Interest Rates and Business Cycles in Emerging Economies: The Role of Financial Frictions*

Andrés Fernández† Adam Gulan‡

Work in Progress

This version: November 11, 2011

Abstract

Countercyclical country interest rates have been shown to be both a distinctive characteristic and an important driving force of business cycles in emerging markets. In order to capture this, most business cycle models of emerging economies have nonetheless relied on ad hoc and exogenous countercyclical interest rate processes. We offer a solution to this shortcoming by embedding a financial contract à la Bernanke et al. (1999) into a standard real business cycle model of a small open economy. Because of the existence of agency problems between foreign lenders and domestic borrowers, this financial structure allows us to fully endogenize the existence of an external finance premium that drives country interest rates. We then take the model to data from emerging economies and show that this modification allows to properly account for many of the stylized facts of business cycles in emerging economies, particularly the strong volatility and countercyclicality of interest rates.

Keywords: Business cycle models; Emerging economies; Financial frictions; GMM estimation

JEL Classification: E32; E44; F41

*Any views or opinions presented in this article are solely those of the authors and do not necessarily represent those of the Bank of Finland. We are thankful to Sergio Castellanos for his excellent research assistance. We received fruitful comments from Roberto Chang, Cristina Fuentes-Albero, John Landon-Lane and Bruce Mizrach. Any errors or shortcomings are ours.

†Departamento de Economia, Universidad de los Andes, Calle 19A No. 1-37 Este · Bloque W, Bogota, Colombia; E-mail: andrfern@uniandes.edu.co

‡Research Unit, Monetary Policy and Research Department, Bank of Finland, Snellmaninaukio, PO Box 160, Helsinki 00101, Finland. E-mail: adam.gulan@bof.fi

1 Introduction

A well documented fact in international macroeconomics are the significant differences in business cycle dynamics between developing and developed economies. Aguiar and Gopinath (2007a), using a pool of 26 small open developing and developed economies, documented how business cycle fluctuations in developed markets have moderated in recent decades, while business cycles in emerging markets are increasingly characterized by large macro volatility, dramatic current account reversals, and the so-called “sudden stop” phenomenon[1].

The main source of this sharp contrast in business cycle properties has been explained by Aguiar and Gopinath (2007a) as coming from differences in the size of the shocks to the permanent component in the TFP process. In light of this argument, developing economies appear to be subject to stronger shocks to the growth rate of the aggregate productivity. This drives agents to drastically modify the optimal path of their consumption and investment allocations as the shock hits, thus generating the strong countercyclical trade balance observed in the data. In contrast, developed economies appear to be subject to much less volatility in the permanent component of the productivity process. Instead, they are perturbed by standard transient productivity shocks to which agents react optimally by smoothing consumption, thereby giving rise to an acyclical trade balance path, in line with that observed in developed economies.

This explanation, however, is not the only one in the literature. Important contributions such as the works by Neumeyer and Perri (2005), Oviedo (2005) and Uribe and Yue (2006) have pointed out that an additional key dimension in which business cycles in developing countries differ from their developed counterparts is the negative correlation between the GDP growth rate and the cost of borrowing that these countries face in international financial markets. While in emerging economies real interest rates are countercyclical and lead the cycle, real rates in developed economies are mildly procyclical. Motivated by this stylized fact, these works build business cycle models for emerging economies in which exogenous interest rate shocks are the main driving force of the cycle and financial frictions, in e.g. the form of working capital requirements, amplify them further. Both Neumeyer and Perri (2005) and Uribe and Yue (2006) take their models to the data on emerging economies and find that their models successfully account for the observed business cycle facts and that financial frictions are a key to this success. Motivated by the differences in both approaches, Chang and Fernández (2010) assess the two sources of business cycles in developing economies by building a DSGE model with both permanent shocks to productivity and interest rate shocks coupled with financial frictions and fit the model to Mexican data using Bayesian methods. Their findings point to the negative correlation between interest rate shocks and output as the key modeling property when trying to account for business cycles in Mexico, a result that was previosuly stressed also by Oviedo (2005).

[1] See also the works by Agénor et al. (2000) and Benczúr and Rátfai (2010)

Despite the apparent success of interest rate shocks coupled with financial frictions in replicating business cycles in emerging economies, the literature has been silent about why the country premium depends upon domestic variables such as output and the level of productivity. More specifically, the extant models have taken as given — rather than derived from first principles — the laws of motion for the country interest rates and no microfoundations have been provided, suggesting that more work is needed to further study the mechanisms through which fundamental shocks induce interest rate fluctuations. This problem has been highlighted recently by Mendoza and Yue (2008) who stress the disconnect between country risk and business cycles in emerging economies that materializes in business cycle models being unable to explain the default risk premia. Furthermore, in another work by Aguiar and Gopinath (2007b) it is shown that a business cycle model where the country interest rate is orthogonal to productivity shocks does poorly in matching the features of the data in emerging market countries.

While Mendoza and Yue (2008) advance in simultaneously endogenizing the default risk and the business cycle, this line of research has exclusively focused on sovereign risk and has not explicitly made the distinction between private and public default risk. More generally, business cycle models of emerging economies have been silent with respect to other types of financial frictions that may arise in the credit markets of private corporate debt due to asymmetric information and moral hazard. This is mainly because they abstract from the presence of a credit market and/or a financial system that allocates credit under imperfect information. Finally, none of the works that identify financial frictions as a key element in developing economies' business cycles have quantified the extent to which these frictions are relevant in explaining aggregate fluctuations in developed economies.

This paper fills this gap in the literature. We build a business cycle model in which a productivity shock is the sole driving force and where the domestic interest rate is fully endogenous and is determined by the default risk in the private sector. We do so by embedding a financial contract à la Bernanke et al. (1999), henceforth BGG, into a somewhat standard real business cycle model of a small open economy. This financial structure allows us to endogenously generate the existence of an external finance premium that drives country interest rates. This premium is due to the existence of agency problems between foreign lenders and domestic borrowers. The financial contract is then designed to minimize the expected agency costs in an environment where default occurs in equilibrium. Our objective is to focus on the role of the propagation mechanism of the financial accelerator and its share in explaining the stylized facts, especially the dynamics of interest rates. We argue that this mechanism is particularly well suited to account for data patterns in developing countries, because it naturally gives rise to countercyclical interest rates. For example, a positive productivity shock not only increases output, but also increases the net worth of entrepreneurs, thereby reducing the aggregate default risk and lowering the country premium.

We take our model to the data of emerging economies and estimate some of the key parameters governing the financial contract, among other parameters of the model that also determine the aggregate dynamics over the business cycle. We do so by matching some of the key second moments that distinguish emerging economies from their developed counterparts.

Our main findings can be summarized as follows. The financial structure allows to properly account for the dynamics of emerging economies' business cycle and, most importantly, it endogenously generates the strong countercyclical interest rates we observe in the data. This result relies on the developing countries being largely leveraged. This high leverage allows to generage large movements in entrepreneurial net worth and, in consequence, in the country risk premium.

Aside from the papers mentioned above, our work can also be associated to others in the literature. Perhaps the closest paper to ours is that of Elekdağ et al. (2006) who develop a small open economy model with financial frictions a la BGG and estimate it using Bayesian methods. Unlike ours, their objective is to evaluate the importance of balance sheet effects and they do not assess the implications of financial frictions for the country interest rates along the business cycle, which is central to our analysis.

Our paper also relates to Céspedes et al. (2004) who use the framework developed by BGG to stress the importance of balance sheet effects during the financial crises that affected developing economies in the 90s. In their framework liabilities are dollarized and the country risk premium is endogenously determined by domestic net worth. In addition, nominal rigidities make monetary and exchange rate polices have real effects. This framework was later enriched by including, among other things, a nontradable sector (Devereux et al. (2006)) and endogenous capital utilization rates (Gertler et al. (2007)). Further important research on the role of credit market imperfections in emerging economies has also been explored by Tornell and Westermann (2002a,b, 2003)[2], who present empirical evidence on the presence of financial frictions in middle income countries in the form of sectoral asymmetries in financing opportunities, with smaller, nontradable sector firms having less access to credit than larger tradable sector ones. They also point to low levels of contract enforceability and high levels of currency mismatch that result from liabilities denominated in foreign currency. This mismatch manifests itself in the balance sheets of banks and high exposure to the nontradable sector. While these works significantly increased the understanding of the various channels through which financial frictions have real effects in developing economies, much of the analysis was devoted to the study of the effects of different exchange rate and monetary regimes and less attention was given to the study of the direct effect of the frictions considered on the business cycle and their relevance in accounting for the intrinsic properties of business cycles in these economies.

Lastly, our work can also be linked to the important amount of evidence that financial frictions, in

[2] This research agenda is nicely summarized in Tornell and Westermann (2005).

the form of a financial accelerator, are important propagation mechanisms for business cycles in developed economies. The works by Christiano et al. (2008) and Christiano et al. (2010), Iacoviello (2005) and Gilchrist and Zakrajšek (2011), among others, have greatly enriched the understanding of the relevance of financial frictions for business cycle fluctuations in developed economies. Clearly, our work extends this research agenda to developing economies.

The rest of this paper is divided into six sections including this introduction. In section 2 we present some of the main stylized facts about business cycles in emerging and developed economies. Section 3 develops our small open economy business cycle model. Section 4 summarizes our estimation strategy. The key results of the paper are presented in section 5. Concluding remarks are given in section 6. An appendix gathers some of the technical details of our analysis.

2 Stylized Facts in Emerging Market Business Cycles

Since at least the seminal empirical study of Agénor et al. (2000) it has been documented that some of the patterns of business cycles in emerging economies differ in nontrivial ways from those observed in developed economies. This fact has been traditionally studied by comparing simple second moments of macroeconomic variables, filtered at business cycle frequencies, across pools of emerging and developed small open economies. Using industrial production as the basis for dating business cycles, Agénor et al. (2000) concluded that aggregate fluctuations in emerging economies were more volatile than those of more advanced economies. This study also documented how in emerging economies some of the aggregate demand components, investment and most notably consumption, were even more volatile over the business cycle, thereby generating strong countercyclicality in the trade balance. This set of stylized facts was then complemented by Neumeyer and Perri (2005) with quarterly GDP data for a pool of five emerging and five developed economies. While their empirical findings were consistent with those of Agénor et al. (2000) they also noted that, in their sample of emerging economies, country interest rates were strongly countercyclical and tended to lead the cycle, unlike those of developed economies that were, if anything, procyclical. The study of business cycle differences between developed and developing economies was further pursued by Aguiar and Gopinath (2007a) who also used quarterly data but extended the number of countries studied to thirteen developed and thirteen developing economies between the 1980s and 2003. In line with previous studies, Aguiar and Gopinath (2007a) found significant differences across business cycle patterns in developing and developed economies, particularly in the relatively strong volatility of emerging economies' fluctuations. Importantly, however, they did not document country interest rates dynamics in any of the two types of countries.

Tables 1, through 4 present some of the key second moments that characterize business cycles across

Table 1: Emerging and developed markets business cycle moments (averages).

Second moment	**Emerging markets**	**Developed markets**
$\sigma(Y)$	3.00	1.75
$\sigma(C)/\sigma(Y)$	1.08	0.72
$\sigma(I)/\sigma(Y)$	4.00	2.78
$\sigma(NX/Y)$	2.89	1.32
$\rho(NX/Y, Y)$	-0.32	0.16
$\rho(C, Y)$	0.64	0.63
$\rho(I, Y)$	0.72	0.69
$\sigma(R)$	2.38	1.90
$\rho(R, Y)$	-0.29	0.18

Table 2: Emerging and developed markets business cycle moments, post 2004 (averages).

Second moment	**Emerging markets**	**Developed markets**
$\sigma(Y)$	2.48	2.01
$\sigma(C)/\sigma(Y)$	0.87	0.66
$\sigma(I)/\sigma(Y)$	3.99	2.59
$\sigma(NX/Y)$	2.00	1.39
$\rho(NX/Y, Y)$	-0.17	0.23
$\rho(C, Y)$	0.46	0.68
$\rho(I, Y)$	0.78	0.74
$\sigma(R)$	2.73	2.41
$\rho(R, Y)$	-0.30	0.40
$\sigma(R_{CDS})$	2.07	N.A
$\rho(R_{CDS}, Y)$	-0.26	N.A

emerging and developed market economies. The statistics are computed by extending Aguiar and Gopinath's national accounts dataset in two dimensions. First, each of the two sets of countries from their original dataset was updated up to the third quarter of 2010[3]. While this implies that we augmented the range of

[3] While we were able to update data for all 13 developed economies Aguiar and Gopinath (2007a) considered, data limitations of country interest rates prevented us from doing so for two developing economies (Israel and Slovak Republic). We then decided to replace these two countries with data from two other developing economies — Chile and Colombia. The dataset for developing economies comes from Fernández and Zamora (2011).

Table 3: Volatility of main macro variables.

	$\sigma(Y)$	$\sigma(C)/\sigma(Y)$	$\sigma(I)/\sigma(Y)$	$\sigma(NX/Y)$	$\sigma(R)$
Emerging Markets					
Argentina	4.99	1.23	3.24	3.07	9.04
Brazil	2.38	0.93	3.66	1.05	2.35
Chile	2.22	1.17	4.46	3.37	1.22
Colombia	2.41	1.00	4.65	1.72	1.39
Equador	2.31	1.09	7.05	4.37	6.45
Korea	3.06	1.39	3.32	3.30	1.25
Malaysia	3.06	1.42	5.61	5.00	1.59
Mexico	2.67	1.34	3.00	1.66	1.34
Peru	3.06	0.96	3.27	1.87	1.36
Philippines	2.61	0.59	3.03	3.54	1.23
South Africa	1.99	0.87	3.98	1.33	1.07
Thailand	3.77	0.94	4.31	4.64	1.10
Turkey	4.49	0.95	3.61	2.65	1.56
Developed Markets					
Australia	1.11	0.89	4.26	1.17	1.68
Austria	1.42	0.29	1.63	0.90	0.73
Canada	1.39	0.52	2.69	1.07	0.96
Belgium	1.50	0.80	2.91	1.20	1.43
Denmark	1.72	1.01	2.96	1.33	1.08
Finland	3.45	0.63	2.14	1.89	0.97
Netherlands	1.67	0.62	2.53	0.95	8.67
New Zealand	1.91	0.78	3.16	2.02	1.30
Norway	2.12	0.82	2.97	2.07	3.46
Portugal	1.49	0.87	2.80	1.15	0.68
Spain	1.36	1.08	3.48	1.20	1.40
Sweden	2.04	0.74	2.70	1.11	1.27
Switzerland	2.61	0.37	1.95	1.10	1.08

the dataset by 7 years, this period allows us to include the recent financial crisis and thus assess whether the extant stylized facts are robust to this period of worldwide macroeconomic volatility. Second, in the

Table 4: Correlation of main macro variables with output.

	$\rho\,(NX/Y,Y)$	$\rho\,(C,Y)$	$\rho\,(I,Y)$	$\rho\,(R,Y)$
Emerging Markets				
Argentina	−0.62	0.91	0.81	−0.52
Brazil	−0.05	0.70	0.62	−0.40
Chile	−0.00	0.19	0.65	−0.16
Colombia	−0.60	0.76	0.81	−0.02
Equador	−0.40	0.57	0.71	−0.48
Korea	−0.76	0.86	0.91	−0.71
Malaysia	−0.49	0.50	0.77	−0.58
Mexico	−0.54	0.72	0.79	−0.04
Peru	−0.19	0.63	0.85	−0.33
Philippines	0.72	0.02	0.05	0.25
South Africa	−0.26	0.75	0.74	0.02
Thailand	−0.44	0.78	0.77	−0.47
Turkey	−0.51	0.87	0.83	−0.38
Developed Markets				
Australia	−0.08	0.49	0.66	0.27
Austria	0.81	0.41	0.77	0.70
Canada	0.44	0.53	0.63	0.09
Belgium	0.01	0.79	0.70	0.36
Denmark	−0.14	0.73	0.69	0.14
Finland	0.20	0.79	0.83	0.05
Netherlands	0.26	0.73	0.70	−0.21
New Zealand	0.18	0.61	0.57	0.10
Norway	0.47	0.22	0.34	−0.06
Portugal	−0.15	0.79	0.82	0.21
Spain	−0.63	0.84	0.89	0.24
Sweden	0.03	0.68	0.83	−0.08
Switzerland	0.71	0.60	0.60	0.46

spirit of Neumeyer and Perri (2005) we extended the dataset to include the expected 3-month real interes rate at which firms in each country can borrow[4] in order to assess the extent to which the different patterns of cyclicality of this variable across developing and developed countries are robust to the inclusion of more countries and more periods, including the recent financial crisis. Lastly, table 2 zooms in on the last seven years of the dataset, between 2004 and 2010, capturing the expansion and the subsequent recession that characterized the period surrounding the recent financial crisis.

Several conclusions can be drawn from these tables. First, aggregate volatility, measured by the standard deviation of the Hodrick–Prescott filtered time series of GDP[5], is almost twice as large in emerging market economies, relative to developed markets. Second, in emerging markets the relative volatility of the two largest components of aggregate demand, consumption and investment, is roughly 50% larger than those in developed markets. For instance, in seven out of the thirteen emerging markets, the volatility of consumption is actually higher than that of output, while only two developed economies exhibit this property. Third, not surprisingly given these two previous stylized facts, emerging economies exhibit therefore much more volatile and countercyclical trade balances. In twelve out of the thirteen emerging economies the trade balance is countercyclical while this is the case in only four developed economies. Fourth, the correlations of both consumption and investment with output are nonetheless quite similar across the two pools of economies. Fifth, domestic interest rates in emerging markets are both relatively more volatile and countercyclical, while this variable is mildly procyclical in developed economies. Sixth, zooming in on the last period of the sample, the overall pattern of higher volatility in emerging countries is robust to this period, too. Interestingly, however, it appears that emerging economies have managed to lower both income and consumption volatility despite the financial crisis, thereby reducing the countercyclicality of trade balance. It is also worth mentioning that the differences across the two types of economies seem to have grown in terms of the pattern exhibited by country interest rates. While developed economies show much more procyclical interest rates, undoubtedly related to the countercyclical policies implemented in many of these economies during the financial crisis, in emerging economies these variables exhibit even more countercyclical dynamics. Seventh, it is important to note that the pattern of stronger volatility and countercyclicality of interest rates in emerging economies is robust to alternative measures of interest rates. In the last two rows of table 2 country interest rates are computed by replacing the EMBI spread, which captures solely sovereign risk, by the credit default swaps'

[4]Following Neumeyer and Perri (2005) we measure country interest rates in developing economies as the 3-Month U.S. T-Bill rate plus the country specific EMBI; and use interest rates from 90-day corporate commercial paper or interbank rates. For all countries the real rate is obtained by subtracting the expected GDP deflator (or, when not available, the CPI) inflation from the nominal rate. Expected inflation in period t is computed as the average of inflation in the current period and in the three preceding periods.

[5]To be consistent with the model presented in the next section, our measure of GDP does not incorporate public expenditure. See the Technical Appendix for a comparison of the stylized facts including this macroeconomic aggregate.

spread, a proxy for corporate risk. It is evident that the distinctive patterns of country interest rates in emerging market economies is robust to these two alternative measures of risk.

Summing up, these stylized facts are very much in line with the previous literature in that business cycles in emerging economies continue to show patterns that are different to those observed in developed countries. This continues to be true despite the large macroeconomic volatility experienced by many developed economies during the recent financial turmoil. In particular, emerging economies continue to show countercyclical interest rates, regardless of whether the interest rates are measured using sovereign or corporate risk measure. Motivated by these stylized facts, the next section builds a business cycle model of a small open economy where interest rates are endogenously determined.

3 Model

The starting point of our model is the real business cycle model of a small open economy (see e.g. Mendoza (1991)) with one homogenous final good and no money or nominal variables. The key modification is to extend the model with a financial accelerator mechanism, developed by Carlstrom and Fuerst (1997) and Bernanke et al. (1999). We follow the latter exposition. It is described in detail in subsection 3.1. The model economy is inhabited by four types of agents: households, entrepreneurs, capital producers and the foreign sector. The foreign sector is the only source of credit for the domestic economy, both for the entrepreneurs, as well as for households.

3.1 Entrepreneurs

In this framework, the key role is played by the entrepreneurial sector. The sector is perfectly competitive and produces final goods which are later consumed or used for investment. At the heart of the financial accelerator mechanism is the fact that entrepreneurs have to borrow funds from lenders in order to finance their production, in particular to purchase capital from capital producing firms. Therefore, the assets of an i-th entrepreneur are a sum of their net worth $\tilde{N}$ and borrowed funds $\tilde{B}$:

$$Q_t \tilde{K}_{i,t+1} = \tilde{N}_{i,t+1} + \tilde{B}_{i,t+1} \tag{3.1}$$

where $\tilde{K}$ is the capital stock and Q is the price of capital expressed in terms of final goods[6]. We assume that all borrowing takes place from abroad. In order to make the borrowing mechanism operative, we additionally

[6] The model economy is assumed to follow a deterministic trend $\tilde{X}$ with the growth rate $\frac{\tilde{X}_{t+1}}{\tilde{X}_t} = g \geq 1$. We use tildes to denote variables that trend in equilibrium, e.g. $\tilde{K}_t = K_t \tilde{X}_t$.

need to assume that a fraction of entrepreneurs $1-\phi$ "die" each period and consume their estate. This prevents the entrepreneurial sector from accumulating net worth to the point where no borrowing would be necessary. To keep the number of entrepreneurs constant, the same number of them is "born" in every period. In order to endow those starting final goods producers with some initial capital, we assume that entrepreneurs also work and receive wages $\tilde{W}^e$.

The production function of the i-th entrepreneur is given by

$$\tilde{Y}_{i,t} = \omega_{i,t} A_t \tilde{K}_{i,t}^{\alpha} \left(\tilde{X}_t L_{i,t}\right)^{1-\alpha}$$

where $\tilde{K}_{i,t}$ and $L_{i,t}$ are capital and labor inputs, respectively and A_t is the economy-wide level of total factor productivity, which follows a stationary stochastic process:

$$\ln A_t = \rho_A \ln A_{t-1} + (1-\rho_A) \ln A + \epsilon_{A,t} \tag{3.2}$$

Additionally, every entrepreneur is subject to an idiosyncratic productivity shock captured by $\omega_{i,t}$. In each period the realization of the shock is random and comes from a log-normal distribution with and expected value $E\omega = 1$. It is assumed that the realization of $\omega_{i,t}$ is private information of the entrepreneur. In order to learn its value, the foreign lender has to pay a monitoring cost μ, which is a fraction of the entrepreneur's remaining assets (output plus undepreciated capital)[7]. The optimal contract between (foreign) lenders and domestic borrowers (entrepreneurs) specifies a cutoff value of ω_t, denoted as $\bar{\omega}_t$[8]. Entrepreneurs, whose realized $\omega_{i,t}$ falls below $\bar{\omega}_t$ are considered bankrupt and their estate is taken over by the lenders. The net income of the lenders from the bankrupt entrepreneurs is therefore

$$(1-\mu) \int_0^{\bar{\omega}_t} \omega_{i,t} f(\omega_{i,t})\, \mathrm{d}\omega_{i,t}\, R_{i,t}^K Q_{t-1} \tilde{K}_{i,t}$$

where

$$R_{i,t}^K = \frac{\alpha \frac{\tilde{Y}_{i,t}}{\tilde{K}_{i,t}} + Q_t (1-\delta)}{Q_{t-1}} \tag{3.3}$$

is the ex post return on capital and Q_t is the price of capital in terms of final goods. The fraction of entrepreneurs whose $\omega_{i,t} \geq \bar{\omega}_t$ pay their debt and retain the profit. The revenue of the lenders from solvent entrepreneurs is

$$\bar{\omega}_t \int_{\bar{\omega}_t}^{\infty} f(\omega_{i,t})\, \mathrm{d}\omega_{i,t}\, R_{i,t}^K Q_{t-1} \tilde{K}_{i,t}$$

[7]The financial contract with asymmetric information and agency costs is based on the idea initially developed by Townsend (1979).

[8]Note that the optimal contract is homogenous and standardized. Also, there exists one aggregated loan supply curve, identical for all entrepreneurs. This aggregation, a complex problem in principle, is possible because of a few assumptions introduced to the model, in particular constant returns to scale of the entrepreneurial production function, independence of $\omega_{i,t}$ from history as well as the constant number of entrepreneurs in the economy and their risk neutrality and perfect competitiveness. See Carlstrom and Fuerst (1997) and Bernanke et al. (1999) for a more detailed dicussion.

The timing of events is as follows. At the end of $t-1$, there's a pool of entrepreneurs, who have not gone bankrupt (their $\omega_{i,t-1}$ was $\geq \bar{\omega}_{t-1}$) and have not "died". Those firms decide upon the optimal level of capital $\tilde{K}_t$, and hence the level of borrowing $\tilde{B}_t$. At this point R_t^K is not known, since time t TFP shock is not realized. However, the riskless international rate R^* over which the risk premium is determined (i.e. the rate from $t-1$ until t) is known. The cutoff value for the optimal contract $\bar{\omega}_t$ is not yet determined, so entrepreneurs make their decision based upon $E_{t-1}\omega_{i,t}$, subject to the zero-profit condition of the lenders. Formally, they solve the following profit maximization problem:

$$\max_{\tilde{K}_{i,t}, E_{t-1}\bar{\omega}_t} E_{t-1}\left[1-\Gamma\left(\bar{\omega}_t\right)\right] R_{i,t}^K Q_{t-1}\tilde{K}_{i,t}$$

subject to

$$R^*\left(Q_{t-1}\tilde{K}_{i,t}-\tilde{N}_{i,t}\right)=\left[\Gamma\left(\bar{\omega}_t\right)-\mu G\left(\bar{\omega}_t\right)\right] R_{i,t}^K Q_{t-1}\tilde{K}_{i,t}$$

where

$$\Gamma\left(\bar{\omega}_t\right) \equiv \int_0^{\bar{\omega}_t} \omega_{i,t} f\left(\omega_{i,t}\right) \mathrm{d}\omega_{i,t}+\bar{\omega}_t \int_{\bar{\omega}_t}^{\infty} f\left(\omega_{i,t}\right) \mathrm{d}\omega_{i,t} \quad \text{and} \quad G\left(\bar{\omega}_t\right) \equiv \int_0^{\bar{\omega}_t} \omega_{i,t} f\left(\omega_{i,t}\right) \mathrm{d}\omega_{i,t}$$

The left hand side of the optimization constraint expresses the opportunity cost of lending, i.e. gross return on a riskless loan. The right hand side expresses returns of the lenders on a risky loan, net of monitoring costs, which is proportional the first component of $\Gamma\left(\bar{\omega}_t\right)$. It includes the repayment from solvent borrowers (a fraction given by the second component of $\Gamma\left(\bar{\omega}_t\right)$), as well as the bankrupt's estate (i.e. fraction $G\left(\bar{\omega}_t\right)$). The combined first order conditions yield[9]

$$E_{t-1}\left\{\left[1-\Gamma\left(\bar{\omega}_t\right)\right]\frac{R_t^K}{R^*}+\frac{\Gamma'\left(\bar{\omega}_t\right)}{\Gamma'\left(\bar{\omega}_t\right)-\mu G'\left(\bar{\omega}_t\right)}\left[\frac{R_t^K}{R^*}\left(\Gamma\left(\bar{\omega}_t\right)-\mu G\left(\bar{\omega}_t\right)\right)-1\right]\right\}=0 \tag{3.4}$$

Next, the morning of t comes and the aggregate TFP shock is realized. Its value pins down the value of all time t-indexed variables, in particular the aggregate return on capital R_t^K becomes known. This is when lenders decide on the value of $\bar{\omega}_t$, i.e. the threshold which determines the bankruptcy cutoff. Since lenders are perfectly competitive, $\bar{\omega}_t$ simply solves the following zero-profit condition:

$$R_t^K=R^*\left(\frac{\tilde{B}_t}{Q_{t-1}\tilde{K}_t}\right)\frac{1}{\Gamma\left(\bar{\omega}_t\right)-\mu G\left(\bar{\omega}_t\right)} \tag{3.5}$$

This equation can be, after taking expectations, interpreted as an economy-wide loan supply curve. The i index has been dropped because of the aggregation discussed in footnote 8.

[9]Second order conditions which guarantee a maximum are provided in appendix B. This equation constitutes, after some modifications, a basis of the entrepreneurial demand for capital. See Christiano et al. (2010) for a detailed discussion.

Once $\bar{\omega}_t$ is set, the idiosyncratic productivity shock is realized, some firms go bust, some remain solvent. Note though, that this is important only at the firm level. On the aggregate level the economy-wide rate of return R_t^K and output $\tilde{Y}_t$ was known already when the aggregate shocks were realized, i.e. at the dawn of t. Once the debts are liquidated, a fraction $1-\phi$ of the remaining firms shuts down anyway. Those firms simply consume their value, so that entrepreneurial consumption in each period is expressed as

$$\tilde{C}_t^e = (1-\phi)\,\tilde{V}_t \tag{3.6}$$

where $\tilde{V}_t$ is the aggregate ex post value of entrepreneurial firms:

$$\tilde{V}_t = R_t^K Q_{t-1}\tilde{K}_t - \left(R^* + \frac{\mu\int_0^{\bar{\omega}_t}\omega f(\omega)\,\mathrm{d}\omega\, R_t^K Q_{t-1}\tilde{K}_t}{Q_{t-1}\tilde{K}_t - \tilde{N}_t}\right)\left(Q_{t-1}\tilde{K}_t - \tilde{N}_t\right) \tag{3.7}$$

It is computed as the gross return on their capital (first term) less debts of the solvent firms captured by $R^*(Q_{t-1}\tilde{K}_t - \tilde{N}_t)$, less bankrupt's estate of the insolvent ones given by $\mu\int_0^{\bar{\omega}_t}\omega f(\omega)\,\mathrm{d}\omega\, R_t^K Q_{t-1}\tilde{K}$. The net worth of the sector for the next period is then simply the value of the remaining fraction of firms combined with the proceeds from their own work H^e[10]:

$$\tilde{N}_{t+1} = \phi\,\tilde{V}_t + \tilde{W}_t^e \tag{3.8}$$

3.2 Capital producers

Entrepreneurs are not permanent owners of capital which they use as input for production. Instead, they purchase (or rent) the capital stock $\tilde{K}_t$ from perfectly competititve capital producing firms at the end of period $t-1$, at the price Q_{t-1}. This capital is used in production at t and its undepreciated part $(1-\delta)\,\tilde{K}_t$ is re-sold to capital producers once the production is over[11] at price $\bar{Q}_t$. Capital producers combine this capital with new investment using the following technology:

$$\tilde{K}_{t+1} = (1-\delta)\,\tilde{K}_t + \tilde{I}_t - \frac{\varphi}{2}\left(\frac{\tilde{K}_{t+1}}{\tilde{K}_t} - g\right)^2\tilde{K}_t \tag{3.9}$$

where the last term captures the presence of adjustment costs in the capital production technology similar to those recently modeled by Garcia-Cicco et al. (2010).

The new capital stock $\tilde{K}_{t+1}$ is then re-sold at price Q_t to entrepreneurs and the cycle closes. Formally, capital producers solve the following profit-maximization problem:

$$\max_{\tilde{K}_{t+1},\tilde{I}_t} E_0\sum_{t=0}^{\infty}\beta^t\left[Q_t\tilde{K}_{t+1} - \bar{Q}_t\,(1-\delta)\,\tilde{K}_t - \tilde{I}_t\right]$$

[10] Entrepreneurial labor is assumed to be inelastic and normalized to 1.

[11] Depreciation of capital occurs not between $t-1$ and t, but during the production process.

subject to equation 3.9. We assume that capital producing firms are owned by households (discussed below) and therefore use their subjective discounting factor β. The combined first order conditions give[12]:

$$Q_t = 1 + \varphi\left(\frac{\tilde{K}_{t+1}}{\tilde{K}_t} - g\right) + \beta E_t\left\{(1-\delta)\,Q_{t+1} - (1-\delta) - \varphi\left(\frac{\tilde{K}_{t+2}}{\tilde{K}_{t+1}} - g\right)\frac{\tilde{K}_{t+2}}{\tilde{K}_{t+1}} + \frac{\varphi}{2}\left(\frac{\tilde{K}_{t+2}}{\tilde{K}_{t+1}} - g\right)^2\right\} \quad (3.10)$$

From the point of view of capital producers the timing of events is as follows. At dawn of t, the aggregate TFP shock becomes known. Because this determines the aggregate levels of $\tilde{Y}_t$ and R_t^K, all information necessary to determine $\tilde{I}_t$ and $\tilde{K}_{t+1}$ becomes known. This is when their maximization problem is solved. Therefore, time t TFP shock affects both investment and the price of capital on impact.

3.3 Households

The small open economy is inhabited by a continuum of identical atomistic households. A representative household maximizes its expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(\tilde{C}_t - \tau \tilde{X}_t \frac{H_t^\gamma}{\gamma}\right)^{1-\sigma}}{1-\sigma}$$

where σ is the constant relative risk aversion coefficient (inverse of the intertemporal elasticity of substitution). The preferences are assumed to take the Greenwood et al. (1988) form. Households obtain income from working for the entrepreneurial sector. Their optimal labor supply function is given by

$$\tau \tilde{X}_t H_t^{\gamma-1} = \tilde{W}_t \quad (3.11)$$

This functional form reflects the key property of GHH preferences, i.e. labor supply is not dependent on the level of consumption. In other words, the income effect on labor is absent. This in turn allows these preferences to replicate important business cycle properties, especially the volatility of consumption, more closely (see e.g. Correia et al. (1995) or Neumeyer and Perri (2005)).

In order to smooth consumption, households borrow funds. They are assumed to be able to borrow solely from foreign lenders. We assume that their borrowing rate is linked to the entrepreneurial sector. In particular, at $t-1$ households borrow at $E_{t-1}R_t^K$, a rate similar to the rate of return of the entrepreneurs R_t^K. This rate is not exactly equal to the entrepreneurs' borrowing rate for two reasons. The household's rate $E_{t-1}R_t^K$ is risky in the sense that it exhibits a premium over the world riskless rate R^*. However, it

[12] As discussed in Bernanke et al. (1999), the difference between Q_t and $\bar{Q}_t$ is of second order importance and is therefore suppressed in further exposisiton.

is not risky in the sense that it doesn't change *ex post*. In particular, when the time t TFP shock comes, they pay back D_t at $E_{t-1}R_t^K$ and adjust their new consumption, working hours and the new debt level D_{t+1} accordingly. In that sense our setup is similar to that of Neumeyer and Perri (2005). Secondly, there's a stationarity inducing Ψ term which may differ from 1 in the steady state.

This device is an important modification in our model and it serves several purposes. First, there's a strong empirical evidence that interest rates faced by private households in developing countries incorporate a risk premium over the riskless rate. Secondly, in our setup the consumers' borrowing rate is linked to the financial accelerator mechanism and therefore it stems, albeit indirectly, from first principles. We therefore offer an alternative to the more ad hoc reduced form mechanisms used in previous studies to account for the risk premium in the consumer sector[13]. Last but not least, we can do away with the risk premium shock which is commonly used to account for relatively high consumption volatility in developing countries. In sum, the budget constraint is given by

$$\tilde{C}_t - \tilde{D}_{t+1} = \tilde{W}_t H_t - \Psi_t E_{t-1} R_t^K \tilde{D}_t \tag{3.12}$$

where Ψ_t is the risk premium elasticity defined as

$$\Psi_t = \left\{ \bar{\Psi} + \tilde{\Psi} \left[\exp\left(\frac{\tilde{D}_t}{\tilde{X}_t} - d \right) - 1 \right] \right\} \tag{3.13}$$

The term $\tilde{\Psi}$ is calibrated to a very low number and its sole purpose is to induce stationarity to net debt, consumption and trade balance (see e.g. Schmitt-Grohé and Uribe (2003)). It has no other bearing on the dynamics of the model. Also, although households own the capital producing firms, perfect competition in that sectors makes the profits equal to zero and therefore the profit term drops.

Given this specification of consumers' preferences and budget constraint the optimal intertemporal consumption choice is given by the following Euler equation

$$\tilde{\lambda}_t = \beta E_t \Psi_{t+1} R_{t+1}^K \tilde{\lambda}_{t+1} \tag{3.14}$$

where the marginal utility of consumption

$$\tilde{\lambda}_t = \left(\tilde{C}_t - \tau \tilde{X}_t \frac{H_t^\gamma}{\gamma} \right)^{-\sigma} \tag{3.15}$$

is trending at the rate $\tilde{X}_t^{-\sigma}$, so that $\lambda_t = \frac{\tilde{\lambda}_t}{\tilde{X}^{-\sigma}}$. Note also that in principle a derivative of Ψ should appear in the Euler equation. However, for simplicity we assume no internalization. In particular, an atomistic

[13] One such mechanism makes the risk premium a linear function of expected future productivity or output, as in Neumeyer and Perri (2005). In Garcia-Cicco et al. (2010) the premium is a quadratic function of foreign debt with a high degree of elasticity.

household takes the level of total debt in the economy as given and as a price taker has no impact on its level. The household's debt and the total economy debt are equal in equilibrium.

3.4 Labor market and remaining specification

The economywide version of the production function of entrepreneurs is of the standard Cobb-Douglas type: Production function

$$\tilde{Y}_t = A_t \tilde{K}_t^{\alpha} \left(\tilde{X}_t L_t \right)^{1-\alpha} \tag{3.16}$$

Recall that in this environment labor is supplied both by households and entrepreneurs. Therefore the total labor input L_t is the aggregate of the two:

$$L_t = \left(H_t^e \right)^{\Omega} H_t^{1-\Omega} \tag{3.17}$$

where the working hours of entrepreneurs H_t^e are normalized to 1 (are therefore are perfectly inelastic) and Ω is the share of entrepreneurs' share of total labor. This also means that there exist two separate labor demand functions:

$$(1-\alpha)\,\Omega \frac{\tilde{Y}_t}{H_t^e} = \tilde{W}_t^e \tag{3.18}$$

as well as

$$(1-\alpha)\,(1-\Omega)\,\frac{\tilde{Y}_t}{H_t} = \tilde{W}_t \tag{3.19}$$

We close the model by specifying the market clearing condition for the final goods:

$$\tilde{Y}_t = \tilde{C}_t + \tilde{C}_t^e + \tilde{I}_t + \tilde{NX}_t + \mu \int_0^{\bar{\omega}_t} \omega f(\omega)\, \mathrm{d}\omega\, R_t^K Q_{t-1} \tilde{K}_t \tag{3.20}$$

The last term in this expression captures the wasted resources employed as monitoring costs. Note that the existence of this term may in principle have nontrivial consequences for the basic business cycle moments in a small open economy, for example for the correlation of the trade balance NX_t with output. Its impact will be more pronounced with high monitoring costs μ as well as a large fraction of firms which go bankrupt in every period $G(\bar{\omega})$. We discuss this issue in more detail further.

4 Parametrization and Estimation

We turn now to the empirical strategy where we take the model to the data on emerging and developed economies. First, we ask whether the business cycle dynamics in developing economies can be associated to (some parts or the whole of) the financial accelerator mechanism. Secondly, does the data provide us any information regarding differences in the financial sector between developed and developing countries. Since we want to focus on the role of the accelerator and do not want to attribute the difference in business cycle characteristics to differences in preferences between developed and developing countries, we calibrate this part of the model following the previous literature and the data. Table 5 summarizes the values that we use. Instead, we focus on estimating two other groups of parameters: those describing the financial accelerator mechanism, as well as those describing the strength and persistence of shocks.

Table 5: Calibrated parameters.

Parameter	**Description**	**Value**	**Source**
g	trend, emerging	1.0092	data
g	trend, developed	1.0057	data
$\frac{C}{Y}$	cons. to GDP, emerging	0.7202	data
$\frac{C}{Y}$	cons. to GDP, developed	0.6918	data
α	capital share in production	0.32	Aguiar and Gopinath (2007a)
β	subjective discount factor	0.98	Aguiar and Gopinath (2007a)
γ	GHH labor parameter	1.6	Neumeyer and Perri (2005)
δ	depreciation rate	0.05	Aguiar and Gopinath (2007a)
σ	relative risk aversion	2	Aguiar and Gopinath (2007a)
Ω	entrepreneurial labor share	0.01	Bernanke et al. (1999)
R^*	foreign interest rate	$(1.0079)^{1/4}$	data
H	steady state labor	0.33	Aguiar and Gopinath (2007a)

Table 6: Estimated parameters.

Parameter	**Description**
μ	monitoring costs
σ_ω	std dev. of idiosyncratic productivity
φ	capital adjustment cost parameter
ϕ	survival rate
ρ_A	persistence of TFP shock
σ_A	std dev. of TFP shock

To estimate the 6 parameters we use Generalized Method of Moments (GMM). The method involves minimizing the distance between a set of preselected moments generated by the model and their empirical counterparts

$$\min_{\boldsymbol{\theta}} f\left(\boldsymbol{x_t}, m\left(\boldsymbol{\theta}\right)\right)' \boldsymbol{\Sigma} f\left(\boldsymbol{x_t}, m\left(\boldsymbol{\theta}\right)\right) \tag{4.1}$$

where $\boldsymbol{\Sigma}$ is a weighting matrix and $\boldsymbol{\theta}$ is the vector of estimated parameters, listed in details in table 6:

$$\boldsymbol{\theta} = \begin{bmatrix} \mu & \sigma & \varphi & \phi & \rho_A & \sigma_A \end{bmatrix}'$$

Following the stylized facts emphasised in section 2 we choose the following 9 second moments:

$$m\left(\boldsymbol{\theta}\right) = \begin{bmatrix} \sigma^2\left(y\right) & \sigma^2\left(c\right) & \sigma^2\left(i\right) & \sigma^2\left(tb\right) & \rho\left(tb, y\right) & \rho\left(c, y\right) & \rho\left(i, y\right) & \sigma^2\left(r\right) & \rho\left(r, y\right) \end{bmatrix}' \tag{4.2}$$

where σ^2 denotes a variance and ρ indicates correlation coefficients. Their empirical counterparts are based on variables $\{y_t, c_t, i_t, tb_t, r_t\}$, denoting output, consumption, investment, trade balance and the domestic interest rate, respectively. Empirical moments were derived using HP cycle components of logs of series in levels. The exception is trade balance TB_t, i.e. the ratio of net exports to output $TB_t \equiv NX_t/Y_t$, where no logarithms were taken prior to HP-filtering. These transformations are denoted by lower-case notation. The HP-filtered model moments were obtained using the procedure suggested by Burnside (1999). Given this specification, the GMM criterion function used is

$$f\left(\boldsymbol{x_t}, m\left(\boldsymbol{\theta}\right)\right) = E\left\{\begin{array}{c} m_1\left(\boldsymbol{\theta}\right) - y_t^2 \\ \frac{m_2(\boldsymbol{\theta})}{m_1(\boldsymbol{\theta})} - \frac{c_t^2}{m_1(\boldsymbol{\theta})} \\ \frac{m_3(\boldsymbol{\theta})}{m_1(\boldsymbol{\theta})} - \frac{i_t^2}{m_1(\boldsymbol{\theta})} \\ \frac{m_4(\boldsymbol{\theta})}{m_1(\boldsymbol{\theta})} - \frac{tb_t^2}{m_1(\boldsymbol{\theta})} \\ m_5\left(\boldsymbol{\theta}\right) - \frac{tb_t y_t}{\sqrt{m_1(\boldsymbol{\theta}) m_4(\boldsymbol{\theta})}} \\ m_6\left(\boldsymbol{\theta}\right) - \frac{c_t y_t}{\sqrt{m_1(\boldsymbol{\theta}) m_2(\boldsymbol{\theta})}} \\ m_7\left(\boldsymbol{\theta}\right) - \frac{i_t y_t}{\sqrt{m_1(\boldsymbol{\theta}) m_3(\boldsymbol{\theta})}} \\ \frac{m_8(\boldsymbol{\theta})}{m_1(\boldsymbol{\theta})} - \frac{r_t^2}{m_1(\boldsymbol{\theta})} \\ m_9\left(\boldsymbol{\theta}\right) - \frac{r_t y_t}{\sqrt{m_1(\boldsymbol{\theta}) m_8(\boldsymbol{\theta})}} \end{array}\right\} \tag{4.3}$$

The dataset used in estimation is constructed by stacking the stationary HP detrended series country over country. Since series differ in length across countries, we obtain an unbalanced panel with missing years removed. In sum, we have 683 observations for each series. Because we work with a panel rather than pure time series, as would be the case for a single country data, it is not clear whether one should correct for autocorrelation in estimating the variance by using a HAC estimator and how to specify the sample size parameter in the HAC. Neither is it obvious to construct the variance by pretending that the data is a cross section. We therefore proceed by assuming an identity weighting matrix, sacrificing efficiency for consistency.

5 Results

5.1 Developing countries

The main GMM estimation results for developing countries are presented in tables 7 through 9. In general the model performs well in terms of matching the key 9 moments for developing countries and it is able to reproduce all of the main characteristics of business cycle moments in developing countries. In particular, it is able to match the high volatility of output and, roughly, the relative volatility of investment. Importantly, consumption is more volatile than output, slightly less than in the data. Secondly, we are also able to reproduce the behavior of the trade balance (i.e. net exports to output ratio), both in terms of its volatility and countercyclicality. Most importantly, the model reproduces almost perfectly the volatility of domestic interest rates. It also matches well in terms of countercyclicality. It is able to do so without retorting to risk premium or foreign interest rate shocks. Instead, the interest rate dynamics is driven solely by the variation of the endogenous risk premium markup in the financial accelerator. Therefore, we are able to offer a structural and microfounded alternative to the previously proposed mechanisms of explaining the interest rate behavior in developing countries.

Table 7: Estimated parameter values for developing countries.

Parameter	μ	σ	φ	ϕ	ρ_A	σ_A
Estimated value	0.536	0.098	8.814	0.548	0.999	0.012

Table 8: Parameters of the financial accelerator for developing countries.

Parameter	$\bar{\omega}$	$F(\bar{\omega})$	$\frac{QK}{N}$	$\frac{R^K}{R^*}$	$\eta_{s,k}$
Estimated value	0.833	0.035	9.664	1.096	0.085

The model performs slightly worse in terms of the comovement of investment and, most significantly, of consumption with output. In the model consumption correlation is as high as 0.94 as opposed to 0.73 in the data. Although the model doesn't perform well in this dimension, it is also true that the empirical moment that we try to match differs from what has been reported in previous studies. For example, Aguiar and Gopinath (2007a) match only the correlation of Mexico, which they report to be 0.92. Their model also generates correlations above 0.9, depending on the specification. In Neumeyer and Perri (2005) the reported empirical correlation for developing countries is around 0.8. Yet, they match the correlation of Argentina, 0.97. Depending on the version, their model generates a correlation between 0.82 and 0.97. Secondly, it is worth noting that our reported empirical moments include only private consumption and, for consistency,

Table 9: Model generated moments for emerging markets.

Second Moment	Emerging Markets[a]	Model
$\sigma(y)^b$	3.07	3.21
$\sigma(c)/\sigma(y)$	1.18	1.10
$\sigma(i)/\sigma(y)$	4.05	3.88
$\sigma(tb)$	3.10	3.15
$\rho(tb, y)$	−0.38	−0.27
$\rho(c, y)$	0.73	0.94
$\rho(i, y)$	0.75	0.65
$\sigma(r)$	3.68	3.68
$\rho(r, y)$	−0.35	−0.27

[a] The moments differ from those reported in section 2 because here they are weighted by country specific sample size.

[b] Standard deviations are expressed in %.

output net of public consumption. Concluding, the sum of squared errors between the data end model moments presented in table 9 is 0.245, which we regard as a good fit.

A closer look at the estimated parameter values reveals some interesting results. First, we note that our estimated monitoring costs of 0.536 are significantly higher than the value of 0.12 calibrated originally by BGG based on U.S. data. They are also higher than in some other studies focusing on the U.S. and Europe. For example, Carlstrom and Fuerst (1997) consider calibrations for the U.S. with 0.2, 0.25 and 0.36. Using Bayesian techniques, Queijo von Heideken (2009) reports posterior means of 0.159 for the U.S. and 0.271 for the Euro Area. Using a partial equilibrium model, Levin et al. (2006) show how these costs have varied over time in the U.S. case. In their estimation, they ranged between $[0.1, 0.3]$ over the 1997-2000 period, but then oscillated between 0.3 and 0.5 in the years 2000-2003. In the study of Fuentes-Albero (2009) the U.S. number is 0.24 until 1983, but only 0.04 from 1984 on. However, that study reports a major increase in the volatility of monitoring costs during the Great Moderation era — a paralell "Financial Immoderation". On the other hand, Christiano et al. (2010) calibrate this parameter to as much as 0.94 in order to match other steady state values. A proxy of direct costs can be also found in the Doing Business database of the World Bank. The average cost of closing a business (expressed as % of estate) is 16.08% for our sample of 13 developing and 6.46% for the sample of small open developed economies. Yet, as argued by Carlstrom and Fuerst (1997), such costs are only direct and they don't include e.g. lost profits or sales. We share their view that μ should be regarded in this broader sense.

Secondly, we find a strikingly low value of the entrepreneur's survival rate, as low as 0.548, well below the value around 0.98 usually used for calibration for developed countries. This parameter turns out to play an important role in our result and in determining the levels of steady state leverage and risk premium. As these parameters deserve special attention, the discussion is postponed until subsection 5.2.

The steady state default productivity cutoff $\bar{\omega}$ is relatively high, not much below the expected idiosyncratic productivity $E\omega = 1$. The corresponding value of the default rate in the optimal contract is 3.51%, or 13.33% annualized. This is again a higher number than those seen in some previous studies, e.g. 3% annualized in BGG. Yet, the data on failure rates beyond the U.S. is scarce and also poses considerable problems of interpretation. The only multicountry study which reports official bankruptcy rates that we are aware of is that of Claessens and Klapper (2005). According to their data, the average annual rate for Argentina, Chile, Colombia, Peru, Korea and Thailand is 0.15% a year, as opposed to e.g. 4.62% for South Africa. Therefore, the official rates seem to reflect much more the legal system of a country rather than pure economics and are therefore not directly comparable in economic terms[14].

Moving to the estimates of forcing process we note that the traditional productivity shock is very persisent. The TFP shock volatility of 1.2% is much lower than that of the idiosyncratic productivity, σ, which is estimated to be 9.8%, a plausible number in light of previous literature.

In sum, the model with the financial accelerator performs very well in terms of matching the empirical moments of developing countries. It also points to very high death rates of entrepreneurs. We find it instructive to inspect the economic mechanism embedded in the model that allows to generate this very good model fit and why it requires some surprising values in the parameterization of the financial accelerator.

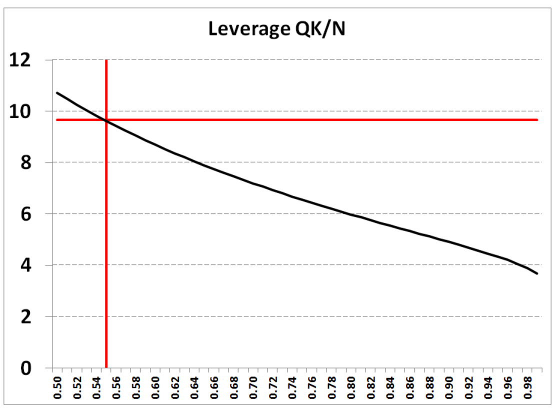
5.2 Inspecting the mechanism

In what follows, we will explain the results reported in the previous subsection. Note that the GMM algorithm described in section 4 attempts to match, among others, two moments which have very different characteristics across developing and developed economies, namely the volatility of the real interest rate and its correlation with GDP. As reported previously, the real interest rate is more volatile in developing economies and countercyclical. The main focus will therefore be on the explanation of interest rate movements and their origins.

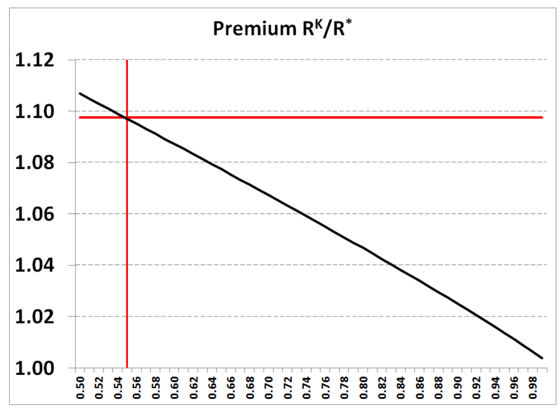
We start by providing some intuition behind the impact of different parameter values on the nonstochastic steady state. In principle this can be done by considering equation B.1. This equation can be treated as an implicit function of optimal solvency threshold $\bar{\omega}$ and the subset of estimated parameters $\{\mu, \sigma, \phi\}$.

[14] As another example, compare the official bankruptcy rate for Spain which is 0.02% versus 3.65% for the U.S. or 2.62% for France.

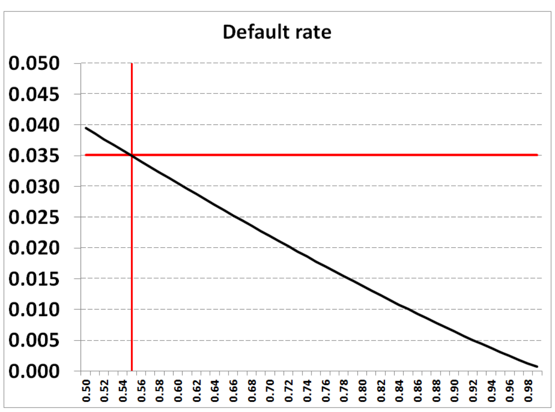
Alternatively, it can be treated as an implicit function of $s(\bar{\omega}) = \frac{R^K}{R^*}$ or $k(\bar{\omega}) = \frac{QK}{N}$, since both expressions have known functional forms with respect to $\bar{\omega}$ (see appendix B). First, we perform a comparative statics style exercise to see how the steady state is affected by different values of ϕ (most importantly), as well as μ and σ. Although this can in principle be done by obtaining a closed-form solution to the implicit derivatives, the algebra becomes extremely elaborate and therefore we proceed with numerical simulations. In particular, we calibrate the model according to the best estimation vector reported in subsection 5.1 and vary one parameter at a time. In the following graphs, red crosses denote the estmated parameter values and the corresponding value of the accelerator characteristics.



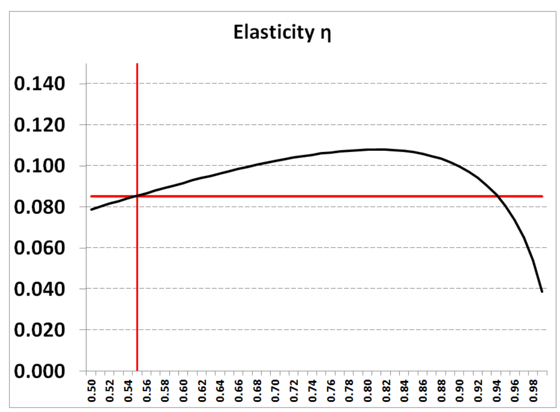
(a) Leverage



(b) Risk premium



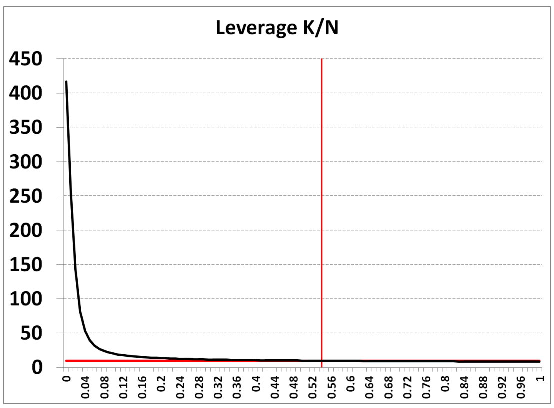
(c) Default rate



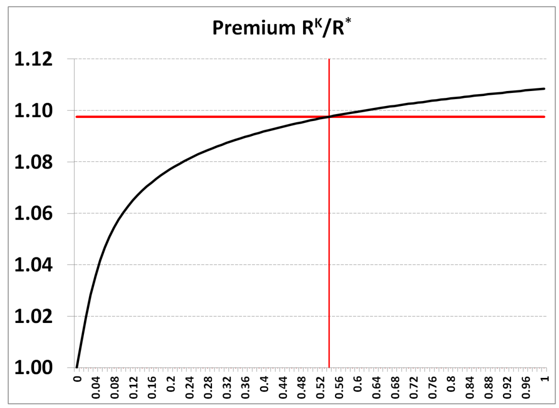
(d) Elasticity

Figure 1: Steady state characteristics under different ϕ.

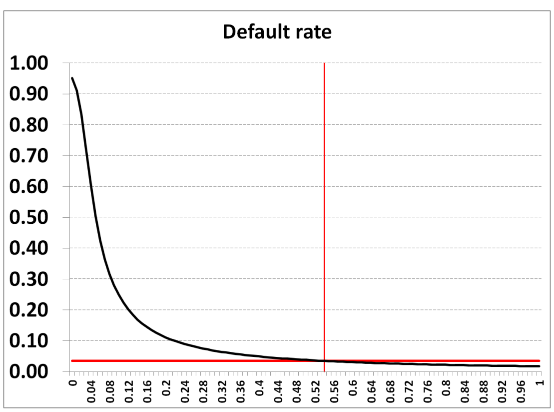
First, consider changing the entrepreneurial survival rate ϕ, summed up in figure 1. As we move to higher parameter values, steady state level of leverage falls significantly, dropping below 4 for ϕ close to 1, as seen in 1(a). This pattern can be explained with the construction of eq. 3.8 which is used to derive B.1. The higher the ϕ, the higher, *ceteribus paribus*, is the net worth and hence the leverage. A similar story can be told about the impact of ϕ on steady state level of risk premium, as R^K is a decreasing function of ϕ (subfigure 1(b)). For very low death rates, the markup over risk free interest rate almost disappears but gets very high for low parameter values. Intuively, as the economy gets less leveraged, the economy-wide risk gets lower, too. Entrepreneurial default rates follow a similar pattern, i.e. they're high for low ϕ and relatively low for high survival rates. Lastly, the elasticity of risk premium with respect to leverage exhibits a hump shape. As we move to lower survival rates, it goes up, but then starts falling as ϕ reaches values below, roughly, 0.8.



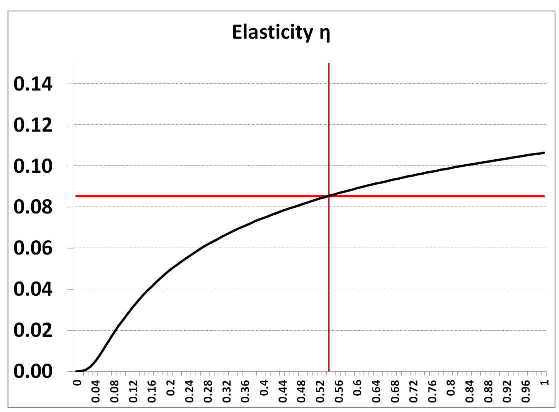
(a) Leverage



(b) Risk premium



(c) Default rate

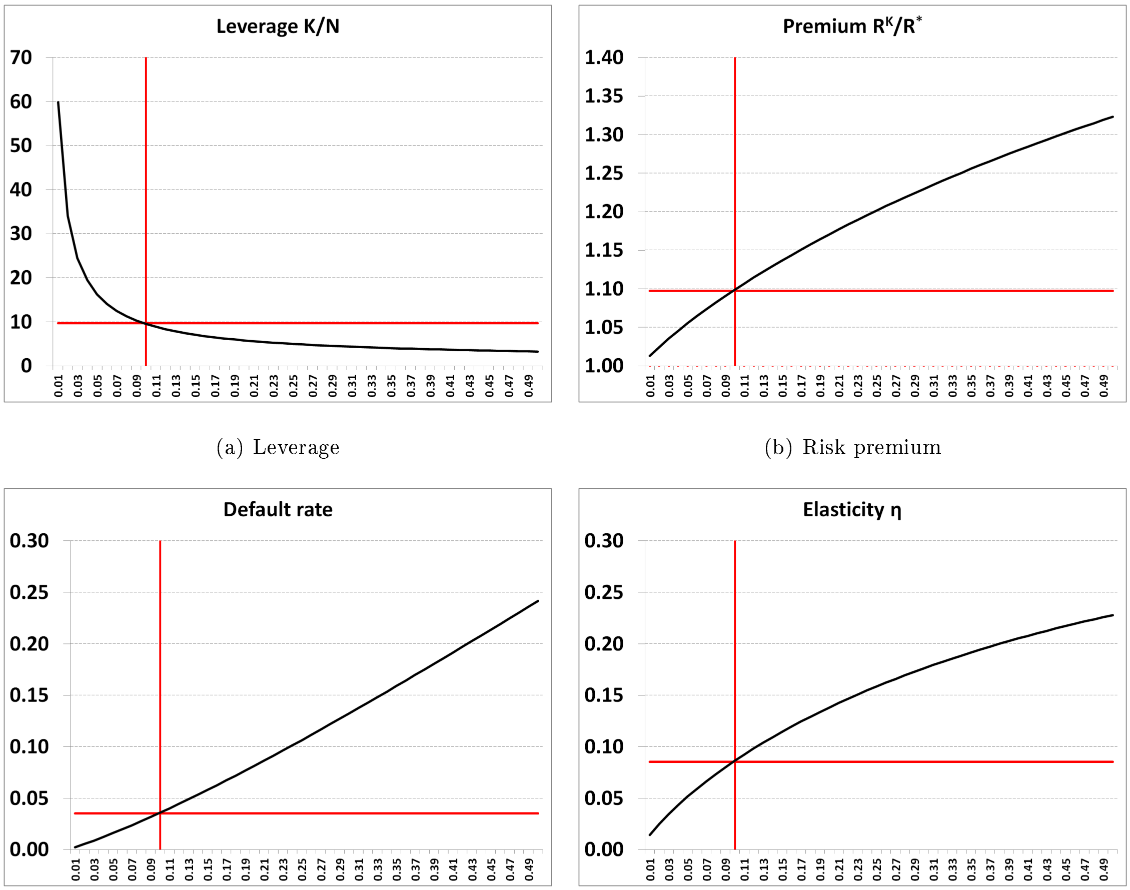


(d) Elasticity

Figure 2: Steady state characteristics under different μ.

Secondly, consider the changes in monitoring costs μ, reported in figure 2. As monitoring costs get lower, the economy approaches a model with no asymetric information costs. In consequence optimal leverage becomes unbounded. At the same time, risk premium approaches zero. Similarly, the risk premium elasticity fades away to zero.

Finally, consider varying the variance of idiosyncratic variance σ, which is summed up in figure 3. This



(a) Leverage

(b) Risk premium

(c) Default rate

(d) Elasticity

Figure 3: Steady state characteristics under different σ.

parameter has an impact on the steady state mainly because of the asymmetricity of the lognormal distribution function. In some dimensions the qualitative relationships are similar to varying μ. In particular, steady state leverage is higher for low idiosyncratic productivity volatility. Risk premium rises as volatility goes up, as does does the default rate. Finally, the elasticity of the premium dies out as σ falls.

Before moving to impulse response analysis, it is worth pointing to one mechanism. Changing the monitoring cost parameter μ as well as σ translates into a change in the costs of borrowing. Therefore these changes affect the steady state position of the loan supply curve

$$E_t\left(\frac{R^K_{t+1}}{R^*}\right) = E_t\left(\frac{1}{\Gamma\left(\bar{\omega}_{t+1}\right) - \mu G\left(\bar{\omega}_{t+1}\right)}\right)\left(\frac{\tilde{B}_{t+1}}{Q_t\tilde{K}_{t+1}}\right) \tag{5.1}$$

while keeping the demand curve fixed. In a $K - R^K$ space this induces a negative comovement between capital (and, for given net worth, leverage) and the risk premium. This can be seen by confronting the subfigures for leverage (decreasing function of μ and σ) and the risk premium (increasing function of μ and σ). Varying the survival rate ϕ, as in figure 1, on the other hand, moves the demand for loans, while keeping the loan supply curve 5.1 unchanged. This induces a positive comovement between leverage and the risk premium with changing ϕ.

We shall now move to the impulse response analysis and show how the model dynamics is affected by parameterization of the steady state. Recall that the risky domestic interest rate is proxied by $E_t R^K_{t+1}$ and the economy is hit solely by stationary total productivity shocks. The best estimation will therefore point to a vector of parameters for which, on impact, GDP will rise, the interest rate will fall and this movement will be rather strong. After a positive TFP shock the marginal productivity of capital R^K_t goes up, thus increasing the value of the firm (equations 3.3 and 3.7), which in turn increases the entrepreneurial net worth (eq. 3.8). This by itself doesn't yet per se determine the behavior of the future expected return $E_t R^K_{t+1}$, our interest rate proxy. Whether the interest rate will actually fall or rise depends on the change of net worth relative to the change in total assets $Q_t K_{t+1}$ and borrowing B_{t+1}. If net worth N_{t+1} goes up relatively little, then the leverage will go up and, according to the loan supply curve (eq. 3.5), the premium over the riskless rate will go up. However, this means a risk premium and interest rate procyclicality. Therefore, for the premium to fall, the net worth has to go up by more than assets, i.e. the leverage has to fall on impact.

The way to achieve a large increase in the entrepreneurial firm value V_t and, in consequence, N_{t+1} after a positive shock, is to be highly leveraged in the first place. The same shock would generate smaller profits for a less leveraged economy than for a more leveraged one[15]. And, as discussed previously, it is precisely the low value of the ϕ parameter that allows us for a very high leverage of the economy in the nonstochastic steady state. This can be seen by inspecting figures 4 through 6[16]. As the survival rate ϕ decreases, the responses of capital and its price both increase, but net worth increases by even more. In consequence, leverage starts falling on impact. In sum, the initial steady state leverage is very high, but after the shock the leverage falls significantly due to a windfall in profits. This in turn drives the risk premium and the interest rate down.

Compare the above mechanism to the situation with high ϕ, e.g. 0.97-0.99, as used in the literature for developed economies. The dynamics of these variables is now reversed. Since the corresponding NSSS

[15]To see this, consider an example economy in which the return on investment $R^K = 5\%$ and borrowing cost $R^* = 1\%$. Firm A is highly leveraged. It borrows $B = 900$ and has net worth (equity) $N = 100$, so that $K = 1000$. Firm A's revenue is $1000 \times 1.05 = 1050$ and debt payments are $900 \times 1.01 = 909$. Net income is $1050 - 909 = 141$ and it's the new net worth of the firm. Net worth increase is therefore 41%. Firm B is lowly leveraged. It borrows $B = 100$ and has net worth (equity) $N = 900$, so again $K = 1000$. Firm B's revenue is $1000 \times 1.05 = 1050$ and debt payments $100 \times 1.01 = 101$. Net income is $1050 - 101 = 949$ and it's the new net worth of the firm. Net worth increase is approx. 5%.

[16]For exposition purposes solely, the impulse responses presented in figures 4 through 6 have been generated under a "benchmark" calibration, different than the estimation results reported in the paper. Here, $\mu = 0.18$ and $\sigma = 0.2254$ are averages of values used in the financial frictions literature, $\rho_A = 0.95$, whereas φ and σ_A were set to match basic business cycle moments in developing countries.

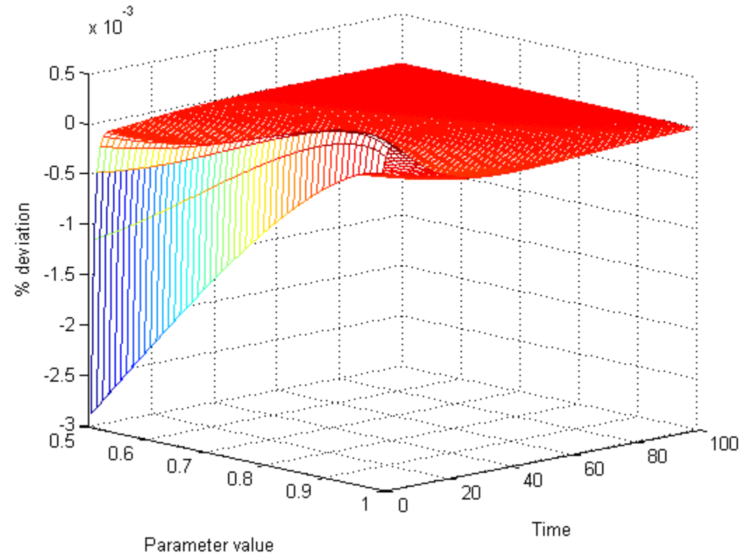


Figure 4: Respones of risk premium $E_t R^K_{t+1}$ after a TFP shock for different values of ϕ.

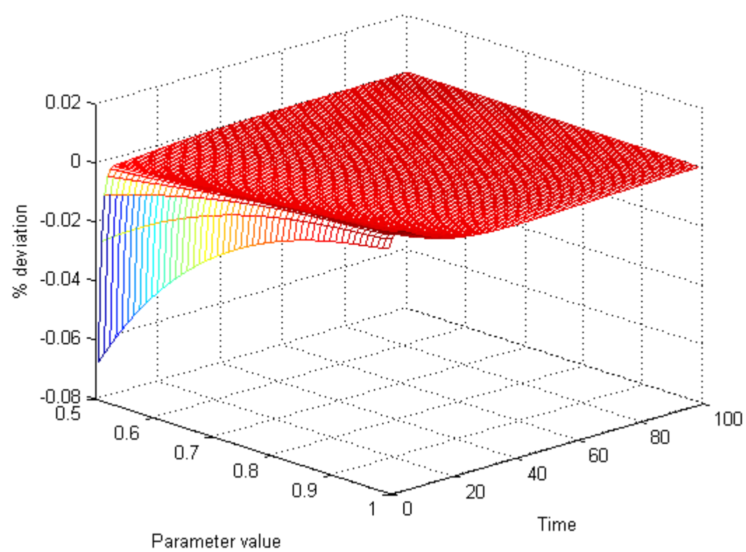


Figure 5: Respones of leverage $\frac{Q_t K_{t+1}}{N_{t+1}}$ after a TFP shock for different values of ϕ.

leverage is very low, entrepreneurial profit is reduced and the increase in V_t and N_{t+1} becomes low as well. Assets $Q_t K_{t+1}$ increase on impact by more than net worth. In consequence, the risk premium and the interest rate itself go up on impact and become procyclical. The cyclicality of interest rates as a function of the survival rate can be seen directly in figure 4.

Consider now the market for capital. A very high increase in the net worth allows for a major rise in

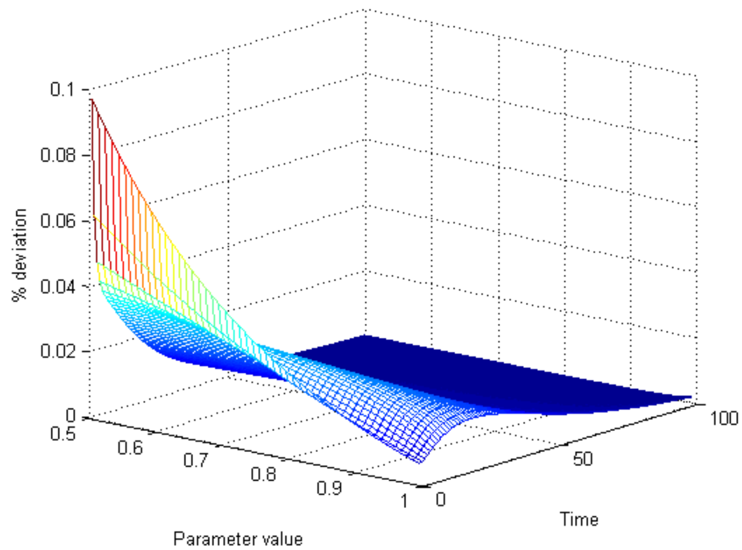
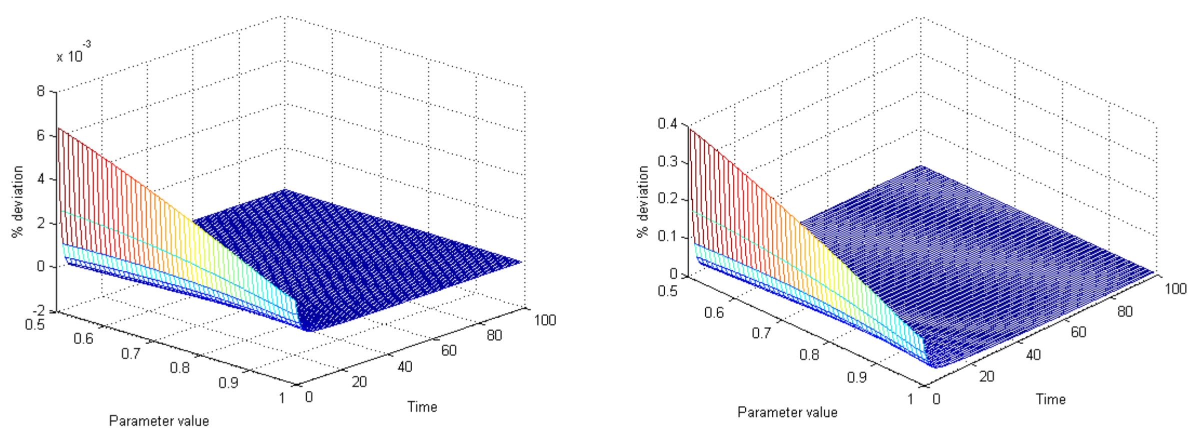


Figure 6: Respones of net worth N_{t+1} after a TFP shock for different values of ϕ.



(a) Price of capital

(b) Investment

Figure 7: Respones of price of capital Q_t and investment I_t after a TFP shock for different values of ϕ.

assets and hence generates a very high demand for capital. Since capital is predetermined on impact, this demand is reflected in a large increase in capital price Q_t as well as investment I_t, as can be seen in figure 7. The windfall effect is strong enough to dominate the capital adjustment costs and in consequence to kill the hump shape response of investment. Also, although the increase in assets comes predominantly from new equity (internal funding), borrowing goes slightly up as well, due to lower leverage and a drop in external funding costs. In consequence borrowing becomes procyclical, as in the data. It is worth noting that this result is different than in Christiano et al. (2010)[17]. Turning back to our model, in the next period after the shock the price of capital falls significantly. First, the supply is now higher due to large investment at t. Secondly, the demand is now lower. This is due to the fact that leverage has fallen in the previous period t (on shock impact) and limited the increase in V_{t+1} and N_{t+2} relative to the previous period. In consequence, there's a capital loss between t and $t+1$ and the return on capital in $t+1$ falls. Since this mechanism is expected as of t, it further decreases $E_t R^K_{t+1}$ and allows the model to match the large interest rate volatility in emerging economies.

5.3 Extensions

An obvious question which arises in the present context is whether a model with a high steady state level of ϕ (as in the benchmark) coupled with a shock to the entrepreneurial net worth could be a feasible alternative for the estimation presented above:

$$\ln \upsilon_t = \rho_\upsilon \ln \upsilon_{t-1} + (1-\rho_\upsilon)\ln \upsilon + \epsilon_{\upsilon,t} \tag{5.2}$$

where υ_t is assumed to follow a stationary $AR(1)$ process. This shock has been interpreted as a conveyor of asset bubbles or deviations of net worth from its fundamentals. Alternatively, it may be thought of as the volatility of financial sector efficiency. Some recent studies, e.g. Nolan and Thoenissen (2009) have found, based on U.S. data and theoretical predictions of Gilchrist and Leahy (2002), that it may play a significant role in explaining business cycle fluctuations. In the context of developing countries, it has also been used by Elekdağ et al. (2006). However, this shock is not likely to bring the model much closer to the data for a few reasons. Essentially, this shock does not move the loan supply curve. Rather, by shifting the demand for loans and capital it generates a positive instead of a negative comovement between the amount of capital and the risk premium, as in the steady state analysis with varying ϕ at the beginning of the section. In other words, this shock increases the net worth and assets, but at the same time reduces the leverage, and in consequence the premium. Secondly, the shock moves the financial variables on impact, but it does not affect (on impact) the entrepreneurial productivity. Hence, it decouples interest rate movements from GDP fluctuations. Yet, this correlation is relatively strong and negative in developing economies.

Following this reasoning, a more successful shock would be one that affects the cost of the financial contract, so as to move the loan supply curve. This has been done, in a reduced form, by Gilchrist et al. (2009) who add a free standing spread shock term to equation 5.1. Using a partial equilibrium model, Levin et

[17] The main problem with their "financial accelerator" model version was that borrowing was countercyclical. Therefore these authors proposed an introduction of the "risk shock", which perturbs the variance of idiosyncratic entrepreneurial productivity and is able to generate procyclical credit under U.S. and Euro Area parameterizations.

al. (2006) have found evidence for varying costs monitoring costs μ in the U.S. Following this paper, Fuentes-Albero (2009) has introduced a shock to monitoring costs in a New Keynesian DSGE model and reached similar conclusions as well as a structural break in its value. Finally, Christiano et al. (2010) introduce the shock to the variance of σ, a "risk shock" which also has a potential of shifting the loan supply curve. Given our steady state analysis from the beginning of the section we presume that introducing varying monitoring costs and or a "risk shock" could improve the fit of the model and account for a large fraction of interest rate volatility in developing countries without retorting to very high steady state leverage. It would also possibly address the problem of countercyclical leverage dynamics that we currently observe in the model, and which is likely to be counterfactual. We leave this as a next step on the research agenda.

6 Concluding Remarks

The key task reported in this paper was to propose a model of business cycle fluctuations in developing countries with fully structural and microfounded financial frictions. We show that many of the characteristics of cyclical fluctuations in emerging economies can be accounted for without the use of ad hoc, reduced form constructions. Most importantly, using the financial accelerator mechanism, initially developed by Bernanke et al. (1999), we are able to reproduce very closely both the volatility and the countercyclicality of the risky domestic interest rate. Hence we do not have to resort to risk premium or foreign interest rate shocks. This is possible because of the countercyclical nature of the accelerator. In good times, e.g. after a positive productivity shock, net worth of firms goes up, which reduces the fraction bankrupt firms and drives the risk premium down. Therefore, our modeling technique addresses another important point made by Oviedo (2005) and Aguiar and Gopinath (2007b), namely that fluctuations of the interest rates should be linked to changes in productivity. For the same reason we abstain from incorportaing working capital requirement to our model, because, as shown by Chang and Fernández (2010), such friction is empirically not relevant compared to the productivity based markup. Nevertheless, the financial accelerator still shares, in a more structural form, part of the idea of working capital constraint, in that production (and therefore implicitly payments for input factors) is financed with borrowed money.

We do not necessarily interpret our results as an argument against "the cycle is the trend" hypothesis in favor of "financial frictions". Rather, as suggested by Aguiar and Gopinath (2007b), financial and other imperfections present in emerging economies may simply manifest themselves in changes in the Solow residuals and more precisely, in the form of shocks to the nonstationary component of the productivity process. In the next step of our research agenda, we intend to provide more concrete evidence for this interpretation. This task can be implemented by performing the following exercise. In the first step, one would generate artificial data for output, consumption, investment and net exports, using our present model with the financial accelerator. In the second step, one would estimate the same model as in Aguiar and Gopinath (2007a) on this artificial dataset. One would find evidence for this interpretation if the estimation results were similar to those in that paper, i.e. that nonstationary component of the TFP process was the main driving force of business cycle fluctuations.

The ongoing research program in financial frictions literature, including e.g. papers of Christiano et al. (2010) and Fuentes-Albero (2009), provides evidence that the financial accelerator plays a statistically significant role in explaining fluctuations in developed economies, e.g. in the U.S. and the Euro Area. Our work suggests that the mechanism may have an even higher potential in the context of business cycles in emerging economies.

Appendices

A Data

to be completed...

B Steady state

First, normalize $H_t^e \equiv 1 \ \forall t$ (labor supply of entrepreneurs). Secondly, set $A = 1$ (technology), $H = 0.33$ (labor supply) as well as $R^* = (1.0079)^{1/4}$ (foreign interest rate).

The optimal $\bar{\omega}$ is found by maximizing the return of the entrepreneurs subject to zero-profit condition of the lenders:

$$\max_{\bar{\omega},K,\lambda} \left[1 - \Gamma\left(\bar{\omega}\right)\right] R^K QK - \lambda \left\{R^* \left(QK - N\right) - \left[\Gamma\left(\bar{\omega}\right) - \mu G\left(\bar{\omega}\right)\right] R^K QK\right\}$$

with $Q = 1$. The first order conditions are:

$$\frac{\partial}{\partial \bar{\omega}} : -\Gamma'\left(\bar{\omega}\right) R^K QK + \lambda \left[\Gamma'\left(\bar{\omega}\right) - \mu G'\left(\bar{\omega}\right)\right] R^K QK = 0$$

$$\frac{\partial}{\partial K} : \left[1 - \Gamma\left(\bar{\omega}\right)\right] R^K Q - \lambda \left\{R^* Q - \left[\Gamma\left(\bar{\omega}\right) - \mu G\left(\bar{\omega}\right)\right] R^K Q\right\} = 0$$

$$\frac{\partial}{\partial \lambda} : R^* \left(QK - N\right) - \left[\Gamma\left(\bar{\omega}\right) - \mu G\left(\bar{\omega}\right)\right] R^K QK = 0$$

The second order conditions which guarantee a maximum are given by the following condition for the bordered hessian:

$$\det H = \begin{vmatrix} 0 & -\left(\Gamma' - \mu G'\right) R^K K & R^* - \left(\Gamma - \mu G\right) R^K \\ -\left(\Gamma' - \mu G'\right) R^K K & -\Gamma'' R^K K + \lambda \left(\Gamma'' - \mu G''\right) R^K K & -\Gamma' R^K + \lambda \left(\Gamma' - \mu G'\right) R^K \\ R^* - \left(\Gamma - \mu G\right) R^K & -\Gamma' R^K + \lambda \left(\Gamma' - \mu G'\right) R^K & 0 \end{vmatrix} > 0$$

At this point, we have the values for all the necessary parameters to solve for optimal cutoff $\bar{\omega}$. We follow Gertler et al. (2003), correcting for the fact that we have a deterministic trend and borrowing directly from abroad at R^*. Specifically, take 3.3, 3.18 combined with 3.8 as well as 3.7 combined with zero-profit condition of lenders, to get:

$$s\left(\bar{\omega}\right) - \frac{1-\delta}{R^*} = \frac{\alpha}{\Omega\left(1-\alpha\right)} \left[\frac{g}{R^*} \frac{1}{k\left(\bar{\omega}\right)} - \phi\left(1 - \Gamma\left(\bar{\omega}\right)\right) s\left(\bar{\omega}\right)\right] \tag{B.1}$$

where $s\left(\bar{\omega}\right) = \frac{R^K}{R^*}$ as well as $k\left(\bar{\omega}\right) = \frac{QK}{N}$.

Now, we obtain

$$R^K = s\left(\bar{\omega}\right) R^* \tag{B.2}$$

Next, find the values for output Y and capital K by combining 3.16 with 3.3 to get

$$Y = \left\{ \left[\frac{\alpha}{R^K - \left(1-\delta\right)}\right]^{\alpha} L^{\left(1-\alpha\right)} \right\}^{\frac{1}{1-\alpha}} \tag{B.3}$$

and

$$K = Y \frac{\alpha}{R^K - \left(1-\delta\right)} \tag{B.4}$$

Investment follows automatically from the assumption in 3.9:

$$I = \left(g - 1 + \delta\right) K \tag{B.5}$$

By definition, net worth is $N = K/k\left(\bar{\omega}\right)$.

Now, using 3.1 lending becomes simply

$$B = \left[k\left(\bar{\omega}\right) - 1\right] N \tag{B.6}$$

Wages of entrepreneurs W^e and households W follow now from 3.18 and, respectively, 3.19:

$$W^e = \left(1-\alpha\right) \Omega Y \tag{B.7}$$

$$W = \left(1-\alpha\right)\left(1-\Omega\right) \frac{Y}{H} \tag{B.8}$$

Value of the firm may be computed in at least two ways, e.g. using 3.8:

$$V = \frac{Ng - W^e}{\phi} \tag{B.9}$$

or, equivalently, from 3.7.

Entrepreneurs' consumption follows from 3.6:

$$C^e = (1-\phi)\, V \tag{B.10}$$

Risk premium comes from 3.14:

$$\Psi = \bar{\Psi} = \frac{g^\sigma}{\beta R^K} \tag{B.11}$$

Domestic consumption comes from $C = \frac{C}{Y} Y$.

Net exports NX comes from 3.20

$$NX = Y - C - C^e - I - \mu \int_0^{\bar{\omega}} \omega f(\omega)\, \mathrm{d}\omega\, R^K K \tag{B.12}$$

Foreign debt D now stems from 3.12

$$D = \frac{WH - C}{\Psi R^K - g} \tag{B.13}$$

Marginal utility of consumption comes from 3.15

Next, you can obtain the endogenous rescaling parameter τ in the GHH utility function, by combining labor supply and labor demand equations, eliminating wages w and solving for τ:

$$\tau = \frac{(1-\alpha)\,(1-\Omega)\, Y}{H^\gamma}$$

Having τ, obtain the value for marginal utility of consumption λ as:

$$\lambda = \left(C - \tau \frac{H^\gamma}{\gamma} \right)^{-\sigma}$$

Finally, table 10 summarizes all parameters which are found endogenously.

Table 10: Endogenously solved parameters

Variable or ratio	**Description**	**Comment**
$\bar{\Psi}$	constant in risk premium function	solved from 3.14
η	risk premium elasticity	solved from D.1
τ	parameter at GHH utility	solved from 3.11

C Log-linearized model

Budget constraint

$$C\hat{C}_t - Yg\hat{D}_{t+1} = WH\left(\hat{W}_t + \hat{H}_t\right) - R^K D\bar{\Psi}\left(E_{t-1}\hat{R}^K_t + \hat{\Psi}_t\right) - \bar{\Psi} R^K Y \hat{D}_t \tag{C.1}$$

where we define$\hat{D}_t = \frac{D_t - D}{Y}$ to account for a negative D in the nonstochastic steady state.

Risk premium

$$\hat{\Psi}_t = \frac{\tilde{\Psi} Y}{\bar{\Psi}} \hat{D}_t + \hat{\Phi}_t \tag{C.2}$$

Labor supply for GHH preferences

$$(\gamma - 1) \hat{H}_t - \hat{W}_t = 0 \tag{C.3}$$

Marginal utility of consumption for GHH preferences

$$\hat{\lambda}_t + \frac{\sigma C}{C - \tau \frac{H^\gamma}{\gamma}} \hat{C}_t - \frac{\sigma \tau H^\gamma}{C - \tau \frac{H^\gamma}{\gamma}} \hat{H}_t = 0 \tag{C.4}$$

Euler with foreign bonds

$$\hat{\lambda}_t = E_t \hat{R}^K_{t+1} + E_t \hat{\lambda}_{t+1} + \hat{\Psi}_{t+1} \tag{C.5}$$

Production function

$$\hat{Y}_t = \hat{A}_t + \alpha \hat{K}_t + (1 - \alpha) \hat{L}_t \tag{C.6}$$

Labor aggregation

$$\hat{L}_t = (1 - \Omega) \hat{H}_t \tag{C.7}$$

Entrepreneurial labor demand

$$\hat{Y}_t = \hat{W}^e_t \tag{C.8}$$

Labor demand

$$\hat{Y}_t - \hat{H}_t = \hat{W}_t \tag{C.9}$$

Investment funds

$$\hat{Q}_t + \hat{K}_{t+1} = \frac{N}{K} \hat{N}_{t+1} + \frac{B}{K} \hat{B}_{t+1} \tag{C.10}$$

Return on capital *ex post*

$$\hat{R}^K_t = \frac{\alpha \frac{Y}{K}}{R^K} \hat{Y}_t - \frac{\alpha \frac{Y}{K}}{R^K} \hat{K}_t + \frac{1 - \delta}{R^K} \hat{Q}_t - \hat{Q}_{t-1} \tag{C.11}$$

Interest rates

$$\frac{\bar{\omega} \left[\Gamma' (\bar{\omega}) - \mu G' (\bar{\omega}) \right]}{\Gamma (\bar{\omega}) - \mu G (\bar{\omega})} \hat{\bar{\omega}}_t = \hat{R}^*_t - \hat{R}^K_t + \hat{B}_t - \hat{K}_t - \hat{Q}_{t-1} \tag{C.12}$$

where $\hat{\bar{\omega}}_t = \frac{\bar{\omega}_t - \bar{\omega}}{\bar{\omega}}$

Evolution of net worth

$$\hat{N}_{t+1} = \frac{\phi V}{N g} \left(\hat{\upsilon}_t + \hat{V}_t \right) + \frac{W^e}{N g} \hat{W}^e_t \tag{C.13}$$

Value of firm

$$\hat{V}_t = \frac{\Xi R^K K}{V}\hat{R}_t^K + \frac{K\left(\Xi R^K - R^*\right)}{V}\hat{Q}_{t-1} - \frac{\bar{\omega}\mu G' R^K K}{V}\hat{\bar{\omega}}_t + \frac{K\left(\Xi R^K - R^*\right)}{V}\hat{K}_t - \frac{R^*\left(K-N\right)}{V}\hat{R}_t^* + \frac{R^* N}{V}\hat{N}_t \tag{C.14}$$

where $\Xi = [1 - \mu G(\bar{\omega})]$.

Entrepreneurs consumption

$$\hat{C}_t^e = \hat{V}_t \tag{C.15}$$

Motion of capital

$$g\hat{K}_{t+1} = (1-\delta)\hat{K}_t + (g - 1 + \delta)\hat{I}_t \tag{C.16}$$

Market clearing

$$\widehat{nx}_t = \left(1 - \frac{NX}{Y}\right)\hat{Y}_t - \frac{C}{Y}\hat{C}_t - \frac{C^e}{Y}\hat{C}_t^e - \frac{I}{Y}\hat{I}_t - \frac{\mu G R^K K}{Y}\left(\hat{R}_t^K + \hat{Q}_{t-1} + \hat{K}_t\right) - \frac{\bar{\omega}\mu G' R^K K}{Y}\hat{\bar{\omega}}_t \tag{C.17}$$

where

$$\widehat{nx}_t \equiv \frac{NX_t}{Y_t} - \frac{NX}{Y} = nx_t - nx$$

Home technology shock

$$\hat{A}_t = \rho_A \hat{A}_{t-1} + \epsilon_{A,t} \tag{C.18}$$

Optimal omega

$$\bar{\omega}\frac{\Gamma''\Lambda - \Sigma\Gamma'}{\Lambda^2}\left(\frac{R^K}{R^*}\Theta - 1\right)E_t\hat{\bar{\omega}}_{t+1} + \frac{R^K}{R^*}\left[(1-\Gamma) + \frac{\Theta\Gamma'}{\Lambda}\right]\left(E_t\hat{R}_{t+1}^K - \hat{R}_{t+1}^*\right) = 0 \tag{C.19}$$

where $\Theta = \Gamma(\bar{\omega}) - \mu G(\bar{\omega})$, $\Lambda = \Gamma'(\bar{\omega}) - \mu G'(\bar{\omega})$, $\Sigma = \Gamma''(\bar{\omega}) - \mu G''(\bar{\omega})$ and $\Gamma \equiv \Gamma(\bar{\omega})$, $\Gamma' \equiv \Gamma'(\bar{\omega}) = \frac{\partial}{\partial\bar{\omega}}\Gamma(\bar{\omega})$, $\Gamma'' \equiv \Gamma''(\bar{\omega}) = \frac{\partial^2}{\partial\bar{\omega}^2}\Gamma(\bar{\omega})$ as well as $G \equiv G(\bar{\omega})$, $G' \equiv G'(\bar{\omega}) = \frac{\partial}{\partial\bar{\omega}}G(\bar{\omega})$, $G'' \equiv G''(\bar{\omega}) = \frac{\partial^2}{\partial\bar{\omega}^2}G(\bar{\omega})$.

Price of capital

$$\hat{Q}_t = \varphi g\hat{K}_{t+1} - \varphi g\hat{K}_t + \beta E_t\left\{(1-\delta)\hat{Q}_{t+1} - \varphi g^2\hat{K}_{t+2} + \varphi g^2\hat{K}_{t+1}\right\} \tag{C.20}$$

D Risk premium elasticity

The following computation derives the elasticity of the risk premium with respect to the leverage ratio, denoted as $\eta_{s,k}$. It closely follows Gertler et al. (2003). By definition, $s(\bar{\omega}) = \frac{\lambda(\bar{\omega})}{\Psi(\bar{\omega})}$ and $k(\bar{\omega}) = \frac{\Psi(\bar{\omega})}{1-\Gamma(\bar{\omega})}$, where $s(\bar{\omega}) = \frac{R^K}{R}$ is the risk premium and $k(\bar{\omega}) = \frac{QK}{N}$ is the leverage ratio. The elasticity is computed as $\eta_{s,k} = \frac{\mathrm{d}\log s}{\mathrm{d}\log k} = \frac{\mathrm{d}\log s}{\mathrm{d}\bar{\omega}}\frac{\mathrm{d}\bar{\omega}}{\mathrm{d}\log k}$.

$$\frac{\mathrm{d}\log s}{\mathrm{d}\bar{\omega}} = \frac{\mathrm{d}\left[\log\lambda(\bar{\omega}) - \log\Psi(\bar{\omega})\right]}{\mathrm{d}\bar{\omega}} = \frac{\lambda'(\bar{\omega})}{\lambda(\bar{\omega})} - \frac{\Psi'(\bar{\omega})}{\Psi(\bar{\omega})}$$

and

$$\frac{\mathrm{d}\log k}{\mathrm{d}\bar{\omega}} = \frac{\mathrm{d}\left[\log \Psi\left(\bar{\omega}\right) - \log\left(1-\Gamma\left(\bar{\omega}\right)\right)\right]}{\mathrm{d}\bar{\omega}} = \frac{\Psi'\left(\bar{\omega}\right)}{\Psi\left(\bar{\omega}\right)} + \frac{\Gamma'\left(\bar{\omega}\right)}{1-\Gamma\left(\bar{\omega}\right)}$$

Combining, we obtain

$$\eta_{s,k} = \frac{\left[\frac{\lambda'(\bar{\omega})}{\lambda(\bar{\omega})} - \frac{\Psi'(\bar{\omega})}{\Psi(\bar{\omega})}\right]}{\left[\frac{\Psi'(\bar{\omega})}{\Psi(\bar{\omega})} + \frac{\Gamma'(\bar{\omega})}{1-\Gamma(\bar{\omega})}\right]} \tag{D.1}$$

E Log-normal distribution and related functions

We follow the standard notation established in the original BGG paper. The idiosyncratic productivity of a firm is denoted by ω. It is distributed log-normally, i.e. $\ln\omega \sim N\left(\mu_\omega, \sigma_\omega^2\right)$. Let $f\left(\omega\right)$ be the probability distribution function (pdf) of ω. It is given by

$$f\left(\omega\right) = \frac{1}{\omega\sigma_\omega\sqrt{2\pi}}\exp\left[-\frac{\left(\ln\omega - \mu_\omega\right)^2}{2\sigma_\omega^2}\right]$$

And the cumulative distribution function (cdf) is

$$F\left(\bar{\omega}\right) = \int_0^{\bar{\omega}} f\left(\omega\right)\mathrm{d}\omega$$

In the model $E\omega$ is normalized to 1, therefore $\mu_\omega = -\frac{\sigma_\omega^2}{2}$.

The gross fraction of entrepreneurs' revenue that goes to the lenders is defined as

$$\Gamma\left(\bar{\omega}\right) \equiv \int_0^{\bar{\omega}} \omega f\left(\omega\right)\mathrm{d}\omega + \bar{\omega}\int_{\bar{\omega}}^{\infty} f\left(\omega\right)\mathrm{d}\omega$$

and

$$G\left(\bar{\omega}\right) \equiv \int_0^{\bar{\omega}} \omega f\left(\omega\right)\mathrm{d}\omega$$

$$\frac{\partial}{\partial\bar{\omega}}\Gamma\left(\bar{\omega}\right) = \Gamma'\left(\bar{\omega}\right) = 1 - F\left(\bar{\omega}\right)$$

$$\frac{\partial}{\partial\bar{\omega}}G\left(\bar{\omega}\right) = G'\left(\bar{\omega}\right) = \bar{\omega}f\left(\bar{\omega}\right)$$

$$\frac{\partial^2}{\partial\bar{\omega}^2}\Gamma\left(\bar{\omega}\right) = \Gamma''\left(\bar{\omega}\right) = -F'\left(\bar{\omega}\right) = -f\left(\bar{\omega}\right)$$

$$\frac{\partial^2}{\partial\bar{\omega}^2}G\left(\bar{\omega}\right) = G''\left(\bar{\omega}\right) = f\left(\bar{\omega}\right) + \bar{\omega}f'\left(\bar{\omega}\right)$$

where

$$f'\left(\bar{\omega}\right) = -\frac{1}{\bar{\omega}^2\sigma_\omega\sqrt{2\pi}}\left(1 + \frac{\ln\bar{\omega} + \frac{\sigma_\omega^2}{2}}{\sigma_\omega^2}\right)\exp\left\{-\frac{\left(\ln\bar{\omega} + \frac{\sigma_\omega^2}{2}\right)^2}{2\sigma_\omega^2}\right\}$$

References

Agénor, Pierre-Richard, C. John McDermott, and Eswar S. Prasad, "Macroeconomic Fluctuations in Developing Countries: Some Stylized Facts," *The World Bank Economic Review*, 2000, *14* (2), 251–285.

Aguiar, Mark and Gita Gopinath, "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, 2007, *115* (1), 69–102.

_ and Guita Gopinath, "The Role of Interest Rates and Productivity Shocks in Emerging Market Fluctuations," Working Papers Central Bank of Chile 445, Central Bank of Chile December 2007.

Benczúr, Péter and Attila Rátfai, "Economic fluctuations in Central and Eastern Europe: the facts," *Applied Economics*, October 2010, *42* (25), 3279–3292.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist, "The financial accelerator in a quantitative business cycle framework," in J. B. Taylor and M. Woodford, eds., *Handbook of Macroeconomics*, Vol. 1 of *Handbook of Macroeconomics*, Elsevier, 1999, chapter 21, pp. 1341–1393.

Burnside, Craig, "Real Business Cycle Models: Linear Approximation and GMM Estimation," May 1999. working paper.

Carlstrom, Charles T. and Timothy S. Fuerst, "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis," *The American Economic Review*, 1997, *87* (5), pp. 893–910.

Chang, Roberto and Andrés Fernández, "On the Sources of Aggregate Fluctuations in Emerging Economies," NBER Working Papers 15938, National Bureau of Economic Research, Inc April 2010.

Christiano, Lawrence, Roberto Motto, and Massimo Rostagno, "Shocks, structures or monetary policies? The Euro Area and US after 2001," *Journal of Economic Dynamics and Control*, August 2008, *32* (8), 2476–2506.

_ , _ , and _ , "Financial Factors in Economic Fluctuations," Technical Report 1192, European Central Bank May 2010.

Claessens, Stijn and Leora F. Klapper, "Bankruptcy around the World: Explanations of Its Relative Use," *American Law and Economics Review*, 2005, *7* (1), 253–283.

Correia, Isabel, João C. Neves, and Sergio Rebelo, "Business cycles in a small open economy," *European Economic Review*, 1995, *39* (6), 1089 – 1113.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco, "Balance Sheets and Exchange Rate Policy," *The American Economic Review*, 2004, *94* (4), pp. 1183–1193.

Devereux, Michael B., Philip R. Lane, and Juanyi Xu, "Exchange Rates and Monetary Policy in Emerging Market Economies," *Economic Journal*, 04 2006, *116* (511), 478–506.

Elekdağ, Selim, Alejandro Justiniano, and Ivan Tchakarov, "An Estimated Small Open Economy Model of the Financial Accelerator," *IMF Staff Papers*, 2006, *53* (2), 2.

Fernández, Andrés and Diego Zamora, "Business Cycles in Emergin Economies: The Role of Common Trends," April 2011. working paper.

Fuentes-Albero, Cristina, "Financial Frictions, the Financial Immoderation, and the Great Moderation," November 2009. working paper.

Garcia-Cicco, Javier, Roberto Pancrazi, and Martín Uribe, "Real Business Cycles in Emerging Countries?," *American Economic Review*, 2010, *100* (5), 2510–31.

Gertler, Mark, Simon Gilchrist, and Fabio M. Natalucci, "External Constraints on Monetary Policy and the Financial Accelerator," *Journal of Money, Credit and Banking*, 03 2007, *39* (2-3), 295–330.

_ , _ , and Fabio Natalucci, "External Constraints on Monetary Policy and the Financial Accelerator," Working Paper 10128, National Bureau of Economic Research December 2003.

Gilchrist, Simon, Alberto Ortiz, and Egon Zakrajšek, "Credit Risk and the Macroeconomy: Evidence from an Estimated DSGE Model," July 2009. working paper.

_ and Egon Zakrajšek, "Credit Spreads and Business Cycle Fluctuations," Working Paper 17021, National Bureau of Economic Research May 2011.

_ and John V. Leahy, "Monetary policy and asset prices," *Journal of Monetary Economics*, January 2002, *49* (1), 75–97.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman, "Investment, Capacity Utilization, and the Real Business Cycle," *The American Economic Review*, 1988, *78* (3), 402–417.

Iacoviello, Matteo, "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *The American Economic Review*, 2005, *95* (3), 739–764.

Levin, Andrew T., Fabio M. Natalucci, and Egon Zakrajšek, "The Magnitude and Cyclical Behavior of Financial Market Frictions," 2006. working paper.

Mendoza, Enrique G, "Real Business Cycles in a Small Open Economy," *American Economic Review*, September 1991, *81* (4), 797–818.

Mendoza, Enrique G. and Vivian Z. Yue, "A Solution to the Disconnect between Country Risk and Business Cycle Theories," Working Paper 13861, National Bureau of Economic Research March 2008.

Neumeyer, Pablo A. and Fabrizio Perri, "Business cycles in emerging economies: the role of interest rates," *Journal of Monetary Economics*, 2005, *52* (2), 345 – 380.

Nolan, Charles and Christoph Thoenissen, "Financial shocks and the US business cycle," *Journal of Monetary Economics*, 2009, *56* (4), 596 – 604.

Oviedo, P. Marcelo, "World Interest Rate, Business Cycles, and Financial Intermediation in Small Open Economies," Staff General Research Papers 12360, Iowa State University, Department of Economics May 2005.

Queijo von Heideken, Virginia, "How Important are Financial Frictions in the United States and the Euro Area?," *Scandinavian Journal of Economics*, 09 2009, *111* (3), 567–596.

Schmitt-Grohé, Stephanie and Martín Uribe, "Closing small open economy models," *Journal of International Economics*, 2003, *61* (1), 163 – 185.

Tornell, Aaron and Frank Westermann, "Boom-Bust Cycles in Middle Income Countries: Facts and Explanation," *IMF Staff Papers*, 2002, *49*, pp. 111–155.

_ **and** _ , "The Credit Channel in Middle Income Countries," Working Paper 9355, National Bureau of Economic Research December 2002.

_ **and** _ , "Credit Market Imperfections in Middle Income Countries," Working Paper 9737, National Bureau of Economic Research June 2003.

_ **and** _ , *Boom-Bust Cycles and Financial Liberalization* CESifo Book Series, MIT Press, 2005.

Townsend, Robert M., "Optimal contracts and competitive markets with costly state verification," *Journal of Economic Theory*, 1979, *21* (2), 265 – 293.

Uribe, Martín and Vivian Z. Yue, "Country spreads and emerging countries: Who drives whom?," *Journal of International Economics*, 2006, *69* (1), 6 – 36. Emerging Markets - Emerging Markets and macroeconomic volatility:Lessons from a decade of financial debacles a symposium for the Journal of International Economics.