_{e,t}$ term in the foreign credit supply curve (equation 40). Movements in this variable capture changes in the conditions available to exporters in the international credit markets. A sudden stop is a large positive increase in $\tilde{\psi}^*_{e,t}$ such that, for any given level of leverage, the spread on the foreign debt is higher. We assume that $\tilde{\psi}^*_{e,t}$ follows an AR(1) process in logs.

1.3.1.9 Equilibrium

We close the model with the home good resource constraint and the balance of payments. In the case of the former, we have that

$$Y_{H,t}\Delta_t = \left(\frac{L_t}{\alpha}\right)^{\alpha}\left(\frac{K_t}{1-\alpha}\right)^{1-\alpha} \tag{48}$$

where Δ_t is a measure of the price dispersion[19] in the retail sector:

$$\Delta_t = \int_i \left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\eta} di. \tag{49}$$

Aggregating the budget constraints of households and the government, and replacing the profit functions as necessary, one can derive the balance of payments (in terms of the foreign currency)

$$P^*_{H,t-1}C^*_{H,t-1} - C_{F,t} - K_{F,t+1} = D^*_{e,t-1}\psi^*_{e,t-1}R^* - D^*_{e,t} + FA_t - R^*FA_{t-1} \tag{50}$$

In the appendix A, we list all the equations that determine the dynamic equilibrium of the economy. Of the fundamental equations, many are standard: consumer Euler equation, labor supply, resource constraint and balance of payment. The core of our model is given by the equations related to the financial aspects of firms in the wholesale and export sectors: equation (33) guides the exporters' decision about how much to borrow domestically and abroad; equations (19) and (34) determine the leverage (and, given the level of net worth, investment) in each sector; while equations (21) and (35) present the evolution of each

[19]The resource contraint includes the price dispersion term because we use non linear methods to solve the model. See the discussion in the expanded version of Schmitt-Grohé and Uribe (2005).

aggregate sectorial net worth. Together with the characteristics of the financial intermediation, equations (40) and (44), these equations drive the propagation of the sudden shock in the economy.

1.3.1.9.1 Eliminating the Financial Frictions

In this subsection we show how to eliminate the financial frictions from the model. This is particular important for the case of the domestic frictions because it highlights exactly the additional assumptions of our model, when compared to the no-domestic-friction standard in the previous papers of the literature. More importantly, in the simulations of Section 1.4, we use the frictionless case presented here to show how important the domestic frictions are to understand the role of credit policies.

We start by briefly pointing out that one can eliminate the international financial friction by setting the debt-elasticity (η_e) of the spread in the foreign credit supply curve (equation 40) close to zero[20]. This allows the domestic rate to differ from the international interest rate but this difference would be independent of the leverage conditions in the export sector.

The economy has no domestic friction if we set $\tilde{\Xi} = 0$ in equation (41) and replace equations (21) and (35), describing, respectively, the evolution of the net worth in the wholesale and export sectors, with two equations imposing that $\eta_{w,t} = \eta_{e,t} = 1$. The first condition eliminates any spread in the domestic debt market, while the latter equations allow the firms to adjust their equity at any time.

In this case, the two following Euler equations, which can be derived from (18) and (32) when $\eta_{w,t} = \eta_{e,t} = 1$, drive the investment decisions in the wholesale and export sectors

$$E_t\left[\beta \frac{\lambda_{t+1}}{\lambda_t} \frac{R_{b,t}}{\Pi_{t+1}}\right] = 1 \tag{51}$$

[20]Setting η_e equal to a small positive value instead of zero ensures the independence of the deterministic steady state from initial conditions (see Schmitt-Grohé and Uribe 2003).

$$E_t\left[\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{s_{t+1}}{s_t}\psi^*_{e,t}R^*\right]=1. \tag{52}$$

Finally, note that in the absence of frictions, the composition of domestic debt and equity is not determined and is completely irrelevant. In the simulations below with a perfect domestic market, we simply assume the steady-state level.

1.3.2 Solution Method and Calibration

A crisis in the model begins with an abrupt and unexpected increase in the cost of foreign credit. Starting from the non-stochastic steady state, at period t_0 , agents learn about the current realization and the future (deterministic) path of the exogenous processes. To capture the occurrence of a sudden stop event, we consider a large increase to the exogenous process $\tilde{\psi}^*_{e,t}$ in equation (40). This implies that, for the same leverage at the firm level, the spread practiced on the foreign credit market rises substantially.

To solve for the dynamic equilibrium, we use a shooting algorithm under the assumption that the economy will return to its steady state after T periods. At every period, one must check if the exporters' debt condition (33) holds as an equality or as a strict inequality. In the parametrization we consider here, the latter holds in the steady state and, therefore, the exporters contract only foreign debt at that point. However, when the shock hits the economy, the cost of international debt increases and exporters start to borrow in the domestic market as well. In other words, the condition will hold as an equality upon impact and will typically continue to hold as such for a few periods after the initial shock.

We use an algorithm designed to control for just such an "occasionally binding constraint". We first guess that equation (33) holds as an equality from the period t_I to t_N and solve the model. Then we check whether $d_{e,t}\geq 0$ for all $t\in[t_I\ ,\ t_N]$ and if (33) holds as inequality for $t\notin[t_I\ ,\ t_N]$ (where $d_{e,t}=0$). If not, we adjust the interval $[t_I\ ,\ t_N]$ and start over.

The method described also captures the nonlinearity present in the model quite well. Given that our stated objective is to study the effects of large financial shocks, taking into account the nonlinearities is absolutely fundamental. Several recent papers, including Gertler, Gilchrist, and Natalucci (2007), Braggion, Christiano, and Roldos (2009) and Christiano, Eichenbaum, and Rebelo (2009), have also studied crisis experiments under perfect foresight using methods similar to the one we apply here.

A period in the model is a quarter and there are 22 parameters to calibrate. Table Parameters in the Model (Appendix B) lists all of them and their calibrated values. For those parameters that we can directly match to moments in the data, we use figures from Brazil, which is the focus of our simplified case study.

First, we start with the description of the more conventional parameters, whose values we take from the literature on nominal DSGE models calibrated or estimated for emerging economies. We set the inverse of the intertemporal elasticity of substitution (σ) to 1 and the inverse of the labor supply elasticity (ψ) equal to 2. The value of the export price elasticity (v^*) commonly varies from the fairly inelastic 0.6 in Cúrdia (2008) and Cook (2004) to perfectly elastic in Devereux, Lane, and Xu (2006) and Braggion, Christiano, and Roldos (2009). Perfect elasticity is also true for most of the papers in the emerging market real business cycle literature, where the world is assumed to absorb any quantity exported at the international price. Here we follow Céspedes, Chang, and Velasco (2004), Gertler, Gilchrist, and Natalucci (2007) and Elekdag, Justiniano, and Tchakarov (2006) and choose a median value of 1. With respect to the nominal part of the model, in line with the estimations in Elekdag, Justiniano, and Tchakarov (2006), we use 2/3 for the degree of price stickiness (α_p) and 8 for the elasticity of substitution across the different varieties of home goods (η).

To calibrate the labor coefficient in the production function (α), the preference bias for home goods (δ) and the share of home goods in the production of capital goods (δ_k), we use the Brazilian national accounts. These coefficients are set, respectively, to 0.80, 0.967 and 0.50 to match the GDP share of investment expenditures (0.20), of imported consumption goods (0.02) and of imported capital and inputs (0.10). All these shares were computed from post-1995 data, after the economy was stabilized by the Real Plan. For the elasticity of

substitution in the production of capital goods, we follow Gertler, Gilchrist, and Natalucci (2007) and consider a small degree of substitutability (0.25). This is particularly important in the short time horizon of the crisis that we consider here.

To obtain the leverage ratio of firms for the steady-state debt-to-assets ratio of the wholesale firm (d_w), we first consider Brazilian firm level studies[21] that have computed an average ratio of debt-to-assets of about 0.35. These studies are, however, somewhat outdated, with the most recent one covering firms only up to 2004. Since then, the volume of corporate credit as percentage of GDP in the country has almost doubled. Therefore, we consider a rate of 0.5, a number close to the value used by Devereux, Lane, and Xu (2006), which is itself based on firm-level studies for Asian economies. In the case of trading companies, we set the steady state foreign debt-to-assets ratio (d_e^*) to 0.97, which implies that the steady-state amount of export-related trade finance credit lines equals 0.12 of the quarterly GDP. This is consistent with the average value of trade finance debt in the data ranging from 2006 to 2010 and represents approximately 1/5 of the total amount of foreign debt in Brazil. Note that, in the steady state, exporters do not borrow in the domestic market ($d_e = 0$).

We now turn to the less traditional parameters regarding the financial portion of the model. The leverage ratios d_w and d_e^* determined in the previous paragraph pin-down, respectively, the coefficients κ_w and κ_e to 0.0047 and 0.00034. The fraction of managers who stay in their group (θ_w and θ_e) are set such that the average life of a firm is 10 years.

For given values of ξ and η_e , calibrating the two steady state-values for the domestic and international spreads sets, respectively, the $\tilde{\Xi}$ term in the domestic credit supply curve (6) and the $\tilde{\psi}_e^*$ coefficient in the international credit supply curve (5). For both rates, we consider proprietary data – provided by four large cap banks operating in Brazil – on the spreads charged on loans to top rated companies in the country. In the case of the international spread, we use the main short term, foreign currency denominated, trade finance credit line available to exporters. A firm can access this credit line only if it provides – not necessarily at

[21] Terra (2003) and Bonacim, Ambrozini, and Nagano (2006).

the beginning of the loan – proof that they have performed an international trade transaction. For the domestic rate, we compute the average spreads of working capital credit lines that are denominated in domestic currency and have short term maturity similar to that of the trade finance line. The average domestic and international spreads in the data set are, respectively, 2.4% and 1.6% in annual terms, in the 2004 to 2007 period. This was a financially and economically stable time in Brazil and we use it as a proxy for a "non-crisis" steady-state measure.

For the curvature of the international credit supplies, η_e , we set it to 1, a conservative level of spread-debt elasticity. This value implies that at the steady-state, an increase of 1pp (percentage point) in foreign debt as a share of GDP raises the international spread by 0.16pp. Garcia-Cicco, Pancrazi, and Uribe (2010) estimate this number to be around 0.5pp. By assuming a smaller number, we are being conservative about how much a decrease in the leverage of exporters against the international private sector reduces the spread on its foreign debt. In the case of the domestic market (ξ), we assume in our baseline calibration that $\xi = 22$. This replicates the observed initial increase in the domestic spread during the crisis.

In terms of the Taylor Rule followed by the monetary authority in setting the policy rate, we fix $\phi_\pi = 2$ and $\phi_y = 0.75$. These values are common in the literature and provide a good description of the flexible inflation target rule currently in place in Brazil.

Furthermore, we choose to normalize, without loss of generality, the steady-state value of output and the terms of trade to 1. The first assumption determines the household disutility of labor $\tilde{L}$, and the second sets the steady-state value of the exogenous component in the foreign demand for domestic goods (C_t^*). Finally, the household time discounting (β) is set to equal 0.99. This results in a 4% annual domestic policy (or saving) real interest rate, which, for simplicity, we also assume to be the international interest rate.

Finally, for the exogenous process $\tilde{\psi}_{e,t}^*$, estimating a simple AR(1) process for the international spread statistics collected by the Central Bank results in an autocorrelation coefficient of 0.93. This value is consistent with the more elaborate law of motion of sovereign spreads in Latin American countries estimated by Fernández-Villaverde, Guerrón-

Quintana, Rubio-Ramirez, and Uribe (2010). Therefore, we set the autocorrelation of the shock to 0.9.

1.4 Crisis Experiment and Credit Policies

In this section, we conduct crisis experiments and study the scope for credit policies by central banks. A crisis in the model begins with a large shock to the exogenous process $\psi^*_{e,t}$ in the foreign credit supply curve (equation (40)). This shock is able to produce a reversal on credit flows to an emerging market economy. We start with simulations under the baseline calibration and with the implemented credit policies.

The initial shock to the foreign credit supply implies an increase, before any adjustments in the economy, of 10 percentage points (pp) in the international spread. In equilibrium, which take into account the variations in leverages and the implemented credit policies, this implies an increase of 7pp in the international spreads in the first period of the crisis. This jump from a steady-state level of 1.6% is within the range observed in Brazilian data during the financial crisis of 2008-2009. The average rate of trade finance credit lines to exporters, compiled by the Central Bank of Brazil, shows that the spread peaked, in December of 2008, at 7.9%, or 6.4pp above the average of 1.5% that prevailed over 2006 and 2007. Similar measures using the data from privately-owned institutions further illustrate that, for firms with high credit ratings, the maximum increase was 5.7pp, while it reached 8pp for firms with intermediate ratings.

The main goal here is to assess the impact of the unconventional credit policies on the evolution of the main variables in the economy and evaluate their welfare implications. As described in Section 1.2, there were two main types of policies used in Brazil, and these are representative of most of what was done in developing economies. One was directed to exporters and denominated in US dollars, and the other provided liquidity to the domestic banking sector to support their lending to firms. In our model, we associate the former with a policy targeted to the trading companies and linked to their trade finance borrowing, and the

latter with a policy aimed at all firms borrowing in the domestic credit market. More specifically, the two types of policies above are implemented in the model as follows:

Credit to Exporters: The central bank offers a fixed amount of a one period loan, which is denominated in foreign currency and with the interest rate set in a competitive auction where *only* the exporters can bid. The auction process implies that the interest rate will be the market rate of the trade finance credit lines available to exporters ($R^{*}\psi_{e,t}^{*}$). In our base case, we assume that these US dollar interventions are fully funded by previously accumulated foreign exchange reserves. The importance of the source of funding will become clear below, as we relax this last assumption[22].

Domestic Credit: The central bank offers a fixed amount of a one-period loan, denominated in domestic currency. The interest rate is set in a competitive auction in which *all* firms can bid. In this case, the interest rate will be the borrowing rate in the domestic credit market ($R_{b,t}$).

In determining the importance of this second policy we convert the total central bank-sponsored loans to the domestic market, $D_{g,t}$, into a reaction function to the prevailing spreads, as follows:

$$D_{g,t} = \left(\frac{1+\Xi_{t}^{'}}{1+\overline{\Xi}^{'}} \right)^{\phi} \tag{53}$$

with $\phi = 0.10$. This number falls, based on microeconometric evidence for the Brazilian economy, within the range of our best estimates for the impact of the domestic credit policy on prevailing spreads[23].

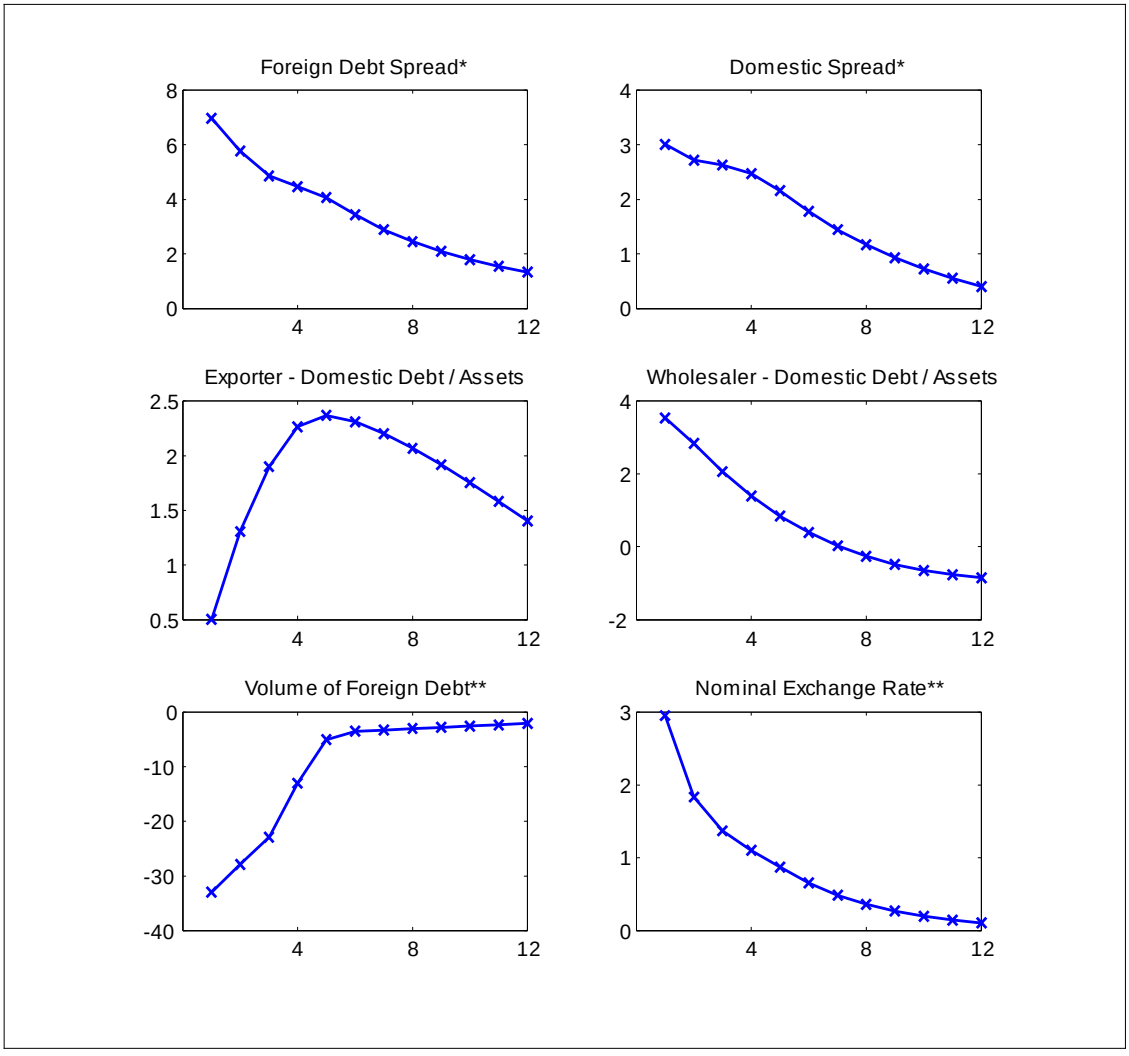
[22]In defining the size of these interventions, we focus on the Central Bank's balance-sheet and, from it, approximate the volume of trade credit extended, measured as a percentage of quarterly GDP. Starting in the last quarter of 2008, the estimated quantities are: 3%, 2.5%, 2%, 1%, and 0.15% of quarterly GDP.

[23]To calibrate for the effect of domestic credit facilities on prevailing spreads, we start by looking at evidence from microeconometric studies on the total effect of central bank reserve requirements on the average domestic spreads in Brazil. Costa (2004), in a comprehensive investigation of the Brazilian banking sector, estimates that reserve requirements account for about 10.66% of average spreads. Combining this with the 39% reduction – compared to the pre-crisis rules – in reserve requirements during the crisis, as shown by Mesquita and Torós (2010), we construct a range for the total impact of the domestic credit policy on the prevailing, post-crisis, average domestic spreads implied by our model (the model-based spreads with no credit policy can be found in figure 7).

1.4.1 Understanding the Mechanism

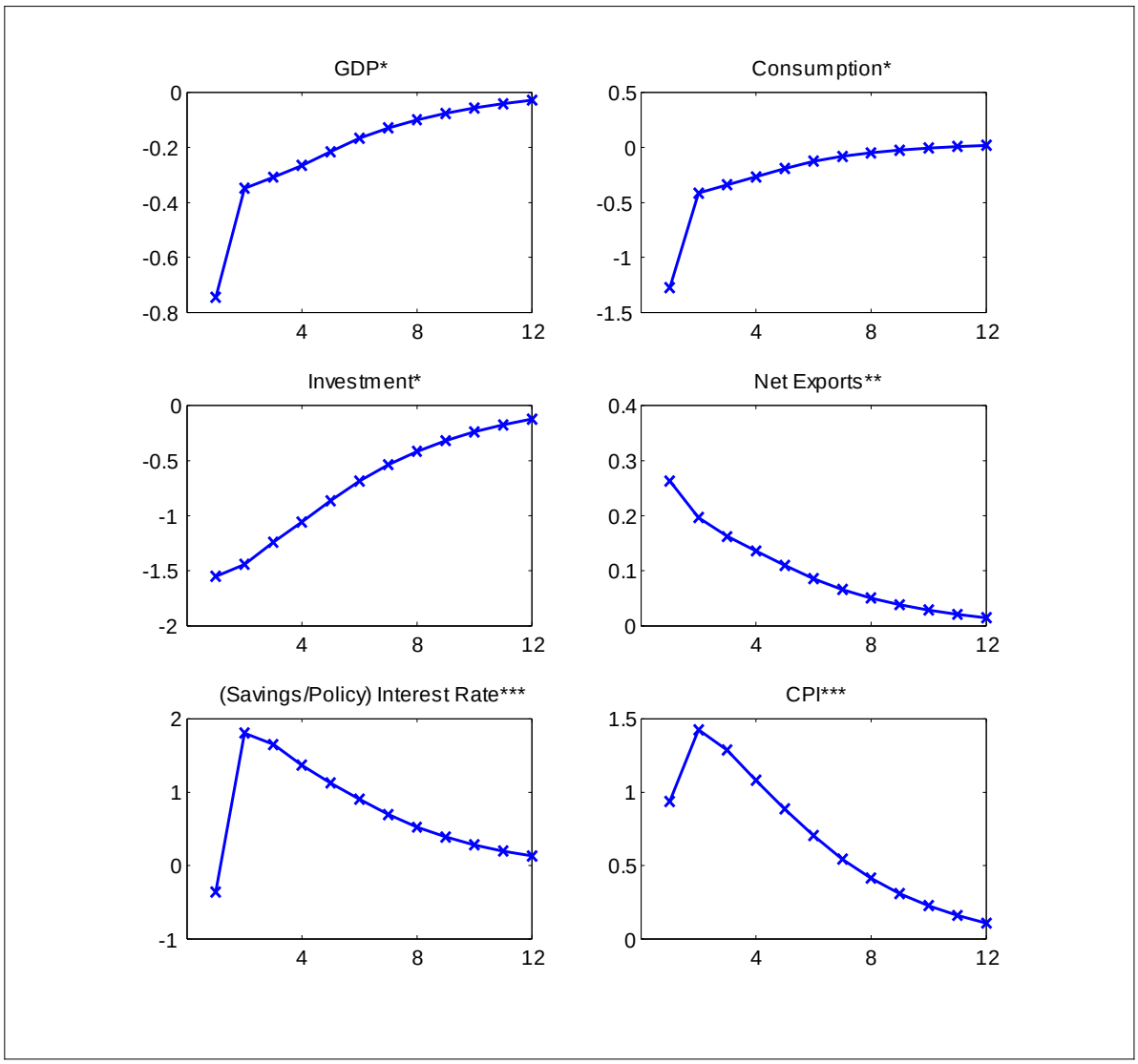
The main mechanisms in the model can be understood by looking at the export and wholesale sectors during a crisis. This is done in figures 4 and 5, where we plot the dynamics of selected variables in our baseline scenario and with credit policies. When faced with the higher cost of borrowing abroad (1st graph on the left in figure 4), trading companies start to repay their foreign debt (3rd graph on the left of figure 4) and switching to other sources of funding. Their alternative is to contract debt with banks in the domestic market (2nd graph on the left of figure 4). In terms of the model, this means that the Euler equation (33) now holds as an equality.

Figure 4 - Crisis Experiment - Baseline Calibration
The figure reports the dynamics of selected variables under the baseline calibration, including the implemented policies



All variables are deviations from the steady state. *Annualized(pp). ** Log deviation (%)

Figure 5 - Crisis Experiment - Baseline Calibration (continued)
Same as figure 4



All variables are deviations from the steady state. * Log deviation (%). ** Share of GDP (pp). ***Annualized (pp).

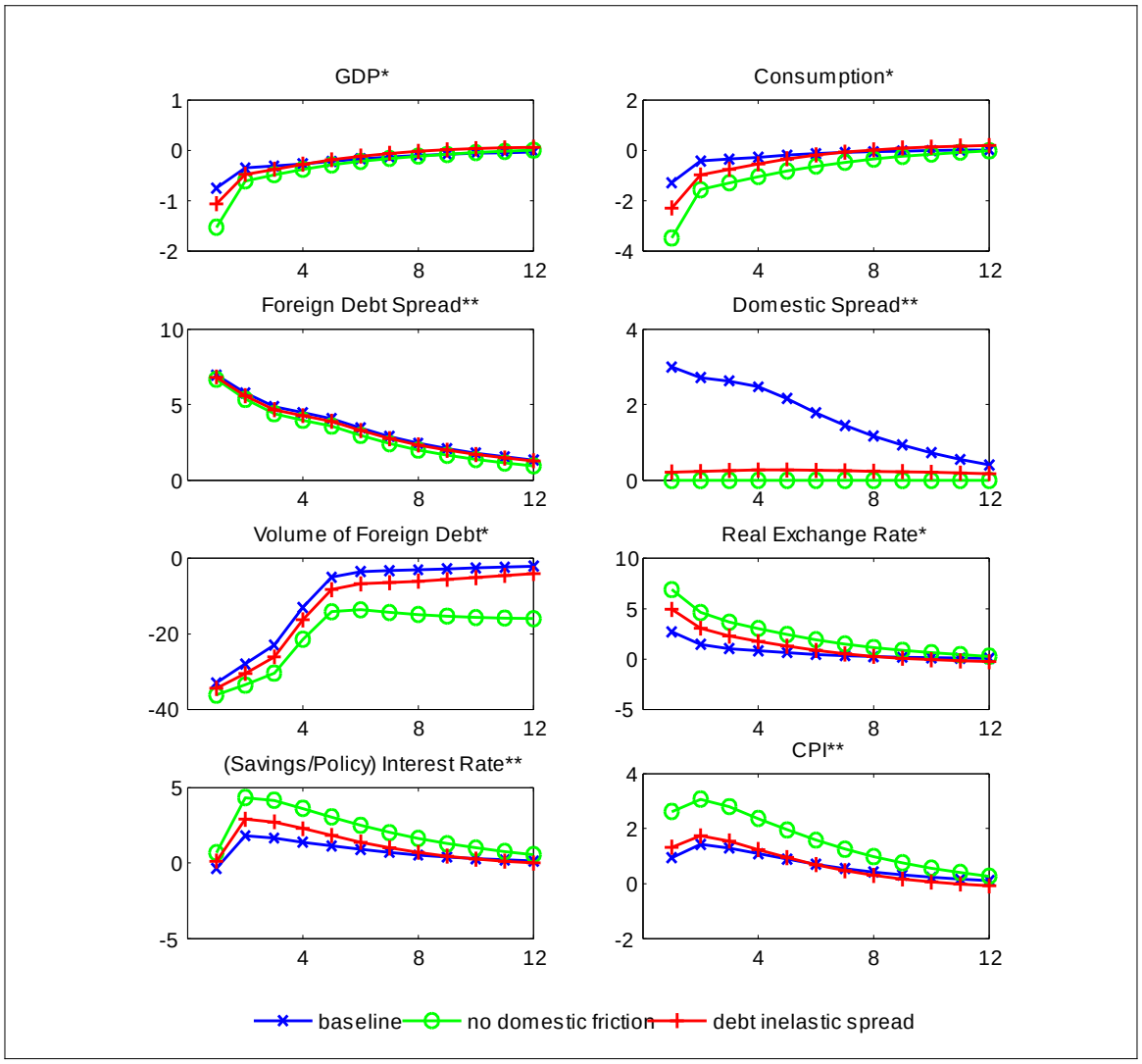
The exporters' transition into domestic debt financing propagates the shock to other sectors in the economy through two channels. First, it puts pressure on both lending (3rd graph on the left in figure 5) and borrowing rates (1st graph on the right in figure 4). With higher rates, the demand for goods from borrowers – investments by the wholesale firms (2nd graph on the left of figure 5) – and lenders – consumption by the households (1st graph on the right of figure 5) – decreases. The second transmission conduit comes from the balance of payments: the repayment of foreign debt stresses the exchange rate (3rd graph on the right of figure 4). Given the high share of imported capital goods, that mainly causes a further decline in investments.

Firms in the wholesale sector are affected by both channels, as figures 4 and 5 clearly demonstrate. The higher borrowing rate increases the required future return on capital. More importantly, the fall in the demand for domestic goods, coming from higher rates and the adjustment to the balance of payments, decreases the current return on capital and, as a consequence, the net worth of wholesale firms. This last effect amplifies the initial shock because the wholesale firms now need to borrow more in the domestic market as well, further increasing the local rates and reducing domestic demand. It also disseminates the shock, as in the "financial accelerator" literature, because the net worth of these firms takes several periods to recover.

Overall, the initial declines in output, consumption and investment can be significant. In the quarter of the impact, they fall, at annualized rates, in the range of about 4% to 6%. Moreover, even though they start to recover in the next few quarters, these variables remain below their steady-state levels for a significant period. These facts, together with the increase in net exports, are robust empirical effects of shocks to the external supply of credit that our model, as well as most previous models in the literature, can replicate.

There is, however, something fundamentally different about our model: it accounts for the domestic credit frictions that characterize most developing economies. In figure 6, we highlight the importance of this through the behavior of a set of basic economic variables under three separate situations: (i) our baseline case, already seen in figures 4 and 5, which assumes the highest level of spread-debt elasticity; (ii) a case where there is no distortion in the domestic market, as described in Section 1.3.1.9; and (iii) an inelastic spread-debt relation ($\xi = 1$), which represents an environment with low distortion. A comparison between the domestic spreads' schedules for the baseline scenario and the no-distortion setting shows that the borrowing rates can increase significantly with the financial frictions (2nd graph on the right of figure 6).

Figure 6 - Crisis Experiment without Frictions in the Domestic Financial Market
"Baseline" includes the frictions, in the "no domestic friction" case the domestic market is complete and in the "debt inelastic spread" the domestic spread is inelastic with respect to the volume of intermediation.



All variables are deviations from the steady state. * Log deviation (%). ** Annualized (pp).

Because of this feature, our setup, unlike most existing models, can ease the effects of the crisis on both the economy's base interest rate and CPI inflation, despite the fact that it does not account for the full size of the Brazilian credit market[24] or for the demand reducing terms of trade of shock. In most emerging market economies, both the policy rate (lending rate) and inflation declined during the financial crisis of 2008-2009. In the traditional framework, without domestic credit frictions, this simply cannot happen: the unique interest rate rises with

[24]The full size of the Brazilian credit market was 120% of the quarterly GDP in 2008. Our model, which looks only at a specific part of the corporate sector debt accounts for a credit volume of 22% of GDP.

the increase in the international spread. In our model, the lending rate also increases when the financial frictions are low (inelastic spread-debt case). However, the higher the value of ξ, the smaller is the increase. If the domestic financial system can only increase lending with sizeable increases in spreads, as one might suspect to be true in the short run in emerging economies with less developed financial markets, the policy rate might actually decrease. Our baseline scenario does not introduce enough distortions to generate this behavior for longer periods, but the rate decrease in the first period of the crisis and comparison across schedules clearly demonstrates that it goes in the right (data defined) direction.

The intuition for the above result is simple. The policy rate reacts to inflation and output. The drop in GDP pushes the interest rate down. The exchange rate depreciation, however, increases inflation and, hence, requires a higher interest rate. But larger spreads decrease the demand for goods from borrowers, reducing inflation and, as a consequence, lowering interest rates. If this last effect is strong enough, the policy rate will fall. In terms of inflation, our model goes in the same direction, with smaller increases for higher values of ξ. It is important to note that the increase in net exports follows immediately from the depreciation of the nominal (and real) exchange rate in the model, whereas it has more of a J-curve behavior in the data. This is to be expected, given that we are not controlling for the setup (adjustment) costs of international trade and that we assume away the significant terms of trade shock suffered concomitantly by the Brazilian economy. The instantaneous jump in net exports and the lack of deflationary pressures, in the model, from a drop in commodity prices (a demand shock for a commodity exporter) can partially account for this deviation of inflation from the data.

Finally, with a more detailed description of how the initial credit shock propagates into the economy, we can address the question of why targeting credit to exporter or to the domestic credit market in general, as implemented by various central banks, might be important or not. This is the main question of the paper, which will be addressed in the next section, and the framework of previous models in literature could not deal with it.

1.4.2 Discussion of the Credit Policies

We now turn our attention to the main question of the paper and evaluate the effectiveness of credit policies in the context of sudden stops. The aim of these policies is to alleviate conditions in credit markets: the credit facilities to exporters target the market for foreign loans and the domestic credit auctions aim at the market for domestic loans. A first observation is that, as mentioned before, in both cases, the central bank provides credit at the market rate. The only operating channel of any intervention is its general equilibrium effect on spreads as the volume of intermediation by the private sector varies.

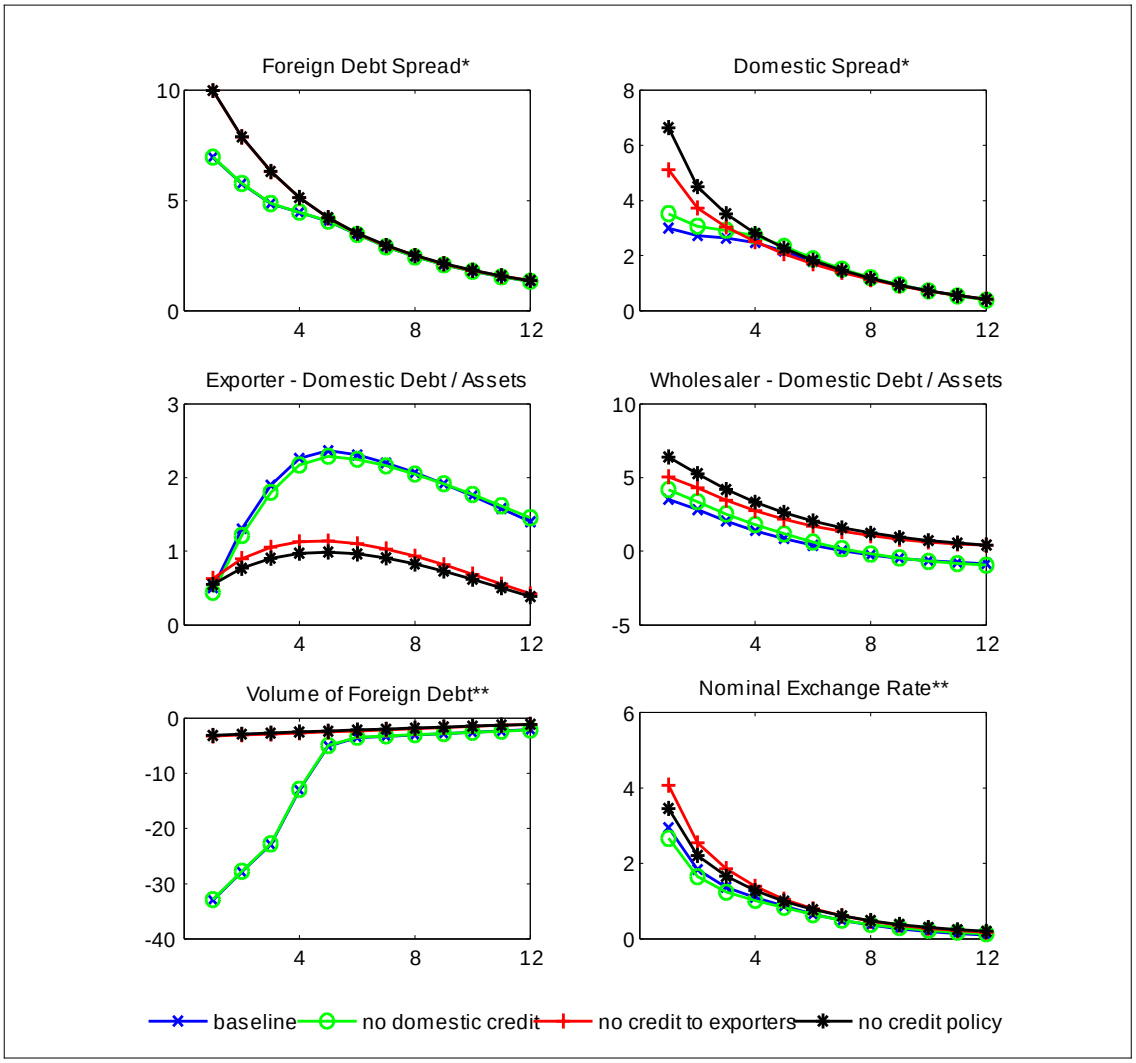
We also point out that abstract from direct costs associated with the credit procedures of the central bank. An underlying assumption is that the central bank doesn't need to impose these costs on the borrowers. To the extent that, as it will become clear, some of our results are that certain policies would reduce welfare, the presence of central bank costs should only strength those conclusions. The absence of these costs are also less important for questions about the different benefits of different policies, another point that we emphasize in the discussion below.

A final important consideration is that our analysis is restricted to the periods during and after the crisis. For example, we ignore the effects that the knowledge that a sudden stop can occur would have on the behavior of agents before it happens. This is true, even though the implementation of some of the policies might depend on actions (for example, the accumulation of foreign reserves by the central bank) taken prior to the crisis. A complete assessment of the policies should consider these aspects. We leave those issues for future research, but one should keep in mind this caveat while reading the results below.

1.4.2.1 Credit to Exporters

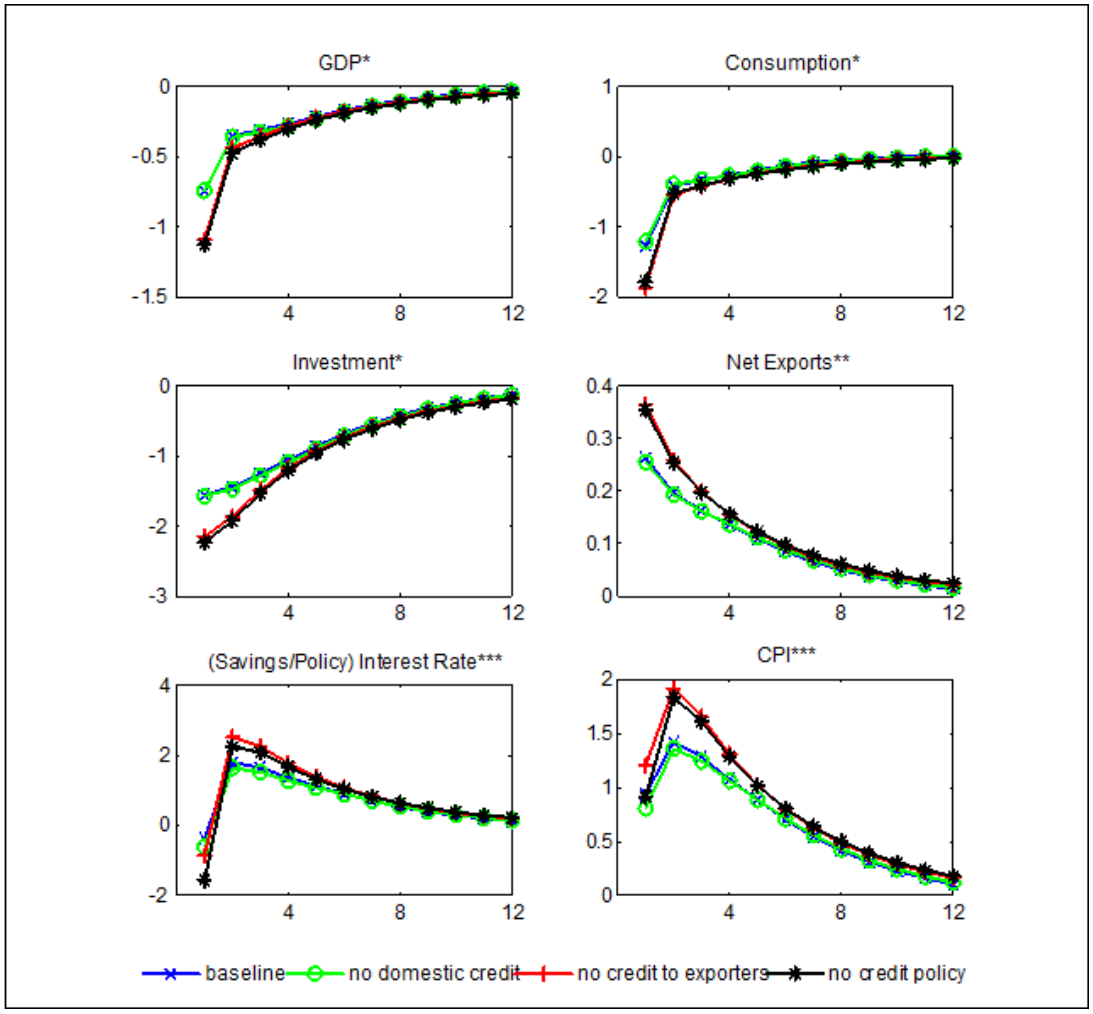
Figures 7 and 8 present the counterfactual implications of removing each of the two policies, one at a time (“no domestic credit” and “no credit to exporters”) and, then, of eliminating all interventions in the credit markets (“no credit policy”). In the case of credit to exporters, one can see that by providing an alternative source of funding, the central bank allows exporters to repay a larger fraction of their foreign debt. In equilibrium, this reduces the international spread. Since previously accumulated foreign reserves are used to fund the central bank loans, the repayment of external debt does not, however, put pressure on the exchange rate.

Figure 7 - Counterfactual Analysis
The figure reports the dynamics of selected variables under the baseline calibration, but assumes different scenarios with respect to which credit policy is implemented



All variables are deviations from the steady state. * Annualized (pp). ** Log deviation (%).

Figure 8 - Counterfactual Analysis (continued)
Same as figure 7



The wholesale firms also benefit from the credit to exporters policy through two channels. First, exporters contract less debt in the domestic market, and, as a result, they do not generate as much strain on local spreads. Second, a lower international spread reduces the costs of exports for any given level of exchange rate depreciation, and, as a consequence, increases the overall demand for the home good. The profits and the net worth of the wholesale firms also rise accordingly. This last effect improves their balance sheets and, hence, their capacity to invest. This further increases the demand for home goods and helps reduce local spreads.

On the whole, the policy has significant impacts. Aggregate variables such as real GDP, consumption, and investment improve (figure 8) by as much as 0.5% in the first quarter of the shock when compared to the "no credit to exporters" case. In terms of welfare, measured as

the steady state consumption equivalent and presented in Table 1, the policy reduces the negative impact of the crisis by 36% (from -0.0293% to -0.0187%). It should not come as a surprise that providing credit to exporters is an effective countercyclical tool in the case of a sudden stop in the trade finance credit lines. The initial shock is a negative shift in the supply of external credit to domestic firms. By offering its previously accumulated foreign exchange reserves, the central bank is effectively replacing part of the more expensive external credit lines.

Table 1 - Welfare Loss

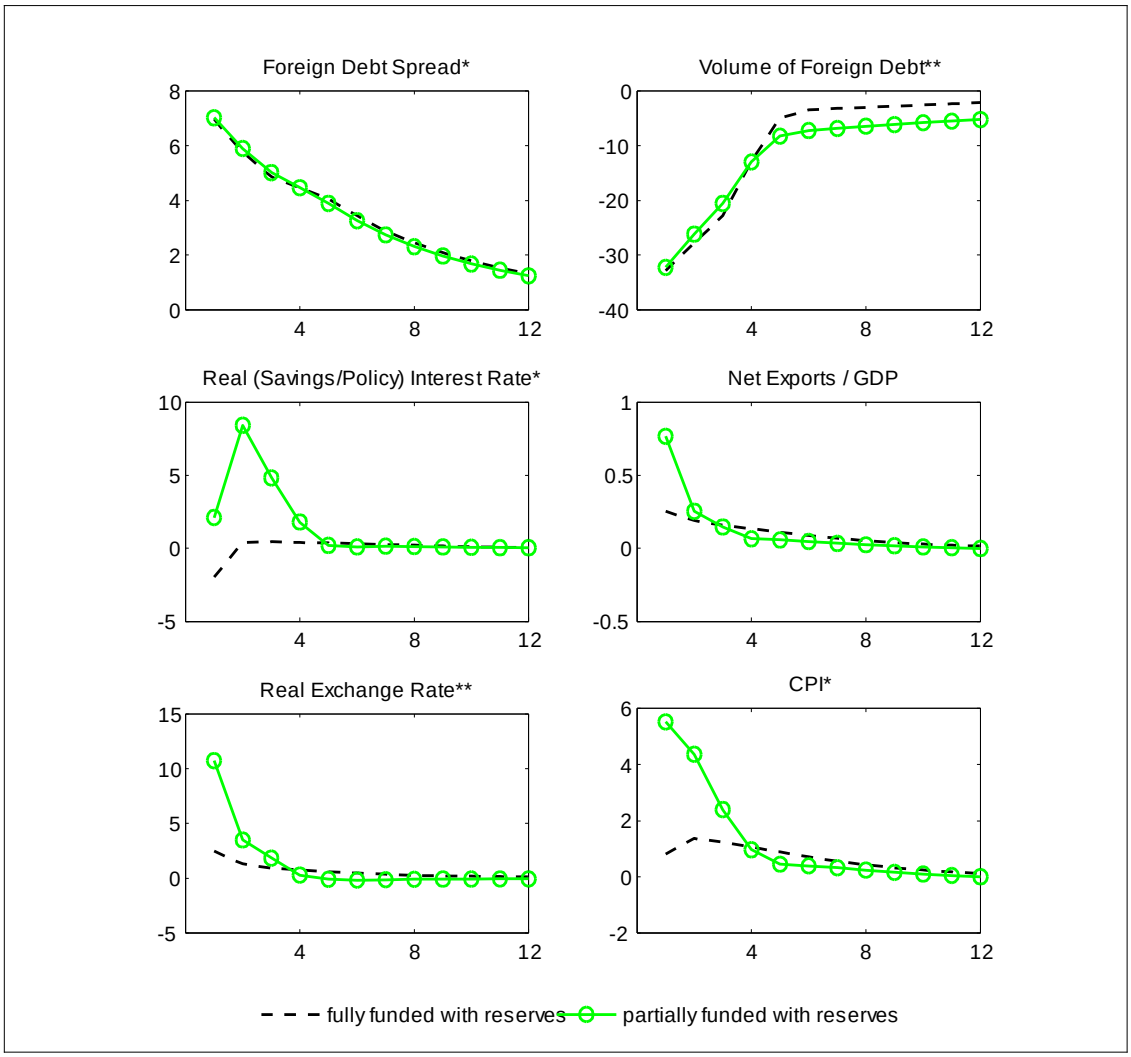
	Baseline Calibration	Flexible Prices	Flexible Prices & Same Price Index
Both Credit Policies	-0.01867	-0.01318	-0.01622
No Domestic Credit	-0.01767	-0.01310	-0.01625
No Credit to Exporter	-0.02927	-0.02233	-0.02491
No Credit Policy	-0.02695	-0.02226	-0.02494
Credit to Exporter - Partially Funded*	-0.04920	-0.01296	-0.01710
Larger Domestic Credit Intervention**	-0.04050	-0.02282	-0.02393

Consumption equivalent (pp). *Foreign reserves cover at most 80% of the credit to exporters. ** Ω

To assess the key role played by foreign reserves, Figure 9 shows what would have happened had the central bank provided credit to exporters by issuing domestic bonds to households, instead of using foreign reserves to fully fund its operation. Exporters would still have repaid a significant fraction of their foreign debt, but, without being compensated by a reduction in the central bank holdings of foreign reserves, this movement would have resulted in a net negative outflow of capital. As a consequence, both the real interest and the exchange rate depreciation would have risen further to decrease the domestic absorption (consumption and investment). In addition, the exchange rate depreciation would have caused higher inflation. Under the baseline calibration, these combined effects reduce welfare (Table 1), when compared with the case with no policy intervention. Note that with flexible prices, the policy would improve welfare. However, given that in most emerging economies inflation stabilization is the most important objective of the central bank (in fact, as noted in the introduction, many countries adopt an "inflation targeting" regime), we consider the baseline calibration to be the more relevant case.

Figure 9 - Credit to Exporters and the Role of Foreign Reserves

In the "fully funded" case foreign reserves cover 100% of the amount of credit provided by the Central Bank, while in the "partially funded case" they cover at most 80%.



All variables are deviations from the steady state. * Annualized (pp). ** Log deviation (%).

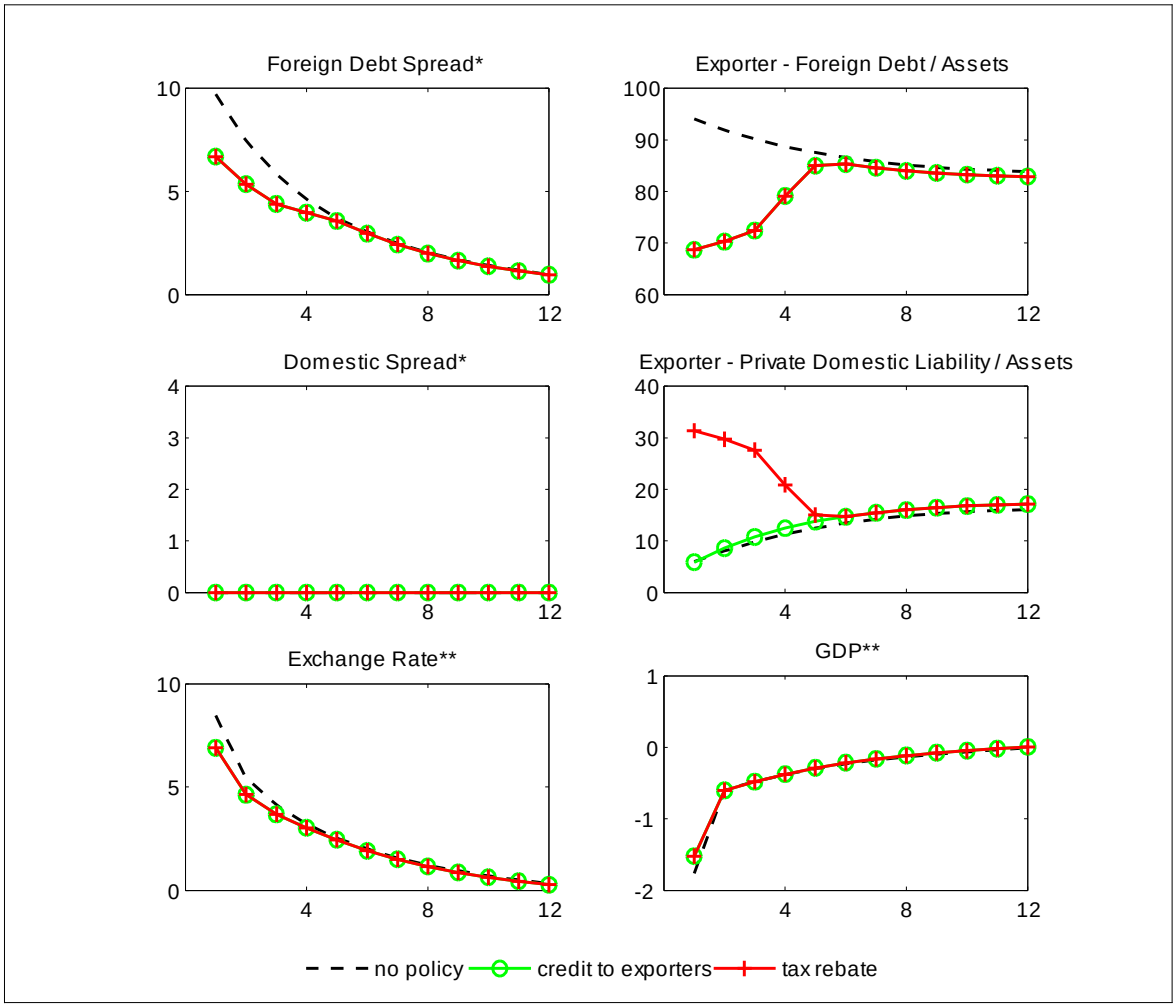
To show how crucial is the correct assessment of the behavior of domestic credit spread is for the design of credit policies, we consider the case where there are no domestic frictions, as defined in section 1.3.1.9, and the case in which the domestic spread is debt inelastic ($\xi = 1$). The most interesting conclusion from this exercise is that in both cases only the use of foreign exchange reserves matters. The intuition is straightforward: in the absence of domestic frictions, it doesn't matter where in the economy the central bank injects resources, as funds will always end up where they are most needed.

We highlight this point by comparing two policies: (i) credit to exporters funded with foreign reserves ("credit to exporters"), as in the baseline scenario, and (ii) selling foreign reserves in the spot market and transferring the proceeds to the households as a tax rebate ("tax rebate")[25]. To make the analysis more straightforward, we also include the case without any credit policy. As can be seen in Figures 10 and 11, the only difference between the policies is that, with a "tax rebate", the financial liabilities the trading companies sustain against the domestic private sector are higher in comparison to the case where the central bank provides credit to exporters. However, this difference is irrelevant in the absence of domestic frictions or in the debt inelastic case. In both situations, the spreads remain constant (at zero in the case of the former). As a consequence, the equilibrium paths of all the relevant variables – foreign borrowing, international spreads, GDP, exchange rate, as well as all other variables in the model – are the same for both policies.

[25]If, instead of a tax rebate, we consider a reduction in the government domestic debt, the results are the same.

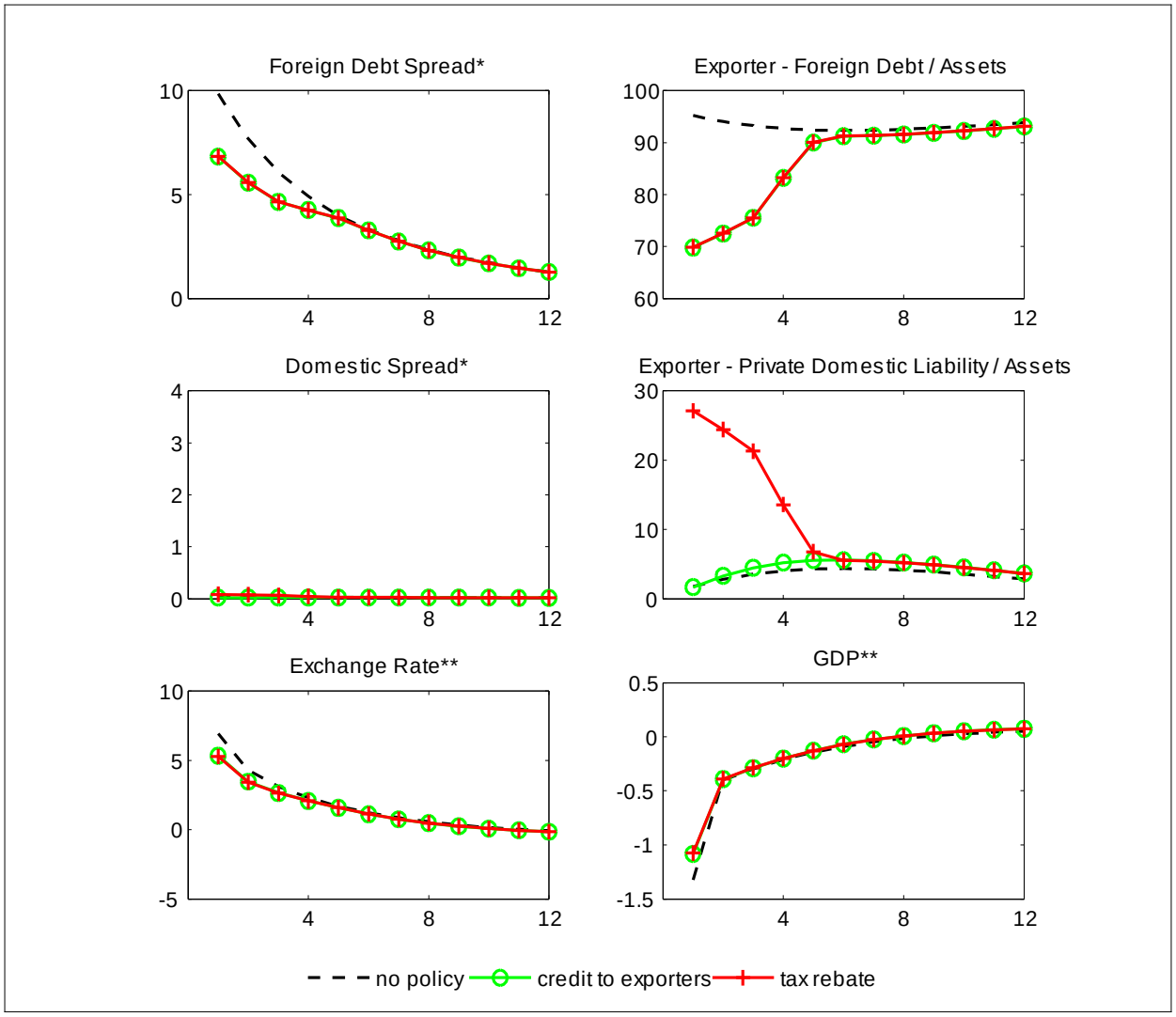
Figure 10 - Policies without Domestic Frictions

Three assumptions with respect to the use of foreign reserves: no change ("no policy"), lend foreign reserves to exporters ("credit to exporters"), sell reserves in the spot market and transfer the proceeds to the households as a lump sum transfer ("tax rebate").



All variables are deviations from the steady state. * Annualized (pp). ** Log deviation (%).

Figure 11 - Policies with Debt Inelastic Domestic Spread
Three assumptions with respect to the use of foreign reserves: no change ("no policy"), lend foreign reserves to exporters ("credit to exporters"), sell reserves in the spot market and transfer the proceeds to the households as a lump sum transfer ("tax rebate").



All variables are deviations from the steady state. * Annualized (pp). ** Log deviation (%).

Finally, these results also indicate a specific reason for central banks to accumulate foreign reserves in "normal" times (i.e., prior to the crisis): to be able to lend to exporters during the crisis. Note also that the social benefit of reserves accumulation would be higher than the private one because by providing credit directly to exporters during the crisis, the central bank can avoid the inefficiencies in the domestic financial intermediation. This result goes along the lines of the precautionary argument for foreign reserves accumulation (see, for example, Jeanne and Ranciere (2006), Aizenman and Lee (2007) and Jeanne (2007)).

1.4.2.2 Domestic Credit

The goal of the intervention in the domestic market ("domestic credit") is to improve the allocation of funds between domestic savers and borrowers. In our economy, the domestic spread is the result of the private financial system's inefficiencies in coordinating this allocation. In that sense, comparing, for example, the plotted lines for "no domestic credit" and for the "baseline" scenario in Figure 6, we can see that the policy achieves its objective. However, we find no impact at all in the volume and spread of foreign debt, and only modest implications for GDP, consumption and investment.

Moreover, our results indicate that providing domestic credit might reduce welfare. The first reason for this is that the policy can conflict with other objectives of the central bank. More specifically, by improving the local financial intermediation, the central induces a higher level of domestic borrowing, which facilitates the repayment of the foreign debt. As a consequence, net capital outflow increases, putting pressure on the exchange rate and, due to the pass-through effects of currency depreciation, raises inflation. In the baseline calibration, the nominal frictions imply that this chain of events reduces welfare from -0.01767%, with no domestic credit, to -0.01867% with both policies (Table 1).

The impact is smaller if we assume flexible prices, but the policy still reduces welfare because exchange rate movements can have effects beyond their impact on inflation. For example, as discussed above, capital goods contain a larger share of imports and, hence, their real price index is more affected by currency depreciations. The last column in Table 1 shows that if the consumption and capital composites contained the same weight of imports, domestic credit would improve welfare.

Finally, it is important to point out that all these welfare results are similar when we consider a larger volume of intervention in the domestic credit market, as can be seen in the last row of Table 1.

1.4.2.3 Two Broader Lessons for Credit Policies in Emerging Markets

1.4.2.3.1 Domestic frictions matter for the design of credit policies

This statement comes as no surprise: credit policies play a role because of financial frictions in the private sector. The interesting aspect is that, in emerging markets, the policies were implemented in response to a shock in the foreign supply of credit, where international financial frictions faced by the economy are usually viewed as being the central ones. These international imperfections are the focus of a vast literature on the importance of financial frictions in emerging market economies. In fact, in most cases, the domestic market is assumed to be perfect (or irrelevant) and, hence, can be completely ignored. That approach is justified when the focus is not on credit policy, for economies with insignificant domestic financial markets.

But, as we showed above, ignoring the empirically observed domestic frictions can be misleading when considering credit policies. In particular, one could erroneously conclude that there is *no need for credit policy* at all as the central bank could achieve the same results by simply selling foreign exchange reserves in the spot market and transferring the proceeds of the auction to the households. Given how cautious some countries are in their use of international reserves (Aizenman and Sun 2009), it is clear that considerations of the type we study here are significant to the problem.

We are not, of course, the first to note that domestic financial frictions matter to understand policies in the presence of sudden stops. Caballero and Krishnamurthy (2001) point out that a financial crisis in emerging economies can be originally caused by a shock to the quality of their international collateral. But it is the scarcity of domestic collateral that justifies the precautionary accumulation of foreign exchange reserves by the central bank, as well as its use during a crisis. More closely related to our conclusions, Calvo (2006) suggests that "for the success of this surgical operation [central bank directly channel international reserves to sectors which, on net, display a positive marginal social return to the use of international reserves], it is necessary for the central bank to be well on top of developments in domestic credit markets".

1.4.2.3.2 The mere fact of an increase in credit frictions does not necessarily imply that central bank credit policy will raise welfare

We saw two examples where credit policies (credit to exporters partially funded with reserves, and domestic credit) facilitated the allocation of funds between domestic borrowers and savers, but did not improve welfare – they actually did the opposite. This happened because the policies increased – each in their own way – the pressure on the balance of payments, as exporters could more easily borrow in the domestic market to repay their foreign debt. If foreign exchange reserves are not used to counterbalance the strain on currency markets, the resulting exchange rate depreciation and higher inflation decrease welfare.

Similar effects have been previously emphasized in the literature. For example, Obstfeld, Shambaugh, and Taylor (2010) consider a model in which the provision of domestic liquidity by the monetary authority to support the domestic financial system during a bank run "...magnifies the potential claims on official foreign exchange reserves, and hence magnifies the currency depreciation...". In their model, this observation justifies the hoarding of large sums of foreign exchange reserves by emerging economies.

This point is worth emphasizing because policies designed to act exclusively upon the inefficiencies of the domestic financial markets are exactly the ones recommended in most works for closed economies – or at least for developed economies. In particular, this is the case of the recent literature addressing the responses of the US Federal Reserve during the great recession of 2008-09. For instance, Geanakoplos (2010) argues that, in a model of margins requirement and collateralized debt, "[t]he Fed must step around the banks and lend directly to investors, at more generous collateral levels than the private markets are willing to provide". Gertler and Karadi (2011) use their "model to evaluate the effect of expanding central bank credit intermediation to combat a simulated financial crisis", and conclude "that the welfare benefits may be substantial if the efficiency costs of government intervention are modest". Cúrdia and Woodford (2010a) also describe assumptions under which a disturbance that increases credit spreads would justify central bank lending to private non-financial borrowers.

What our results show is that those policy recommendations depend on the financial structure that is assumed. For many emerging markets, given the structure of their economies and how

the crisis reached them, the most effective credit policies are of a different type. They must be funded out of previously accumulated foreign exchange reserves and are most appropriately targeted to the export sector.

1.5 Conclusion

Crises have long been fertile ground for economic theory. The last global installment, over 2007-2009, was certainly no exception. Macroeconomics, in particular, benefited not only from the emergence of a new set of questions searching for answers, but also from the resurgence a whole repository of controversies that many believed to have been pacified: “what should the instruments of monetary policy be?”, “do credit policies have a role to play in the management of economic crises?”, “do we really understand all the functions of foreign-exchange reserves' accumulation?”, “what financial frictions should be taken into account when dealing with sudden stops?”. These are but a few topics that have either resurfaced or gained centrality in academic research agendas as a direct consequence of the latest crisis.

Our paper belongs to this broader agenda. More specifically, we have tried to answer the following important question: were the credit policies implemented, during the recent crisis, by several developing economies useful in dealing with the economic effects of the sudden stop in international credit flows?

To answer this question, we've built a quantitative small open model with two imperfect credit markets, one domestic and the other international. This innovation delivers a financial market entrance differentiation that exists in many developing economies: while domestic credit markets are open to most firms, only some specific companies (trading companies or exporters) have access to foreign borrowing. It also allows shocks to the foreign supply of credit to affect domestic spreads through a simple mechanism: firms that previously borrowed abroad turn to the local credit market for funding to a great extent and, hence, increase the cost of domestic loanable funds. This works as a clear, but seldom highlighted, transmission mechanism for the external crisis, as the jump in spreads in both markets raises financing costs for all borrowers in the economy and depresses output.

Our main findings suggest, first, that it can make sense for the central bank to provide credit directly to exporters, (even) at the prevailing market price. Not only does this restrain spreads, increasing GDP, but it also generates an unambiguous welfare improvement, as long as the intervention is funded out of previously accumulated foreign-exchange reserves. After all, by providing a cheaper alternative of foreign credit to exporters during the crisis, the credit facility generates positive general equilibrium effects on spreads as exporters reduce the amount of debt contracted with the private sector, without having a government in search of new funding to fill that gap.

Without the use of reserves to fund the operation, however, credit facilities to exporters would have reduced welfare in our model, as the incentive to repay their foreign debt would pressure the exchange rate, without providing much relief for domestic spreads. Inflation would, consequently, creep up to undesirable levels. This result shines a new light in the large literature on the accumulation and management of foreign-exchange reserves, as it is the first to demonstrate, in a quantitative macroeconomic model, that using foreign reserves to provide credit to exporters during a sudden stop can improve welfare.

Our second finding deals with policies aimed more generally at the domestic market, and it suggests that, even though they are effective in reducing domestic spreads, their upshot on welfare will be negative. Much like in the case without the use of reserves, the incentives towards repaying foreign debt are distorted and the resulting capital outflow weights on the exchange rate and, consequently, on inflation. As was pointed out before, however, this result should be viewed with caution. There are many – potentially good – reasons to intervene in the domestic credit markets, such as avoiding possible bank runs. These have been thoroughly studied in the literature and are not the subject of our investigation here. With this caveat in mind, nevertheless, one can clearly understand the importance of this negative result, as some developing economies engaged in domestic credit market interventions with the unmistakable (and apparently wrong-headed) objective of reducing spreads to all firms.

Finally, we highlight the importance of accounting for domestic financial frictions by showing that, in their absence, the central bank has no reason to engage in any kind of credit policy. Comparing a policy of direct credit to exporters, funded with foreign-exchange reserves, with a policy of selling foreign reserves in the spot market and rebating the proceeds

to the households, we find that both approaches are equivalent in an economy with perfect domestic financial markets. Without frictions or if domestic spreads are positive but remain constant during the crisis, it does not matter where in the economy the central bank injects resources, because they will always end-up where they are most needed.

Overall, our findings suggest that intervening only in domestic credit markets, or engaging in more general credit policies without the necessary backing of foreign-exchange reserves, is not a good recipe for dealing with sudden stops in capital flows. Credit focused at the more affected sectors in a developing economy – mainly the export-import firms, which use more borrowing to fund their operations – can be quite helpful during a crisis, as long as the central bank funds its actions with reserves hoarded before the crisis. In designing these policies, however, one needs to account for the fundamental aspects in the economy, like the observed, crisis-induced increase in domestic spreads.

Major revisions in the pre-established consensus are, obviously, important. Credit interventions seem to have been an effective countercyclical, welfare-improving policy during the financial crisis of 2008-09, in emerging economies. However, this general statement does not apply to all cases, and some misguided interventions can clearly reduce welfare. The one fundamental lesson that comes out of our analysis is that the desirability or not of engaging in credit policies depends crucially on their implementation. A deep understanding of the economy's fundamental characteristics should, therefore, be an absolute requirement before considering any deviation from the usual, time-established economic policies.

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APPENDICES

APPENDIX A – COMPLETE LIST OF EQUATIONS

APPENDIX B – TABLE - PARAMETERS IN THE MODEL

APPENDIX A. COMPLETE LIST OF EQUATIONS

The equations below describe the dynamic equilibrium in the private sector, the interest rate rule, the government budget constraint and the balance sheet of government. Prices in real terms (with respect to the consumption basket) are denoted in small caps.

$$E_t\left[\beta\frac{\lambda_{,t+1}}{\lambda_t}\frac{R_t}{\Pi_{t+1}}\right]=1 \tag{54}$$

$$\lambda_t=\left(C_t-\tilde{L}\frac{L_t^{1+\psi}}{1+\psi}\right)^{-\sigma} \tag{55}$$

$$L_t=\tilde{L}^{-1/\psi}w_t^{1/\psi} \tag{56}$$

$$C_{H,t}=\gamma\frac{C_t}{p_{H,t}} \tag{57}$$

$$C_{F,t}=(1-\gamma)\frac{C_t}{s_t} \tag{58}$$

$$L_t=\frac{\alpha}{(1-\alpha)}\left(\frac{p_{w,t}}{w_t}\right)^{\frac{1}{1-\alpha}}K_{t-1} \tag{59}$$

$$P_{K,t}K_{t+1}=P_tN_{w,t}+P_tD_{w,t} \tag{60}$$

$$E_t\left[\mu_{w.t+1}\frac{1}{\Pi_{t+1}}\left(R_{K,t+1}-R_{b,t}\right)\right]=0 \tag{61}$$

$$N_{w,t}=\theta_w\left[\frac{R_{K,t}-R_{b,t-1}}{\Pi_t}p_{K,t-1}K_t+\frac{R_{b,t-1}}{\Pi_t}N_{w,t-1}\right]+\kappa_w p_{K,t}K_{t+1} \tag{62}$$

$$\eta_{w,t} = E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{R_{b,t}}{\Pi_{t+1}}\left((1-\theta_w)+\theta_w\eta_{w,t+1}\right)\right\} \tag{63}$$

$$\mu_{w,t} = \beta\frac{\lambda_t}{\lambda_{t-1}}\left((1-\theta_w)+\theta_w\eta_{w,t}\right) \tag{64}$$

$$p_{H,t}C^*_{H,t} = N_{e,t} + D_{e,t} + s_t D^*_{e,t} \tag{65}$$

$$s_t P^*_{H,t} = p_{H,t}\psi^*_{e,t}R^* \tag{66}$$

$$E_t\left[\mu_{e,t+1}\frac{s_{t+1}}{s_t}\psi^*_{e,t}R^*\right] \le E_t\left[\mu_{e,t+1}\frac{1}{\Pi_{t+1}}R_{b,t}\right] \tag{67}$$

$$N_{e,t} = \theta_e\left(s_t P^*_{H,t-1}C^*_{H,t-1} - s_t\psi^*_{e,t-1}R^*D^*_{e,t-1} - \frac{R_{b,t-1}}{\Pi_t}D_{e,t-1}\right) + \kappa_e p_{H,t}C^*_{H,t}. \tag{68}$$

$$\eta_{e,t} = E_t\left\{\beta\frac{\lambda_{t+1}}{\lambda_t}\frac{s_{t+1}}{s_t}\psi^*_{e,t}R^*\left((1-\theta_e)+\theta_e\eta_{e,t+1}\right)\right\} \tag{69}$$

$$\mu_{e,t} = \beta\frac{\lambda_t}{\lambda_{t-1}}\left((1-\theta_e)+\theta_e\eta_{e,t}\right) \tag{70}$$

$$F_t = \lambda_{w,t}Y_{H,t}p^{\eta}_{H,t}p_{w,t} + \alpha_p\beta E_t[\Pi^{\eta}_{t+1}F_{t+1}] \tag{71}$$

$$G_t = \lambda_{w,t}Y_{H,t}p^{\eta}_{H,t} + \alpha_p\beta E_t[\Pi^{\eta-1}_{t+1}G_{t+1}] \tag{72}$$

$$p_{H,t} = \left[(1-\alpha_p)\left(\frac{F_t}{G_t}\right)^{1-\eta} + \alpha_p\left(\frac{p_{H,t-1}}{\Pi_t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{73}$$

$$\Delta_t = (1-\alpha_p)\left(\frac{F_t}{G_t}\frac{1}{p_{H,t}}\right)^{-\eta} + \alpha_p\left(\Pi_t \frac{p_{H,t}}{p_{H,t-1}}\right)^{\eta}\Delta_{t-1} \tag{74}$$

$$p_{K,t} = \left[\gamma_k\left(p_{H,t}\right)^{1-\rho_k} + (1-\gamma_k)\left(s_t\right)^{1-\rho_k}\right]^{\frac{1}{1-\rho_k}} \tag{75}$$

$$K_{H,t+1} = \gamma_k K_{t+1}\left(\frac{p_{H,t}}{p_{K,t}}\right)^{-\rho_k} \tag{76}$$

$$K_{F,t+1} = (1-\gamma_k)K_{t+1}\left(\frac{s_t}{p_{K,t}}\right)^{-\rho_k} \tag{77}$$

$$R_{b,t} = (1+\Xi_t^{'})R_t \tag{78}$$

$$\Xi_t = \tilde{\Xi}\left(D_{w,t} + D_{e,t}\right)^{\xi} \tag{79}$$

$$\psi_{e,t}^{*} = 1 + \tilde{\psi}_{e,t}^{*}\left(\frac{s_t D_{e,t}^{*}}{p_{H,t}C_{H,t}^{*}}\right)^{\eta_e} \tag{80}$$

$$\left(\frac{L_t}{\alpha}\right)^{\alpha}\left(\frac{K_t}{1-\alpha}\right)^{1-\alpha} = \Delta_t\left(C_{H,t} + K_{H,t+1} + C_{H,t}^{*} + \Xi_{H,t}\right) \tag{81}$$

$$C_{H,t}^{*} = C^{*}\left(P_{H,t}^{*}\right)^{-\nu^{*}} \tag{82}$$

$$P_{H,t-1}^{*}C_{H,t-1}^{*} - C_{F,t} - K_{F,t+1} = D_{e,t-1}^{*}\psi_{e,t-1}^{*}R^{*} - D_{e,t}^{*} + FA_t - R^{*}FA_{t-1} \tag{83}$$

$$1 = p_{H,t}^{\gamma}s_t^{1-\gamma} \tag{84}$$

$$\frac{R_{K,t}}{\Pi_t} = \frac{p_{w,t}}{p_{K,t-1}} \left(\frac{w_t}{p_{w,t}} \right)^{-\frac{\alpha}{1-\alpha}} \tag{85}$$

$$\frac{R_t}{R} = \left(\Pi_t \right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}} \right)^{\phi_y} \tag{86}$$

$$T_t = D_{g,t} + s_t FA_t - B_{g,t} + \left(\frac{R_{t-1}}{\Pi_t} B_{g,t-1} - \frac{R_{g,t-1}}{\Pi_t} D_{g,t-1} - R^*_{t-1} s_t FA_{t-1} \right) \tag{87}$$

$$D_{g,t} + s_t FA_t = B_{g,t} \tag{88}$$

APPENDIX B. TABLE – PARAMETERS IN THE MODEL

The table describes all the parameters in the model and their baseline calibration

Parameter	Value	Description
Conventional parameters calibrated from the literature in emerging market economies		
σ	1	inverse of the intertemporal elasticity of substitution
ψ	2	inverse of the labor supply elasticity
$\nu*$	1	exports price elasticity
η	8	elasticity of substitution across the different varieties of home goods
α_p	2/3	probability of a retail firm not being able to adjust its price
ρ_k	0.25	elasticity of substitution in the production of capital goods
ϕ_π	2	response of the policy rate to inflation
ϕ_y	0.75	response of the policy rate to output
Parameters calibrated to match moments of the Brazilian data in the steady state		
α	0.80	share of labor (set to match the GDP share of investment expenditures: 0.20)
δ	0.967	home good bias (share of imported consumption goods: 0.02)
δ_k	0.50	home good bias in capital goods (share of imported capital and input: 0.10)
Ξ	-	domestic credit supply curve (domestic spread at 2.4% in annual terms)
ψ_e	-	foreign credit supply curve (international spread at 1.6% in annual terms)
κ_w	0.0047	start-up in the wholesale sector (net worth – assets ratio at sector at 0.5)
κ_e	0.00034	start-up in the export sector (net worth – assets ratio at sector at 0.03)
Less Conventional Parameters		
ξ	22	domestic spread volume elasticity
η_e	1	international spread leverage elasticity
θ_w	0.975	fraction of wholesaler staying in their group (average firm life: 10 years)
θ_e	0.975	fraction of exporters who stay in their group (average firm life: 10 years)
Other parameters		
L	1.552	disutility of working (normalizes the steady-state output to 1)
C*	0.12	foreign demand (normalizes the steady-state terms of trade to 1)
β	0.99	time discounting (steady-state policy rate to 4% annual terms)

2 NOT ALL DEFAULTS ARE CREATED EQUAL: AN EMPIRICAL INVESTIGATION OF OCCURRENCES IN "GOOD & BAD TIMES"[26]

2.1 Introduction

Sovereign debt defaults have been an integral part of the economic landscape for many centuries (Reinhart and Rogoff, 2009). Over the past 200 years for which data has been compiled in a more consistent fashion, these occurrences have been widespread and their costs substantial, both in terms of economic and social hardships[27]. But despite 30 years of intense, creative theoretical research on the subject, since Eaton and Gersovitz (1981) first published their seminal paper on debt repudiation, several of the salient features in the data remain unaccounted for by the profession's most widely used models.

Tomz and Wright (2007), using a proprietary dataset covering 179 countries and spanning 185 years, from 1820 to 2004, show that only about 62% of all sovereign defaults occur in so-called bad times, as measured by a Hodrick-Prescott filter[28]. In other words, over 38% of defaults happen in good times and, therefore, as shall be seen below, cannot be satisfactorily explained by the dominant strands of the theoretical literature in international economics. But there is more to this story than meets the eye. Here, we propose to further explore these occurrences, highlighting characteristics that should be taken into account by any researcher looking for models that explain these rather curious facts.

First, however, it is important to understand that the most common view of defaults states that these events should be examined through the lenses of economic self-insurance. This class of models counts among its most recent developments the sovereign default framework proposed by Aguiar and Gopinath (2007)[29], which, following Tomz and Wright (2007), we

[26] With Renata Rizzi.
[27] See, Hatchondo, Martinez and Sapriza (2007), Tomz and Wright (2007), among others.
[28] The HP filter defines the trend growth rate of output and allows the authors to compare current output with the one implied by the trend. If output is above trend, we have a good time. When output is below trend, it is called a bad time.
[29] See Arellano (2008) and Yue (2006) for other contributions in a similar vein that share many characteristics with the paper by Aguiar and Gopinath.

will use as a reference point here. This model assumes that defaults provide costly insurance against negative shocks and rationalizes the decision to renege on the debt as a pure cost-benefit analysis[30]. This mechanism, however, builds-in a significant negative correlation between output and defaults, clearly implicating that *almost* all defaults should take place when the gross domestic product (GDP) is below potential.

The *almost* qualifier used in the previous sentence comes – as will be made clear by the model simulation reproduced in Table 2 below – from the fact that Aguiar and Gopinath look not only at transitory shocks to the economy, but also at permanent disturbances that alter the trend of its expansion, thus establishing that some defaults could take place as the country converges from above to a new, lower growth standard. In any case, both types of shocks imply that defaults occur, on average, with output significantly below trend – and more so in the case of transitory shocks.

The model suggests that, even after accounting for permanent shocks, roughly 86% of all defaults should take place with output below potential. Only the remaining 14% of repudiation episodes could, therefore, be potentially characterized as strategic or inexcusable, in the sense that the country is not forced into this situation by dire circumstances which trigger the implicit – and imperfect – contingency clauses of sovereign debt[31]. In these repudiations, the sovereign acts in a manner that goes against the reputation-building aspect of recurrent interactions with (international) credit markets (see Grossman and Van Huyck, 1988). That is one reason why such incidents are hard to justify in equilibrium.

Alas, as mentioned above, these predictions are in stark contrast to what is established by the data. Tomz and Wright (2007) also show that defaults occur, on average, when output is just marginally below trend (-1.6%). What is more, many countries suffering major drops in output decide not to renege on the debt despite the fact that, at that point, the model suggests that defaulting would be the reasonable choice. Given the common intuition about these

[30] There is a 2% direct output cost of default, introduced in a *ad-hoc* fashion, and calibrated using the values put forth by Chahuan and Sturzenegger (2005).

[31] This interpretation is, obviously, not strictly consistent with Aguiar and Gopinath's analysis, or our own views, as the occurrence of a permanent negative shock to growth could be seen as a dire enough circumstance to justify the use of a debt default as an insurance device. Nevertheless, this type of shock introduces enough uncertainty as to the country's situation relative to the new trend that defaults on those instances could be seen by some as strategic, especially in purely empirical analysis.

episodes, this is almost as surprising as the authors' finding that over 38% of all debt repudiations are unjustifiable (inexcusable). All these empirical observations fall considerably outside our current understanding of the issues involved.

But these observations lead to a fundamental question: are defaults in good and bad times really the same thing or do they have distinct determining factors? For if they are different events altogether, the quest for a unique, all-encompassing model of sovereign defaults may not necessarily be the correct research agenda. One objective of the present work is to approach this question in a systematic way, applying modern micro-econometric tools to derive interesting implications from the data that may inform future theoretical research on the subject.

Two driving forces lie behind our investigation of these issues: one is the fact that different definitions of good and bad times can have a significant impact on the interpretation of the data; and the other is the view that defaults have important political – as well as other environmental – components besides the economic one. Several researchers have previously discussed the relevance of the political environment in determining the nature of the interaction between the sovereign and its creditors. Hatchondo et al (2007), for instance, offer a nice review of the political factors that may, potentially, drive a country towards default. And a number of works, such as Citron and Nickelsburg (1987) and Kohlscheen (2003), among others[32], point to the empirical relevance of these hypotheses. Our contribution is to further refine this analysis by taking into account the existence of good and bad times and testing whether political and other economic factors are more prevalent in one type of default rather than the other.

Before looking at the implications of our hypotheses, though, we first establish that the findings of Tomz and Wright's (2007) are not a feature of a specific proprietary dataset. Using only publicly available data, we construct, in section 2.2, a significantly shorter panel – focusing on modern defaults, after the 1970's, which seem more relevant for understanding today's environment – and still obtain roughly the same results as them, despite the differences in the group of countries and in the time span covered in our panel. This shows

[32] See, for example, Van Rijckeghem and Weder (2004), Enderlein, Müller and Trebesch (2008), Sturzenegger and Zettelmeyer (2006).

that, at least as a first pass, the Tomz and Wright critique of the theoretical literature seems robust to alternative selections of data.

Subsequently, we review a few definitions of good and bad times, and illustrate how many of the previously mentioned findings depend crucially on how these periods are classified. In section 2.3, we present the results of our econometric estimates of the determinants of sovereign defaults, which seem to support the basic premise that political factors are more prevalent in determining inexcusable defaults. Then, we perform some basic duration analysis to understand if and how the length of default episodes depends on our covariates. We find that the duration of defaults is significantly longer when countries decide to renege on the debt despite being in superior economic conditions. We explore this point further by looking at the dissimilar duration of defaults under autocratic and democratic regimes, and take into account the prevailing international economic conditions. We conclude, in section 2.5, that defaults are, indeed, very diverse events depending in which point of the business cycle they start, and suggest further avenues for empirical research on this topic.

2.2 Exploring the Data

2.2.1 Dataset

Our dataset spans from 1970 to 2004 and includes 71 economies, forming a panel with 2,485 data points, for which all the descriptive statistics can be found in the appendix. The source for economic and financial indicators is the World Bank. (World Development Indicators and Global Development Finance databases). We use the Standard and Poor's definition of sovereign default and focus on national government defaults on foreign currency loans and bonds to private creditors. We draw on Beers & Chambers (2004) to construct two series of dummy variables for defaults. The first of these deals with the beginning of a default episode, and hence only takes the value 1 on the year a given country reneges on its debt. The second dummy variable measures the duration of any given default episode, taking the value 1 for the entire period the country remains in default. We start with a dataset of 210 countries but reduce it to 71 countries by including only those that report positive amounts of public and

publicly guaranteed debt to the World Bank and for which default data is available from S&P's.

Having established the relevant economic and financial data to be used, we then focus on the political environment, which is of major importance for the underlying hypotheses we intend to test. The Polity 2 Index, from the Polity IV Project[33], is employed as a measure of political regime characteristics and as an indicator of regime transitions (political shocks). It is commonly used in the political economy literature as well as in political science research for this purpose and, thus, fits are goals quite well. It is opportune to note that the Polity score is a measure of regime type that reflects the degree of political competition, the qualities of executive recruitment and institutional constraints on the executive authority. There are no economic variables among its components.

2.2.2 Probability of Default

In this subsection, we present some interesting results that can be drawn from the simple exercise of examining the data in this fully publicly available dataset. First, we replicate TW's analysis and generate numbers that are not very different from what they report (Table 2). The puzzle remains there: almost 40% of defaults begin in good times.

[33] www.systemicpeace.org/polity/polity4.htm

Table 2 - The Relationship between Output and Default

	Historical Data		Simulation	
	Tomz & Wright Data	Rizzi & Salles Data	Transitory Shocks	Permanent Shocks
Mean Deviation from trend (%)				
In the first year of default	-1.6	-1.1	-4.6	-7.4
In periods of default	-1.4	-2.1	-25.7	-5.6
In last year of defaults	-1.3	0.4	-13.6	-4.5
In periods of non-default	0.2	0.8	0.0	0.4
Country years below trend (%)				
In the first year of default	61.5	61.7	100.0	85.9
In periods of default	56.2	63.6	83.8	78.1
In last year of defaults	58.8	50.5	75.5	72.9
In periods of non-default	47.2	45.5	50.0	48.3

Note: Simulations and proprietary dataset presented by Tomz and Wright (2007). Rizzi and Salles statistics come from the dataset constructed in the present paper using only publicly available sources.

Second, we examine mean values of selected variables in years of non-default and in years when defaults start and get quite interesting "hints" (Table 3). Although defaults occur with output only marginally below trend, we find that GDP in the first year of default is, on average, 7.5% below its historical peak. Also, before defaults start, U.S. interest rates experience an average 2-year growth of 5.9%, as opposed to a 0.4% drop in years of non-default.

Table 3 - What do Simple Means Tell Us?

	First Year of Default	Year of Non-default	Total
GDP HP deviation from trend	-1.1%	0.8%	-0.3%
Current GDP/historical GDP peak	-7.5%	-3.0%	-5.1%
Two-year U.S. interest rate growth	5.9%	-0.4%	-1.2%
Dummy for bad HP time	0.62	0.46	0.52
Dummy for GDP below historical peak	0.66	0.28	0.38
Polity2 Index	-1.32	-0.97	-0.85

Finally, we differentiate between default events that start in bad and in good HP times and redo the analysis. Good-time-defaults seem to be explained partly by increases in international interest rates and partly by political factors (Table 4). We consider three "political" variables

in particular: a dummy to indicate whether a country is an autocracy or not[34], a dummy to signal that a change in political regime took place within the two previous years[35] and a dummy that takes value 1 in years for which GDP in constant terms is below the country's historical peak. In the first year of good-time defaults, 53.3% of country-years correspond to autocracies, 55.6% take place below historical GDP peak and 26.7% are years of political regime transition. Furthermore, 52.8% of country-years are concomitant with U.S. interest rate hikes[36].

Table 4 - Frequency of each Dummy in Different Sub-samples

	Begin of good-time default	Begin of bad-time default	Total sample
Autocracy	53.3%	37.5%	46.6%
Below historical peak	55.6%	72.4%	38.1%
Political regime change	26.7%	16.1%	24.1%
U.S. interest rate hike (2-year growth > 10 p.p.)	52.8%	43.1%	38.1%

Finally, inspired by Levy Yeyati and Panizza (2011), we replicate the exercise using quarterly data as opposed to annual data (Table 5). Our original findings are strongly reinforced by high-frequency data, as the share of good HP times defaults that cannot be explained via political variables drops to as low as 5%[37].

Table 5 - Yearly versus Quarterly Data

% of defaults beginning in	Bad HP Time	Below historical GDP peak
Yearly Data	62%	66%
Quarterly Data	75%	95%

[34] According to the classification in Polity IV project.
[35] We use the variable "durable", from Polity IV project. This variable provides a running measure of the durability of the regime's authority pattern for a given year, that is, the number of years since the last substantive change in authority characteristics (defined as a 3-point change in the Polity score).
[36] U.S. 10-year treasury bonds.
[37] These results are available upon request.

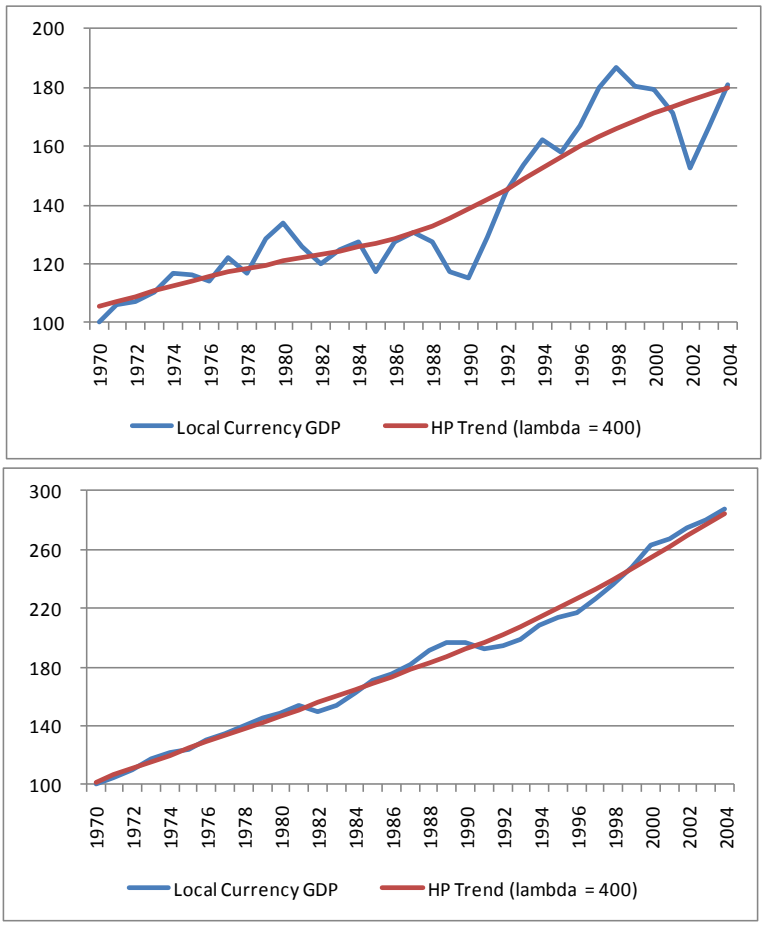
2.2.3 Bad Times are not Robust to the Definition Employed

Although Tomz and Wright (2007) classified good and bad times by applying the Hodrick-Prescott filter to real gross domestic product in local currency, they did recognize that alternative definitions of bad times could produce a stronger negative relationship between default and output in the data. Our own experiments indicate that simple changes in the methodology used for classification do, in fact, yield quite different results.

One possibility would be to filter the GDP series considering the incidence of shocks to trend growth on top of transitory fluctuations around a stable trend, as advocated by Aguiar & Gopinath (2007). Using the methodology by King, Plosser, Stock and Watson (1991) to decompose the variance of the series into that due to permanent shocks and transitory shocks would certainly alter the classification of bad and good times (particularly for emerging economies).

Figure 12 shows the evolution of output for Argentina and Canada and reveals the high degree of variation in trend volatility among countries. It is easy to see that, in the case of Argentina, the introduction of a stochastic trend would transform some of the good HP times in bad times and vice-versa.

Figure 12 - Evolution of GDP in Argentina (top) and Canada (bottom)

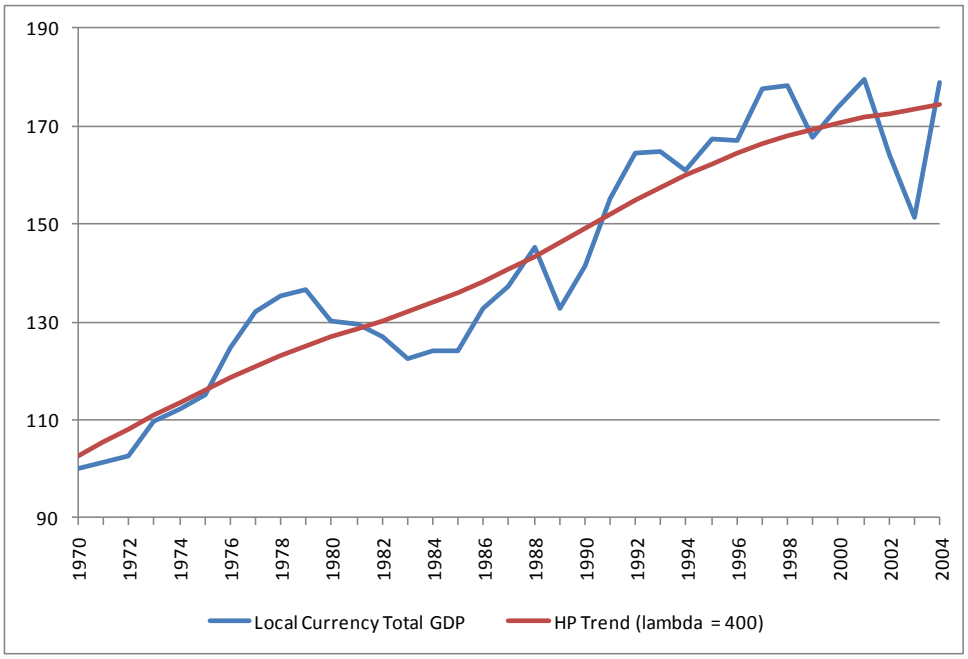


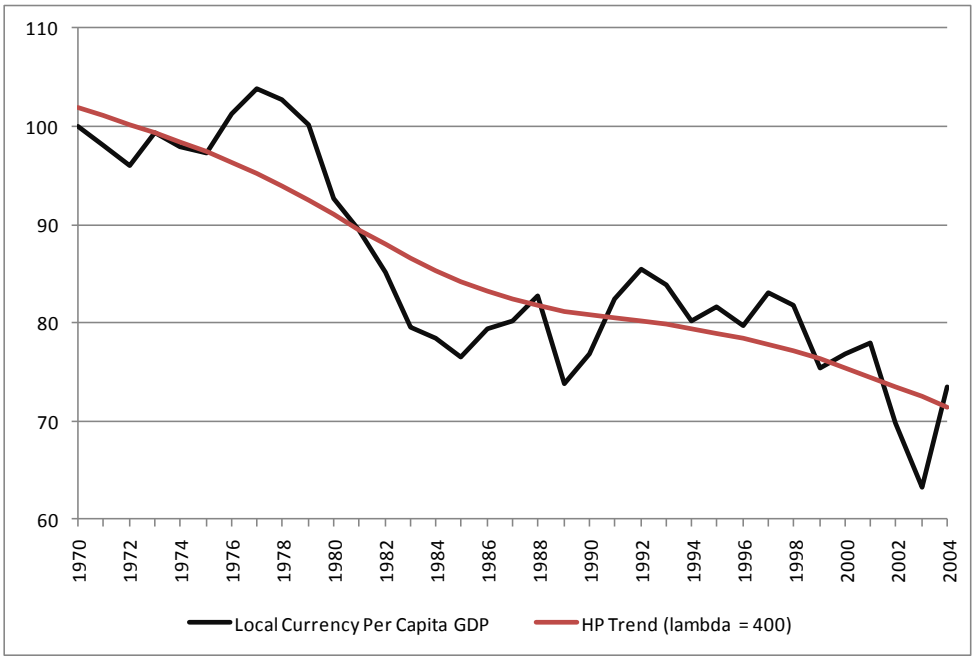
Using a different statistic to classify the state of the world could also be an alternative. One could argue that filtering the GDP per capita series instead of aggregate GDP would be more appropriate, even though GDP per capita does not have a direct theoretical counterpart – few papers deal with population growth. The case of Venezuela shows the potential disparity between these two series and helps rationalize the 1995 default episode, which took place in a good HP time (figure 13). The country had experienced the last peak of its GDP per capita 18 years before it declared default. That does not exactly sound like the description of a good time.

The Venezuelan example is convenient to illustrate this further aspect that we wish to bring up, namely the peculiar but recurrent situation in which a country's output stands below (or way below) its last peak during good HP times. This was the case in Venezuela between 1991 and 1999, for example. The fact that a country may experience negative growth during good

times (and they do, otherwise GDP would never return to trend) is somewhat counterintuitive but well-understood. Now, when a country faces a downward sloping trend, the label "good times" seems unsuitable even when employed to refer to positive growth years. In such instances, the HP classification really fails to match our basic intuitive notion of "good times".

Figure 13 - Evolution of GDP (top) and GDP per capita (bottom) in Venezuela





The point we make here is simply that although fluctuations above and below trend are undeniably the proper statistics for comparisons with theoretical outcomes, the understanding of stories beyond this binary classification may help guide future research. Testing for robustness of the definition of bad times is beyond of the scope of this paper.

Having said that, however, we can see in Tables 3 and 4 above that the measure of Depth of Recession – the fact that the country finds itself below its historical peak – seems to be fundamental in defining the decision to default. In the next section, we will take this analysis one step further by incorporating the lessons of the simple means analysis into a more robust econometric framework, using logit regressions to determine probabilities of defaults implied by certain economic fundamentals and the prevailing political environment.

2.2.4 Duration of Default

We also perform some basic duration analysis to understand if the length of the default episodes also varies with the kind of defaults that precede them. Duration (or survival) analysis was originally employed to estimate how the survival time of patients was affected by different factors. By now, the methodology has become widespread in empirical work, mainly in labor and population economics applications. In short, it aims at understanding movements from one state to another and at relating the time elapsed until that movement occurs to one or more explanatory variables. The analytical unit in most studies is the individual (sometimes the firm or the country) and examples of explained variables include the duration of unemployment, the lifetime of firms, the duration of marriages, the length of wars and newborn survival time.

In our case, the idea is to complement the findings of Sandleris, Gelos and Sahay (2004), Benjamin and Wright (2009) and some others[38] who find that, besides a renegotiation period of about eight years, countries are, on average, excluded from international capital markets for only four years[39]. We look at the length of defaults (with start and end points as defined by Standard and Poor's) and our goal is to make a distinction (if we find one) between the

[38] Richmond and Dias (2008), Arráiz (2006), Panizza, Sturzenegger and Zettelmeyer (2009) .
[39] In stark contrast with the permanent exclusion assumption needed for modern calibrated theoretical models to match the data.

duration of good and bad times defaults, autocratic and democratic regime defaults, excusable and inexcusable defaults.

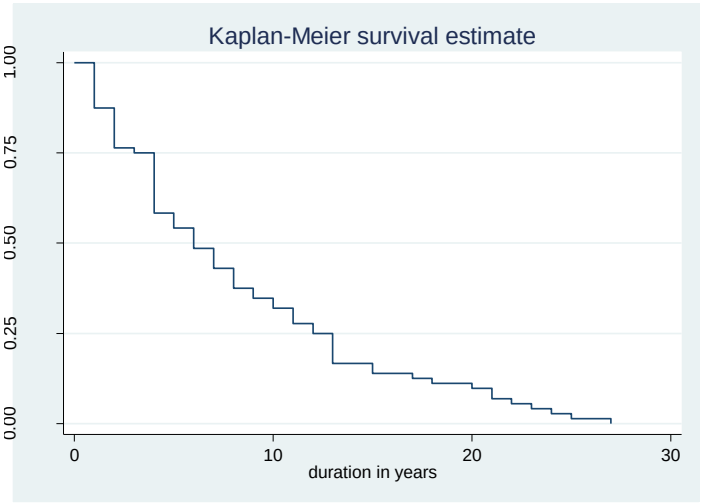
Although our dataset does not exhibit the problems normally associated with duration data[40], this kind of modeling is a natural approach to this analysis since the dependent variable is generated by a series of sequential decisions.

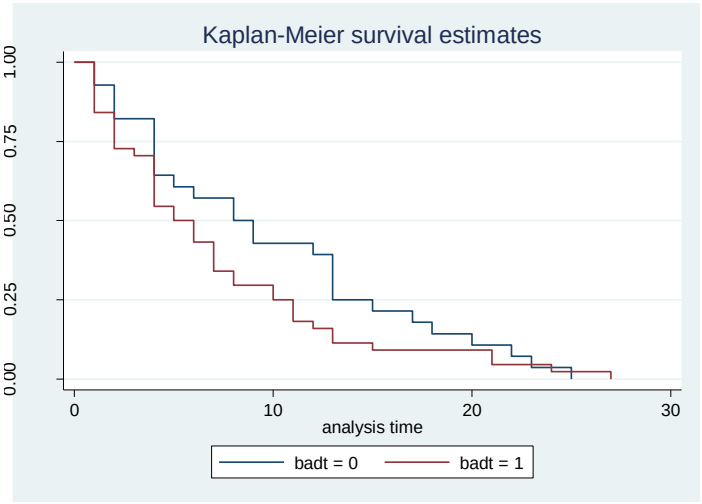
We start by looking at the Kaplan-Meier curves estimating the distribution of the survival function in our sample which, in this case, relates to the probability that a given default will last beyond a certain period of time. We study the curves, not only for the overall dataset, but also for some of its sub-samples, taking into account the dominant political regime and the economic situation of the country. Moreover, we look at the mean duration of episodes starting in different economic circumstances, considering both its last peak and regular HP estimates.

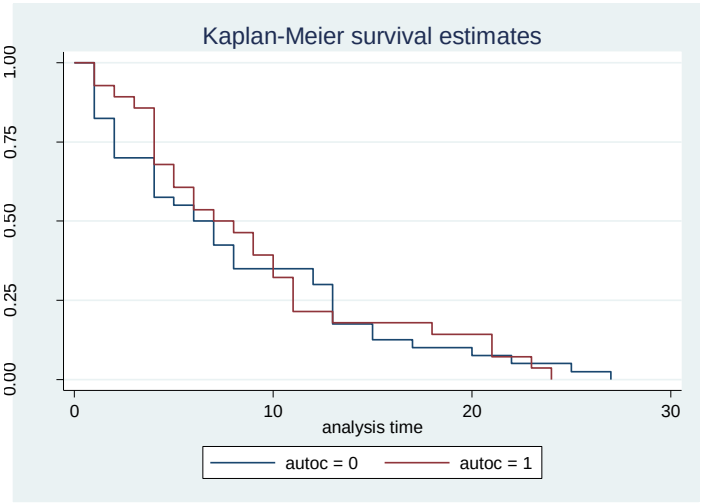
The visual examination of the Kaplan-Meyer non-parametric survivor estimates (Figure 14) is quite revealing.

[40] Censoring, truncation and left-bias sampling.

Figure 14 - Kaplan Meier Survival Curves







Approximately 25% of all defaults end within one year and a little more than 30% last for more than ten years. But aggregate numbers are misleading. When countries declare default in bad times, the length of the episode is typically shorter than when they repudiate debt in good times. Roughly 45% of these default events last for more than ten years. It looks like outright repudiations do indeed receive harsher punishment. There seems to be no significant difference between the duration of defaults declared by autocratic and non-autocratic countries.

Table 6 shows, in its columns, the mean length of defaults beginning in bad and in good HP times. Bad time defaults are shorter than good time defaults. Additionally, when countries start a default in a bad HP year but with output above its last peak, the duration of the episode tends to be much smaller, suggestive of the interplay between creditors' punishment and ability to recover. The occurrence in a bad HP year possibly makes the default excusable, and the fact that it happens during a new peak in the economy may allow the sovereign to recover fast.

Table 6 - Mean Duration of Default

Mean of default duration in years	Bad HP time	Good HP time
Below historical GDP peak	6.52	7.25
	(1.09)	(1.64)
Above historical GDP peak	2.81	8.25
	(0.74)	(2.02)

2.3 Empirical Analysis

The empirical literature on debt defaults has commonly used probit and logit estimates to identify factors influencing the probability of such events occurring, given a set of – usually macroeconomic – control variables[41]. As several authors point out, including Greene (2000), the differences between these two estimation techniques are usually not very significant, and a choice between them can simply be made on the basis of standard maximum likelihood criteria (see Catão and Kapur, 2004). However, as Manasse, Roubini and Schimmelpfennig

[41] See Catão and Sutton (2002), Detragiache and Spilimbergo (2001), Reinhart (2002), among many others.

(2003) explain, the logit approach usually performs better than probit when the dependent variable is not evenly distributed between the two possible outcomes – a common feature of default episodes.

Another issue one must take into account when choosing the estimation procedure is the potential for so-called unobserved effects. When employing probit models, as well as random-effects logit, one must assume the normality of the distribution of the unobserved random variable, conditional on the vector of explanatory variables. One could, conceivably, deal with a potential correlation between the unobserved variable and the controls by including a more specific conditional distribution for that variable, as proposed by Chamberlain (1980), but such technique requires some very specific knowledge on the part of the econometrician.

It is with these potential problems in mind that we choose to estimate a Logit Model with Fixed Effects[42] that allows the unobserved variable to be arbitrarily related to the explanatory variables[43], which are lagged to avoid any endogeneity.

We, therefore, run the following regression:

[42] We do perform Hausman tests for the random effects (RE) model and do not reject its validity and, therefore, its superior efficiency in our case. So, we present the RE estimates as well. They do not vary substantially from our preferred fixed effects model (FE). Nevertheless, given the potential size problems of these tests, we feel more comfortable with our FE approach, which yields consistent results in any case.
[43] For more details, see chapter 16 of Wooldridge (2002).

$$P(Y = 1|X) = \frac{\exp(\beta X)}{1 + \exp(\beta X)}$$

$Where$

$Y = Begin\ of\ Default\ Dummy$

$$X = \begin{bmatrix} \left(\frac{Res}{Ext\ Debt}\right) \\ \left(\frac{PPG\ Debt\ Serv}{GDP}\right) \\ \left(\frac{PPG\ Ext\ Debt}{GDP}\right) \\ \left(\frac{US\$\ PPG\ Debt}{Total\ PPG\ Debt}\right) \\ Bad\ Times\ Dummy \\ Depth\ Dummy \\ U.S.Interest\ Growth \\ Autocracy\ Dummy \\ Regime\ Change\ Dummy \end{bmatrix}$$

$With$:

$Res = Foreign\ Exchange\ Reserves$

$Ext\ Debt = External\ Debt$

$PPG\ Debt\ Serv = Public\ and\ Publicly\ Guaranteed\ Debt\ Service, including\ Interest$

$PPG\ Ext\ Debt = Public\ and\ Publicly\ Guaranteed\ External\ Debt$

$Depth\ Dummy = Dummy\ equal\ to\ 1\ if\ GDP\ \ is\ below\ its\ historical\ peak$

$U.S.Interest\ Growth = 2 - year - United\ States\ Interest\ Rate\ Increase$

$Regime\ Change\ Dummy = Dummy\ equal\ to\ 1\ if\ variable$ Durable > 3 years $(Polity\ 2)$

$Good\ Times\ Dummy = Dummy\ equal\ to\ 1\ if\ Default\ occurs\ in\ Good\ HP\ Times$

$US\$\ PPG\ Debt = U.S.Dollar\ denominated\ PPG\ Debt$

$Bad\ Times\ Dummy = Dummy\ equal\ to\ 1\ if\ Default\ occurs\ in\ Bad\ HP\ Times$

$Autocracy\ Dummy = Dummy\ equal\ to\ 1\ if\ Polity\ 2\ index\ between - 10\ and - 6$

This specification pools together good and bad time defaults. We then proceed to test for differences between the two types of defaults using the following specification for explanatory variables:

$$\beta X = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 (Good\ Times\ Dummy).X_2$$

$Where$

$$X_1 = \begin{bmatrix} Bad\ Times\ Dummy \\ Depth\ Dummy \end{bmatrix}$$

$$X_2 = \begin{bmatrix} \left(\frac{Res}{Ext\ Debt}\right) \\ \left(\frac{PPG\ Debt\ Serv}{GDP}\right) \\ \left(\frac{PPG\ Ext\ Debt}{GDP}\right) \\ \left(\frac{US\$\ PPG\ Debt}{Total\ PPG\ Debt}\right) \\ U.S.Interest\ Rate\ Growth \\ Autocracy\ Dummy \\ Regime\ Change\ Dummy \end{bmatrix}$$

In order to evaluate the duration of default episodes, we assign to each default observation the values of its covariates in the year default was declared. We estimate hazard models experimenting with different theoretical distributions and select the Weibull distribution – which is clearly the best fit for our data. In the models, we include the world GDP growth and all covariates that determine the beginning of default (from the logit analysis), so as to avoid confusion between what causes a default to be long and what causes a default to start in the first place. We also include year dummies to account for the state of the world economy in each episode or cluster of episodes. Finally, we estimate a Cox proportional hazard model with time invariant covariates.

2.4 Results

2.4.1 Probability of Default

We first reproduced TW's analysis using our dataset and reached very similar conclusions. We then performed logistic regressions to estimate the coefficients of interest, as discussed in section 2.3. Our results indicate that defaults in bad and good times are indeed distinct phenomena. Table 7 displays the resulting coefficients of fixed and random effects logistic regressions when the dependent variable is the "begin of default dummy" and the explanatory variables are interacted with the Good Times Dummy in order to segregate the effects.

All defaults were found to be associated with inter-temporal variations in the liquidity and solvency status of countries[44], with the dummy indicating that output stands below its last peak and with the growth in U.S. interest rates in the two years preceding default. The coefficient for the bad times dummy is found not to be significant, the opposite happening to the depth dummy. The results indicate that increased reserves/external debt ratios are negatively correlated to the probability of default, whereas higher U.S. interest rate growth rates and required levels of debt service and interest raise the chances of default. The negative coefficient on PPG external debt/GDP may reflect output declines or credit constraints in the run-up to default. Also, defaulting is usually more costly the more it ends up hurting creditors. Therefore, countries with too much external debt may also feel compelled not to default in order to avoid too costly a process. Larger portions of debt denominated in dollars increases the probability of default only in bad times and changes in the political regime raise the odds of a default only in good times. This result corroborates the notion that mixed-motive models may be needed to satisfactorily explain what we see in the data.

Additionally, defaults are less likely to start soon after changes in the political regime take place. When interacted with the good times dummy, however, the political regime change dummy exhibits a positive coefficient and a higher one, in absolute terms, than the one obtained when all defaults are considered.

[44] As measured by the following variables: ratio of public and publicly guaranteed debt service and interest obligations to GDP, ratio of reserves to external debt, ratio of PPG external debt to GDP.

Table 7 - Logistic Regressions

Dependent Variable: **Begin of Default Dummy**	**Fixed Effects Logit Coefficients**		**Random Effects Logit Coefficients**	
Bad times dummy	0.6608		0.0573	
	(1.1514)		(1.0311)	
GDP below historical peak dummy	1.1650	***	1.2170	***
	(0.3118)		(0.2700)	
Reserves/external debt	-0.0530	***	-0.0164	
	(0.0202)		(0.0117)	
% PPG debt in US dollars	0.0177		0.0064	
	(0.0133)		(0.0084)	
(PPG debt service+interest)/GDP	10.4389	**	9.2812	***
	(4.5130)		(3.4850)	
PPG external debt/GDP	-2.2333	***	-1.6115	***
	(0.7799)		(0.5797)	
2-year U.S. interest rate growth	1.9685	**	2.0279	**
	(0.8438)		(0.8272)	
Political regime change dummy	-0.9159	**	-0.7480	**
	(0.4442)		(0.4075)	
Autocracy dummy	-0.5427		-0.4231	
	(0.4505)		(0.3518)	
Interaction with Good Times Dummy				
Reserves/external debt	-0.0496	*	-0.0426	*
	(0.0300)		(0.0256)	
% PPG debt in US dollars	0.0048		-0.0065	
	(0.0161)		(0.0137)	
(PPG debt service+interest)/GDP	4.6297		0.0557	
	(6.3947)		(5.4520)	
PPG external debt/GDP	0.0466		0.4091	
	(1.0391)		(0.8709)	
2-year U.S. interest rate growth	-0.6520		-0.2731	
	(1.3611)		(1.3182)	
Political regime change dummy	1.5227	**	1.2753	**
	(0.6662)		(0.6069)	
Autocracy dummy	0.3979		0.4165	
	(0.5914)		(0.5601)	
Observations	1,488		1,691	
Number of countries	49		64	

Stars indicate statistical significance at 1% (***), 5% (**) and 10% (*) levels.
Independent variables are lagged one period, but for political change dummy and U.S. interest rate growth.

As mentioned above (see footnote 40), we have performed Hausman tests to evaluate if the more efficient random effects model would also be consistent for our case and the null hypothesis could not be rejected. The results obtained are very similar to those generated by the fixed effects model, our preferred specification.

We have performed robustness checks of two types. We repeated the econometric estimation: i) excluding countries with PPG debt to concessional debt ratio higher than 80%, ii) including a "contagion dummy"[45] in the analysis, and iii) doing both (i and ii). For the construction of the contagion dummy, we have generated groups of countries based on the pairwise correlation of the variation in the spreads of their sovereign bonds in time (see the groups in the Appendix). We have then created a dummy which takes value 1 for a certain country in a given year if in that same year, any of the countries in its "contagion group" is in default. The results (with the fixed effects specification) are shown in table 8. The contagion dummy is highly significant, indicating that the probability of default in one country is positively influenced by the occurrence of default in one or more countries in its contagion group. Additionally, we verify that our main findings are robust to these changes in the model.

[45] We thank Marcos Rangel and João Manoel Pinho de Mello for the suggestion.

Table 8 - Fixed Effects Logistic Regressions with Concessional Debt/Total Debt < 80%, with "Contagion Dummy" and both

Dependent Variable: Begin of Default Dummy	**Concessional debt < 80%**		**Contagion dummy**		**Both**	
Bad times dummy	-0.4679		0.6663		0.0298	
	(1.1671)		(1.1659)		(1.4181)	
GDP below historical peak dummy	1.4256	***	1.1371	***	1.3667	***
	(0.3114)		(0.3162)		(0.3718)	
Reserves/external debt	-0.0067		-0.0532	***	-0.0345	
	(0.0114)		(0.0206)		(0.0221)	
% PPG debt in US dollars	0.0124		0.0179		0.0315	**
	(0.0098)		(0.0135)		(0.0161)	
(PPG debt service+interest)/GDP	10.6809	**	10.3437	**	10.2227	*
	(4.2938)		(4.5318)		(5.2589)	
PPG external debt/GDP	-2.1253	***	-2.1035	***	-2.2945	**
	(0.8224)		(0.7628)		(0.9768)	
2-year U.S. interest rate growth	1.1850		1.6015	*	0.8165	
	(0.9371)		(0.8561)		(0.9980)	
Political regime change dummy	-0.7168		-1.0486	**	-1.0702	**
	(0.4668)		(0.4537)		(0.5171)	
Autocracy dummy	-0.4253		-0.5265		-0.5429	
	(0.4144)		(0.4526)		(0.5094)	
Interaction with Good Times Dummy						
Reserves/external debt	-0.0454	*	-0.0462		-0.0481	
	(0.0258)		(0.0307)		(0.0329)	
% PPG debt in US dollars	-0.1296		0.0036		-0.0066	
	(0.0154)		(0.0166)		(0.0187)	
(PPG debt service+interest)/GDP	-3.5874		3.8435		0.1912	
	(6.1606)		(6.5005)		(7.4178)	
PPG external debt/GDP	1.1479		0.1563		0.7579	
	(1.0258)		(1.0209)		(1.1857)	
2-year U.S. interest rate growth	-0.0131		-0.7723		-0.1709	
	(0.0154)		(1.3778)		(1.5230)	
Political regime change dummy	1.4501	**	1.6840	**	1.8143	**
	(0.6616)		(0.6797)		(0.7381)	
Autocracy dummy	0.4515		0.5497		0.6452	
	(0.6268)		(0.5972)		(0.6731)	
Contagion dummy			1.9801	***	2.1150	***
			(0.6558)		(0.6706)	
Observations	1,279		1,488		1,179	
Number of countries	47		49		39	

Stars indicate statistical significance at 1% (***), 5% (**) and 10% (*) levels.
Independent variables are lagged one period, but for political change dummy and U.S. interest rate growth.

2.4.2 Duration of Default

Table 9 presents the outcomes of the estimation of the parametric model following a Weibull baseline distribution and of the Cox regression.

Table 9 - Duration Models

Dependent Variable: Duration of default **Coefficients: Hazard Ratios**	**Weibull Distribution**		**Cox Regression**	
Depth of GDP (compared to historical peak) (more positive values indicate poorer economic conditions)	0.0357		0.0557	
HP deviation from trend	0.0043	*	0.01416	
World GDP growth	0.0134	***	0.0294	***
Reserves/external debt	1.0409	*	1.0427	*
% PPG debt in US dollars	1.0045		0.9974	
(PPG debt service+interest)/GDP	3.7226		2.0271	
PPG external debt/GDP	1.1093		1.5680	
2-year U.S. interest rate growth	2.20×10^{-9}	***	1.99×10^{-7}	***
Political regime change dummy	0.7620		0.8216	
Polity2 index	1.0592	*	1.0495	*
Number of countries	58		58	

Stars indicate statistical significance at 1% (***), 5% (**) and 10% (*) levels.

The coefficients of both models are similar, statistically significant and confirm that longer defaults are associated with more autocratic regimes and outright repudiation of debt (and even though these two variables may be correlated, they are both significant). Moreover, the results imply that a default episode is likely to be longer the higher growth in world GDP or U.S. interest rates are when it starts. In other words, the international economic situation is important in determining the length of a default episode, and not only its occurrence, as many intuitively believe.

The results of this procedure strengthen our premise that not all defaults are created equal. As far as our knowledge of the literature extends, this is the first time such duration analysis is

applied to this type of problem. The findings presented here shed light on some important, previously unknown characteristics of sovereign debt defaults.

2.5 Concluding Remarks

The findings of Tomz and Wright (2007) have changed the way many economists look at sovereign debt defaults. The data put forth by these authors have crushed many of the common intuitions of researchers, who had not previously considered the overall importance of defaults in good economic times. A disconnect between the dominant strand of the theoretical literature and the behavior implied by the data remains ever present. More recently, though, some noteworthy efforts to bridge this gap have started to emerge (see Benjamin and Wright, 2009). But, so far, our knowledge of the data remains too sketchy, at best, to really shore up the quest for new, all-encompassing models. The present paper, with its more in-depth look at the underlying diversity in default events, aimed to close some of the gaps in our comprehension.

First, we established the robustness of the results published by Tomz and Wright, which do not seem to depend on specific datasets or time periods. We have obtained results that are qualitatively (and quantitatively, actually) equivalent to theirs with a much shorter span of data and a different set of countries under examination. We have, of course, also shown that these findings rely entirely on the use of Hodrick-Prescott filters to determine good and bad times. But since this is a common approach to simulating these models, the fact that over 30% of defaults occur in such good times is of great relevance to any researcher who wishes to match the appropriate data. We show here that most good-time defaults can be rationalized. They either take place in i) bad interest rate times, ii) bad political times (in terms of a GDP below historical peak), or iii) political transition times.

Second, using logistic regressions, we have found that defaults can be extremely different events depending on whether they start in good or bad times. When a country reneges on its sovereign debt, the determining factors for its decision can all be found in the usual financial/economic restrictions. However, when defaults occur in good times, an additional determining factor becomes important: the political motivation, as represented by our measure

of regime transitions. Hence, we have found some very strong evidence that these two kinds of defaults are quite different from each other.

But there is more to it. The third, and final, finding of this paper is that these events are also quite different when it comes to their duration. Outright repudiation of the debt – in other words, inexcusable defaults – seem to last longer, suggesting that countries that take that route are punished. And autocracies also tend to take longer to re-enter the markets and re-establish their international credit. The causality here, however, is quite hard to identify and opens new avenues for research.

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APPENDIX

DESCRIPTIVE STATISTICS

Variable	Observations	Mean	Std. Dev.	Min	Max
% concessional debt/total external debt	2268	36.68	27.34	0.00	100.00
% dollar debt/total PPG debt	2268	47.63	21.52	0.00	100.00
Interest plus service on PPG external debt/GDP	2101	0.05	0.05	0.00	0.54
Reserves/external debt	2107	21.88	35.95	-0.17	502.18
HP deviation of local currency GDP	2182	0.00	0.08	-0.72	0.60
Bad times dummy	2182	0.51	0.50	0.00	1.00
Year default begins dummy	2125	0.04	0.21	0.00	1.00
Year of default dummy	2125	0.35	0.48	0.00	1.00
Regime transition dummy	2150	0.24	0.43	0.00	1.00
Polity 2 index	2148	-1.40	6.70	-10.00	10.00
Openess	2375	53.67	29.89	0.31	220.41
PPG external debt/GDP	2101	0.61	0.72	0.00	8.64
2-year U.S. interest rate growth (ten-year notes)	2272	-0.01	0.19	-0.42	0.43
10-year GDP volatility	2356	0.13	0.07	0.00	0.99
Autocracy dummy	2149	0.47	0.50	0.00	1.00
GDP depth compared to last peak	2182	-0.05	0.11	-0.92	0.00
GDP under last peak dummy	2182	0.38	0.49	0.00	1.00

Table 1 - "Contagion groups" - countries with correlated risk (correlation > 0.5)

abudhabi	argentina	australia	austria	bahrain	belgium	brazil	bulgaria	canada	chile	china	colombia	croatia
qatar		newzealand	ireland		spain	turkey	turkey			vietnam	vietnam	turkey
malta		malta	denmark		portugal	poland	southafrica			turkey	venezuela	southafrica
dubai		cyprus	czech		ireland	philippines	russia			southafrica	turkey	slovakia
cyprus					estonia	panama	romania			skorea	poland	skorea
					egypt	mexico	poland			russia	philippines	russia
					denmark	croatia	lithuania			poland	panama	romania
					czech	colombia	hungary			philippines	mexico	poland
							czech			panama	indonesia	philippines
							croatia			malaysia	croatia	peru
										indonesia	brazil	panama
										czech		mexico
										croatia		malta
												malaysia
												lithuania
												latvia
												kazakhstan
												indonesia
												hungary
												estonia
												czech
												cyprus
												colombia
												china
												bulgaria
												brazil

Table 2 - "Contagion groups" - countries with correlated risk (correlation > 0.5)

cyprus	czech	denmark	dominican rep	dubai	ecuador	egypt	estonia	finland	france	greece	guatemala	hungary
saudiarabia	ukraine	spain	malta	abudhabi	newzealand	belgium	poland	ireland	spain	spain		turkey
newzealand	turkey	netherlands	ecuador		dominican rep		hungary	france	netherlands	romania		portugal
dominicanr~i	spain	malta	cyprus		denmark		czech	denmark	ireland	portugal		poland
denmark	southafrica	italy			czech		croatia	czech	iceland	poland		philippines
czech	slovenia	france					belgium		finland	malta		indonesia
croatia	slovakia	finland							denmark	lithuania		estonia
australia	skorea	ecuador								italy		czech
abudhabi	russia	cyprus								ireland		croatia
	romania	belgium								czech		bulgaria
	portugal	austria										
	poland											
	philippines											
	panama											
	malta											
	malaysia											
	lithuania											
	latvia											
	kazakhstan											
	italy											
	ireland											
	indonesia											
	hungary											
	greece											
	finland											
	estonia											
	ecuador											
	cyprus											
	croatia											
	china											
	bulgaria											
	belgium											
	austria											

Table 3 - "Contagion groups" - countries with correlated risk (correlation > 0.5)

iceland	indonesia	ireland	italy	kazakhstan	latvia	lebanon	lithuania	morocco	pakistan	peru	philippines	poland
netherlands	vietnam	spain	spain	turkey	czech	malta	turkey			turkey	vietnam	turkey
malta	turkey	portugal	portugal	russia	croatia		portugal			philippines	turkey	spain
france	southafrica	netherlands	greece	philippines			poland			croatia	southafrica	southafrica
	skorea	greece	denmark	indonesia			philippines				skorea	slovakia
	russia	france	czech	czech			indonesia				russia	skorea
	romania	finland		croatia			greece				romania	russia
	poland	czech					czech				poland	romania
	philippines	belgium					croatia				peru	portugal
	panama	austria					bulgaria				panama	philippines
	malta										mexico	panama
	malaysia										malta	mexico
	lithuania										malaysia	malaysia
	kazakhstan										lithuania	lithuania
	hungary										kazakhstan	indonesia
	czech										indonesia	hungary
	croatia										hungary	greece
	colombia										czech	estonia
	china										croatia	czech
											colombia	croatia
											china	colombia
											brazil	china
												bulgaria
												brazil

Table 4 - "Contagion groups" - countries with correlated risk (correlation > 0.5)

portugal	romania	russia	southafrica	spain	turkey	ukraine	venezuela	vietnam	netherlands	qatar	saudiarabia	malta
spain	turkey	vietnam	turkey	portugal	vietnam	czech	mexico	turkey	ireland	abudhabi	malta	turkey
romania	southafrica	turkey	russia	poland	southafrica		colombia	skorea	iceland		cyprus	saudiarabia
poland	portugal	southafrica	romania	italy	russia			russia	france			portugal
malta	poland	poland	poland	ireland	romania			philippines	denmark			philippines
lithuania	philippines	philippines	philippines	greece	poland			malaysia				norway
italy	indonesia	panama	malaysia	france	philippines			indonesia				newzealand
ireland	greece	kazakhstan	indonesia	denmark	peru			colombia				lebanon
hungary	czech	indonesia	czech	czech	panama			china				indonesia
greece	croatia	czech	croatia	belgium	mexico							iceland
czech	bulgaria	croatia	china		malta							greece
belgium		china	bulgaria		malaysia							dominicanr~i
		bulgaria			lithuania							denmark
					kazakhstan							czech
					indonesia							croatia
					hungary							australia
					czech							abudhabi
					croatia							
					colombia							
					china							
					bulgaria							
					brazil							

Table 5 - "Contagion groups" - countries with correlated risk (correlation > 0.5)

slovakia	slovenia	malaysia	norway	mexico	israel	panama	newzealand	japan	skorea
poland	czech	vietnam	malta	venezuela		turkey	malta		vietnam
czech		turkey		turkey		russia	ecuador		poland
croatia		southafrica		poland		poland	cyprus		philippines
		skorea		philippines		philippines	australia		malaysia
		poland		croatia		indonesia			indonesia
		philippines		colombia		czech			czech
		indonesia		brazil		croatia			croatia
		czech				colombia			china
		croatia				china			
		china				brazil			