Business Cycles in a Credit Constrained Small Open Economy

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work.

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

Abstract

This thesis addresses the sources and propagation mechanisms of business cycles in small open emerging economies. Vector autoregressive analyses (Chapter 1) of Brazil – whose regularities are common to other emerging economies – show that exogenous global credit disturbances affecting international liquidity, uncertainty and risk appetite account for over 40% of output variability. These disturbances explain the bulk of emerging economies' excess macroeconomic volatility. They transmit via credit frictions, mainly as shocks to the real interest rates that emerging economies face in international markets. They comprise about 60% of the country spread variations. Responses of output and other real aggregates to credit shocks reveal growth persistence, hump-shaped recession and recovery patterns. These regularities are examined within proposed dynamic stochastic general equilibrium models of a small open economy with permanently binding endogenous constraint on foreign credit. When accumulating capital works as collateral in the constraint, the model (Chapter 2) exhibits unprecedented intertemporal propagation, mainly through wedges between consumption's marginal rate of substitution and the return on capital. Interest rate shocks have significant persistent effects which mitigate the dominance of uncorrelated productivity shocks. The model nests properties of real business cycle models and overcomes typical anomalies of small open economy models which are derived from weak consumption substitution effects. A second model (Chapter 3) tackles the macroeconomic implications of country spread as an endogenous state variable affecting credit and business cycles. The spread is built into an endogenous credit constraint, similar to an external financial premium. Amplification and propagation mechanisms are further enhanced through an enriched intertemporal wedge. Independent US real interest rate and exogenous country spread shocks – representing exogenous credit disturbances to emerging economies – are equally important over business cycle horizons. Calibrated for Brazil, both models match qualitative and quantitative regularities empirically observed in response dynamics, second moments and variance decompositions.

To my father,

José Sarquis.

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Introduction

This thesis addresses the sources and propagation mechanisms of business cycles in small open emerging economies from both an empirical and a theoretical perspective. It argues that global credit shocks represent a major source of emerging economy fluctuations. Such shocks considerably transmit as disturbances to the real interest rate, and specifically to the country spread, that emerging economies face in global financial markets. The dynamics of amplification and propagation of these shocks into the domestic economy and their overall business cycle implications reveal persistent effects in output and other real aggregates. These effects are consistent with the workings of foreign credit frictions, in particular those of financial accelerator mechanisms that stem from permanent endogenous credit constraints on foreign borrowing.

The thesis is motivated by empirical work that contrasts business cycle regularities of emerging economies with those of advanced ones (e.g. Calvo, 1999; Agénor et al., 2000; Neumeyer and Perri, 2005; Uribe and Yue, 2006; Aguiar and Gopinath, 2007). First, these economies exhibit a higher variability of aggregate activity than advanced small open economies. Second, they face higher and more volatile real interest rates and country spreads in international credit markets. Third, their real interest rates and country spreads are countercyclical, with their lagged values negatively correlated to output. Fourth, a combination of both domestic fundamentals and international credit factors might contribute to an explanation for the variability of country spreads and international real interest rates of emerging economies.

From a theoretical perspective, the thesis seeks to respond to some of the main challenges that are recurrently observed in small open economy (SOE) models. In particular, such models reveal serious limitations to address emerging economy regularities under reasonable shock assumptions. Real business cycle SOE models (Mendoza, 1991; Schmitt-Grohé and Uribe, 2003) and extensions that include working capital constraints (Neumeyer and Perri, 2005; Uribe and Yue, 2006) tend to display weak intertemporal propagation mechanisms. Consequently, independent real interest rate shocks have a limited role in determining business cycle dynamics, except when they are assumed to be excessively large or correlated to productivity shocks in alternative forms (Oviedo, 2005). Also, the vast majority of SOE business cycle models have not yet incorporated the workings of a permanently binding endogenous credit constraint in their intertemporal mechanisms.

This thesis seeks to close this gap by building on advances in macroeconomics that integrate credit constraints into closed-economy models (e.g. Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997) and SOE models (Kocherlakota, 2000; Chari et al., 2005). In the latter model class, rather different approaches have arisen to address distinct emerging economy issues, such as monetary policy (e.g. Gertler et al., 2003) and sudden stops (e.g. Mendoza, 2006).

I provide support to relate the contrasting stylized facts of emerging economies to the hypotheses that they are relatively impatient and permanently constrained in their ability to access foreign credit. These hypotheses particularly differ from those assumed by SOE models of sudden stops, which have mainly relied on the occasional binding of a foreign credit constraint and its resulting nonlinear effects (Mendoza, 2006). Therefore, I distinctively propose a SOE framework that incorporates the lasting effects of endogenous credit frictions over business cycle horizons.

The thesis is divided into three Chapters that can be read independently, although they are systematically interconnected and may seemingly overlap at times. Despite their specific questions and purposes, they constitute a coherent unity of quantitative and qualitative analyses of emerging economy business cycles.

Chapter 1 comprises empirical vector autoregressive (VAR) analyses of the Brazilian economy, whose regularities are common to other emerging economies. Besides being a representative country in this category, Brazil is also a significant case among emerging economies. The analyses are based on monthly data, in order to capture the interactions between international financial variables, and between the latter and macroeconomic variables. The Chapter identifies global credit disturbances affecting international liquidity, uncertainty and risk appetite through a representation of global credit markets based on the US short term interest rate, term premium and risk premium (Fama and French, 1989), which are independent from emerging markets. These exogenous global shocks account for 45% of output variability, and explain the bulk of the excess macroeconomic volatility of emerging economies. They mainly transmit as shocks to real interest rates and, specifically, to the country spreads that emerging economies face in international financial markets. Global credit shocks are responsible for 60% and 50% of the variations in interest rates and country spreads, respectively.

These empirical analyses are robust to the consideration of a variety of domestic variables and fundamentals, which are associated with the debt dynamics of the public sector and changes in relative prices in the external sector. Furthermore, allowing for the exchange rate channel enhances the effects of global credit shocks and the roles of interest rate and country spread. By and large, the evidence suggests the existence of international credit constraints which impair the macroeconomic dynamics, and that "financial accelerators" ensure the persistent propagation of credit shocks over realistic business cycle horizons.

Chapters 2 and 3 examine some of these regularities within two dynamic stochastic general equilibrium models of a SOE that faces a permanently binding endogenous credit constraint on foreign borrowing. They can realistically address the amplification and propagation of global credit shocks. Calibrated to Brazil, the simulated models match a variety of business cycle regularities and dynamics from both a qualitative and a quantitative perspective. Both Chapters proceed to the analyses of the models on the basis of quarterly VAR identifications that are consistent with Chapter 1, and that provide realistic specifications for the model's exogenous processes.

In the model in Chapter 2, accumulating capital also works as aggregate collateral, besides being a production factor (Kiyotaki and Moore, 1997). The collateral constraint permanently binds and imposes a dynamic interaction between capital and foreign debt. The model exhibits unprecedented intertemporal propagation, mainly through wedges between consumption's marginal rate of substitution and the return on capital. The simulated responses of output and consumption to real interest rate shocks feature growth persistence and, therefore, match their respective estimated VAR hump-shaped responses. These empirical responses are consistent with recession and recovery patterns, in analogous terms to productivity or monetary shocks (Cogley and Nason, 1995;

Christiano et al. 2005). Independent real interest rate shocks have significant and persistent effects that mitigate the dominance of uncorrelated productivity shocks over business cycles. In addition to productivity shocks, real interest rate shocks are also key to ensuring a realistic matching of second moments and cross-correlations between output and lagged interest rate. They account for over 20% of output variability. When interest rate shocks are exogenously allowed to adversely induce productivity and collateral formation, the actual matching of the model improves further. Also, variance decompositions reveal a more important role for foreign credit sources, to the detriment of real domestic sources.

Moreover, the model nests properties of both closed-economy real business cycle models and standard SOE business cycle models. The latter models results from assuming the economy's ability to transform accumulating capital into collateral can be completely fulfilled. This is consistent with the assumption of perfect international credit markets. Under collateral specifications that reasonably replicate the steadiness of the debt to capital ratio and business cycle dynamics, the model overcomes typical anomalies of SOE models, which derive from weak intertemporal consumption substitution effects, and further improve its empirical matching.

Chapter 3 tackles the macroeconomic role and implications of country spreads. Consistent with the findings of Chapter 1, it provides additional evidence to support the role of the spread not only as a source of the excessive macroeconomic volatility, but also as a key propagator of shocks. The latter is specifically examined with regard to the interactions of the spread with the short term foreign debt to GDP ratio over realistic horizons of Brazilian fluctuations. On the whole, the empirical evidence suggests that the spread can be seen as an endogenous state variable affecting both credit and business cycles.

Therefore, the SOE model in Chapter 3 incorporates the spread as part of an endogenous credit constraint that permanently binds. Spreads are a function of the foreign debt to GDP ratio. The model is subject to independent productivity shocks and credit shocks from two sources: the risk-free international real interest rate, and the exogenous component of the country spread. Therefore, global disturbances to emerging economy real interest rates are represented and identified in a more comprehensive way than in the model in Chapter 2. The constraint is similar to an external financial premium, rather than a collateral constraint on foreign borrowing. In comparison to the model in

Chapter 2, amplification and propagation of shocks are further enhanced through an enriched intertemporal wedge. They also constitute a lasting debt-deflation mechanism (Fisher, 1933). An increase in the spread prompts a decrease in the debt ratio, thereby curtailing consumption and investments in a progressive way. In response to adverse temporary shocks, the economy can undergo deeper and more prolonged recessions than in the model in Chapter 2.

Both the US real interest rate and exogenous country spread shocks are equally important over business cycle horizons. Concurrent with productivity shocks, credit shocks have significant and sustained effects on business cycles, leading them and accounting for over 35% of the variability of output, consumption and investment. Calibrated for Brazil, the model replicates various second moments, potentially accounts for excessive spread and consumption volatility, and generates countercyclical interest rates.

Furthermore, the model helps to examine the country spread persistence, a feature common to other spreads in financial markets (Collin-Dufresne, 2001). A combination of endogenous and exogenous forces can determine such persistence. The exogenous forces relate to moderate or weak persistence in global credit markets, such as those affecting liquidity, uncertainties or risk appetite documented in Chapter 1. Endogenous forces derive from some inherent autoregressiveness in the spread, but mainly from the endogenous forces brought about by the financial accelerator.

The models in Chapters 2 and 3 manage to reconcile the distinguishing emerging economy regularities with macroeconomic theory thanks to a realistic combination of interest rate shocks and endogenous credit constraints. The propagating mechanisms that are implied in this approach suggest that the intertemporal wedge and disturbances play an important role, together with other shocks - such as those to productivity - that propagate rather conventionally through efficiency and labour wedges (Chari et al., 2006; Christiano et al., 2006).

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1

Global Credit Shocks, Real Interest Rate and Business Cycles in Emerging Economies

1.1 Introduction

Over the last few decades, small open emerging economies have exhibited a large degree of volatility in real and financial variables. Furthermore, their business cycles have been characterized by stylized facts that sharply contrast with the corresponding and better known facts of small open advanced economies (e.g. Agénor, McDermott and Prasad, 2000, Aguiar and Gopinath, 2007; Neumeyer and Perri, 2005). Namely, emerging economies have featured high, volatile and countercyclical real interest rates. As Frankel (2005) summarizes: "Apparently developing countries are different, or at least emerging market countries are. Figuring out why may amount to figuring out what aspect of these countries requires us to modify the macroeconomic models standardly applied to advanced economies".

This paper responds to such a challenge from an empirical viewpoint, focusing on the Brazilian case from 1994 to 2005. I suggest that global credit shocks can have a determinant role in emerging economy business cycles, and that they mainly transmit through the effects of real interest rates that emerging economies face in global credit markets. In this respect, country spreads can be specially crucial. They contain relevant information of the country's financial conditions, being a measure of the excess return of the country's real interest rate in relation to an international benchmark rate, such as the US short term real interest rate. I find that global credit shocks explain over 60% and over 50% of the variations of the real interest rate and the country spread, respectively. They also account for close to 50% of the variability in output, investment and real net export. Therefore, global credit shocks appear to be more important than shifts in fundamentals over realistic business cycle frequencies. The results are robust to the consideration of other domestic variables and transmission channels, such as those associated with the exchange rate and foreign debt dynamics. Overall, credit shocks, including unexplained innovations to the country spread, can be the strongest source of macroeconomic fluctuations.

These results are derived from an empirical strategy of vector autoregressive (VAR) models, with different blocks to address representations of global credit markets and the small open economy (SOE). In line with appropriate tests, I assume the latter block cannot influence the core of global markets. Therefore, the SOE is exposed to changes in the general economic and financial conditions that prevail at the core of global markets, and separate from the intrinsic business conditions of emerging economies. I identify relevant global credit shocks, resorting to recursive VARs, and analyse their effects on the real interest rate, especially through the country spread, and on real macroeconomic aggregates.

I systematically concentrate on three kinds of global credit shocks that disturb: (a) the world benchmark real interest rate; (b) the term premium in world real interest rates; and (c) the risk premium in world financial markets. In the spirit of Fama and French (1989), these variables contain relevant information about how credit is priced in view of fundamental changes in global credit and business conditions. Changes in world interest rates and in global term and risk premia offer a representation of how liquidity, uncertainty and risks are being perceived and shifted in global credit markets. Changes at the core of global credit markets are, therefore, allowed to affect emerging markets. In fact, the interest rates that emerging economies pay internationally are determined within imperfectly integrated global markets and are exposed to variations in returns, expectations, uncertainties and risks that arise from changes in the state of the world economy and finance.

The empirical VAR results indicate that changes in risks are as important as the overall changes in uncertainties and in the benchmark interest rate. Risk premium innovations account for about 40% and 30% of the variability of the country spread and interest rate, respectively. Movements in global uncertainties, implied by changes in the term premium, can be more important than a benchmark short term interest rate, because of: the international significance of uncertainties at the core of the global economy and financial markets; the implications of longer term financing to investment projects.

Furthermore, analysis of the empirical responses to shocks and variance decompositions of the country spread and of real aggregates consistently indicate that global credit shocks mainly transmit through the workings of the interest rate, in particular the country spread. Other possible variables, such as the exchange rate and foreign debt, and corresponding channels can only play minor and complementary roles, which are often induced by credit transmission mechanisms. On the whole, the results bring further support to the hypothesis that emerging economies might be subject to non-negligible international credit constraints. They suggest that it is key to understanding the macroeconomic implications of such constraints as mechanisms through which perturbations to the country interest rate propagate into the real economy.

This study is based on an unprecedented combination of monthly real and financial data at both international and domestic levels. The country of choice, Brazil, is not only a major emerging economy, it also reveals the same key contrasting regularities observed in many economies of this kind.[1] The analysis period (1994 to 2005) follows the country's re-entry into international capital markets. It encompasses important changes in global credit markets and global business conditions, as well as a number of domestic contractions and recoveries. Interestingly, the period also comprehends a shift from the semi-fixed (crawling-peg) exchange rate regime to a floating one in early 1999.

This paper relates to a vast literature in international finance that addresses the linkages between international capital markets and emerging economies (e.g. Calvo, 1998; Calvo at al., 1993, 1996; Obstfeld, 1998). In particular, it is associated with explanations of these linkages that highlight the role of international financial imperfections or shocks (e.g. Frankel and Roubini, 2001; Calvo, 2002; Mody and Taylor, 2002; Canova, 2005). These explanations challenge views that emerging market country spreads should be mainly determined by macroeconomic fundamentals and domestic factors, which include: international reserves, export or foreign debt ratios, terms of trade, and exchange rates (Edwards, 1984; Min, 1998). As Calvo (1998) and Eichengreen and Mody (1998, 2000), González-Rozada and Yeyati (2008) and Hartelius et al. (2008) show, variations

[1] See for instance Neumeyer and Perri (2005).

in country spreads are significantly affected by exogenous global financial factors, and they could hardly be explained only on the grounds of a country's fundamentals.

This debate has expanded to open macroeconomics, specifically with the purpose to reconcile the determinants of real interest rates with those of business cycles of emerging economies. Arellano (2005) and Aguiar and Gopinath (2007) try to explain real fluctuations as being driven by interest rates that are motivated by endogenous default probabilities. Neumeyer and Perri (2005) and Uribe and Yue (2006) explore the role of exogenous international interest rates in the determination of the country spread and macroeconomic fluctuations. The latter authors, in a panel VAR of six emerging economies, find that shocks to the US short term interest rate and the country spread account for about 20% and 10% of output variability, respectively.

I advocate that exogenous global credit sources, financial transmitters and propagators, via credit frictions, play a relevant role in driving emerging economy fluctuations. I supplement the existing literature by producing stronger and more significant evidence. In particular, I provide a deeper and more comprehensive representation of global credit forces, as well as an integrated framework for the analysis of the transmission mechanisms of global credit shocks through the country interest rate. There is a key interplay between the identification of global shocks and the role of the country interest rate in their propagation into the macroeconomy. Such shocks cause hump-shaped responses in output, which induce prolonged recessions and current account reversals in emerging economies.

As long as the economy has to rely on foreign credit and faces international credit constraints, there might be amplification and propagation of shocks through "financial accelerator" mechanisms. Although these constraints might derive from international frictions, their macroeconomic propagation could be analogous to those suggested in a closed-economy framework (Bernanke and Gertler, 1989; Bernanke, Gertler and Gilchrist, 1996; Kiyotaki and Moore, 1997). A worsening of world credit conditions triggers a rise in the country interest rate[2], hitting emerging economies through the mechanism of constrained borrowers, who confront higher financing costs and declining collateral or net worth.

[2]Persistence and sluggishness in financial markets have been more and more emphasized. See Cochrane (1999) for a general review. Collin-Duffresne et al. (2001) present evidence of persistence of spreads, in particular. Broner and Rigobon (2004) stress the persistent effects of shocks to capital flows into emerging economies.

Beyond the scope of this paper, international financial contagion can also affect emerging economies.[3] Here, however, I am principally interested in financial shocks that, regardless of their origin, arise at the core of world credit markets and whose implications are not confined to a class of country or market.

Section 1.2 presents the VAR analytical framework. Section 1.3 studies additional relevant aspects of the Brazilian case. Section 1.4 examines the role of world interest rate and term spread shocks. Section 1.5 incorporates innovations in world risk premium. Section 1.6 considers the exchange rate regime shift. Section 1.7 explores the exchange rate channel. Section 1.8 addresses the robustness of results to a variety of additional variables. Section 1.9 concludes.

[3]See Edwards (2000) and Kaminsky et al. (2003), who provide a review of the theories and findings.

1.2 Analytical framework

1.2.1 Conceptual framework

Small open emerging economies interact with world credit markets in a more vulnerable way than advanced economies. Often they tend to reveal structural weaknesses, such as underdevelopment of credit markets, and/or have to rely on foreign savings, while catching up with advanced economies.[4] Overall, these features can imply an inability of emerging economies to overcome international financial constraints (e.g. Caballero and Krishnamurthy, 2001). They are, therefore, prone to be more affected by shocks originating from global credit markets. I want to test such a hypothesis, as well as the hypothesis that these shocks are mostly transmitted to the real economy through the country interest rate. The latter is key in two main transmission mechanisms: (a) it is clearly dependent on changes in world credit conditions; (b) it is at the centre of a "financial accelerator" that affects the real economy. Both mechanisms serve to amplify and propagate the original global shock.

The country real interest rate, r_t, is the sum of an international benchmark (default free) real interest rate, r_t^*, and the country spread, s_t; that is $r_t = r_t^* + s_t$.[5] I am abstracting from nominal aspects and, therefore, assuming that world credit markets comprehend real return rates that can be derived from nominal rates denominated in world currency - the US dollar - minus the expected corresponding world inflation rate. The country-spread can often be as large as, and as variant as, the benchmark interest rate.

The emerging economy and its real interest rate are embedded in a world in which credit is realistically determined by global uncertainties, asymmetric information and varying risk aversion. In such a world, risky credits, such as those to emerging economies, are especially subject to changes in those global factors.

I model the emerging economy facing world credit markets in two steps. In the first step (Section 1.4), I represent world markets by simply a term structure of world interest rates. The country interest rate and the country spread are subject to varying benchmark international interest rates and global term spreads. For simplicity, I as-

[4]For a discussion of some of these aspects, see Aghion et al. (2004).

[5]The country real interest rate is similarly defined by Neumeyer and Perri (2005), and Uribe and Yue (2006) among others. The mentioned authors differ in assuming the benchmark rate as the one applied for risky assets and non-risky assets, respectively. In line with the latter authors, I avoid claiming independence of the country spread with respect to the benchmark interest rate and allow the country-spread to be exposed to changes in global markets.

sume the term structure has a linear form, so that the term spread (slope of the term structure) can be fully described by the difference between a long term interest rate and a short term interest rate, which is set as the benchmark rate. In the second step (Section 1.5), I incorporate possible innovations in global risk premium within the class of investment grade assets. Beyond the effects of shifts in global interest rates and corresponding uncertainties, changes in risk appetite or risk aversion can also influence the returns of risky assets, including emerging market assets. Therefore, the latter have returns and excess returns (country spread) that are affected by the current state and expectations at the heart of global credit markets that manifest in changes in returns and premia.[6]

Fluctuations in emerging market real interest rates around an equilibrium can be due to both endogenous and exogenous factors. The former typically includes changes in country fundamentals, while international sources eventually prevail among the latter.[7] Even those who recognize or support that country spreads reflect fundamentals also seem to agree that there is room for other determinants over business cycle frequencies that are not necessarily country specific (e.g. Kamin and Kleist, 1999; Ferrucci, 2003). Usually situated below investment grade, emerging economy assets are sensitive to changes in worldwide liquidity and risks. Perhaps investor heterogeneity, asymmetric information and costly evaluation are behind their sensitivity to global shocks. Such an argument has been put forward by Calvo (1998, 2002), who associates capital reversals and other typical emerging economy phenomena with high interest rates and high risk aversion in world markets. Therefore, the country interest rate might be pushed, over a reasonable period, beyond the equilibrium levels that would be consistent with domestic fundamentals.

Furthermore, in developing countries entrepreneurs, especially those who import machines and equipment, have to rely on external funds and international finance. In many cases such reliance is coupled with the underdevelopment of domestic financial markets and lack of currency convertibility.

The amplification and propagation of credit shocks into the real economy arise from changes in the interest rate (country spread), that produce analogous effects such as

[6]See Fama and French (1989) and Cochrane (1999) for a discussion on how returns, and term and risk premia can reflect credit and business conditions.

[7]Literature on developing economies usually analyzes international (exogenous) shocks of various sorts: oil price, terms of trade, global demand or productivity, and industrial country interest rates. See for instance Agénor et al. (1999), Frankel and Roubini (2001), and Canova (2005).

those associated with "financial accelerator" mechanisms. Both of the theories motivated by agency costs in Bernanke and Gertler (1989), and by collateral constraints in Kiyotaki and Moore (1997) are consistent with my arguments. A rise in the real interest rate (the country spread) aggravates the balance sheet and net worth problems of debtors who rely on external finance. In either credit friction mechanism, investment activity might be undermined, as argued by Gertler, Hubbard and Kashyap (1990).

1.2.2 Modelling framework

I model the VAR within three blocks. The first represents the world credit block and is characterized by the vector w_t^*. The second block consists of a single variable, the country spread, s. The third block represents the real side of the SOE and corresponds to the vector w_t. Therefore, the VAR has therefore the following structure:

$$A \begin{bmatrix} w_t^* \\ s_t \\ w_t \end{bmatrix} = \sum_{l=1}^{T} C_l \begin{bmatrix} w_{t-l}^* \\ s_{t-l} \\ w_{t-l} \end{bmatrix} + B\varepsilon_t$$

where $A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix}$, $C_l = \begin{bmatrix} C_{11,l} & C_{12,l} & C_{13,l} \\ C_{21,l} & C_{22,l} & C_{23,l} \\ C_{31,l} & C_{32,l} & C_{33,l} \end{bmatrix}$, B an identity matrix and ε_t is the vector comprising the error terms.

The dynamics of the first block are assumed exogenous.[8] Therefore, I set $A_{12} = A_{13} = 0$ and $C_{12,l} = C_{13,l} = 0$ for all $l = 1, ..., T$. The global variables entering the w_t^* vector are short term and term premium interest rates (see Section 1.4). A measure of global risk premium is also included in vector w_t^* in Section 1.5. As in Uribe and Yue (2006), three real variables enter the third block: domestic output, investment and an export-import ratio, which works as a proxy for the current account position. Such a parsimonious structure is enough to capture the core of business cycles in SOEs. The country spread is determined by past and current values of variables in the first and third blocks, as well as by past values of itself: $s_t = s\left(\left\{w_{t+1-l}^*\right\}, \left\{w_{t+1-l}\right\}, \left\{s_{t-l}\right\}\right)$, $l = 1, ..., T$. Other variables could be added to w^* and w_t, so as to allow for better

[8]This assumption, which is examined in Appendix 1.D, is widely used in both theoretical and empirical literature of SOEs. See for instance Genberg et al. (1987), Cushman and Zha (1997), Canova (2005), and Uribe and Yue (2006).

identification of global shocks and greater degree of endogeneity of the country spread, respectively. However, they do not interfere with the main results. For the sake of simplicity and dimensionality, I keep the modelling specification parsimonious in all blocks.

It is worth noting that there are two possible block recursive identifications of A with respect to the causality of w_t and s_t, given the exogeneity of w_t^*. The country spread can only be contemporaneously affected by the world credit markets: $A_{23} = 0$. Alternatively, it can also be affected by the country's macroeconomic variables, while not simultaneously affecting the latter: $A_{32} = 0$. In this second case, it would be coherent to restrict the impact of all sources of credit altogether, by setting $A_{31} = A_{32} = 0$. This would be consistent with the hypothesis that all forms of credit can only affect real aggregates with some lag.

These two recursive identifications could, in theory, have different implications. Nevertheless, they qualitatively and quantitatively generate equivalent results for both country spreads and the real economy.[9] For simplicity, I maintain the identification of $A_{23} = 0$ as the baseline, and occasionally refer to the alternative. My preference for not assuming contemporaneous causality from real aggregates to country spread is also motivated by the fact that the probability of rejecting the restrictions of the second identification is higher than that of the first one.

[9] See also the discussion on robustness to order of blocks in Appendix 1.C.

1.3 Brazil and world credit markets

1.3.1 Motivation

The monthly analysis of Brazil from 1994 to 2005 is motivated by various reasons. First, it is a key emerging economy, which on average accounts for about 50% (34%) of the total GDP of South America (Latin America). At the same time, Brazilian bonds have had the highest weight in the EMBI Global, equivalent to 21% (32%) of its total (Latin American) capitalization. Despite its relative regional and global importance among developing economies, Brazil's limited participation in global trade (1%) and in global foreign direct investment (1.3%) is consistent with the proposition of a small open economy.[10]

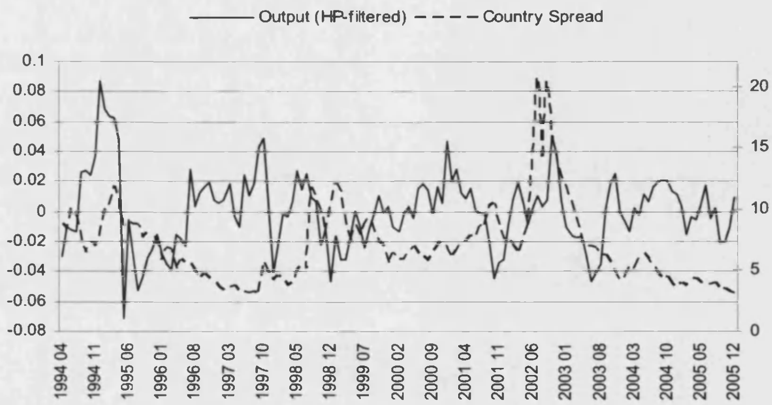
Second, Brazil pursued considerable trade and financial openness, according to its own historical standards, from 1991 to 1994. The average nominal import tariff, which peaked in the eighties at 31% (in 1986), was reduced to 12% in 1993, and thereafter it has been at an even lower level. By the mid nineties, the country re-emerged in international capital markets, after concluding foreign debt negotiations with official and private creditors in 1992 and issuing Brady bonds in April 1994. Since then, interactions with global credit and capital markets have expanded in various forms. A more open market economy has also been supported by economic reforms, including privatization, labour market flexibility and the achievement of more stable monetary and fiscal policies. Despite the currency crisis of 1999 and the fearful response of creditors during the electoral process in 2002, the economy has kept its commitment towards macroeconomic stability and market-friendly reforms. Moreover, no foreign debt default was registered over the analysis period.

Third, pronounced fluctuations in Brazil's real activity and interest rates (country spreads) are observed between 1994 and 2005. Its industrial product has been about 3 times more volatile than that of the US.[11] Moreover, as Figure 1.1 depicts, at least four real contractions have been observed, in which monthly industrial product dropped between 4% and 8% below the trend. These movements in real activity were preceded and/or accompanied by increases in country spreads to the order of 800 basis points.

[10]Participation in global trade and regional GDP (in PPP terms) are calculated as an average of annual data from the World Bank Indicators between 1994 and 2004. Participation in global FDI is calculated from UNCTAD's statistics on inward and outward flows from 1990 to 2000. Brazil's share in inward (outward) flows is 2,4% (0,2%), showing its long term reliance on net foreign capital.

[11]Author's calculation of standard deviations of natural log of Hodrick-Prescott filtered (λ=14400) monthly series of industrial output for both countries over the period of study.

FIGURE 1.1. HP-filtered Output and Country Spread.



Variables are expressed in percentage points. Output is Hodrick-Prescott detrended. Vertical axes refer to output on the left side, and country spread on the right side. Units on the horizontal axis represent months.

Fourth, such Brazilian fluctuations may be associated with global credit factors, reflecting changes in international liquidity, uncertainty and risk appetite or perception at the core of global markets. This period coincides with a series of global events: high US interest rates, both short and long term, even in the years after the Asian crises; the LTCM crisis, coupled with the Russian crisis in the end of 1998; the completion of the longest expansion of the US economy and the subsequent drastic, though temporary, recession in 2001; significant upward and downward corrections in stock markets, at a large scale and, in particular, within relatively riskier industries; and a few corporate crises, such as that of Enron in November 2002. Only a couple of years later, risk appetite returned to the predominant levels before the LTCM and Russian crises. Of course, emerging market crises in Mexico (1994-95), Asia (1997), Russia (1998-99) and Argentina (2001) might have affected Brazil through financial contagion.[12]

Fifth, the vast majority of these events and crises can be viewed in principle as being independent from Brazil's macroeconomic fundamentals. The Brazilian currency crisis in 1999 cannot be seen as an event of global consequences, at least not in the same way as some crises in Asia and Russia were. Even from the perspective of regional markets, the effects of the Brazilian crisis were limited and felt relatively more due to trade rather than financial contagion *per se*. Furthermore, the country spread rise during the presidential electoral process in 2002 is well understood as a very country

[12]Contagion, which is not specifically studied here, can transmit directly or indirectly through the core of global credit and capital markets.

specific phenomenon, despite being subject to adverse conditions in global markets at that conjuncture.

TABLE 1.1. Business Cycle Summary Statistics of Small Open Economies: 1994-2001.

Economy(ies)	Real Interest Rate (r)			GDP	
	% *mean*	% $\sigma(\ )$	$\frac{\sigma()}{mean}$	% $\sigma(\ )$	$\rho(\ ,r)$
Brazil	12.94	2.34	0.18	1.76	-0.38
Emerging	11.55	2.32	0.20	2.79	-0.55
Advanced	8.81	1.66	0.19	1.37	0.20

Table 1a

Economy(ies)	Investment		Consumption		Net Export to GDP	
	$\frac{\sigma()}{\sigma(GDP)}$	$\rho(\ ,r)$	$\frac{\sigma()}{\sigma(GDP)}$	$\rho(\ ,r)$	% $\sigma(\ )$	$\rho(\ ,r)$
Brazil	3.05	-0.12	1.93	-0.39	1.40	-0.02
Emerging	3.29	-0.48	1.30	-0.55	2.40	0.51
Advanced	3.44	0.21	0.92	0.24	0.92	-0.22

Source: Neumeyer and Perri (2005) and author. Emerging economies comprise Argentina, Brazil, Korea, Mexico and the Philippines. Advanced economies include Australia, Canada, the Netherlands, New Zealand and Sweden. All series are originally expressed in natural logarithmic and are Hodrick-Prescott filtered, with the exception of interest rate and net export to GDP ratio. $\sigma(\ )$ and $\rho(.,r)$ stand for standard deviation and contemporaneous correlation with real interest rate.

Finally, as Table 1.1 suggests, Brazil is a very representative case, in that it shares emerging economy regularities that contrast with those of advanced economies, with regard to the behaviour of the real interest rate and to the way it interacts with fluctuations in real macroeconomic activity.

1.3.2 Data

The use of monthly data, rather than quarterly data, further distinguishes this work from others, particularly in the related macroeconomic literature. Monthly data is a good compromise to study the interactions between financial and real variables, in particular when credit and business cycles tend to have higher frequencies than usually expected.

The data, details of which are in Appendix 1.A, encompasses 141 monthly observations from April 1994 to December 2005. For Brazil, it consists of the country spread and real variables that describe the core macroeconomic system. Real variables are industrial product, investment in machines and the ratio of real exports to imports. The first two are seasonally adjusted and expressed in natural logarithms. The export-import ratio is the ratio of their real indexes. Country spread is expressed in percentage point values and comes from the EMBI Global index of international sovereign bonds.

Spreads of this sort are widely regarded as a reference for both private and public borrowing in world capital markets.[13]

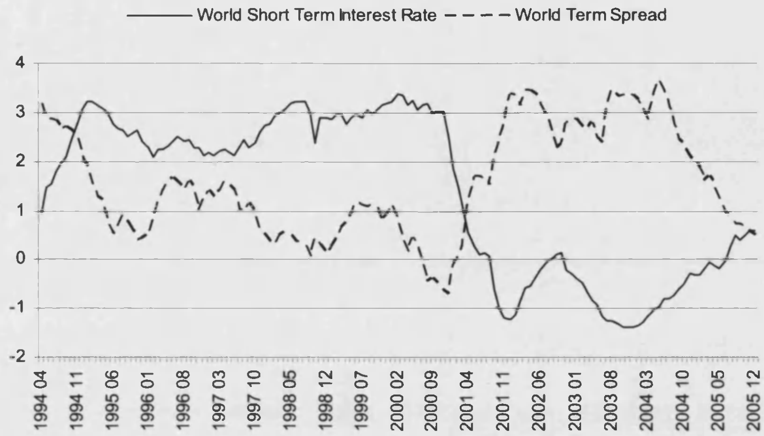
Unit root tests of the series reject the hypothesis that Brazilian output and investment are non-stationary, once a linear trend is added. The export-import ratio and country spread are treated as stationary, although they could not be rejected as being non-stationary. These variables are affected by the poor power of unit root tests, which might exacerbate some "nonlinearities" associated with the 1999 currency crisis, the move from a crawling peg regime to a floating exchange rate regime, and mounting country risk perceptions over the 2002 presidential electoral process.

In the world credit block, the short term real interest rate, which is shown in Figure 1.2, is measured as the US 3 month Treasury bill nominal interest rate minus the average of the past 12 months of CPI inflation. The term spread, which is also depicted in Figure 1.2, is measured by the difference between the rates of the 10 year and 3 month US Treasury bills. The proxy for global risk premium is the spread between the BAA and AAA Moody's corporate bond yields, which is shown in Figure 1.3. All data are maintained in percentage values. Individual unit root tests of the series failed to reject nonstationarity for the US short term interest rate. In order to reconcile this with the expected stationarity of the interest rate, I consider possible nonlinearities in the sample. Actually, both nominal and real interest rates appear to have shifted to a lower stationary level around March 2001, the month that coincides with the end of the longest post-war expansion in the US, according to the NBER's business cycle chronology. Additional support for this comes from the fact that over 2001 the Federal Reserve drastically reduced the federal funds, by 50 basis points in three unscheduled meetings (January, April and September).[14]

[13]In an empirical study of South African corporate bond yields, Peter and Grandes (2005) find that the sovereign premium is the key determinant of corporate bond premia. They, together with Durbin and Ng (2005), report few exceptions to a sovereign ceiling in emerging markets, in cases of firms with substantial export earnings and/or a close relationship with a foreign firm, or with the home government.

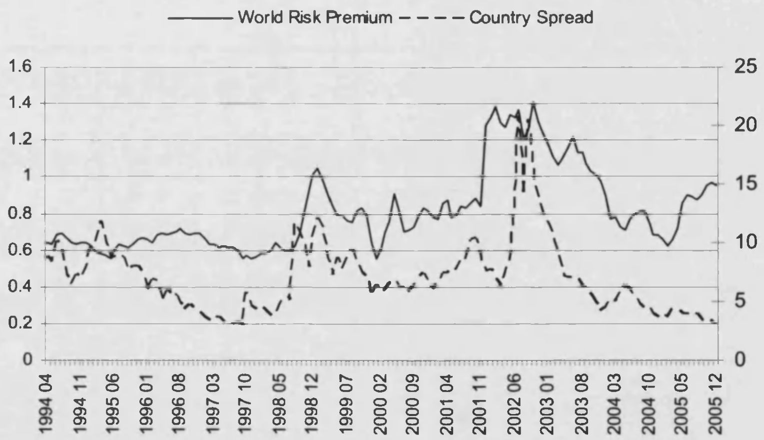
[14]These were the only unscheduled meetings over the period of analysis.

FIGURE 1.2. World Short Term Interest Rate and World Term Spread.



Variables are given in percentage points. Units on the horizontal axis represent months.

FIGURE 1.3. World Risk Premium and Country Spread.



Variables are expressed in percentage points. World risk premium and country spread are represented on the left and right sides, respectively. Units on the horizontal axis represent months.

1.4 Global shocks: interest rate and term spread

I examine the interplay between the short and long ends of the term structure of world interest rates and their effects on the country interest rate (country spread), and on its real activity. There are many reasons and advantages in proceeding so. First, it adds generality and robustness in the analysis of the implications of world interest rates for emerging economies. Often only one interest rate has been used previously.[15] Second, shocks to the term structure gather a lot more information than a single end, being a natural step to study the implications of changing liquidity, uncertainties and expectations in world real business and credit cycles. Specifically, the slope of the curve has been viewed as a good forecaster of business cycles (Estrella and Mishkin, 1998; Stock and Watson, 2003), as well as a predictor of bond and stock returns (Fama and French, 1989). Third, it is realistic to consider shocks to both short and long term world interest rates, since they have specific and distinct appeals to different types of creditors and borrowers. For instance, global investors might borrow in international markets to lend to emerging economies at different maturities, and entrepreneurs in emerging economies might have financial needs for short term working capital and long term investments.

Furthermore, shocks to world short and long term interest rates impact on the emerging economy interest rate both directly and indirectly. The direct effects relate to their status as benchmark interest rates for different purposes. World short term rates impact emerging economies through standard monetary and related channels. In addition, these economies rely on short term borrowing more often than advanced economies, especially in times of credit crunch (Broner et al., 2007). World long term interest rates matter directly as they are the benchmark cost to finance long term fixed capital investments, through importation of machines and equipment. This aspect has been especially relevant for many Latin American countries, which have promoted investment and growth through the running of sustained current account deficits, in contrast to some Asian economies that have managed to develop an export-led growth strategy. Furthermore, emerging economies have tried to lengthen the term structure of their own outstanding debt through long term borrowing.

[15]For instance, Uribe and Yue (2006) study the effects of the world short term interest rate (3 month US Treasury) on the country spread and real activity. Conversely, Eichengreen and Mody (1998) use a long term rate (10 year US Treasury) to analyze its impact only on country spreads.

In an indirect way, world short term and long term rates mainly affect the emerging economy through the country spread, although the exchange rate and other macroeconomic variables might be sensitive to them (see Sections 1.7 and 1.8). Emerging economies might respond to changes in the world short term rate more intensively than small open advanced economies, due to policy considerations of interest rate differentials and the search for yield strategy by investors that can affect capital flows and currency stability. Both short and long term rates matter in this regard, and their respective absolute and relative magnitude might be relevant to country spread determination. For instance, during times of low short term interest rates there is usually a renewed involvement in lending to emerging economies. However, the precise intensity of such involvement might be conditional on the relative level of the long term interest rate, and the country-spread should reflect that.

Finally, the consideration of both short and long ends should be recommended on empirical grounds, since the country spread is a weighted average of excessive yields at different maturities. Ideally, we should envisage the effects of a world term structure on the term structure of the country spread, by also allowing the latter to vary with maturity. For simplicity, and due to the underdevelopment of emerging market term structures, I assume that the country spread is a measure that is invariable with maturity.[16]

1.4.1 Specification

The system is specified with all variables in logarithmic levels, and it includes an intercept and a time linear trend. I assume that, of the six selection criteria most commonly used in applied work, the Akaike Information Criterion (AIC) tends to produce the most accurate indication of the lag order for monthly VARs (Ivanov and Kilian, 2005).[17] Based on the hypothesis that a true order is at the maximum of 24 lags, the AIC suggests an order of 4 lags for the world block and 3 lags for the Brazilian block. Taking into consideration that the main interest is to identify world shocks and that a monthly VAR should be more conservative than lower frequency VARs, I focus

[16]Broner et al. (2007) show that in normal times the country spread does not vary with the maturity of the interest rate. Exceptionally, in crisis times the long term country spread distance itself from the short term spread, due to mounting risk premia, as in Brazil in 2002. Even though, this exceptional movement in the long term spread reflects exclusively trading in secondary markets and not new long term credit instruments. Therefore, a single measure (weighted along different maturities) of the spread looks a reasonable simplification for my purpose.

[17]They comprise the Akaike Information, Schwartz Information and Hannan and Quin Criteria and traditional Likelihood tests.

on a specification with 4 lags.[18] Two shift dummies are added to address the shift in the exchange rate regime in Brazil in January 1999 and at the end of the US business cycle in March 2001. [19] In line with the exogeneity assumption, I restrict the coefficients on the Brazilian variables and the country spread to zero in the world block equations (w^*).

1.4.2 Identification

The world block comprises the US real short term interest rate, r_t^*, and the US term spread, q_t^*, measuring the difference between the long and short term rates. It is simply expressed as $w_t^* = \begin{bmatrix} r_t^* & q_t^* \end{bmatrix}'$.

The term spread, q_t^*, has been seen as a good forecaster of economic activity and also as useful information for both policy makers and credit market participants. In tandem, its use in monetary analysis and term structure analysis has been widespread (Gertler and Lown, 1999; Stock and Watson, 2003). Of course, the identification of the innovations in both interest rates could be sought in a more comprehensive system. However, I opt to identify them in the most parsimonious (bivariate) way, for the sake of both tractability and objectivity.[20]

I recursively identify the world credit shocks by assuming that A_{11} is lower triangular. This is motivated by the belief that the world monetary policy authorities, who influence the short term end, can also affect the long one contemporaneously. Regardless of their origin or nature, shocks to the long term rate would only affect the short term rate with some lag. Such a recursive ordering has been widely explored and supported by the view that information variables and financial variables should be placed after the short term interest rate (Leeper et al., 1996; Christiano, et al., 1998). I acknowledge that, in a recursive VAR with monthly data for short and long term interest rates, the ordering is arguably subject to controversies (Cochrane and Piazzesi, 2002). However,

[18]In the monetary and financial VAR literature, the lag length for monthly data is usually set at six or twelve months. In this study, a higher order implies a greater role of global credit variables in the variability of real aggregates. At the same time, the effects of these variables on the country spread variability, as well as those of the latter on the variability of real aggregates, are weakened. I also find that 4 lags perform better than lower order specifications in providing a balance between the indication of information criteria tests and the avoidance of autocorrelation of residuals in the multivariate setting.

[19]A dummy for January 1997 is also added, only for the equation of the ratio of export to import, which shows a clear outlier on that date, regardless of any seasonal adjustment.

[20]For the purpose of identifying real interest rate shocks, such a simple specification does not differ from more comprehensive ones, which seeking to identify nominal rate shocks explicitly include output and a price index. In fact, with the use of monthly data, many studies do not overcome the "price puzzle", even with the inclusion of a commodity price index.

the results regarding the country spread and other Brazilian variables are invariant to the order.[21]

1.4.3 Empirical analysis

1.4.3.1 Impulse responses

Figures 1.4-1.7 respectively show recursive VAR impulse responses to innovations in the world short term interest rate, global term premium, country spread and output. A positive shock of 15 basis points to the world short term real interest rate (which could be due to a monetary tightening) increases the country spread (see Figure 1.4). The spread response is positive and significant within 2 to 8 months, reaching a peak of 40 basis points around 4 months after the shock. It is faster, more realistic and statistically more significant than previously documented with quarterly data. Contrastingly, Uribe and Yue (2006) do not exclude zero within their confidence interval and reveal a rather delayed peak around 5 quarters after the shock.[22]

Both output and investment react negatively to a positive world short term interest rate shock. Their troughs indicate significant deviations of 0.4% and 1% from the equilibrium path. A sensitive variable to the cost of borrowing, investment is affected by the shock more rapidly than output. It reaches the trough in about 8 months, and output in about 11 months. Output exhibits a rise before it declines, but the phenomenon is short-lived. Using quarterly data, Canova (2005) finds such an output rise for a sample of Latin American countries, and understands it as being part of the monetary and financial transmission of US (nominal) interest rate shocks. Conversely, here such a rise is relatively less pronounced than the following decline. Moreover, it is not within statistically significant confidence intervals. On the whole, this result, which is robust to the inclusion of US output in the identification of global shocks, suggests foreign demand or international trade channels are much less important than credit channels over business cycle frequencies.

World term spread shocks of 20 basis points augment the country spread by 45 basis points (see Figure 1.5). They reduce output and investment by about 0.6% and

---

[21] The impulse responses are virtually identical. The aggregate contribution of the global shocks is invariant, due to the block-recursive structure that places the world block first. Specific contributions of short and long term rate shocks in the variance decompositions are shown in Appendix 1.B for the alternative order q^* r^*.

[22] A quick response is in line with the search for yield hypothesis in global financial markets. In an event study with hourly data, Robitaille and Roush (2005) find that at least unanticipated changes in US interest rates have an impact on the Brazilian C-bond, the mostly traded bond included in Brazil's EMBI index.

1.3%, respectively. The responses of these real variables to term spread shocks are quantitatively equivalent to the their responses to short term interest rate shocks. Nonetheless, the former responses come slightly later (from 1 to 3 months) and last longer than the latter. The dissimilar timing of the responses is particularly noticeable in investment. Shocks to the world term spread distinctively rely on the dual role of this variable: as a forecaster of future short term rates, and as a long term benchmark for emerging economies seeking long term credits in global markets. That is why the further propagation of term spread shock over time cannot merely be explained in terms of its implied transmission via perturbations of the global short term rate.

Country spread shocks of 130 basis points lead to falls of about 0.4% in output and 0.8% in investment (see Figure 1.6). The negative effects on real aggregates are significant and propagate over 18 months. However, in terms of their amplitude, they are less pronounced than those caused by world interest rate and term spread shocks. Therefore, country spread can not only be an independent source of fluctuations, but can also be a key variable in further transmitting global credit shocks. The latter affect the economy directly via benchmark costs for short and long term credits, and indirectly via the effects on the country spread.

Overall, Figures 1.4-1.6 indicate that the three examined credit shocks cause output and investment responses that are consistent with recession and recovery patterns. In particular, these responses reveal output growth dynamics in which a recession (expansion) is characterized by successive drops (rises) in output in relation to the equilibrium trend.

Credit shocks are also inclined towards generating an improvement in the current account or trade balance, which are proxied by the export-import ratio. These variable responses are particularly fast and significant for country spread and short term interest rate shocks. They can be explained by the fact that rises in the country short term interest rate trigger higher saving rates. The responses to term spread shocks initially show a worsening of the trade balance, which is reminiscent of a "J-curve" pattern.[23]

As shown in Figure 1.7, the responses to favorable output shocks reveal patterns with regard to real aggregates that are common to those either documented in other

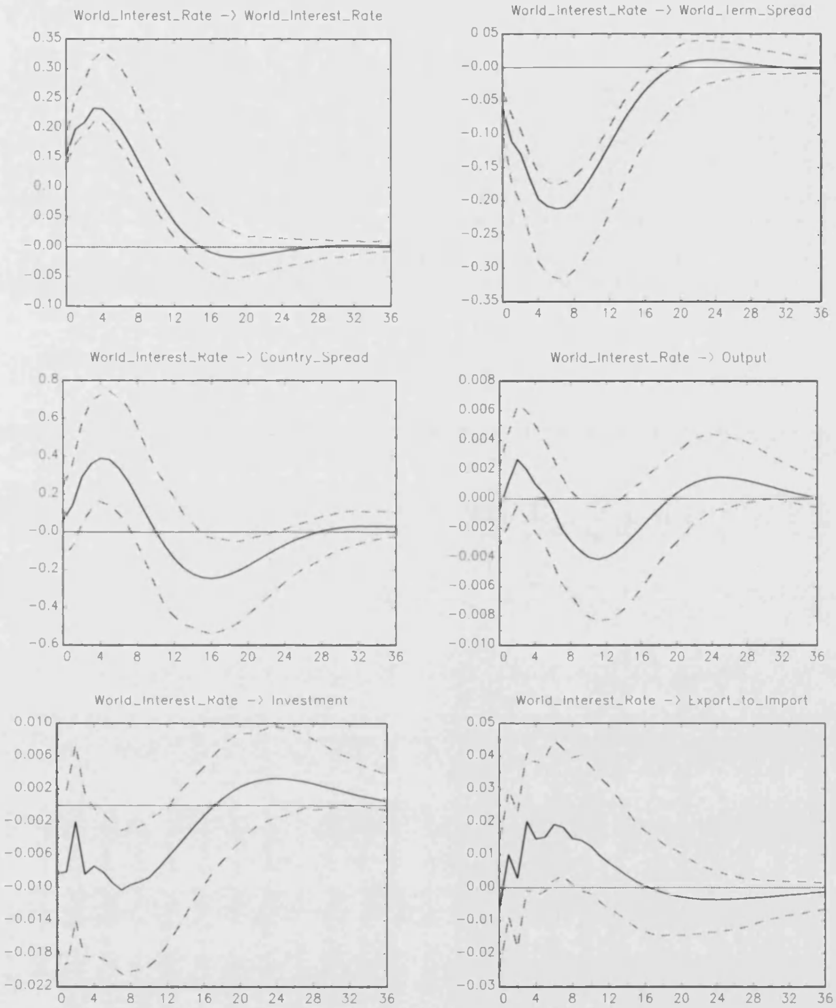
[23] By the "J-curve" hypothesis, a real exchange rate depreciation initially worsens the trade balance, but over time improves it (Rose and Yellen, 1989). As I show in Section 1.7 (Figure 1.18), the exchange rate depreciates following a term premium shock. As I argue, such a transmission is more pronounced due to the credit effect, which exacerbates the exchange rate effect. Cushman and Zha (1997) find an inverted "J-curve" to domestic monetary shocks for Canada.

empirical studies or simulated in a standard SOE model. However, the persistence of the temporary effects of the shocks is much lower than typically estimated or assumed: output and investment return to equilibrium levels within 8 months (3 quarters).[24] The country spread initially falls and suggests that, to some degree, improvement of fundamentals can lower the country risk. Later, however, the spread rises over a relatively long period. This response indicates the economy is subject to credit cycles, and that they might considerably affect and eventually cause business cycles. An underlying reason for this phenomenon relates to the hypothesis that the economy is permanently credit constrained, in particular that it is systematically dependent on foreign credit to sustain investments and imports that follow a rise in output. For the most part, the facts suggest that a recovery in credit confidence cannot be sustained on the basis of domestic performance. When driven by real shocks, the latter appears to be more limited and less persistent than the real damage caused by the worsening of credit conditions.[25]

[24] For instance, in Uribe and Yue (2006) the responses are about halfway from equilibrium levels after 3 quarters and only return to them after 10 to 20 quarters.

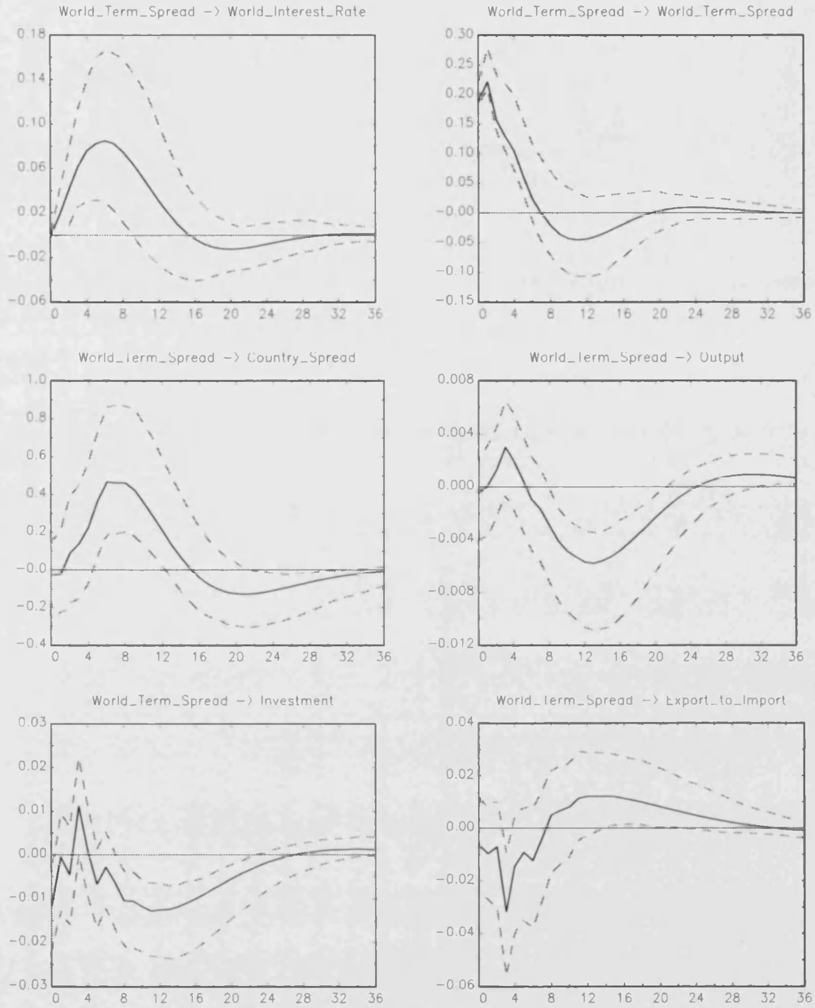
[25] An alternative explanation would require the recognition of a temporary persistence of output, as well as other domestic and possible productivity shocks. In a even more pronounced way, the same cyclical pattern arises in responses to investment shocks.

FIGURE 1.4. Impulse Responses to a World Interest Rate Shock.



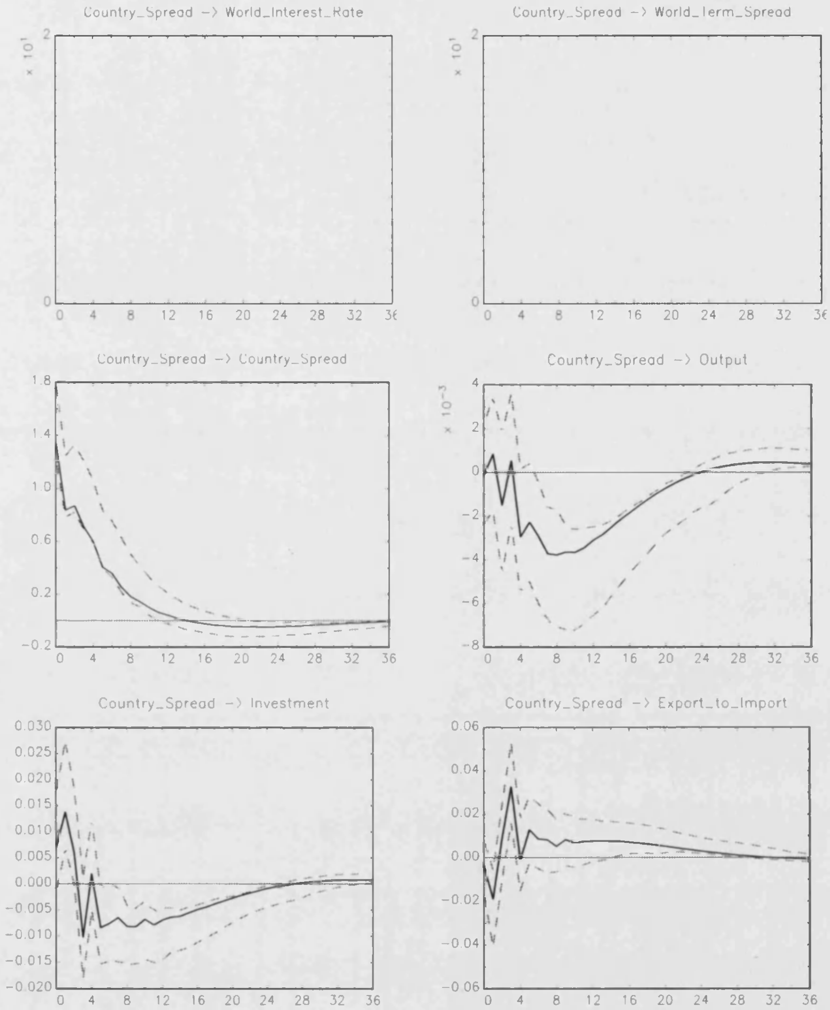
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.5. Impulse Responses to a World Term Spread Shock.



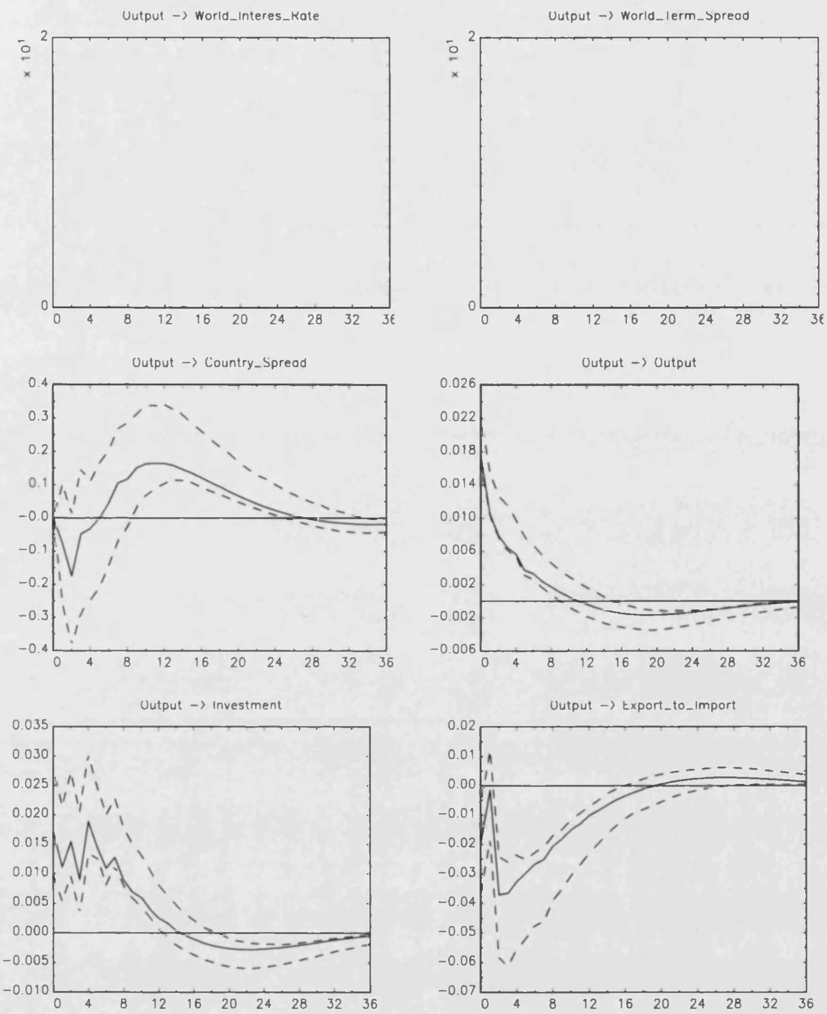
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.6. Impulse Responses to a Country Spread Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.7. Impulse Responses to an Output Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

1.4.3.2 Variance decomposition

Table 1.2 shows variance decompositions of dependent variables, which are listed in the first column. Table 1.3 presents the combined effects of global credit shocks and the total effects of all types of credit shocks. The latter totals the global effects and those caused by country spread shocks. Variance decompositions are reported for 12, 36 and 72 months (4, 12 and 24 quarters or 1, 3 and 6 years).[26] Recall that in my recursive block ordering the country spread is placed just after the world credit block. Appendix 1.B documents an equivalent Table (1.14) for the order in which the country spread comes last.

Exogenous credit innovations account for over 30% of the variability of the country spread in realistic business cycle horizons, from 36 to 72 months. Exhibiting a fast propagation of shocks in financial markets, they explain close to 30% of the country spread variation over the shorter 12-month horizon. Most of the remaining variation is attributed to independent country spread shocks: 63% over 12 months, and 56% from 36 to 72 months. Shocks to domestic real variables can only account for 11% to 12% of the spread volatility. Output, investment or export-import ratio do not play, either individually or collectively, a role as significant as that of the exogenous global credit forces. The latter accounts for 44% of the variability in the country short term interest rate ($r^* + s$), and 55% of the variability in the country long term interest rate ($r^* + q^* + s$).

Exogenous interest rate shocks are also responsible for close to 30% of the variation in real output and investment. Altogether, exogenous credit innovations (including country spread shocks) determine over 35% of the variability of these real aggregates. Also taking into consideration the corresponding impulse responses, we can argue for a strong causality running from global credit markets to the real performance of the emerging economy. Interestingly, term spread shocks have a more prolonged effect on real variables than short term interest rate shocks and, therefore, tend to account for a relatively larger share of the real variability. This latter result can be slightly sensitive to the order that is chosen for the identification of the global block.[27]

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[26]Typically, business cycle frequencies are within 18 to 96 months (6 to 32 quarters), especially for the US. As Brazilian cycles are shorter on average, I consider slightly higher frequencies. Therefore, we can reasonably account for short run variations (12 month forecasts) and detect excessive decompositions in favor of credit innovations over different horizons. As shown in Table 1.2, variance decompositions are usually invariant between 36 and 72 months, reassuring us of the robustness of the results and the short span of the cycles.

[27]See Appendix 1.B.

The export-import ratio accounts for 20% of the variability of output at all relevant horizons. Despite being a major force in understanding the real dynamics, it is less important than any exogenous global source in explaining the country spread variation over realistic business cycles.

TABLE 1.2. Variance Decompositions for the Recursive VAR.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)					
	r^*	q^*	s	y	i	x
r^*	89 89 89	11 11 11	-	-	-	-
q^*	70 71 71	30 29 29	-	-	-	-
s	10 15 15	16 17 17	63 56 56	02 03 03	04 03 03	05 05 05
y	07 09 09	09 20 20	09 09 09	54 40 40	01 01 01	20 21 21
i	09 09 09	10 17 17	09 10 10	20 17 17	49 40 40	03 07 07
x	07 07 07	06 09 09	06 07 07	22 21 21	05 04 04	55 52 52
r	23 25 25	19 19 19	50 46 46	01 01 01	03 03 03	05 05 05
$r+q^*$	08 17 17	38 38 38	46 37 37	01 01 01	03 03 03	05 05 05

Note that r^* and r^*+q^* stand for world short and long term real interest rates, respectively. r and $r+q^*$ represent the country's short and long term real interest rates. As previously defined, $r = r^* + s$.

TABLE 1.3. Variance Decompositions for the Recursive VAR and the credit effecs.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
s	26 32 32	89 88 88
y	16 29 29	25 38 38
i	19 26 26	28 36 36
x	13 16 16	19 23 23
r	42 44 44	92 90 90
$r+q^*$	46 55 55	92 92 92

Note that r^* and r^*+q^* stand for world short and long term real interest rates, respectively. r and $r+q^*$ represent the country's short and long term real interest rates. As previously defined, $r = r^* + s$.

1.4.4 Single identification of world interest rate shocks

I compress the term structure into a single world interest rate within the global credit block and thus study the individual impact of short term and long term rates, as previously analyzed (e.g. Eichengreen and Mody, 2000; Uribe and Yue, 2006). The responses of each interest rate shock are equivalent to those resulting from a bivariate identification. The only noticeable change is in variance decompositions, which are presented in Tables 1.4 and 1.5. The comparison of these Tables with Tables 1.2 and 1.3 demonstrates that the relevance of exogenous credit shocks is strengthened when both interest rates are placed in the system.

VAR models with a single interest rate enhance the role of the country spread and the domestic real variables over business cycle horizons. When I use the world short term interest rate, the results are similar to those in Uribe and Yue (2006), except that I find a slightly more (less) important role for shocks in the country spread (the interest rate). They find that innovations in the short term interest rate and in the country spread each explain about 20% and 12% of the output variability, respectively. I find that any benchmark rate (short or long) and the country spread are jointly responsible for close to 30% of real macroeconomic volatility over 36 to 72 months. 87% of the country spread variation can be explained by innovations in country spread and in a single world interest rate.

Similar to the model with bivariate identification of global shocks, models with a single interest rate result in slightly stronger effects to long term interest rate shocks than to short term ones with regard to the variability of the country spread and the real aggregates, and investment in particular. These results are consistent with the facts that aggregate activity and investment are specially affected by uncertainties and long term financing tightening, and that the country spread is proxied by an index composed of maturities closer to 10 years than to 3 months[28].

On the whole, it is clear that both the world short and long term real interest rates matter both in individual and joint terms.

TABLE 1.4. Variance Decompositions for the Recursive VAR: world short term rate.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	World credit effect $w^* = r^*$	Total credit effect $[w^*, s] = [r^*, s]$
r^*	100 100 100	100 100 100
s	18 20 20	89 87 87
y	09 16 16	24 28 30
i	10 12 12	25 28 28
x	04 04 04	14 14 14

[28] In the Brazilian case, the weighted maturity of the EMBI indexes has been around 10 years.

TABLE 1.5. Variance Decompositions for the Recursive VAR: world long term rate.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	World credit effect $w^* = r^* + q^*$	Total credit effect $[w^*, s] = [r^* + q^*, s]$
$r^* + q^*$	100 100 100	100 100 100
s	21 26 26	85 87 87
y	08 17 17	18 27 27
i	12 19 19	22 29 29
x	03 07 07	11 15 15

Note that $r^* + q^*$ stands for world long term real interest rates.

1.5 Global Shocks: Risk Premium

In this Section, I introduce a proxy for the risk premium, z_t^*, within the global credit block, w_t^*. The main purpose is to identify other global credit shocks that are orthogonal to innovations originating from the world short and long term interest rates. In particular, emerging economies face not only shocks to global liquidity and uncertainty, but also innovations that affect risk appetite in global markets.

The latter innovations can particularly alter credit conditions with respect to assets that are sensitive to changes in risk attitude. Emerging market credits have been viewed as a specialized class of risky assets. The incorporation of global risk premium is a realistic step in understanding credit and business cycles of emerging economies. As suggested by Calvo (1998, 2002), changes in risk perceptions and liquidation of risky assets at the core of global credit markets can be excessively painful for emerging economies.

Recent empirical studies have taken steps in this direction, addressing the financial linkages between emerging and global markets. McGuire and Schrivers (2003) conclude that emerging market spreads are subject to a single common factor that on average accounts for about one third of their movements. They conjecture that this common factor is mostly related to the degree of risk aversion in international credit markets. Ferrucci (2003) understands that capital market imperfections, such as variant risk appetite, might be an important cause for short term misalignment of spreads from a theoretical equilibrium level, although the latter can be mainly determined by macroeconomic and prudential indicators.

In addressing both the financial and macroeconomic implications of global risk premium shocks, I advocate that we need an instrument that has deeper roots in global risk attitudes than those previously used. For instance, Gertler and Lown (1999), Mody and Taylor (2003), and González-Rozada and Yeyati (2008) choose the US high-yield bond spread as the proxy for the risk premium. In Gertler and Lown, the use of the latter variable is justified as a proxy of the external financing premium of agents. Nonetheless, in my case, I need a fundamental variable in global credit markets that is independent from emerging markets and from the effects of international financial contagion among typical risky assets.[29]

[29] With regard to emerging market contagion, see Kaminsky et al. (2003) and Rigobon (2003), who deals with identification problems with high frequency spread data. González-Rozada and Yeyati (2008) find evidence that

I choose the difference between the yields of Moody's AAA and BAA corporate bonds as an instrument for global risk premium. The BAA yields represent excess premia within the investment-grade range. Markets for such bonds are more liquid and less segmented than those for high yield bonds. A clear distinction can thus be established between country spread and risk premium shocks, while identifying the latter at the core of global credit markets. In contrast to high-yield bond spread (González-Rozada and Yeyati, 2008), the investment grade risk premium is less prone to contamination from financial turmoils in risky markets, as arguably occurred in connection with the effects of the Russian default. Therefore, I rely on a more conservative instrument in the identification of global credit shocks so as to analyse their transmission to country spreads and their propagation into the real economy.

1.5.1 Identification

The VAR now includes 7 variables: the US short term interest rate (r_t^*), the US term spread (q_t^*) and risk premium (z_t^*) in the world block (w_t^*); Brazil's country spread (s_t); and industrial product (y_t), investment (i_t) and export to import ratio (x_t) in Brazil's block (w_t). It builds on the identification of the previous Section. The lag length is kept unchanged, and, as described previously, two shift dummies are included to capture changes in the US business cycles, as well as Brazil's monetary and exchange rate regimes.

The world block is ordered first in the VAR, and it is ordered as in the following definition: $w_t^* = [\ r_t^* \quad q^* \quad z_t^*\ ]'$. Therefore, in identifying global credit shocks I maintain the approach of ordering financial variables after the short term interest rate. This ordering keeps the short and long term interest rate close in the chain, representing the global term structure of interest rates. It allows risk premium to react to global liquidity and uncertainties. Analogously, Gertler and Lown (1999) place the high yield premium just after the Federal Funds rate. Alternatively, one could argue that z_t^* should be ordered first, so that the term structure reacts immediately to risk premium shocks.[30] Nevertheless, results are robust to such an alternative ordering.[31]

systemic events within emerging markets, such as the Russian default, can help to explain the variability of emerging market spreads.

[30] A possible argument is that, at least occasionally, monetary policy can specially react to mounting risk aversion in corporate credit markets.

[31] See Appendix 1.B.

1.5.2 Empirical analysis

1.5.2.1 Impulse responses

Figures 1.8-1.12 depict impulse responses to innovations in the world short term interest rate, global term premium, global risk premium, country spread and output. The responses of output, investment and real trade balance to the US interest rate and term premium shocks, as well as to country spread shocks, are almost identical to the responses of the previous Section (Figures 1.4 to 1.7). Therefore, I focus on responses to risk premium shocks and on possible transmission of other global credit shocks through the risk premium.

In reaction to a positive shock in risk premium, the short term interest rate significantly falls between 10 to 18 months, after an aborted attempt to rise. This might reflect a monetary loosening in face of a corporate credit crunch in the US.[32] The long term interest rate rises after the risk premium shock. This behaviour could express greater uncertainty about the future path of the economy.

Global short and long term interest rate shocks eventually cause a relatively prolonged rise in global risk premium. They tend to reduce the premium before such a rise, but the reduction does not appear to be statistically significant. Overall, the risk premium responses are qualitatively similar to those documented by Bernanke and Kuttner (2005) for the excess equity return in face of a monetary tightening in the US.[33]

The responses to shocks in global risk premium suggest a strong transmission of world credit shocks into business cycle dynamics, especially via the country spread. A 6 basis point increase in the risk premium leads to a 60 basis point increase in the country spread. The impulse point estimates peak within 6 and 10 months, but have a positive and significant sign from immediately after the shock and throughout the fifteen consecutive months. Responses of output and investment are quantitatively more responsive to changes in the risk premium than in the term structure. An adverse shock of 6 basis points induces falls of around 0.5% and 1.0% for output and investment, respectively. The trough in output and investment occurs between 10 and 16 months

[32] Although anecdotal evidence suggests a rapid response of the short term interest rate, as the Federal Reserve prompt actions in face of the LTCM crisis, a gradual loosening was pursued by the authorities while the market for risky credits sought to recover in the aftermath of the Enron crisis.

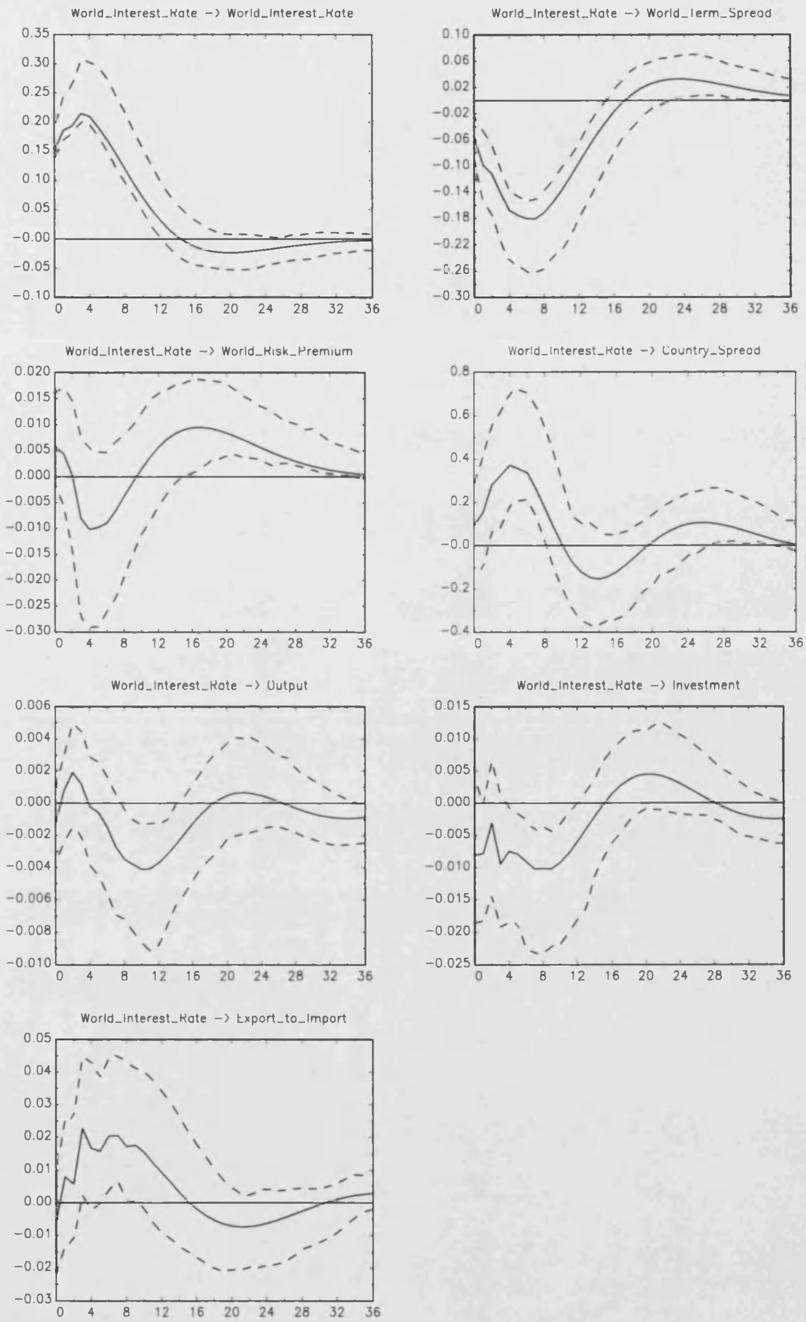
[33] They document that a 1% increase in the Fed Funds rate, which contains a rise of 0.4% in real interest rate rises 0.4%, causes a small positive excess equity return after 6 months. This return peaks later at 1.9%.

after the shock. Negative point estimates around the trough are significant within the bootstrapped 90% Hall percentile confidence interval.

The timing of the troughs in real responses to risk premium shocks suggests that there is a channelling of shocks through the country spread. Innovations in the latter lead to a peak in responses of real aggregates between 4 and 8 months.

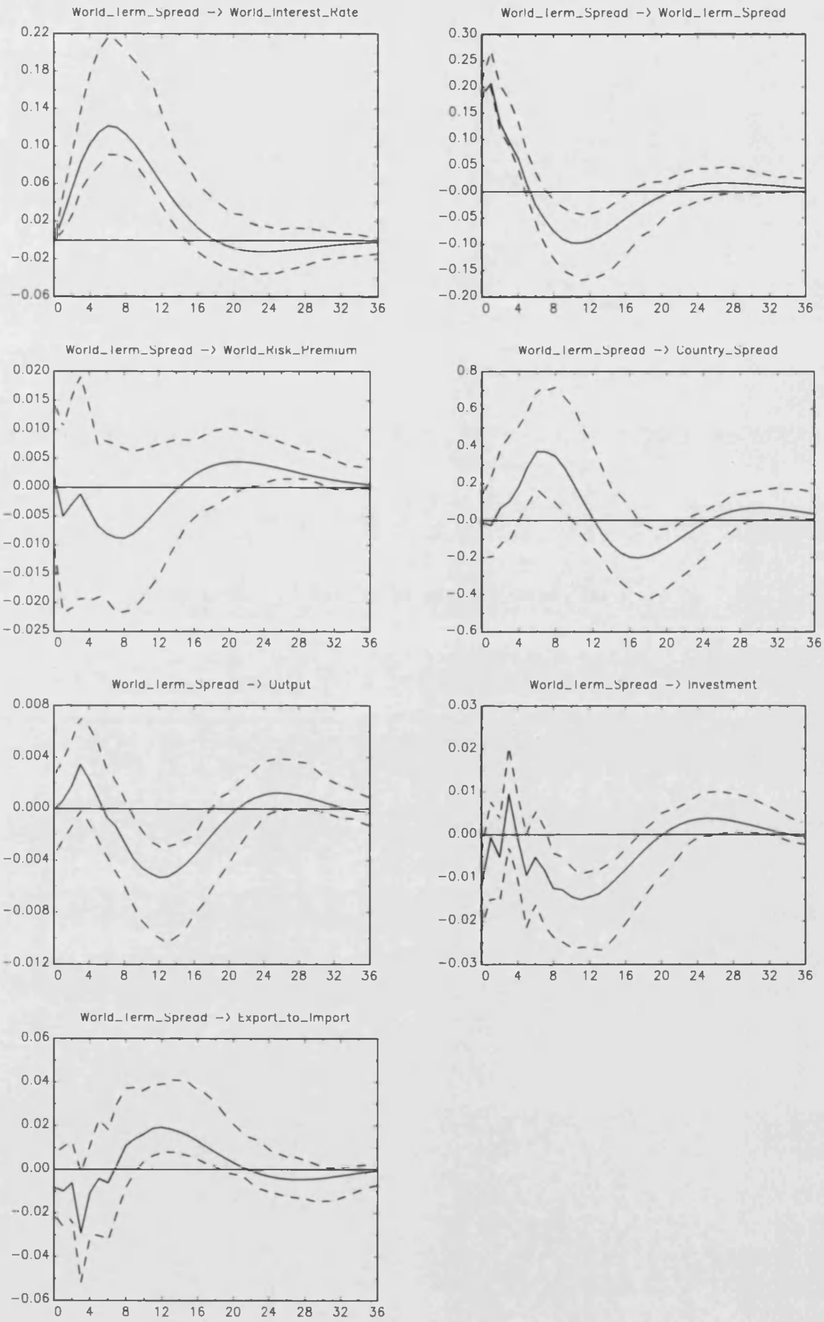
The export-import ratio only responds upwards to shocks in risk aversion after shifting downward for a while. This contradictory behaviour is similar to that observed for term premium shocks. However, it contrasts to the fast rise in the ratio generated by both short term interest rate and country spread shocks.

FIGURE 1.8. Impulse Responses to a World Interest Rate Shock.



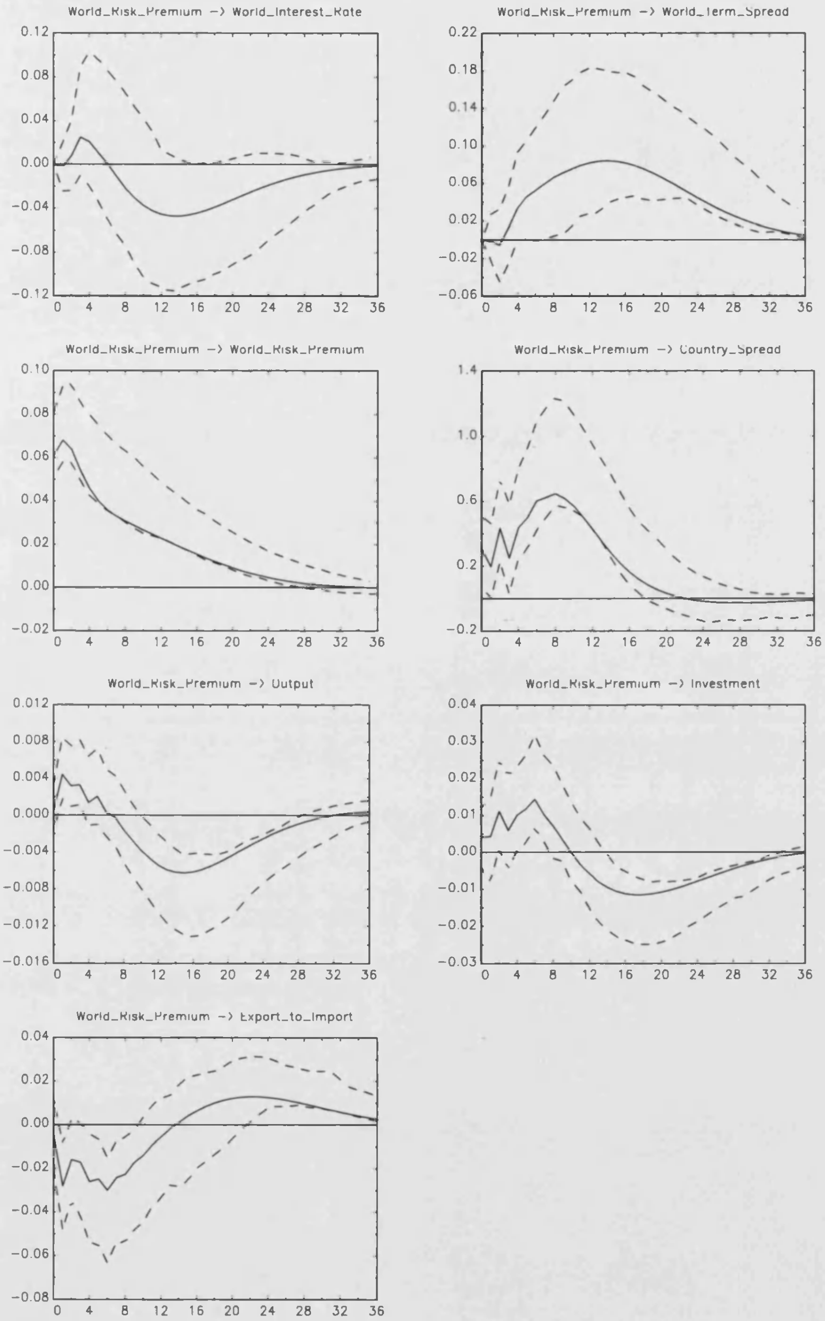
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.9. Impulse Responses to a World Term Spread Shock.



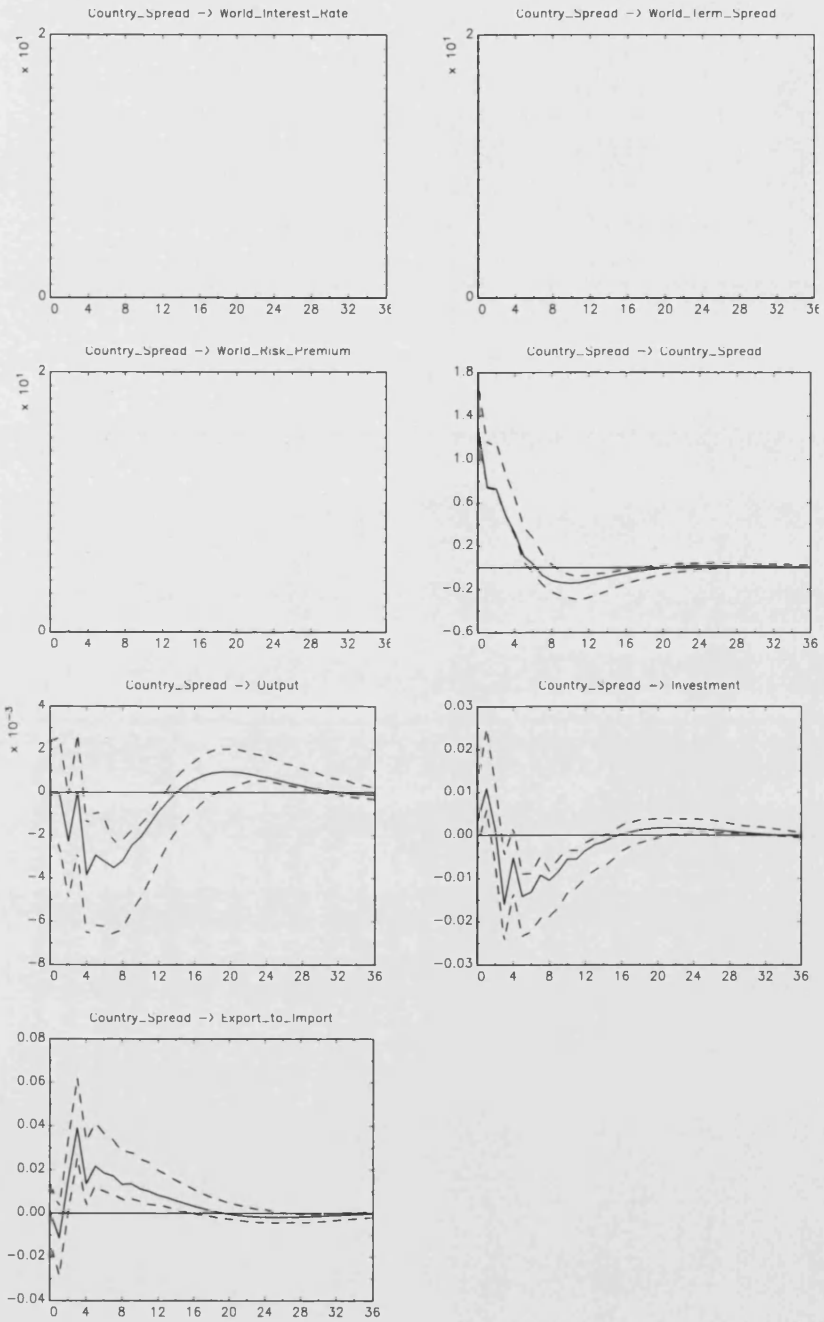
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.10. Impulse Responses to a World Risk Premium Shock.



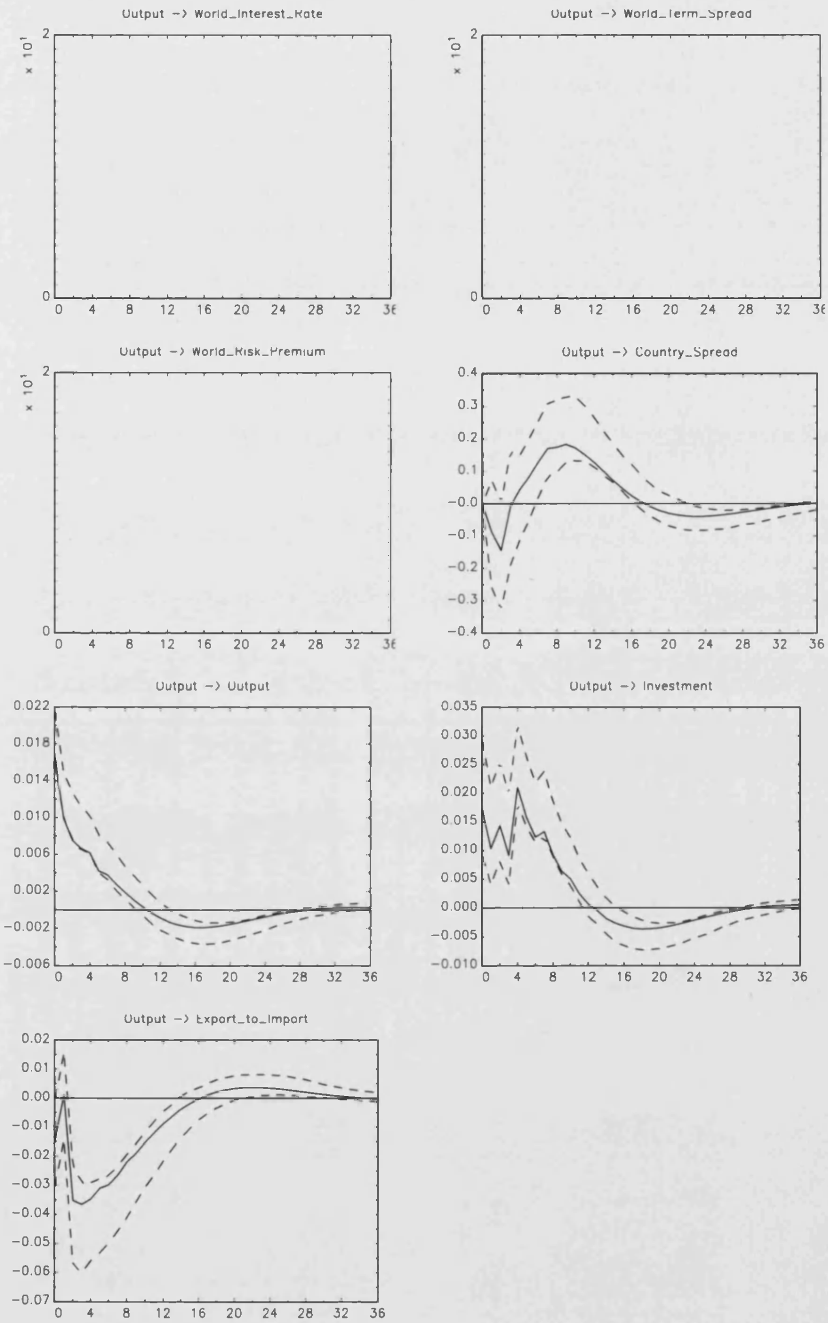
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.11. Impulse Responses to a Country Spread Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.12. Impulse Responses to an Output Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

1.5.2.2 Variance decomposition

The variance decompositions at 12, 36 and 72 months are shown in Tables 1.6 and 1.7. Over 50% (60%) of the country spread (the country interest rate) variability can be attributed to exogenous world credit shocks at any business cycle frequency. These exogenous innovations explain over 40% of the variation in real activity from 36 to 72 months. They also account for about 25% of the real fluctuations over 12 months. If we add country spread shocks, then altogether, credit shocks are responsible for about 50% of business cycle fluctuations.

These results are even more dramatic than those reported in Section 1.4. They definitely indicate that world risk premium is the single most important exogenous source in the determination of country spreads and business cycles, explaining 38% and around 20% of their variability, respectively. Despite the powerful effect of global risk premium, shocks to world short and long term interest rates uphold a significant share. They account for about 20% of the variability of country spread and real aggregates. When risk premium is not added in the identification of global shocks, this share is around 30% (Tables 1.2 and 1.3). The declining share of the term structure is, however, more than offset by global risk premium.

In comparison to the results of the previous Section, the role of country spread has marginally decreased in accounting for the output and investment variability, and also for its own variability. Other innovations that have not yet been identified may account for the remaining share in the country spread. Nevertheless, it is clear that exogenous forces are key to understanding changes in country spread over typical business cycle fluctuations.

If the Brazilian macroeconomic block is placed before the country spread in the block recursive ordering of the VAR, the results do not change.[34] Domestic variables would still account for only 6% of the variations in country spread.

[34] See Appendix 1.C.

TABLE 1.6. Variance Decompositions for the Recursive VAR with Risk Premium.

Forecasted variables	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)						
	r^*	q^*	z^*	s	y	i	x
r^*	74 70 70	25 25 25	01 06 06	-	-	-	-
q^*	59 50 50	33 31 31	07 18 18	-	-	-	-
z^*	02 05 05	02 02 02	96 93 93	-	-	-	-
s	09 10 10	08 10 10	38 38 38	40 36 36	03 03 03	02 02 02	00 01 01
y	07 07 07	08 13 13	08 25 25	06 05 05	49 34 34	01 00 00	21 16 16
i	08 08 08	11 15 15	08 17 17	11 09 09	18 15 15	39 31 31	05 06 06
x	07 08 08	05 09 09	13 16 16	09 09 09	19 18 18	04 03 03	41 38 38
r	20 20 20	13 14 14	30 31 31	33 31 31	02 02 02	02 02 02	00 01 01
$r+q^*$	10 11 11	13 15 15	38 38 38	35 30 30	02 02 02	02 02 02	00 01 01

Note that r and $r+q^*$ represent the country's short and long term real interest rates, respectively. As previously defined, $r = r^* + s$.

TABLE 1.7. Variance Decompositions for the Recursive VAR with Risk Premium and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*, z^*]$	Total credit effect $[w^*, s] = [r^*, q^*, z^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
z^*	100 100 100	100 100 100
s	55, 58, 58	95, 94, 94
y	23, 45, 45	29, 50, 50
i	27, 40, 40	38, 49, 49
x	25, 33, 33	34, 42, 42
r	63 65 65	96 96 96
$r+q^*$	61 64 64	96 94 94

Note that r and $r+q^*$ represent the country's short and long term real interest rates, respectively. As previously defined, $r = r^* + s$.

1.6 The exchange rate regime change

This Section examines the robustness of the results in sub-periods. For example, do they change in light of regime change in Brazil or cycle shift in the world economy? We know that Brazil underwent a change in both monetary and exchange rate regimes in 1999, and that the world, led by the US, went through a recession and switched to a new expansion in 2001.

Therefore, I focus on the sub-period from April 1994 to December 2000 and compare the results with those obtained thus far for the whole sample. This sub-sample incorporates a long expansion in the world economy and a semi-fixed (crawling peg) exchange rate regime in Brazil. I use the same specification of the VAR in seven variables of Section 1.5.[35]

Some different implications arise, although they do not undermine the general analysis of the whole sample. First, global credit shocks generate more pronounced responses in the country-spread and in real activity than in the whole sample. These responses are shown in Figures 1.13 to 1.17. Second, interest rate shocks become relatively more important than global risk premium shocks. They generate more dramatic rises in country spread, and real contractions are 50% sharper than for the whole sample. In particular, global term premium shocks affect the country-spread and real aggregates in a faster way than for the whole sample. Global risk premium shocks also spread through the effects in country spread, and rapidly constrain output.

Tables 1.8 and 1.9 provide variance decompositions of the sub-period exercise. On the whole, global credit shocks can account for 70% of the variability of the country spread and about 60% of the variability of real activity. Including country spread shocks, total credit forces explain 86% of the variations in country spread and approximately 70% of real macroeconomic fluctuations.

The sub-period results are consistent with views about the extra costs incurred by fixed exchange rate regimes. Gertler et al. (2003) stress the additional adverse effects of fixed regimes, in contrast to floating ones. They analyse such effects under the assumption that foreign shocks further transmit into a SOE due to the workings of a domestic financial accelerator.

[35] For obvious reasons, I do not add a shift dummy for the world economy.

Despite the aggravated responsiveness of emerging economies to global credit shocks, the results appear to suggest that the differences between a fixed and floating exchange rate regime relate more to the magnitude of the effects than to the transmission mechanism of the global credit shocks. As in Canova (2005), we can argue that floating regimes provide the system with flexibility, and policy makers with the ability to mitigate the transmission of foreign shocks, especially those of world interest rates. This partially explains the stronger impact of world interest rate shocks in the sub-period. However, even after devaluation or a switch to a floating regime, as in Brazil in 1999, authorities might still face some "fear of floating" (Reinhart, 2000; Calvo and Reinhart 2002). They do not take full advantage of the flexibility of a floating regime. Credibility challenges and the risks of facing capital outflows and exchange rate volatility continue to interfere in monetary policy responses to global credit shocks.

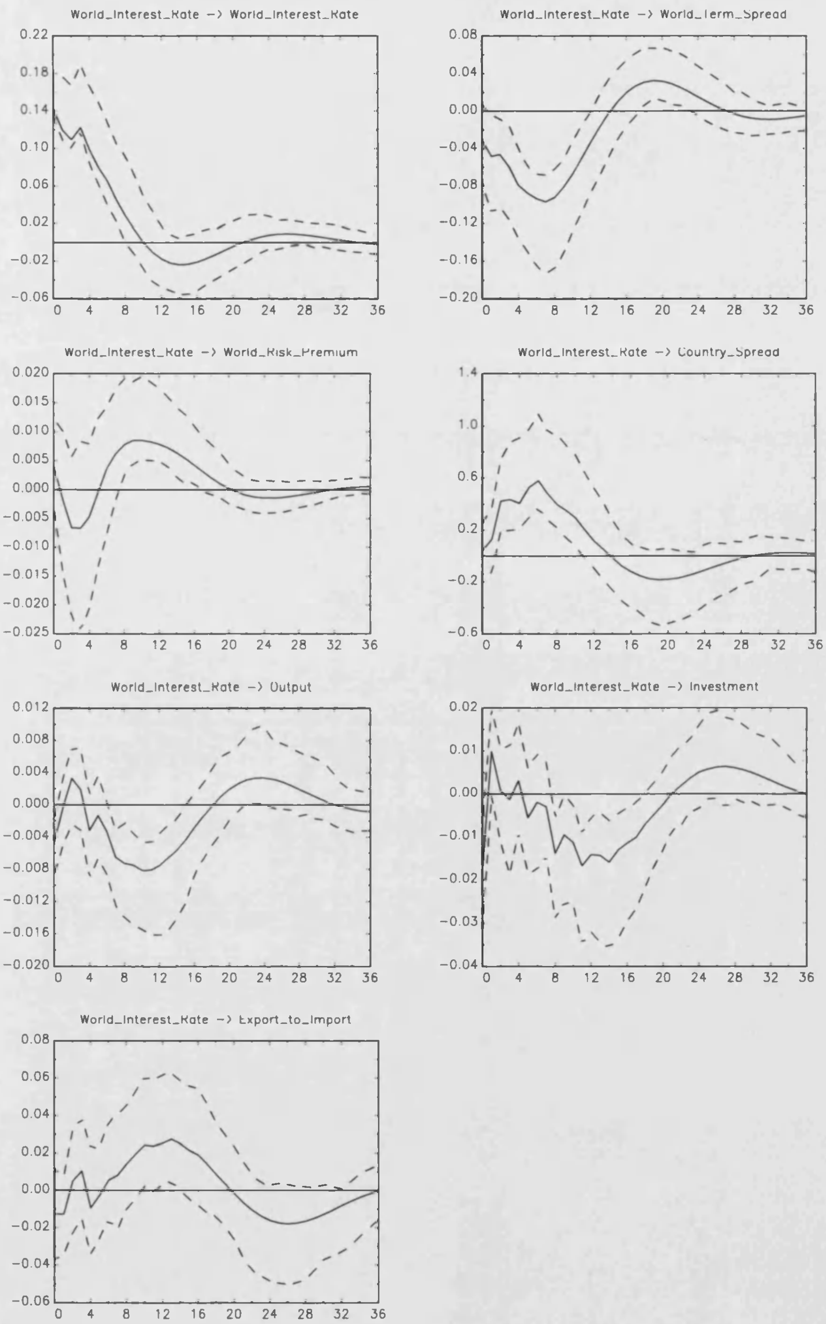
TABLE 1.8. Variance Decompositions for the Recursive VAR: the exchange rate regime change.

Forecasted variables	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)						
	r^*	q^*	z^*	s	y	i	x
r^*	68 67 67	30 29 29	02 04 04				
q^*	31 32 32	46 46 46	23 22 22				
z^*	05 08 08	00 02 02	94 91 91				
s	32 29 29	14 14 14	17 27 27	20 16 16	04 03 03	05 04 04	07 06 06
y	24 28 28	08 10 10	22 25 25	15 11 11	23 17 17	06 05 05	04 04 04
i	15 21 21	16 15 15	12 21 21	16 11 11	09 08 08	29 20 20	04 05 05
x	07 13 13	02 05 05	33 39 39	19 12 12	04 05 05	07 06 06	28 20 20

TABLE 1.9. Variance Decompositions for the Recursive VAR and the Credit Effects: the exchange rate regime change.

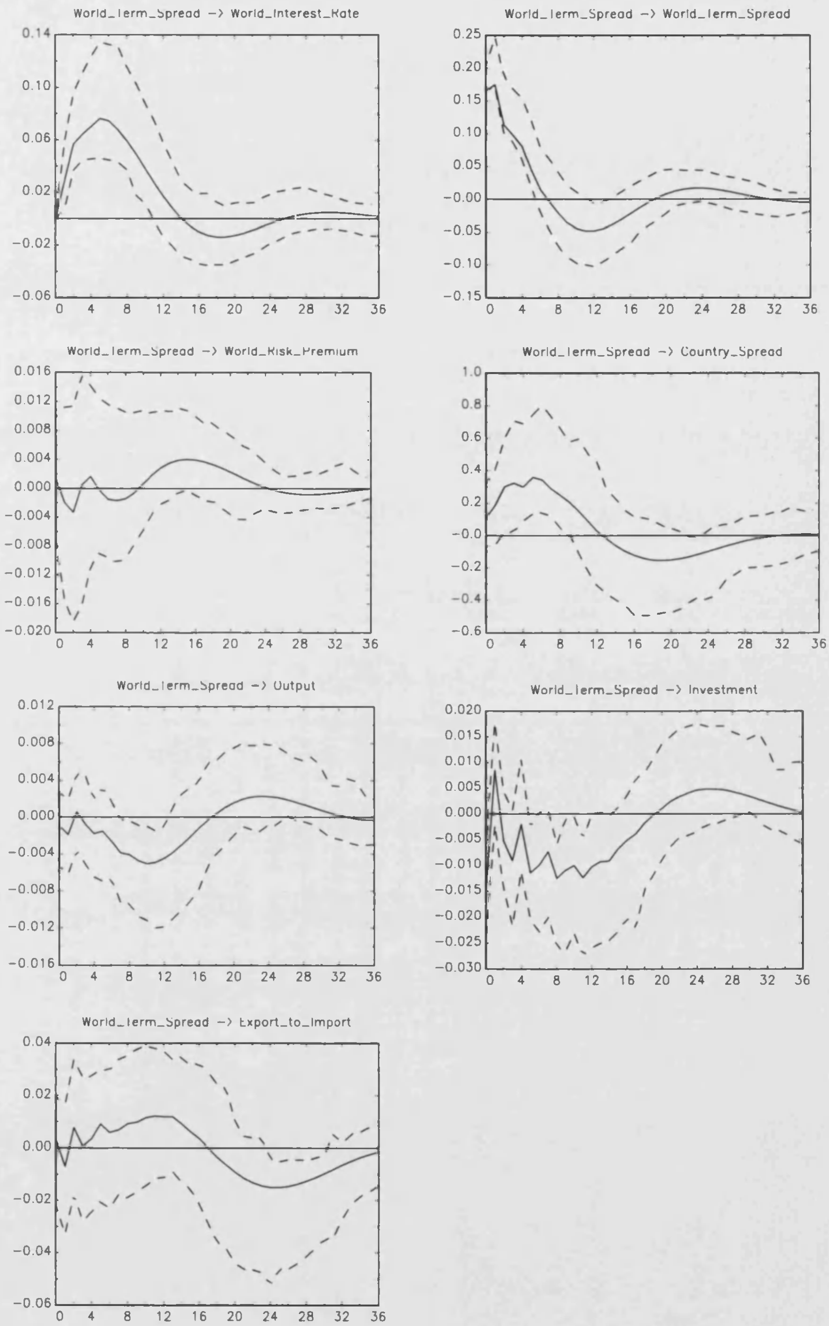
Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*, z^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
z^*	100 100 100	100 100 100
s	63 70 70	83 86 86
y	54 63 63	69 74 74
i	43 57 57	59 68 68
x	42 57 57	59 69 69

FIGURE 1.13. Impulse Responses to a World Interest Rate Shock.



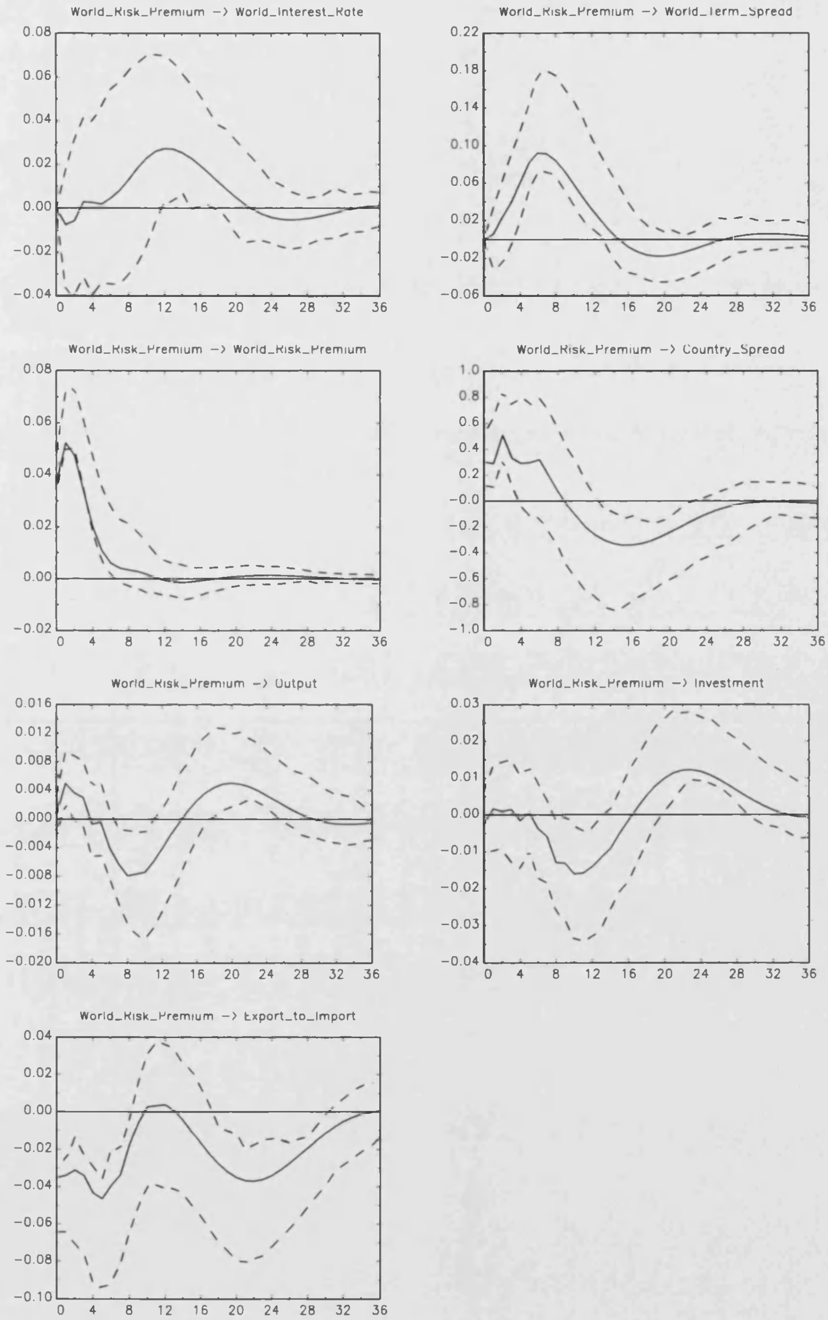
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.14. Impulse Responses to a World Term Spread Shock.



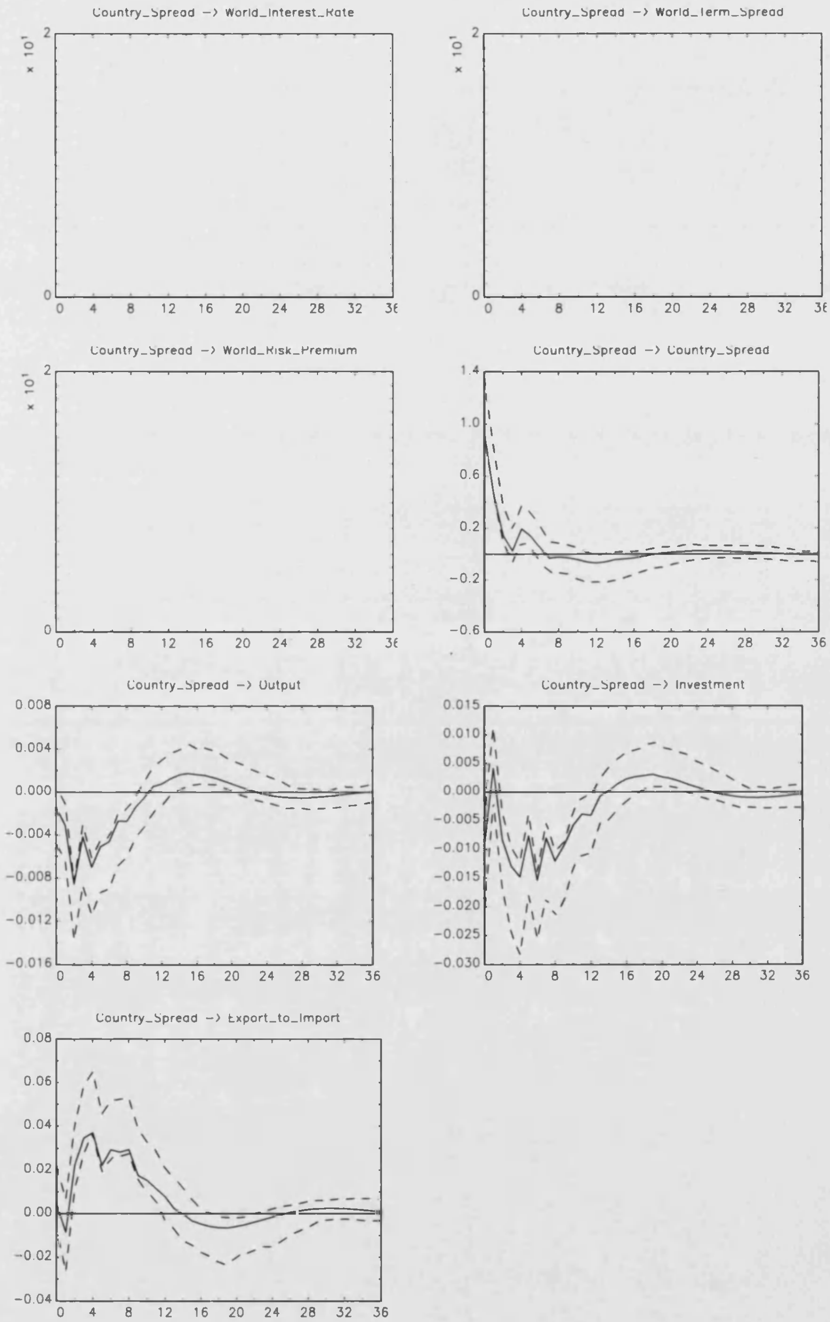
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.15. Impulse Responses to a World Risk Premium Shock.



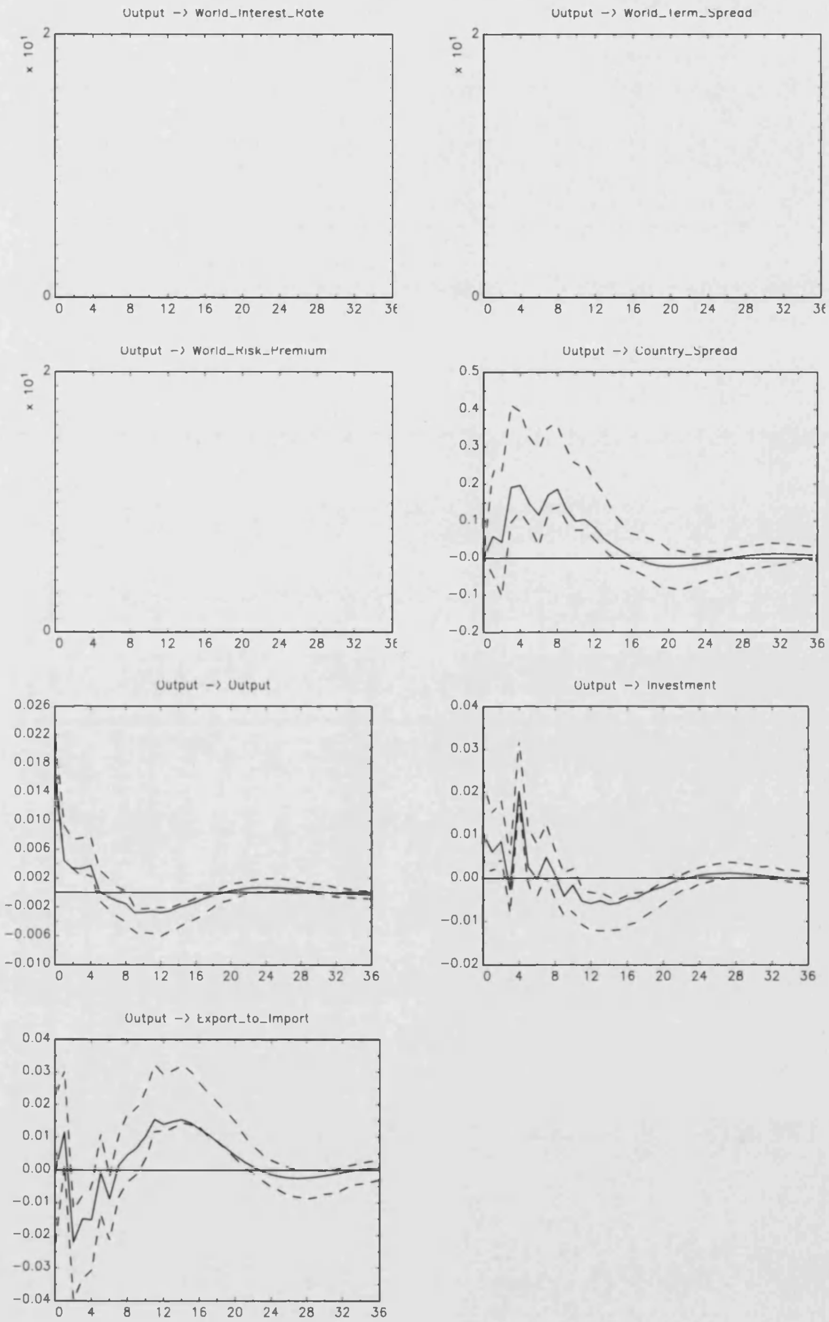
Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.16. Impulse Responses to a Country Spread Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

FIGURE 1.17. Impulse Responses to an Output Shock.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. The responses of the credit variables are given in percentage points. Those of output, investment and the export-import ratio are expressed as deviations from their respective log-linear trends. Units on horizontal axes represent months.

1.7 The exchange rate channel

I now check whether the results are robust to the inclusion of other variables that could act either as an alternative source of shocks, or as an alternative mechanism for their transmission. This Section starts with the exchange rate, which tends to react quickly and in tandem with capital movements. I add the real exchange rate[36] and place it between the country-spread and the Brazilian macroeconomic block.

On the whole, the inclusion of the real exchange rate has two major implications: (a) it enhances the effects of global credit shocks on the fluctuations of both the country spread and the real aggregates; (b) the exchange rate itself is not a source of credit or business fluctuations, but rather an additional transmission channel whose effectiveness relies on interaction with the credit mechanisms.

Figure 1.18 displays the impulse responses of the exchange rate to various shocks. Positive innovations to the country spread or global term premium induce a fast devaluation for a relatively long period. This response is in line with the fact that capital outflows from the country, whose underlying cause might reside in a flight to quality in world credit markets. Positive innovations in global risk premium also induce devaluation, but only after producing a small and short-lived appreciation. Real short term interest rate shocks conversely trigger an appreciation. This phenomenon, which is also documented in Canova (2005)[37], and the delayed devaluation in the case of a risk premium shock can be rationalized by the fact that the monetary response to global credit shocks is constrained by considerations of international capital and exchange rate volatility.

Tables 1.10 and 1.11 indicate that the share of global credit shocks in accounting for country spread variability has risen from 58% to 61% at business cycle frequencies. Global credit shocks now account for 53% of the output variability, and for 45% of the variability in investment and the export-import ratio. Excluding the exchange rate, these shares are at 45%, 40% and 33%, respectively. Total credit shocks explain 58% of output variations, and 52% of fluctuations in investment and the export-import ratio.

Furthermore, domestic sources are weakened with respect to both country spread and real macroeconomic fluctuations. The proportions of variations in output, investment

[36]See Appendix 1.A for details of the data on real exchange rate for Brazil.

[37]For these cases of Brazil, Chile and Peru, Canova finds that international reserves increase following US monetary tightening. The tightening is a means to preclude capital outflow and/or to defend a currency peg.

and net export ratio that are attributed to innovations in themselves fall, respectively from 34% to 24%, from 31% to 25%, and from 38% to 26%.

Real exchange rate shocks are less important than the country spread shocks in accounting for the variability of any Brazilian variable, including the exchange rate itself. Whereas country spread innovations account for nearly 20%, and total credit shocks for nearly 60%, of exchange rate variation, exchange rate shocks can only explain 2% of the country spread variation. Furthermore, the latter are responsible for meagre shares in the variability of any domestic variable. The vast majority of the results are invariant to alternative ordering of the exchange rate in the VAR. Regardless of the order, all credit shocks eventually cause devaluation.[38]

In summary, the exchange rate is not a relevant source of shocks. It is merely an additional element in the amplification and propagation of global credit shocks. Leading to devaluations, adverse credit shocks aggravate the currency mismatch between assets and liabilities. This can be particularly acute in the case of an open economy where agents are willing to borrow abroad, but find themselves constrained by their ability to issue foreign credit.

[38]The only noticeable change is qualitative and relates to the response of the country spread to an exchange rate shock. When s is placed before e, a devaluation causes a fall in the spread. This reflects some reassurance by markets that a devaluation triggers a lowering in the country spread. In the alternative case, in which e is placed before s, a devaluation triggers a rise in the country spread. It suggests that creditors become more averse to the country due to capital outflows.

TABLE 1.10. Variance Decompositions for the Recursive VAR with the Exchange Rate.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)							
	r^*	q^*	z^*	s	e	y	i	x
s	10 11 11	08 10 10	38 39 39	38 33 33	02 02 02	02 02 02	02 02 02	00 01 01
e	04 10 10	06 11 11	36 38 38	27 19 19	19 13 13	03 04 04	06 04 04	00 02 02
y	12 12 12	08 15 15	10 26 26	07 05 05	04 03 03	38 24 24	01 01 01	19 14 14
i	09 09 09	10 15 15	13 21 21	09 07 07	04 03 03	16 13 13	34 25 25	05 07 07
x	08 09 09	05 11 11	24 25 25	07 07 07	05 04 04	18 15 15	03 03 03	30 26 26
r	20 20 20	13 14 14	30 31 31	32 29 29	02 02 02	02 02 02	01 01 01	00 01 01
$r+q^*$	10 12 12	13 14 14	38 39 39	34 29 29	02 02 02	02 02 02	02 01 01	00 01 01

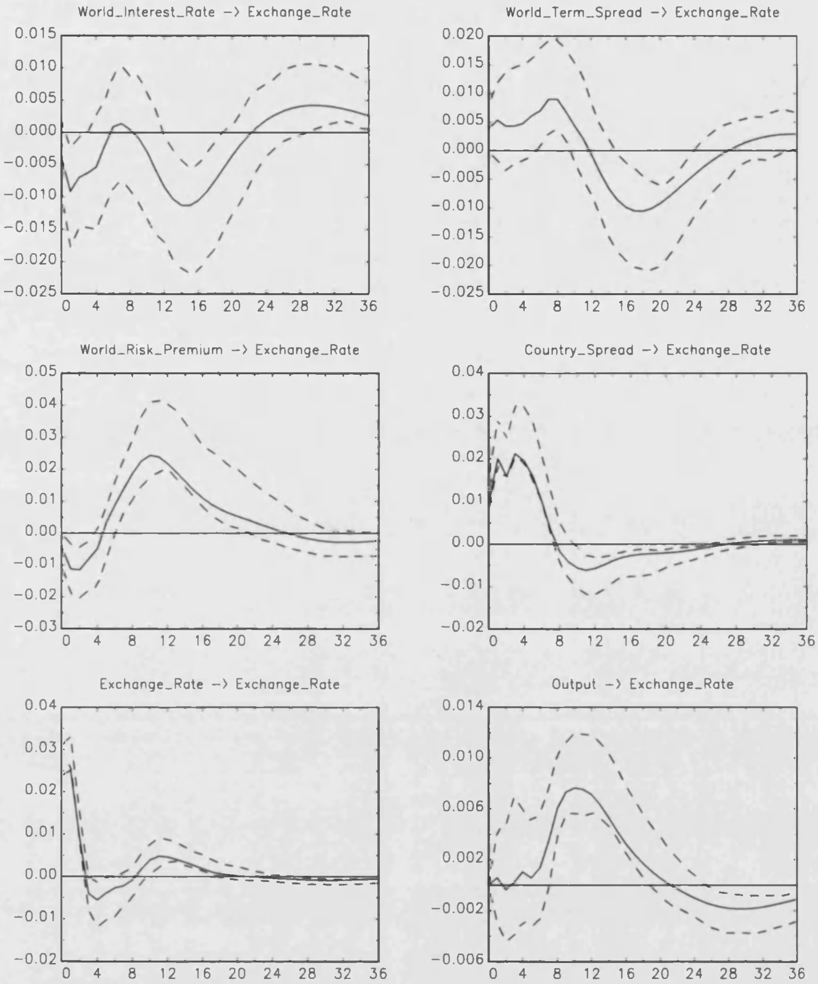
Note that $r = r^* + s$, while r and $r + q^*$ represent the country's short and long term real interest rates, respectively. The variance decomposition of the global credit variables are not shown as they are the same as in Table 1.6. The variables in w are ordered e y i x.

TABLE 1.11. Variance Decompositions for the Recursive VAR with the Exchange Rate and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*, z^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
s	56 61 61	94 93 93
e	46 59 59	73 78 78
y	30 53 53	37 58 58
i	32 45 45	41 52 52
x	37 45 45	44 52 52
r	63 65 65	95 94 94
$r + q^*$	61 65 65	95 94 94

Note that $r = r^* + s$, while r and $r + q^*$ represent the country's short and long term real interest rates, respectively. The variance decomposition of the global credit variables are not shown as they are the same as in Table 1.5. The variables in w are ordered $e\ y\ i\ x$.

FIGURE 1.18. Impulse Responses of Real Exchange Rates.



Solid lines are point estimates. Broken lines represent the 90% bootstrapped Hall confidence interval. Vertical axes indicate percentage points.

1.8 Other sources of shocks

I now consider other sources of shocks that could drive emerging economy business cycles. On the one hand, the SOE literature has given important attention to the terms of trade, in addition to the exchange rate. On the other hand, supporters of the endogeneity of the country spread attach relevance to fiscal and debt variables, often associating the risk of default implicit in the country spread as being reflected or anticipated by the latter (e. g. Edwards, 1984; Min, 1998).[39]

For robustness purposes, I include two variables in the VAR: terms of trade (measured as the price ratio of exports to imports), t; and the percentage ratio of total public sector foreign and domestic debt to the GDP, d. If one uses alternative ratios of either domestic or foreign debt to GDP instead of the latter, then it does not alter the results. The two variables, t and d, are added before y, i, x in the vector w. The country spread, s, and exchange rate, e, are placed between w^* and w, in said order.

Tables 1.12 and 1.13 present variance decompositions. In fact, they do not change at all from those of the previous Section. Furthermore, the decompositions are not sensitive to changes in the order of variables.[40] The terms of trade are almost irrelevant, their only importance being to explain their own variations. The total public sector debt to GDP ratio plays some role in accounting for fluctuations in the country spread, although at a lower proportion (5%) than expected. In fact, this is lower than any proportion associated with one of the three sources of exogenous credit shocks, or with the country spread innovations.

I do not report the impulse responses, as they remain mostly unchanged. It is worth noting that, as expected, a positive shock to the country spread augments the debt ratio, while a positive shock to the debt ratio increases the country spread. As in the case of the exchange rate, the country spread is much more relevant in the determination of the debt ratio, than the reverse. The ability of innovations in real aggregates to explain their respective variability is also further weakened, especially in the case of output. Again, the introduction of additional domestic variables marginally enhances the role of credit factors altogether. Overall, the variability of the country spread and of the real aggregates remains attributable to exogenous credit shocks.

[39] In Brazil in particular, Blanchard (2004) stresses the relevance of fiscal dominance over the 1990s.

[40] See Appendix 1.C for variance decompositions that are obtained from ordering the country spread last, so that it can be affected contemporaneously by innovations in domestic variables, including the debt ratio.

TABLE 1.12. Variance Decompositions for the Recursive VAR with other Sources of Shocks.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months Decompositions (percentage points)									
	r^*	q^*	z^*	s	tot	e	d	y	i	x
s	20 21 21	10 11 11	28 30 30	33 29 29	00 01 01	03 02 02	05 05 05	00 02 02	01 00 00	00 01 01
tot	25 28 28	02 12 12	09 08 09	13 11 10	35 25 24	05 04 04	02 03 03	05 05 05	01 01 01	02 03 03
e	07 15 15	02 06 06	34 37 37	22 15 15	01 01 01	32 22 22	04 04 04	00 00 00	03 02 02	00 00 00
d	05 06 06	04 05 05	42 52 52	12 09 09	01 01 01	06 05 05	25 17 17	03 03 03	01 01 01	01 01 01
y	13 16 17	07 15 16	11 22 22	08 06 06	02 03 03	06 04 04	03 03 03	31 19 18	03 02 02	15 10 10
i	12 15 15	08 14 15	10 15 15	09 07 07	05 05 05	04 04 04	02 03 03	11 09 09	32 24 23	05 05 05
x	10 15 15	04 12 13	23 20 20	08 07 07	05 04 04	08 06 06	03 03 03	12 10 10	03 03 03	25 20 20

The variance decompositions of the global credit variables are not shown as they are the same as in Table 1.6. The symbols *tot*, *e*, and *d* stand for terms of trade, real exchange rate, and the ratio of total debt of the public sector to GDP, respectively. The variables in w are ordered s tot e y i x d.

TABLE 1.13. Variance Decompositions for the Recursive VAR with other Sources of Shocks and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, s, w Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*, z^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
s	58 62 62	84 91 91
tot	36 48 49	49 59 59
e	43 58 58	68 76 76
d	51 63 63	63 72 72
y	31 53 55	39 59 61
i	30 44 45	39 51 52
x	37 47 48	45 54 55

The symbols *tot*, e, and d stand for terms of trade, real exchange rate, and the ratio of total foreign and domestic debt of the public sector to GDP, respectively. The variables in w are ordered s *tot* e y i x d.

1.9 Conclusion

This paper addresses the effects of global credit shocks in emerging economy business cycles. It studies the Brazilian economy from 1994 to 2005. Although applied to a single country, the modelling strategy is more comprehensive and more systematic than previous work with respect to the identification of the shocks, and to their transmission to the real economy via credit channels. In particular, the analysis benefits from the integration of financial and real data at monthly frequencies.

I show that global credit shocks account for over 60% and 50% of the fluctuations in the country interest rate and country spread, respectively. These shocks - to the US real short term rate, term and risk premia - reflect changes in liquidity, uncertainties and the risk appetite at the core of global business and credit conditions. Predominantly transmitted via the country interest rate, they are a major source of macroeconomic fluctuations, accounting for 40-50% of the variability in output.

The results are consistent with the proposition that some emerging economies face constraints on foreign credit. The real interest rates and country spreads they face in international markets are sensitive to global credit shocks. Through the workings of credit frictions, both domestically and internationally, these shocks cause responses of output and investment that are hump-shaped and, therefore, in line with realistic recession and expansion patterns.

It follows that productivity and other domestic sources of fluctuations, in addition to exchange rate and terms of trade shocks, might have a less relevant role than normally posited, at least for some emerging economies. Fiscal performance, the total debt of the public sector, and other variables reflecting domestic fundamentals might be key to understanding structural macroeconomic and financial weakness in the long run. However, they cannot dictate credit and real fluctuations over realistic business cycle horizons. The exchange rate channel interacts with credit channels and further magnifies the effects of global credit shocks.

The empirical results of this paper do not to support a theory of default based purely on domestic and endogenous mechanisms that lead to credit and real cycles in emerging economies (e.g. Aguiar and Gopinath, 2007). The hypothesis that their real interest rates are mainly countercyclical because these economies have a higher default probability in recession than in expansion does not find much support here. Furthermore, traces of productivity or similar shocks streaming from the real economy account for less than 10% of the variability of the country spread. The independence of the latter variable from returns, term and risk premia in global markets appears to be an unreasonably restrictive assumption.

This paper suggests further research on dynamic general equilibrium models of SOE business cycles that could incorporate the workings of domestic and international credit constraints. This suggestion is especially relevant given the inability of standard models to generate sustained and significant impacts of real interest rate shocks (Mendoza, 1991). Moreover, the analysis of this paper could be replicated across a number of emerging economies.[41]

[41] Such a cross country analysis inevitably faces difficulties with regard to the harmonization, quality and frequency of the data, in addition to country idiosyncrasies. That is why perhaps the responses in Uribe and Yue (2005) are less robust to specification changes and statistically less significant in rejecting signs than this study.

1.A Appendix: Data

All Brazilian monthly series, except for the country spread, are available at IPEA-Data (www,ipeadata.gov.br), the on-line macroeconomic database of the Instituto de Pesquisa Pura e Aplicada - IPEA. Further details of the data are the following:

Industrial product. The series was expressed in natural logarithmic of available IPEA's seasonally adjusted index. Instituto Brasileiro de Geografia e Estatística (IBGE) produces the series, whose description can be found at its official website (www.ibge.gov.br).

Investment in machines. The series was expressed in natural logarithmic of the seasonally adjusted index, which is calculated by IPEA. IPEA produces the index on the basis of IBGE's indexes for capital goods production (a component of its industrial product index) and of the quantum indexes of export and import of machines, as provided by Fundação Centro de Estudos do Comércio Exterior (FUNCEX).

Ratio of export to import. The series was calculated by the author as a ratio of export quantum to import quantum. FUNCEX constructs the quantum index on the basis of official foreign trade statistics from the Ministry of Development, Industry and Foreign Trade, Minsitério do Desenvolvimento, da Indústria e do Comércio Exterior (MDIC).

Terms of trade. The series is calculated by FUNCEX as a ratio of the export price to import price.

Real exchange rate. The series is calculated by IPEA on the basis of the nominal exchange rate (Real R$ to US Dollar US$), the CPI indexes of Brazil (INPC) and of the countries that are among the sixteen major destinations for its exports.

Country spread. The series of the EMBI Plus index for Brazil is produced by JP-Morgan and obtained at Datastream.

Public sector net debt to GDP ratios. The series for the ratios of total, domestic and foreign debt are expressed as a percentage. They are calculated by Banco Central do Brasil (www.bcb.gov.br), based on its estimate of monthly GDP, and include currency adjustments, when appropriate.

All US series (3-month and 10-year Treasury bond interest rates, as well as the CPI index and the Moody's AAA and BAA coporate bond yields) come from the FRED database of the Federal Reserve Bank of St Louis.

1.B Appendix: Robustness to order within world block

I illustrate the robustness of changing the identification of global credit shocks, by changing the order of variables within the block, as an alternative to the identification used in Section 1.4. Here, I place the short term rate after the term spread (q^* r^*).

TABLE 1.14. Variance Decompositions and Order Robustness.

Forecasted Variable	VAR (4) ordered w^*, s, w, but w^* ordered q^*, r^* Forecast Horizons: 12 36 72 months					
	Decompositions (percentage points)					
	r^*	q^*	s	y	i	x
r^*	89 89 98	11 11 02	-	-	-	-
q^*	70 71 59	30 29 41	-	-	-	-
s	16 20 20	11 12 12	63 56 56	02 03 03	04 03 05	05 05 03
y	12 17 17	04 12 12	09 09 09	54 40 40	01 01 01	20 21 21
i	13 14 14	06 12 12	09 10 10	20 17 17	49 40 40	03 07 07
x	07 06 06	06 10 10	06 07 07	22 21 21	04 04 04	55 52 52

TABLE 1.15. Variance Decompositions, Foreign Order Robustness and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, s, w, but w^* ordered q^*, r^* Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	Global credit effect $w^* = [r^*, q^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
s	27 32 32	90 88 88
y	16 29 29	25 38 38
i	19 26 26	28 36 36
x	13 16 16	19 23 23

1.C Appendix: Robustness to order of blocks

The Tables below show the variance decompositions that would result from the main models in Sections 1.4 (Tables 1.16 and 1.17) and 1.5 (Tables 1.18 and 1.19), when we use the alternative block-recursive order that derives from setting $A_{31} = A_{32} = 0$, instead of $A_{23} = 0$, that is by placing s after w, and not vice-versa. The robustness to change in the order of the blocks can be extended to the models with additional variables, in Sections 1.7 and 1.8. Only the variance decompositions for the latter model are shown below (Tables 1.20 and 1.21), since the former reveals equivalent robustness to order of blocks.

TABLE 1.16. Variance Decompositions and Block Order Robustness.

Forecasted Variable	VAR (4) ordered w^*, w, s Forecast Horizons: 12 36 72 months					
	Decompositions (percentage points)					
	r^*	q^*	s	y	i	x
r^*	89 89 89	11 11 11	-	-	-	-
q^*	70 71 71	30 29 29	-	-	-	-
s	10 15 15	16 17 17	60 54 54	02 03 03	07 06 06	05 05 05
y	07 09 09	09 20 20	09 09 09	54 41 40	01 01 01	20 21 21
i	09 09 09	10 17 17	08 09 09	20 17 17	49 41 41	03 07 07
x	07 07 07	06 09 09	06 07 07	22 21 22	04 04 04	55 52 52

TABLE 1.17. Variance Decompositions, Block Order Robustness, and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, w, s Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	Global credit effect $w^* = [r^*, q^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
s	26 32 32	86 86 86
y	16 29 29	25 38 38
i	19 26 26	27 35 35
x	13 16 16	19 23 23

TABLE 1.18. Variance Decompositions and Block Order Robustness.

Forecasted Variable	VAR (4) ordered w^*, w, s Forecast Horizons: 12 36 72 months						
	Decompositions (percentage points)						
	r^*	q^*	z^*	s	y	i	x
r^*	74, 70, 70	25, 25, 25	01, 06, 06	-	-	-	-
q^*	59, 50, 50	33, 31, 31	07, 18, 18	-	-	-	-
z^*	02, 05, 05	02, 02, 02	96, 93, 93	-	-	-	-
s	10, 11, 11	09, 11, 11	36, 37, 37	39, 35, 35	03, 03, 03	02, 02, 02	00, 01, 01
y	06, 06, 06	08, 12, 12	07, 25, 25	07, 05, 05	50, 35, 35	01, 00, 00	21, 17, 16
i	06, 06, 06	10, 13, 13	07, 17, 17	11, 09, 09	19, 16, 16	42, 33, 33	06, 06, 06
x	08, 08, 08	04, 07, 07	12, 15, 15	09, 09, 09	20, 18, 18	04, 03, 03	44, 40, 40

TABLE 1.19. Variance Decompositions, Block Order Robustness, and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, w, s Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	Global credit effect $w^* = [r^*, q^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
z^*	100 100 100	100 100 100
s	55 59 59	94 94 94
y	21 43 43	28 48 48
i	23 36 36	34 45 45
x	24 30 30	33 39 39

TABLE 1.20. Variance Decompositions and Block Order Robustness.

Forecasted Variable	VAR (4) ordered w^*, w, s — Forecast Horizons: 12 36 72 months — Decompositions (percentage points)									
	r^*	q^*	z^*	s	*tot*	e	d	y	i	x
s	20 21 21	10 11 11	28 30 30	26 23 23	01 01 01	06 05 05	07 06 06	01 01 01	01 01 01	00 01 01
tot	25 28 28	02 12 12	09 08 09	13 10 10	37 27 26	02 02 02	02 03 03	06 06 06	01 01 01	02 03 03
e	07 15 15	02 06 06	34 37 37	17 13 13	01 01 01	32 22 22	04 04 04	00 00 00	03 02 02	00 00 00
d	05 06 06	04 05 05	42 52 52	04 03 03	01 02 02	04 03 03	32 23 23	04 04 04	01 01 01	01 01 01
y	13 16 17	07 15 16	11 22 22	04 04 04	03 04 04	02 02 01	09 06 06	32 20 20	02 01 01	16 10 10
i	12 15 15	08 14 15	10 15 15	10 08 07	06 05 05	02 02 02	02 03 03	12 10 10	32 24 23	05 05 05
x	10 15 15	04 12 13	23 20 20	10 08 08	06 05 05	03 02 02	03 04 04	14 12 12	03 02 02	25 20 20

The symbols *tot*, e, and d stand for terms of trade, real exchange rate, and the ratio of total debt of the public sector to GDP, respectively. The variables in w are ordered: s *tot* e y i x d.

TABLE 1.21. Variance Decompositions, Block Order Robustness, and the Credit Effects.

Forecasted Variable	VAR (4) ordered w^*, w, s Forecast Horizons: 12 36 72 months	
	Decompositions (percentage points)	
	World credit effect $w^* = [r^*, q^*, z^*]$	Total credit effect $[w^*, s] = [r^*, q^*, s]$
r^*	100 100 100	100 100 100
q^*	100 100 100	100 100 100
z^*	100 100 100	100 100 100
s	58 62 62	84 85 85
tot	36 48 49	49 58 59
e	43 58 58	60 71 71
d	51 63 63	55 66 66
y	31 53 55	35 57 59
i	30 44 45	40 52 52
x	37 47 48	47 55 56

The symbols tot, e, and d stand for terms of trade, real exchange rate, and the ratio of total debt of the public sector to GDP, respectively. The variables in w are ordered: s tot e y i x d.

1.D Appendix: Exogeneity of world block

In checking for the empirical validity of the exogeneity of the world credit block, I find support for the Granger non-causality of all Brazilian real variables (w), but not for all Brazilian variables (w and s), as reported in Table 1.22. If I relax the exogeneity assumption, both by not imposing any restriction on any lagged coefficient and by only restricting the coefficients of real aggregates ($A_{13} = C_{13,l} = 0$), the results in both cases do not differ from the preferred restricted model ($A_{12} = A_{13} = C_{12,l} = C_{13,l} = 0$), except for a feedback in which world interest rates respond downwards to positive innovations in country-spread.[42] The responses of the Brazilian variables to world shocks remain unaltered, both qualitatively and quantitatively. The relative importance of different sources of shocks does not change in a proportion that would call into question the major channels that are claimed within the restricted model. When allowing the country spread to feed back into global credit markets, the contribution of global credit shocks to the variability of the country spread and real activity falls only slightly, from 58% to 51% and from 45% to 41%, respectively (see Table 1.23). Overall, there is support for the empirical consistency and robustness of the exogeneity of the world credit block. The failure to fully pass an empirical test of the exogeneity assumption, which is rarely performed (see Hugh, 2005), might be related to problems encountered in Wald tests of Granger non-causality, if the VAR is in levels and some series show some degree of integration, as discussed in Sims, Stock and Watson (1990) and Toda and Philips (1993).

TABLE 1.22. Block Granger Noc-causality Tests.

Null hypothesis of non-causality	Dummy shifts: not included	Dummy shifts: included
$w, s \nRightarrow w^*$	0.0132	0.0095
$w \nRightarrow w^*$	0.2341	0.2263
$s \nRightarrow w^*$	0.0197	0.0080
$w^* \nRightarrow w, s$	0.0197	0.0196
$w^* \nRightarrow w$	0.0655	0.0838
$w^* \nRightarrow s$	0.0849	0.0554

Column 1 indicates the non-causality directions that are tested. Columns 2 and 3 present p-values of χ^2 from LR-test based on the restricted model as an alternative to unrestricted null. P-values are estimated in the specifications with and without dummy shifts.

[42] This effect might be due to the combined effects of contemporaneous correlation between Brazil's spread and Russia's spread, and of monetary actions in the US in face of the LTCM crises that have been associated with the crisis in Russia.

TABLE 1.23. Variance Decompositions for different exogeneity assumptions.

Forecasted Variables	Variance Decompositions with a forecast horizon of 36 months					
	World block (w^*) exogenous with respect to					
	w, s		w		none	
	w^*	w^*, s	w^*	w^*, s	w^*	w^*, s
s	58	94	51	93	42	88
y	45	50	41	46	34	37
i	40	49	38	44	34	37
x	33	42	30	35	21	26

Decompositions for forecast horizons of 36 and 72 months are equal. For each assumption of exogeneity, the first columm sums up the variance accounted for the world block, while the second columm adds up the contribution of the country spread.

1.E Appendix: Some diagnostics

Overall, the models are not rejected by diagnostic tests for autocorrelation and heteroskedasticity (See Tables 1.24 and 1.25). Normality is not assured in the residuals of the equations for financial variables, that is for the world credit block and for Brazil's country-spread. As expected, they have non-standard distribution, which is mainly due to high kurtosis, resulting from excessive volatility or non-linearity of the series over short periods of time. Most of these are overcome once impulse dummies are introduced, for the months that correspond to: (a) the unscheduled action of the Federal Reserve facing the terrorist attack in unscheduled decision in September 2001; (b) the drastic rise in US corporate risk during the Enron crisis in December 2002; and (c) the dramatic upward shift in Brazilian spreads in June 2002 in anticipation of the outcome of the elections (a shift that precipitated, later in the same month, a statement of the leading candidate in the polls assuring his intention to honour financial contracts). Attempts to achieve normality in light of multivariate tests can be successful, but do not qualitatively change the results.

TABLE 1.24. Diagnostic Tests: without risk premium.

Statistics	Diagnostics for VAR(4) with r^*, q^*					
	Autocorrelation				ARCH	
	Portmanteau		*Breusch-Godfrey*		*Multivariate*	
	Q_{18}	Q_{24}	LM_1	LM_2	$MARCH_3$	$MARCH_4$
Test statistic	549.5	710.4	39.3	91.4	1331.7	1760.1
Approx. distribution	$\chi^2(536)$	$\chi^2(752)$	$\chi^2(34)$	$\chi^2(72)$	$\chi^2(1323)$	$\chi^2(1764)$
p-value	0.33	0.86	0.32	0.06	0.43	0.52

Procedures for tests follow Lütkepohl (2004).

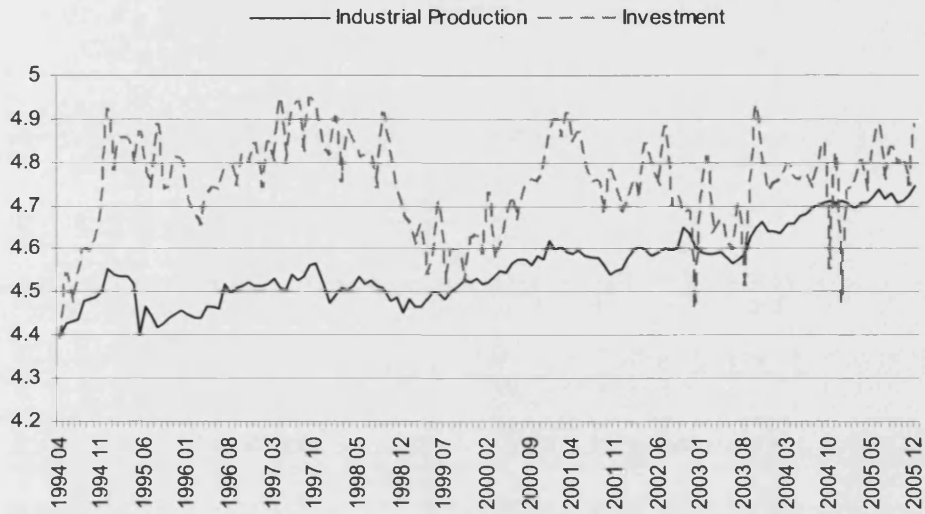
TABLE 1.25. Diagnostic Tests: with risk premium.

Statistics	Diagnostics for VAR(4) with r^* , q^*, z^*					
	Autocorrelation				ARCH	
	Portmanteau		*Breusch-Godfrey*		*Multivariate*	
	Q_{18}	Q_{24}	LM_1	LM_2	$MARCH_3$	$MARCH_4$
Test statistic	761.1	1012.5	51.1	118.6	2367.1	3121.4
Approx. distribution	$\chi^2(734)$	$\chi^2(1028)$	$\chi^2(49)$	$\chi^2(98)$	$\chi^2(2352)$	$\chi^2(3136)$
p-value	0.24	0.63	0.39	0.08	0.41	0.57

Procedures for tests follow Lütkepohl (2004).

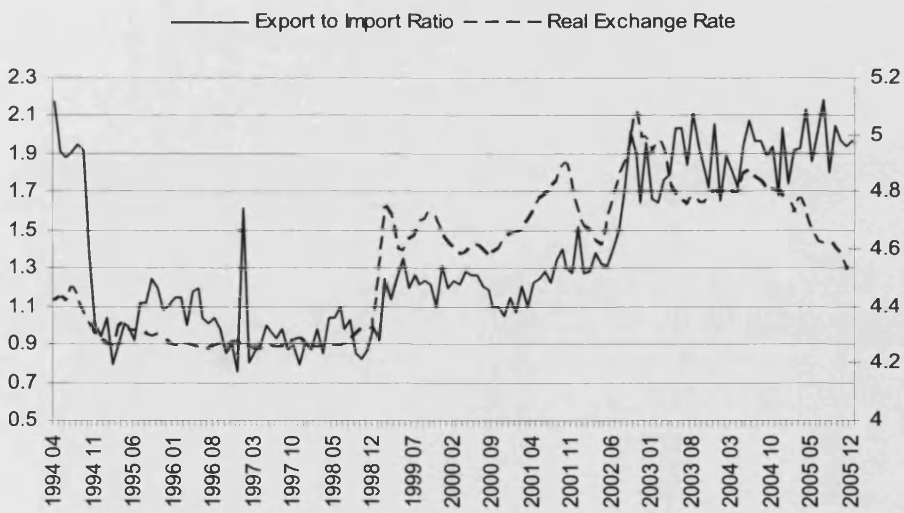
1.F Appendix: Additional Figures

FIGURE 1.19. Industrial Production and Investment.



Variables are given in logarithmic on the vertical axis. Units on the horizontal axis represent months.

FIGURE 1.20. Export to Import Ratio and Real Exchange Rate.



Variables are given in logarithmic on the vertical axis. Units on the horizontal axis represent months.

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2

Interest Rate and Business Cycles in a Credit Constrained Small Open Economy

2.1 Introduction

This Chapter contributes to our understanding of the causal relationship between two emerging economy phenomena that have intrigued both macroeconomists and financial economists over the last two decades. First, emerging economies have registered greater real aggregate volatility than advanced economies. Second, they have faced real interest rates in international financial markets that are higher and more volatile in absolute terms than those of advanced economies.

In this Chapter, I build on the empirical findings of Chapter 1 and provide additional evidence in support of the crucial role of exogenous real interest rate shocks in emerging economy business cycles. More importantly, I formulate a dynamic stochastic general equilibrium (DSGE) model to account for the impact of real interest rates on emerging economies. The model matches most of the empirical regularities related to the impact of real interest rate shocks. These disturbances, independent of total factor productivity shocks, have systematically significant effects over business cycle frequencies. They can account for over 20% of output volatility in line with empirical findings.

As argued by Calvo et al. (1996), international financial factors can be a key driver of the real interest rates of emerging economies over business cycle frequencies. Therefore, they can affect emerging markets, beyond the impact of domestic variables. Recent empirical studies indicate that, although subject to endogenous forces, real interest rates can be essentially driven by exogenous global credit shocks. These shocks transmit by means of international credit frictions and propagate into the domestic economy through the real interest rate. Uribe and Yue (2006) show that interest rate shocks can account for about 20% of output variability in emerging economies. Using a richer identification, which also includes disturbances in global risk appetite, in addition to global liquidity and uncertainty, Chapter 1 finds that global credit shocks are responsible for over 60% of real interest rate volatility, and account for almost 50% of real macroeconomic variability in Brazil. The bulk of such an impact propagates via the real interest rate.

In this Chapter, I use a VAR analysis of the Brazilian economy to characterize the main empirical regularities that a model of emerging economies should be able to reproduce. Since I am predominantly concerned with interest rate shocks, the identification of global credit shocks is much simpler than that used in Chapter 1. Moreover, the frequency of the data is quarterly, rather than monthly. However, the representation of macroeconomy includes consumption and hours, and GDP replaces industrial product as a proxy for output. Adding to previous work which clarifies that real interest rates are exogenous, counter-cyclical and lead cycles (e.g. Agénor et al., 2000; Neumeyer and Perri, 2005; Uribe and Yue, 2006), I simply show that international real interest rates have the ability to generate recessions and recoveries that are consistent with the dynamics of growth persistence. In particular, I highlight that the responses of output and consumption to world real interest rate shocks are hump-shaped. Overall, I argue that in order to deal with such features, a theoretical model requires strong propagation of these shocks.

The credit constrained small open economy (CCSOE) model that I propose contains two main innovations compared to standard small open economy (SOE) business cycle models. First, the stock of net foreign liabilities is endogenously constrained by the accumulation of capital, which also works as collateral in the sense of Kiyotaki and Moore (1997). Second, the economy's representative agent is relatively impatient. Thus, the economy finds itself in a negative net foreign asset position at steady state, and also facing a permanently binding credit constraint. These two complementary assumptions are key to the propagation mechanism.

Following Jaimovich and Rebelo (2006), preferences are set in more general terms, by combining characteristics of the two most widely used formulations in SOE and closed-economy real business cycle (RBC) models. They help to obtain a more realistic timing for the troughs in the hump-shaped responses. Furthermore, I include adjustment costs to labour and capital only to tweak the responses of hours and investment, respectively. Therefore, I control the excessive variability of these variables, especially that of investment, which is typically documented in SOE models. On the whole, the aforementioned assumptions are, both individually and collectively, neutral with regard to the major qualitative implications of the model.

By an impatience hypothesis and the implication of a permanently binding collateral constraint, the model captures two aspects of the financial integration of emerging economies within the world economy. First, it stresses their structural weakness in promoting financial deepening and domestic savings. Consequently, it highlights their dependence on foreign credit, as typically observed in Latin American countries over the last decades. Second, it focuses on frictions in international financial markets which, by the means of collateral, provide foreign creditors and investors with some discipline or rationing over the country's international financial exposure.

The key propagation mechanisms are associated with growth persistence in output and consumption. Such persistence results from the dual role of accumulating capital, which acts as both collateral and a production factor. Reliance on foreign finance, by the means of collateral, gives the economy an additional benefit of avoiding dramatic falls in the capital stock, in response to adverse shocks. Therefore, investment is curtailed less drastically than in standard models. Consumption smoothly adjusts, in particular in a hump-shaped form. Capital accumulation and consumption growth dynamics are interrelated in a unconventional way. The interplay between these two is driven by an intertemporal wedge that is correlated to the variable premium between the marginal product of capital and the real interest rate. Contractions and expansions approximately coincide with premium levels, respectively, both below and above the steady state value. In response to adverse interest rate shocks, the premium declines and the marginal product of capital becomes comparatively low, thereby creating disincentives to invest and consume. Recessions can be prolonged, lasting while the interest rate still declines above its equilibrium value. Recoveries are prompted when the marginal product of capital and the corresponding premium rise.

Calibrated for Brazil, the model closely resembles the empirically given structure of second moments and negative correlations between output and lagged interest rates. Its simulations also replicate the empirical responses of output and consumption to interest rate shocks, displaying humped shapes with troughs that occur realistically around 3 quarters after the shock. Overall, interest rates have significant effects in determining macroeconomic volatility. These effects, over business cycle horizons, are not dampened by productivity shocks, with realistic or similar standard deviations. Interest rate shocks increase the overall variability of real aggregates. Moreover, due to a persistent impact on consumption growth dynamics, they generate a realistically higher volatility of consumption relative to output.[1]

In essence, the CCSOE model appears to outperform other SOE models in systematically addressing key facts related to emerging economy business cycles. Following the *real* business cycle approach (Mendoza, 1991), most SOE models do not impose a financial friction in the endogenous sense proposed here. They share the same poor propagation mechanism in consumption dynamics and are standardly characterized by the use of one of the "ad hoc" hypotheses discussed in Schmitt-Grohé and Uribe (2003) to close the SOE model and render it stationary.[2] Although widely recognized empirically as a potentially important mechanism for transmitting international shocks, the world real interest rate can only play a limited role in these models. This is the reason why alterations have been proposed to the standard framework and to shock specifications. Regarding the latter, Blankenau et al. (2001) reverse the traditional calibration methodology and let the model guide the specification of interest rate shocks that would be responsible for about one-third of Canada's output volatility. They find that the volatility required for these shocks is unrealistically about 8 times the volatility of total factor productivity shocks.

Neumeyer and Perri (2005) and Uribe and Yue (2006) incorporate, among other features, a working capital constraint. The two models perform relatively well in matching certain regularities, the negative correlation between output and lagged interest rates and the responses to interest rate shocks, respectively. However, they depend on additional assumptions to generate the appropriate propagation in each case. Neumeyer and Perri (2005) explicitly acknowledge the reliance on country-spread shocks that are independent from world interest rate shocks, but induced by negative productivity shocks. Whereas Uribe and Yue (2006) use a VAR estimated equation of the country-spread to close the model. Merely incorporating a working capital constraint would not suffice to obtain the results. Overall, to reconcile theory and evidence, most SOE

[1] See for instance Agénor and Prasard (2000) and Kydland and Saragoza (1997).

[2] Schmitt-Grohé and Uribe (2003) address a variety of stationary assumptions in infinite-horizon models (endogenous discount factor, debt-elastic interest rate premium and portfolio adjustment costs). Alternatively, Blanchard (1985) and Yaari (1965) set stationary assumptions in an overlapping generations model.

models have to rely on unrealistically high volatility of interest rates and/or presume a negative correlation between the latter and productivity (Oviedo, 2005).

While intrinsically enhancing the propagation of interest rates, the CCSOE model also overcomes anomalies of standard SOE models: a low and insignificant correlation between output and the net export to GDP ratio, and a lack of serial autocorrelation in investment. It recovers dynamic properties of the closed-economy real business cycle models that, despite being empirically imperative, have been widely neglected within the standard SOE framework. The latter is nested within the CCSOE as the extreme case of a credit frictionless economy.

The CCSOE model inherits some of the features of Kiyotaki and Moore (1997) and Kiyotaki (1998), but differs in the following important aspects. First, as a SOE model, it incorporates exogenous interest rate shocks. Second, by the same token, the economy has a larger variety of routes for adjusting to shocks, namely via reversals in the current account. Third, capital, rather than land, acts as collateral. Since the former asset evolves according to aggregate accumulating dynamics, the economy is widely subjected to the adjustment processes associated with changes in net liabilities. Fourth, the combination of access to foreign finance and aggregate collateral formation enhances the propagation mechanism.

Kocherlakota (2000), Arellano and Mendoza (2002), and Chari et al. (2005) also use foreign credit constraints in SOE models.[3] Mendoza (2006) is in some aspects the closest model, but it has different motivation and hypotheses. Primarily, I am more concerned with regular business fluctuations than occasional sudden stops. Secondly, by closing the SOE model with a permanently binding constraint, I rule out the non-linearity associated with a slack credit constraint, and thus do not need to add another assumption with the sole function of rendering the system stationary.

Output responses to real interest rate shocks in emerging economies share similar features to those frequently documented for domestic monetary policy shocks in advanced economies. In both cases, the humped shapes indicate the need to bring growth persistence to the core of the propagation mechanism of macroeconomic models. A modelling strategy based on nominal rigidities, as in Christiano et al. (2005), could be extended to SOEs and complement the explanation offered in this Chapter. However, by abstracting from nominal rigidities and domestic monetary policies, it allows us

[3] Caballero and Krishnamurthy (2001) also elaborate on the role of capital collateral on foreign borrowing in a three-period model.

to properly address the financial accelerator mechanisms that are responsible for the actual propagation of real interest rates in emerging economies.

Section 2.2 presents the empirical evidence and regularities. Section 2.3 describes the model. Section 2.4 deals with calibration. Sections 2.5 and 2.6 contain the main results, while comparing model simulations to the empirical evidence. Section 2.7 discusses the intuition behind the propagation mechanism of the model. Section 2.8 explores the robustness of the model, and Section 2.9 concludes.

2.2 The Evidence of Real Interest Rate Shock

In order to revisit and clarify the evidence of the role of real interest rate shocks in emerging economies, as well as to set an empirical benchmark for the model of Section 2.3, I conduct a VAR exercise on Brazil for the period 1994-QII to 2005-QIV. Brazil is one of the major developing economies, with a significant presence in emerging markets. The period of analysis covers most of the Brazilian experience of closer integration with global financial markets, common to similar emerging economies.[4] Moreover, the essence of the Brazilian evidence coincides with the cross-country evidence that has been put forward for emerging economies.[5]

The VAR representation is one of a simple SOE economy, in which the following endogenous variables are included: output, hours, consumption, investment and net trade to GDP ratio.[6] They enter vector y in the same order. Real interest rate, r, is also included. It is obtained as the sum of the US real interest rate and the country spread. The former is calculated as the difference between the nominal rate of US 3-month Treasury bonds and the corresponding expected US inflation.[7] The variables are in logs, except for the trade ratio and interest rate, and enter the VAR in levels. Additional details of the data are described in Appendix 2.A.

The VAR is set with only one (1) lag. This choice is guided by information criteria tests (Akaike, Final Prediction Error, Hannan-Quinn and Schwartz), allowing for a maximum of 12 lags. Apart from time trends, which are added in the equations of output, consumption and investment, the unrestricted VAR representation is the following:

$$\begin{bmatrix} y_t \\ r_t \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ r_{t-1} \end{bmatrix} + u_t.$$

2.2.1 Exogeneity and significance

VAR Granger causality tests and variance decomposition[8] analysis firmly support the hypothesis that interest rate can be treated as an exogenous process, independent from

[4]See Kose, Prasad, Rogoff and Wei (2006) for a reappraisal of financial globalization and its relationship with emerging economies.

[5]See e.g. Neumeyer and Perri (2005) and Uribe and Yue (2006).

[6]This representation is similar to the one used by Uribe and Yue (2006), but also includes hours and consumption. The latter and Neumeyer and Perri (2005) treat Brazil as a SOE, whereas Kanczuk (2004) constructs a closed-economy model to study real interest rates and the country's business cycles.

[7]Expected inflation is given by the estimate of an autorregressive process with 8 lags.

[8]Huh (2005) examines the possible limitations of Granger causality tests within VAR analyses of SOEs, and suggests the use of variance decompositions to further assess hypotheses of exogenous (foreign) variables.

TABLE 2.1. Granger Causality Tests.

H_0 :	p-value
$y \rightarrow r$	0.4660
$r \rightarrow y$	0.0023

Tests on the basis of the unrestricted VAR, allowing Brazilian variables to affect US ones.

TABLE 2.2. Variance Decompositions and Interest Rate in VAR Models.

Dependent Variable	VAR specifications with interest rate (r)								
	endogenous r block-restricted VAR						exogenous r $c_{21} = 0$		
	$[y_t\ r_t]'$			$[r_t\ y_t]'$					
	quarters			quarters			quarters		
	4	8	20	4	8	20	4	8	20
Interest rate	90	88	87	99	97	96	100	100	100
Output	23	26	25	22	25	25	26	37	37
Hours	4	3	3	3	2	3	4	4	3
Consumption	34	41	41	32	41	41	35	51	53
Investment	26	32	32	20	28	28	23	38	40
Trade	8	18	17	9	19	18	6	19	22

Variance decompositions are expressed in per cent (%). Unrestricted VAR results in the same decompositions of the restricted VAR with interest rate ordered last.

the representation of the macroeconomy given by the five endogenous variables in y. Granger causality tests, which result from the unrestricted VAR, are shown in Table 2.1.

Variance decompositions are calculated for four specifications: unrestricted VAR; restricted VARs with r ordered last and first; and the VAR with exogenous r. The latter obtains by setting $c_{21} = 0$, and therefore the effects of interest rate shocks do not depend on the ordering at all.

Table 2.2 reports the variance decompositions under the above specifications, at 4, 8 and 20 quarters after the shock. The unrestricted VAR decompositions are not shown, as they coincide with those of the restricted VAR with interest rate ordered last. Overall, all specifications indicate a strong degree of exogeneity for the interest rate and a significant effect of interest rate innovations on economic activity over business cycle frequencies. In line with the Granger tests, there is no empirical support for reverse causality. Interest rates appear to explain around 30% of the variability of output and investment, a higher proportion (40%) of consumption variability, and about 20% of trade movements.

These results are in line with those in empirical literature that support the hypothesis that - to a large extent - exogenous shocks to the interest rates of emerging economies are key to understanding their business cycles. In a panel VAR including seven emerging countries (Argentina, Brazil, Ecuador, Mexico, Peru, Philippines and South Africa), Uribe and Yue (2006) find that on average about 20% of movements in aggregate activity are explained by disturbances in the US real interest rate. This is consistent with the relative importance of US monetary shocks, as shown by Canova (2005). Chapter 1 finds, within a more comprehensive representation of world credit markets, that by including innovations to other US financial variables, such as changes in term spreads in US interest rates and in premia for Moody's BAA corporate bonds (over Moody's AAA corporate bonds), about 60% of the variability of Brazil's real interest rate, and 50% of the country's output volatility, could be attributed to exogenous financial factors that are at the core of global credit markets. These factors, affecting uncertainties and risk perceptions, transmit into the real economy via the interest rate and its corresponding financial acceleration mechanism.

2.2.2 Propagation, persistence and volatility

The solid lines in Figure 2.1 are the estimated responses of *all* endogenous real variables resulting from the VAR with exogenous interest rate shocks. Dotted lines represent 95% confidence intervals. The other VAR specifications have identical responses and confidence intervals.

The estimated responses feature the dynamics of growth persistence. Output, consumption and investment responses conform with recessions (recoveries) in which a drop (rise) in one of these real aggregates is subsequently followed by another.[9] The troughs occur after two to four quarters, and the variables appear to return to their pre-shock levels after six to twelve quarters. The responses indicate that interest rates are effectively countercyclical and lead the cycle.[10] Furthermore, the trade ratio response denotes a positive adjustment to the current account, which can be associated to larger surpluses or smaller deficits. It also seems to be sluggish, with considerable persistence and picks around the fifth quarter. All the responses are thus marked by

[9] Note that, given the one-sided nature of the responses, the likelihood of misrepresented recessions is only 2.5%.

[10] The counter-cyclical feature of real interest rates might not be exclusive to emerging economies. King and Rebelo (1999) and Stock and Watson (1999) report counter-cyclical evidence for the US before the nineties. The latter was likely caused by different factors than those observed in emerging economies, but both might relate to excessive macroeconomic volatility.

hump-shaped patterns. They summarize the propagation of interest rate shocks, with pronounced and magnified recessions. Their sluggishness and growth persistence dynamics are analogous to those found in studies of the impact of productivity shocks and monetary shocks in closed-economy business cycles.[11]

Due to such a strong propagation, correlations between output and lagged interest rate are persistently negative, peaking in absolute terms between two and three quarters after the shock. Otherwise, in the absence of such a propagation, the effects of interest rate shocks would be weakened and dampened by dominant shocks over business cycle frequencies, as in most SOE models. In the CCSOE model, sustained and significant effects are caused by interest rate shocks, among other sources, mainly because of the strength the propagation mechanism derived from its credit frictions.

Interest rates emerge thus as a potentially considerable source of the excessive macroeconomic volatility of emerging economies. Over the period of analysis, Brazil reveals a standard deviation of the HP-filtered GDP series (in logs) that is 1.78 higher than the US counterpart. At the same time, the volatility of Brazil's real interest rate is about twice that of the US rate.

Interest rate shocks can also be an important force behind the high volatility of consumption, relative to output, among emerging economies. As already revealed in Figure 2.1, interest rate shocks are prone to generating an excess in the deviation from steady state in consumption response vis-à-vis output response. This fact is further corroborated by the unconditional second moments of the Brazilian real data, shown in Table 2.5 with the model's simulated moments.[12]

2.2.3 Theoretical challenges

Following the VAR analysis of the Brazilian case, the overall evidence for interest rates and business cycles in emerging economies suggests that:

(a) shocks to the economy's real interest rate can be mainly - or to a great extent - exogenous and they are significantly sustained over business cycle frequencies;

(b) output, consumption and investment respond to these shocks in a hump-shaped form, in agreement with the persistent feature of recessions and recoveries;

[11] See, for instance, Cogley and Nason (1995) and Christiano et al. (2005), respectively.

[12] Table 5 shows an excess of 29% in the standard deviation of consumption relative to output. Neumeyer and Perri (2005) calculate a similar excess of 24% in a shorter period.

(c) the real interest rate is unambiguously countercyclical and leads the cycle, with strong propagating forces, regardless of the effects of other sources of fluctuations;

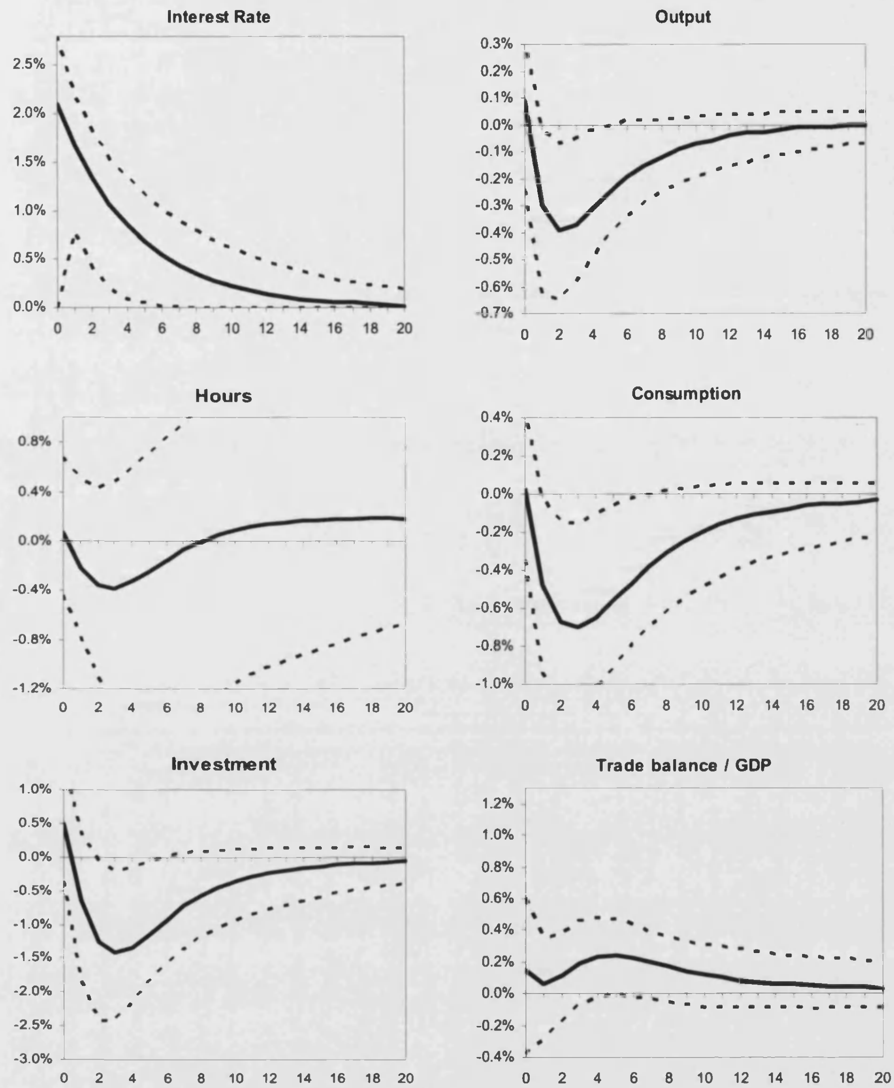
(d) correlations between output and lagged real interest rates are increasingly negative during recessions, picking up in absolute terms around the trough of output responses;

(e) consumption can be more responsive than output to interest rate shocks;

(f) current account responses are also sluggish, in a hump-shaped pattern, and at least as countercyclical as in advanced economies.

Most of these challenges differ from those of advanced economies and cannot be explained in an integrated way by available SOE models. In order to address them all, it appears that ideally a model must have four features: a stronger propagation of interest rate shocks, particularly with respect to consumption's intertemporal dynamics; a propagation mechanism by which recessions are aggravated by negative growth persistence, and by which responses to interest rate shocks conform to humped shapes; as a result of the two aforementioned features, a good matching of standard second moments of data statistics, in particular showing the ability of interest rate to generate excessive macroeconomic variability and more realistic comovements, autocorrelations and relative deviations of the series; and, finally, a good replication of (the dynamic pattern of) correlations between output and interest rate at lags that are empirically meaningful.

FIGURE 2.1. VAR impulse responses.



Solid lines are VAR responses to interest rate shocks. Dotted lines represent 95% confidence intervals. The vertical axes shows deviations from the steady state. Units on the horizontal axes are quarters.

2.3 The Model Economy

The model economy has a single homogeneous good and is populated by a single representative agent. It faces an exogenous world economy against which it has net foreign liabilities (sustained recourse to foreign financing) paying an exogenously determined and variable gross real interest rate R_t. The lower limit of this gross interest rate is given by a benchmark international rate, R_t^*, so that $R_t \equiv 1 + r_t \geq 1 + r_t^* \equiv R_t^*$, and $R \equiv E_t R_t \geq E_t R_t^* \equiv R^*$.

I assume the representative agent is relatively less patient than the world economy's counterpart, whose discount factor $\beta^* \equiv R^{*-1}$, as usually set. Therefore, the CCSOE's discount factor is lower than the rest of the world's, that is $\beta < \beta^*$.[13] Such a parametric relative impatience in relation to the rest of the world is similar to Paasche's (2001). It is also analogous to the impatience gap between heterogeneous agents assumed in the closed-economy models of Kiyotaki and Moore (1997), and of Carlstrom and Fuerst (1997). Moreover, it is in line with the heterogeneous cross-country empirical evidence, which indicates a positive correlation between β and wealth, as in Becker and Mulligan (1997).

The relative impatience gives the model steady state properties that preclude the use of one of the assumptions that is only conventionally set to close SOE models and to render them stationary (Schmitt-Grohé and Uribe, 2003). As long as $R\beta < 1$, there is a steady state equilibrium in which the collateral constraint permanently binds.[14] By positing credit frictions and setting the impatience hypothesis, I assume that in equilibrium the emerging economy would like to borrow as much as it could, but its ability to borrow is endogenously constrained and also subject to interest rate disturbances in global credit markets.

The representative agent maximizes her life-time utility as defined in Jaimovich and Rebelo (2006),

$$U = E_t \sum_{s=t}^{\infty} \beta^{s-t} u(C_t, L_{t,}, J_t), \tag{2.1}$$

where

[13] In line with the SOE assumption, I do not model the rest of the world, which would correspond to the case of an unconstrained SOE representative agent model. Even if it is assumed to be a patient economy, as it lends to the CCSOE, the ratio of its net foreign assets to capital would be close to zero. Accordingly, $\beta^* R^* = 1$.

[14] Note that the impatience hypothesis ($\beta < \beta^*$) is implied by $\beta R < 1$ and $R > R^*$. Arguably, to set $\beta < \beta^*$ appears to be as "ad hoc" as to set $\beta = \beta^*$ or even $\beta > \beta^*$.

$$u(C_t, L_{t,}, J_t) = \frac{(C_t - aH_t^\theta J_t)^{1-\eta} - 1}{1-\eta} \tag{2.1a}$$

$$J_t = C_t^b J_{t-1}^{1-b} \tag{2.1b}$$

and

$$L_s + H_s = 1 \tag{2.1c}$$

L and H stand for leisure and hours worked. While C_t denotes current consumption, it can be shown that J_t refers to an index that tracks the consumption path. It could be interpreted as the "underlying" consumption level, which controls the marginal substitution of leisure relative to actual consumption. The above representation nests, on the one hand, preferences of standard RBC models (e.g. King, Ploser and Rebelo, 1998) and, on the other hand, preferences widely used in SOE models, originally found in Greenwood, Hercowitz and Huffman (1988). These preferences are derived from the proposed representation by setting $b = 1$ (KPR preferences) and $b = 0$ (GHH preferences), respectively. Therefore, a realistic approach to labour dynamics is assured, avoiding excessively fast (short term) and excessively sluggish (long term) labour responses over business cycles. It can provide the supply of labour with reasonably moderate wealth effects.

The agent accumulates capital and not only faces resource and technology constraints, but also a credit collateral constraint on net foreign liabilities.

The resource constraint is the following:

$$C_t \leq Z_t f(K_{t-1,} L_t) - I_t + B_t - R_t B_{t-1} - H_t \Omega(H_t/H_{t-1}) \tag{2.2}$$

Therefore, the agent can finance consumption and investment expenditures with resource to net foreign liabilities.

The interest rate is not known to the agent at the time of the borrowing so as to appropriately consider the uncertainty implied by foreign financing of emerging economies.[15] Conversely, by positing the interest rate is known, $R_{t-1}B_{t-1}$ would replace

[15] This uncertainty might reflect not only emerging economy credit risks, but also the randomness of relative prices that SOEs face with respect to the rest of the world.

R_tB_{t-1} in the resource constraint. The main implications of the model would overall remain intact.[16]

The function $\Omega(\ )$ defines labour adjustment costs, and I assume $\Omega(1) = \Omega'(1) = 0$ and $\Omega''(1) = \pi^h$. These assumptions are sufficient to determine the costs incurred for changes in labour, while no costs are incurred at the steady state. Z_t represents current total productivity. The production function is Cobb-Douglas and therefore:

$$f(K_{t-1},L_t) = K_{t-1}^{\alpha}(1 - L_t)^{1-\alpha} \tag{2.3}$$

The capital accumulation is given by:

$$I_t[1 - G(I_t/K_t)] = K_t - (1 - \delta)K_{t-1} \tag{2.4}$$

The function $G(\ )$ represents capital adjustment costs. Analogous to labour adjustment costs, I simply assume $G(1) = G'(1) = 0$ and $G''(1) = \pi$. The latter parameter does not affect the steady state properties of the model, but its dynamic properties. The rate of capital depreciation is given by $\delta \in [0, 1]$.

The credit collateral constraint, which always binds due to the relative impatience assumption, is:

$$B_t \leq \gamma_t[K_{t-1}(1 - \delta) + \sigma I_t] \tag{2.5}$$

where $\gamma_s \in [0, 1]$ designates the proportion of capital that is actually accounted as collateral formation. Current investment might play a role in collateral formation, by a proportion given by σ. For $\sigma = 0$ or $\sigma = 1$, the constraint would be $B_t \leq \gamma_t K_{t-1}(1 - \delta)$ or $B_t \leq \gamma_t K_t$, respectively. Correspondingly, either current investment would have no value in collateral formation, or it would have exactly the same value as that of physical capital. In the baseline calibration, I set $\sigma = 0$, since it assures less volatility of investment. However, an intermediate case, in which current investment has some value should not be dismissed.

[16] The most noticeable exception would concern the pace of the responses to interest rate shocks. The amplitude is slightly more dramatic and troughs occur earlier in the case the interest rate is fixed beforehand. Oviedo (2005) finds analogous results within a different SOE framework.

The model is subject to three disturbances that can affect the exogenous processes of productivity, interest rate and collateral formation. These processes follow a vector auto-regressive form:

$$w_t = Pw_{t-1} + \varepsilon_t \ ,$$

where $w_t = \begin{bmatrix} z_t & r_t & \gamma_t \end{bmatrix}'$ and $\varepsilon_t = \begin{bmatrix} \varepsilon_t^z & \varepsilon_t^r & \varepsilon_t^\gamma \end{bmatrix}'$. Note that $z_t = \ln Z_t$ and $r_t = \ln R_t$. Each component of the vector ε_t contains i.i.d. innovations with mean zero.

The benchmark model essentially has a diagonal P, with independent shock processes. In order to explore the potential of the model's propagation mechanism of interest rate shocks, alternative (non-diagonal) specifications of P are considered in which the exogenous processes cease to be independent, while shocks remain so.

2.3.1 *First order conditions*

The problem involves maximizing the following Lagrange expression, with ψ_t, λ_t , $\lambda_t q_t$, $\lambda_t \varphi_t$ Lagrange multipliers:

$$\mathcal{L} = E_t \sum_{s=t}^{\infty} \beta^t \left\{ \begin{array}{c} u(C_t, L_{t,}, J_t) + \psi_t [J_t - C_t^b J_{t-1}^{1-b}] \\ \lambda_t [Z_t f(K_{t-1,} L_t) - I_t + B_t - R_t B_{t-1} - C_t - H_t \Omega(H_t/H_{t-1})] \\ +\lambda_t q_t [I_t - I_t G(I_t/K_{t-1}) - K_t + (1-\delta) K_{t-1}] \\ +\lambda_t \varphi_t [\gamma_t K_{t-1}(1-\delta) + \gamma_t \sigma I_t - B_t] \end{array} \right\}$$

Six first order conditions (FOCs) are derived from the Lagrangian maximization problem:

$$u_L(C_t, L_{t,}, J_t) = -\lambda_t \left[f_L(K_{t-1,} L_t) + \Omega(H_t/H_{t-1}) + \frac{H_t}{H_{t-1}} \Omega'(H_t/H_{t-1}) \right] \tag{2.6}$$

$$+\beta E_t \lambda_{t+1} \left(\tfrac{H_{t+1}}{H_t}\right)^2 \Omega'(H_{t+1}/H_t)$$

$$\lambda_t = u_C(C_t, L_{t,}, J_t) - b\psi_t \left(\frac{J_{t-1}}{C_t}\right)^{1-b} \tag{2.7}$$

$$\psi_t = -u_J(C_t, L_{t,}, J_t) + \beta(1-b) E_t \psi_{t+1} \left(\frac{J_t}{C_{t+1}}\right)^{-b} \tag{2.8}$$

$$\lambda_t = \lambda_t q_t \left[1 - G(I_t/K_{t-1}) - \frac{I_t}{K_t} G'(I_t/K_{t-1})\right] + \gamma\sigma\lambda_t\varphi_t \tag{2.9}$$

$$E_t \beta \frac{\lambda_{t+1}}{\lambda_t} R_{t+1} = 1 - \varphi_t \tag{2.10}$$

$$E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \left\{ \begin{array}{c} Z_{t+1} f_K(K_t, L_{t+1}) + q_{t+1}\left[1 - \delta + \left(\frac{I_{t+1}}{K_t}\right)^2 G'(\frac{I_{t+1}}{K_t})\right] \\ +(1-\delta)\gamma_{t+1}\varphi_{t+1} \end{array} \right\} = q_t \tag{2.11}$$

Equations (2.6) and (2.7) govern the standard intratemporal consumption-labour substitution, except that they contain terms related to labour adjustment costs and, more importantly, to deviations from the underlying consumption path, respectively. The latter enriches the standard substitution problem in ways that are determined by Equation 2.8, which sets the dynamics of the disturbances to consumption, as in Jaimovich and Rebelo (2006).

The first order condition pertaining to investment (Equation 2.9), controls the movements in the shadow price of investment. This price would be constant ($q = 1$), had I assumed no investment adjustment cost and no role for current investment in credit collateral formation.

Equations (2.10) and (2.11) are the fundamental Euler conditions. They sharply differ from their counterparts standardly found in RBC or SOE models. They both contain the relative multiplier of the credit collateral constraint, φ_t, which gives the shadow price of collateral relative to consumption. The binding of the constraint imposes a positive value for the shadow price. At the steady state, $\varphi = 1 - \beta R$. Equation (2.10) has been stressed in previous work, such as Chary et al. (2005), Arellano and Mendoza (2002), and Mendoza (2006). However, in their models, except to a certain degree in the latter's, the multiplier does not explicitly apply as in Equation (2.11). The two equations are key to the propagation mechanism that characterizes the CCSOE framework.

The model is fully described by Equations (2.2)-(2.5) and by the FOCs expressed in equations (2.6)-(2.11), as well as by the specification of the underlying exogenous processes, which I address in the next Section. I solve the model by the logarithmic linearisation method, as described in Uhlig (1999).[17]

[17]The Matlab code containing the loglinearized equations can be provided by the author. The simulations use Uhlig's toolkit of Matlab codes for analyzing nonlinear dynamic stochastic models.

2.4 Calibration

2.4.1 Parameters

Calibration is guided by Brazilian data and by the restrictions imposed by the structure of the model. The baseline parameters are shown in Table 2.3. The average international real interest rate was around 8% per annum (therefore $r = 0.02$ on a quarterly basis) in Brazil from 1994 to 2005. According to the country's national accounts, the shares of investment and net export in GDP (I/Y and X/Y) were around 20% and 3%, respectively.

In business cycle studies of Brazil, the choice of the capital ratio (K/Y) varies between 4 (Ellery at al., 2002) and 11.6 (Kanczuk, 2004) on a quarterly basis, that is between 1 and 2.9 on an annual basis. Empirical estimates of capital, and consequently the ratio, have shown similar discrepancies. I set an intermediate value, at 7.45 on a quarterly basis (1.86 on an annual basis). It is just below the typical values used for the US or for small open advanced economies, such as Canada. Regarding the latter, since Mendoza (1991), most studies have set the ratio at 8.8 (2.2 on an annual basis).

With the aim to specify technology parameters, calculations based on income shares usually give developing countries a higher capital share (α) than found for developed economies. I use $\alpha = 0.38$, although Brazilian data would suggest a value close to 0.50. The under-estimation of labour income probably results from the use of informal and/or self-employed labour.[18] The parameters of capital and labour adjustment costs (π and κ) follow typical ranges found in the literature.

The subjective discount rate, that is implied by the discount factor, must be higher than the real interest rate in the CCSOE model. Correspondingly, the steady state premium, φ, given by $\varphi = 1 - \beta R$, is set on a quarterly basis at 0.0051. This is consistent with the hypothesis of relative impatience and with estimates of Brazil's discount factor, which are usually close to 0.9 annually - well below the estimates for the US.[19] Aside from the discount factor, the calibration of the preference parameters is similar to Jaimovich and Rebelo (2006). Particularly in the baseline calibration, I use a small value for b, rendering preferences closer in spirit to the GHH preferences.

[18]See Golin (2002) for an overall discussion on income shares, and Caselli and Feyrer (2006) for cross-country comparisons in capital share. Shares in Latin American economies range from 0.4 to 0.5, while in advanced economies they lie between 0.2 and 0.4.

[19]Estimates by Ferreira and Val (2001), Issler and Piqueira (2001), and Yoshino and Santos (2008), support this value under different utility specifications. Ellery et al. (2002) use a similar value (0.89 annually).

This actually permits hours to react negatively in the short run to adverse interest rate shocks, as indicated in the corresponding VAR response in Figure 2.1.

The collateral parameter γ is set in accordance with the average net foreign liability to GDP ratio, B/Y, as well as the capital to GDP ratio, K/Y. It can be shown from Equations (2.4) and (2.5) that in steady state:

$$\frac{B}{Y} \equiv \frac{K}{Y}\gamma\left[1-(1-\sigma)\delta\right]$$

By setting $\sigma = 0$ and $\delta = 0.027$, we can recover a consistent value for γ. I roughly calculate the country's net foreign liabilities (liabilities minus assets), by adding the net foreign debt (0.28) and remaining net foreign liabilities in equity, minus the international reserves. I arrive at a net foreign liability ratio of 0.42 annually. Thus, γ is around 0.22. A lower γ would obtain had I used a narrow concept of the country's international investment position, such as the stock of merely international debt contracts.

TABLE 2.3. Baseline Parameters.

Parameter	Symbol	Value
Rates		
international real interest rate	r	1.02
subjective rate	β^{-1}	1.0251
Preference		
discount factor	β	0.9755
elasticity of labour supply $= \frac{1}{1-\theta}$	θ	1.01
utility curvature	η	1
utility parameters	a	2.39
	b	0.15
Technology		
capital share	α	0.38
depreciation rate	δ	0.027
capital adjustment cost	π	2.6
labour adjustment cost	κ	2.0
Collateral formation		
collateral share	γ	0.2238
current investment weight	σ	0

2.4.2 Specification of the exogenous processes

The CCSOE model in Section 2.3 is subject to three exogenous processes: productivity (z_t), real interest rate (r_t) and collateral formation (γ_t). They are represented in vector form by $w_t = Pw_{t-1} + \varepsilon_t$,where $w_t = \left[\begin{array}{ccc} z_t & r_t & \gamma_t \end{array}\right]'$.

The first two processes are conventional in SOE models. Collateral formation is proposed here, as an exogenous process that represents innovations in the efficiency by which the country can provide international creditors and investors with collateral through capital accumulation. It relates to a country's ability to borrow and the willingness of creditors to lend. It can result from short or long term factors at home - e.g. underdevelopment of the country's financial markets and other structural weaknesses - or in international financial markets - e.g. segmentation of international financial markets with regard to a country or to a class of countries to which it belongs.

I examine two kinds of specifications to control the dynamics of the exogenous processes: purely independent, and interest rate induced processes. In the former, each process is completely driven by its own independent shocks. In the latter type of specifications, not only can each process be driven by its own shocks, but real interest rate shocks can also affect the collateral and productivity processes. However, all shocks are always treated independently, so that no correlation is allowed between them.

Overall, consistent with the empirical evidence, I assume that innovations to the interest rate are a key source of fluctuations. That is why it is imperative to analyse the specification purely with independent processes. Furthermore, since the interest rate is much more likely to cause all observable macroeconomic aggregates than to suffer from a reverse causality from domestic factors, it should be seen as a good candidate to induce changes in the economy's international macroeconomic and financial conditions, in addition to its domestic impact. The induced specifications can thus be viewed as a representation of means by which interest rate shocks further propagate beyond the independent interest rate self-propelled propagation mechanism.

Therefore, all of the proposed specifications for P feature the restriction that $P_{2j} = 0$, where $j = 1$ and 3. The *purely independent* specification has a diagonal P matrix, in the following general form:

$$P = \begin{bmatrix} \rho^z & 0 & 0 \\ 0 & \rho^r & 0 \\ 0 & 0 & \rho^\Upsilon \end{bmatrix}$$

Interest rate induced processes are alternatively considered if one or more non-diagonal elements in P that reflect an interest rate causation are not zero; that is: $P_{i2} \neq 0$, for $i = 1$ and 3. In general, P would conform to:

$$P = \begin{bmatrix} \rho^z & \rho^{zr} & 0 \\ 0 & \rho^r & 0 \\ 0 & \rho^{\gamma r} & \rho^\gamma \end{bmatrix}$$

The values I attribute to P in the model's simulations are either directly derived from the coefficient estimates of the VAR or indirectly motivated by them. Table 2.4 shows parameter estimates of the unrestricted VAR in Section 2.2. Alternative VAR specifications give almost identical estimates.

TABLE 2.4. Parameter Estimates of the Unrestricted VAR System.

Explanatory	Dependent variables					
variables	$\hat{y}_t$	$\hat{h}_t$	$\hat{c}_t$	$\hat{i}_t$	$\hat{x}_t$	$\hat{r}_t$
$\hat{y}_{t-1}$	0.271	0.061	-0.163	0.479	0.522	-0.127
	(0.154)	(0.230)	(0.249)	(0.579)	(0.098)	(0.154)
	[1.759]	[0.468]	[-0.654]	[0.826]	[5.308]	[-0.823]
$\hat{h}_{t-1}$	0.006	0.917	-0.045	-0.155	0.054	-0.017
	(0.025)	(0.040)	(0.035)	(0.082)	(0.021)	(0.048)
	[0.227]	[22.773]	[-1.294]	[-1.891]	[2.608]	[-0.357]
$\hat{c}_{t-1}$	0.058	-0.189	0.549	-0.180	-0.279	0.054
	(0.110)	(0.188)	(0.145)	(0.342)	(0.126)	(0.223)
	[0.525]	[-1.022]	[3.776]	[-0.234]	[-2.206]	[0.241]
$\hat{i}_{t-1}$	0.011	-0.013	0.075	0.612	-0.136	0.059
	(0.047)	(0.074)	(0.065)	(0.152)	(0.037)	(0.088)
	[0.235]	[-0.170]	[1.161]	[4.029]	[-3.664]	[0.674]
$\hat{x}_{t-1}$	0.127	0.264	0.169	0.486	0.195	-0.043
	(0.074)	(0.129)	(0.097)	(0.228)	(0.101)	(0.153)
	[1.715]	[2.046]	[1.746]	[2.132]	[1.929]	[-0.282]
$\hat{r}_{t-1}$	-0.170	-0.160	-0.268	-0.533	0.042	0.715
	(0.053)	(0.093)	(0.069)	(0.163)	(0.047)	(0.110)
	[-3.221]	[-1.730]	[-3.875]	[-3.274]	[0.901]	[6.527]

Standard deviations and t-statistics are shown in ( ) and [ ], respectively.

2.4.2.1 Independent processes

Independent processes can be modelled on the basis of the following autoregressive matrix, whose parameters are the estimated autoregressive coefficients from the corresponding VAR equations for output (0.27) and interest rate (0.72), as shown in Table 2.4.[20]

[20] In the restricted VAR, with a totally exogenous interest rate, estimates of the autoregressive coefficient of output and interest rate are 0.276 (t-value=1.789) and 0.798 (t-value=8.523), respectively.

$$P^I = \begin{bmatrix} 0.27 & 0 & 0 \\ 0 & 0.72 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

The choice of the autoregressive coefficient for the interest rate process is straightforward, as it is unambiguously given by the estimated autoregressive coefficient in the VAR interest rate equation. The corresponding productivity coefficient is not given by the VAR. However, it can be noted from the VAR estimates that the equations of hours and investment (and in theory by extension capital) contain much more persistent processes than output. Such a fact might suggest that persistence in total factor productivity is weak and not greater than that of output. Anyway, as I explore in the next Section, rather than the relative persistence of the shocks, it is in fact the strength of their propagation that matters. The propagation of interest rate shocks can be quantitatively affected by their persistence relative to productivity, but it remains a key qualitative feature of the model.

2.4.2.2 Interest rate induced processes

Here I conjecture that interest rates might exogenously affect the processes of total factor productivity and/or collateral formation. I try to show this conjecture is empirically plausible and also consistent with the phenomena of economies facing foreign credit constraints. Different causations are associated with different choices of non-zero non-diagonal coefficients in P.

Induced collateral formation

By assuming a permanently binding credit collateral constraint on foreign net liabilities, I assert that the economy finds itself at the extreme situation where it cannot alter, via domestic factors, such a financial condition over realistic business cycles. Long term factors, such as limited financial development, might lead the economy to such a situation, and thereafter it is sensitive to exogenous global credit shocks. Adverse innovations of this sort can directly transmit into higher interest rates, and indirectly by the tightening of the country's collateral formation. The latter means that the formation of collateral via capital accumulation becomes less efficient due to adverse changes in international financial credit conditions and therefore in the perceived values of domestic assets.

Such reasoning coincides with a "credit rationing" view, pioneered by Stiglitz and Weiss (1981), where both prices and quantities respond to changes in perceptions by creditors and investors. Realistically, a rise in the country's interest rate can precede the collateral tightening. Empirically identified as exogenous, the interest rate process is a good candidate to perform the role of a leading indicator with regard to the economy's international macroeconomic and financial conditions. Therefore, adverse global credit shocks via the interest rate precede the weakening of the country's ability to form collateral. As a result, additional exogenous dynamics are introduced between capital and liabilities, beyond that of the collateral constraint.

I arbitrarily set that a 1% rise in interest rate would cause a 2.5% fall in the efficiency to form collateral by the means of capital accumulation. The representation of the auto-regressive matrix P is represented as follows:

$$P^C = \begin{bmatrix} 0.27 & 0 & 0 \\ 0 & 0.72 & 0 \\ 0 & -2.5 & 0 \end{bmatrix}$$

Induced productivity

I assume that real interest rate shocks might adversely affect total factor productivity, or alternatively terms of trade. In fact, changes in the latter can arguably act as changes in the former in a SOE model (Kehoe and Ruhl, 2008).

It has been shown, empirically, that the deterioration of both terms of trade and total factor productivity are accompanied by a worsening of the economy's international credit conditions (e.g. Meza and Quintin, 2007; Kehoe and Ruhl, 2008). Chapter 1 shows that adverse interest rate shocks not only lead recessions, but may also cause real exchange rate depreciation and deterioration of terms of trade.[21] Therefore, the exchange rate and terms of trade work as transmitters of interest rate shocks rather than as a source of fluctuations.

Recessions in the CCSOE model can be associated with periods of high costs of credit, and excessively higher prices and/or financing costs of imported capital relative to domestic capital. The same would imply for the costs of technology that is embodied

[21] The deterioration of terms of trade is consistent with key facts associated with a credit tightening in emerging economies: a trade balance reversal and a fall in investment, which intensively relies on imports.

in imported machines and equipment. Therefore, productivity and terms of trade can be adversely affected by interest rate rises and, consequently, aggravate the negative impact of such credit tightening on investment.

Consistent with the choice of the autoregressive parameter (0.27) for productivity from the output equation, I also use the estimated coefficient for the lagged interest rate (−0.17) in that equation in order to infer a value for the interest rate induced coefficient in the productivity process. The interest rate induced productivity representation of P is as below:

$$P^P = \begin{bmatrix} 0.27 & -0.17 & 0 \\ 0 & 0.72 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Induced productivity and collateral formation

Finally, the combination of both interest rate induced productivity and collateral formation processes can be represented by the autoregressive matrix below.

$$P^{CP} = \begin{bmatrix} 0.27 & -0.17 & 0 \\ 0 & 0.72 & 0 \\ 0 & -2.5 & 0 \end{bmatrix}$$

2.5 Simulated Impulse Responses

The model's simulated responses are shown in Figure 2.2. They come from four specifications of the exogenous processes suggested in Section 2.4: P^I, P^C , P^P and P^{CP}. At all specifications, the CCSOE model is able to produce growth persistence and (inverted) hump-shaped responses, particularly for output and consumption, following interest rate shocks. Overall, such responses conform to the empirical evidence.

The aforementioned properties of the CCSOE model propagation mechanism only relies on the implications of the credit collateral constraint. It does not depend on an induced process. It is an essential feature of purely independent interest rate shocks. Moreover, these properties are not present in standard SOE models. Growth persistence would only result from standard models if some ad hoc elements were introduced to forcefully mimic persistence, such as time to build. But even in such a case, persistence tends to be very short-lived.[22]

The independent specification P^I is a first step in qualitatively matching the essence of the empirical responses: inverted hump-shaped responses and troughs that are sufficiently distant from the shock, indicating propagation and recession as dynamic processes. The induced processes given by the specifications P^C , P^P and P^{CP} quantitatively improve the ability of the model's simulated responses to match empirical responses. The induced collateral formation helps in aggravating negative growth and the trough. Interest rate shocks that impair the country's collateral and productivity can bring about more dramatic implications to the economy.

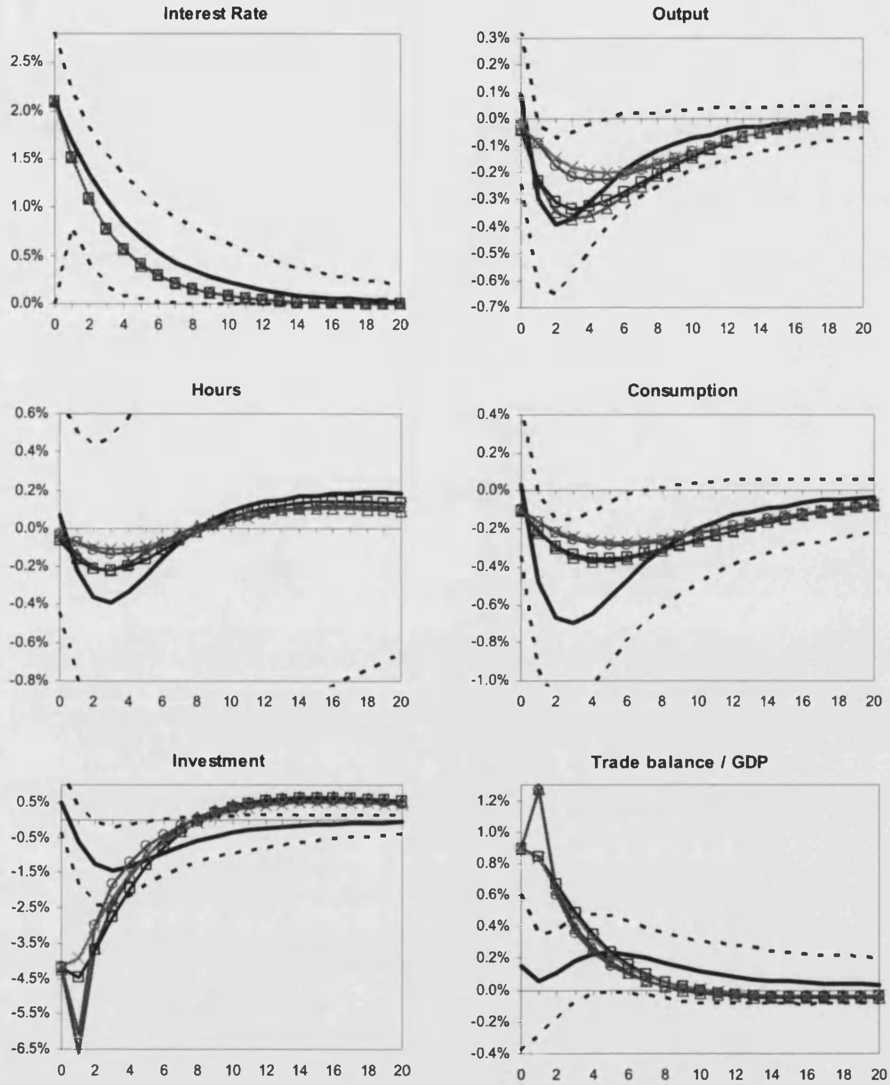
In judging different specifications, a note of caution on the consumption responses should be made. Contrary to the spirit of the model, data on consumption does not exclude durables. Therefore, we should not really strive to account for all the excess deviation in the responses of this variable.

At the same time, as with most RBC and SOE models, the CCSOE model does not generate sufficient growth persistence in investment and trade responses to match the empirical evidence. It does however produce considerable level persistence in investment and trade responses - a feature that is absent in standard SOE models. Accordingly, the propagation mechanism brings enough growth persistence to the dynamics of capital. As in most RBC models, much stronger propagating forces would be required to provide

[22]See for instance the simulated responses in Uribe and Yue (2006), who use time to build in a standard SOE model.

investment and trade with the same sort of sluggishness that is assured for output and consumption.

FIGURE 2.2. Model and VAR Impulse Responses to Interest Rate Shocks.



Solid lines are VAR responses, accompanied by dotted lines representing 95% confidence intervals. The model responses to interest rate shocks are marked with: crosses for a purely independent interest rate process; circles for interest rate induced collateral; squares for interest rate induced productivity; triangles for interest rate induced collateral and productivity. The vertical axis shows deviations from steady state. Units on the horizontal axes are quarters.

2.6 Sustained and Significant Effects of Interest Rate Shocks

I now present the model's implications and results with regard to the simulated second moments. For the sake of transparency, I first report moments that result from a hypothetical specification in which independent productivity and interest rate processes share identical persistence and deviation of shocks. Only then do I report results with the empirically motivated specifications for both independent and interest rate induced processes.

The benchmark is given by Brazilian statistics (second column in Tables 2.5 to 2.7), with two caveats. First, as an alternative reference to total consumption's standard deviation, I calculate an estimate of the standard deviation of nondurable consumption, which is lower than the former.[23] Second, together with moments of total fixed capital investment, I also provide moments of investments in machine and equipment. The latter is typically more volatile than the former. Such alternative statistics for consumption and investment help to avoid an automatic, and sometimes misguided, comparison to the simulated moments of a single-good business cycle model, which conventionally refers to nondurable consumption and to fixed capital investment, including durables consumption.

2.6.1 Non-neutrality

This subsection considers the non-neutrality of world interest rate shocks. I borrow this term from Mendoza (1991), meaning by it the strength by which interest rates can determine business cycle statistics, namely second moments, beyond the effects of productivity shocks. As a general property of the model, non-neutrality of interest rates is better (more strictly) assessed with the assumption of independent and equivalent productivity and interest rate exogenous processes. The idea behind this exercise is to be somehow agnostic on the exogenous processes, without using our empirical knowledge about the relative importance of these processes. I choose the following identical persistence and deviation of independent shocks: $\rho^z = \rho^r = 0.78$ and $\epsilon^z = \epsilon^r = 1\%$. I analyse their implications both separately and simultaneously, so as to precisely determine the significance of their individual effects and to check whether one dominates the other.

[23]These calculations are based on domestic production series for durables and non durables.

TABLE 2.5. Second Moments: Hypothetical Specifications with Independent Exogenous Processes.

	Real data	Simulated model with shocks to:		
		Productivity	Interest Rate	Both
		ρ^z=0.78, ρ^r=0	ρ^z=0, ρ^r=0.78	ρ^z=0.78, ρ^r=0.78
		ϵ^z=1%, ϵ^r=0%	ϵ^z=0%, ϵ^r=1%	ϵ^z=1%, ϵ^r=1%
Standard deviation (%)				
output	2.1	1.82	0.50	1.88
consumption	2.7			
non durables	1.8	0.91	0.60	1.09
investment	5.5			
mach. & equip.	11.0	7.35	9.89	12.33
hours	3.1	1.36	0.44	1.43
trade balance	2.3	0.38	2.01	2.05
Correlation with output				
consumption	0.77	0.87	0.97	0.84
investment	0.74			
mach. & equip.	0.59	0.98	0.29	0.62
hours	0.71	0.96	0.82	0.95
trade balance	-0.02	-0.76	-0.27	-0.21
Serial correlation				
output	0.75	0.67	0.93	0.69
consumption	0.69	0.85	0.92	0.87
investment	0.67			
mach. & equip.	0.70	0.69	0.66	0.67
hours	0.84	0.80	0.93	0.81
trade balance	0.21	0.74	0.64	0.64

The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1990:QI to 2005:QIV. National accounts are seasonally adjusted. All variables are in logarithms, except for the trade balance to GDP ratio, and detrended with the Hodrick-Prescott (HP) filter (λ = 1600). Hours are only available from 1992:QI. ϵ stands for standard deviation of shock.

The simulated moments are reported in Table 2.5. Interest rate shocks are responsible for 3% to 26% of the output volatility. Their relative strength is even greater in consumption and investment volatility. For instance, they can account for 16% to 55% of consumption's variability, and are responsible for at least 40% of investment variability. In contrast to standard SOE models[24], non-neutrality of interest rate is assured and emerges as a central feature of the CCSOE model.

The above ranges attributed to the impact of interest rate in real aggregates are in line with the empirical evidence. However, the trade balance is excessively sensitive to interest rate. Moreover, the model can potentially reconcile macroeconomic theory

[24]See Mendoza (1991) and Schmitt-Grohé and Uribe (2003).

with the higher volatility of consumption relative to output in emerging economies. Interest rate shocks appear to be responsible for such a phenomena. Individual interest rate shocks induce approximately a 20 per cent rise in consumption volatility relative to output.

Furthermore, the CCSOE model overcomes anomalies that are typical of standard SOE models, as the absence of serial correlation in investment and of significantly negative correlation between output and trade ratio.[25] Thanks to the stronger and more persistent effects of the interest rate shocks, moments become more in line with real data. Significant examples of this relate to the standard deviation of trade balance, the serial correlation of investment, and the correlations of output with investment and with trade balance.

It is worth noting that, in contrast to interest rate shocks, independent collateral formation shocks would have negligible effects in second moments over business cycles. I do not report the second moments for these shocks. With the same hypothetical persistence ($\rho^{\gamma} = 0.78$) and standard deviation ($\epsilon^{\gamma} = 1\%$), they would generate a negligible variation in output (of 0.03%) on their own. They would not add a significant share (less than 2%) to the overall macroeconomic volatility caused by productivity and interest rate shocks. Independent collateral formation shocks are, therefore, as insignificant and neutral in the CCSOE model as interest rate shocks are in standard SOE models.

The additional macroeconomic volatility of interest rate shocks indicates the strength of the model's propagation mechanism. If the deviation of the latter was twice that of the productivity, keeping the same persistence ($\rho^{z} = \rho^{r} = 0.78$ and $\epsilon^{z} = 1\%$, $\epsilon^{r} = 2\%$), then the share of output variability attributed to interest rate shocks would rise from the range 3-27%, to 12-47%. The range associated with consumption would rise further from 16-55%, to 40%-80%. The simulated standard deviation of consumption relative to output's would rise from 0.58 to 0.69.

2.6.2 Matching second moments

2.6.2.1 Independent processes

I now address independent processes of productivity and interest rates using the empirically motivated auto-regressive coefficients of P^{I}. Table 2.6 is equivalent to Table 2.5,

[25] Also see Mendoza (1991) and Schmitt-Grohé and Uribe (2003).

TABLE 2.6. Second Moments: Empirically Motivated Independent Exogenous Processes.

	Real data	Simulated model with shocks to:		
		Productivity ρ^z=0.27, ρ^r=0 ϵ^z=1.2%, ϵ^r=0%	Interest Rate ρ^z=0, ρ^r=0.72 ϵ^z=0%, ϵ^r=1.6%	Both ρ^z=0.27, ρ^r=0.72 ϵ^z=1.2%, ϵ^r=1.6%
Standard deviation (%)				
Output	2.1	1.58	0.69	1.73
Consumption	2.7			
non durables	1.8	0.60	0.84	1.03
Investment	5.5			
mach. & equip.	11.0	6.31	14.88	16.16
Hour	3.1	0.89	0.58	1.06
Trade balance	2.3	0.38	3.08	3.10
Correlation with output				
Consumption	0.77	0.86	0.96	0.77
Investment	0.74			
mach. & equip.	0.59	0.99	0.23	0.44
Hour	0.71	0.93	0.83	0.89
Trade balance	-0.02	-0.36	-0.21	-0.11
Serial correlation				
Output	0.75	0.26	0.92	0.36
Consumption	0.69	0.59	0.91	0.80
Investment	0.67			
mach. & equip.	0.70	0.34	0.62	0.58
Hour	0.84	0.54	0.93	0.66
Trade balance	0.21	0.45	0.59	0.59

The empirically motivated specification of independent exogenous processes correspond to P^I. The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1990:QI to 2005:QIV. National accounts are seasonally adjusted. All variables are in logarithms, except for the trade balance to GDP ratio, and detrended with the Hodrick-Prescott filter ($\lambda = 1600$). Hours are only available from 1992:QI. ϵ stands for standard deviation of shock.

apart from the fact that the persistence and the volatility of the shocks are empirically motivated. I am taking the benefit of empirical estimates that indirectly suggest a less persistent productivity process, with relatively weaker perturbations. As a result, interest rate shocks account for 8% to 40% of output variability and for 42% to 81% of the volatility of consumption. Note that the empirically estimated shares of interest rate in the variance decompositions of these variables are within these simulated ranges.

TABLE 2.7. Second Moments: Interest Rate Induced Specifications.

	Real data	Simulated model with induced:		
		collateral P^C ϵ^z=1.2%, ϵ^r=1.6%	productivity P^P ϵ^z=1.2%, ϵ^r=1.6%	both P^{CP} ϵ^z=1.2%, ϵ^r=1.6%
Standard deviation (%)				
Output	2.1	1.77	1.98	2.05
Consumption	2.7	1.07	1.27	1.31
non durables	1.8			
Investment	5.5			
mach. & equip.	11.0	19.46	17.67	20.96
Hour	3.1	1.11	1.35	1.41
Trade balance	2.3	3.80	3.15	3.83
Correlation with output				
Consumption	0.77	0.78	0.82	0.83
Investment	0.74			
mach. & equip.	0.59	0.35	0.57	0.49
Hour	0.71	0.89	0.90	0.90
Trade balance	-0.02	-0.07	-0.28	-0.24
Serial correlation				
Output	0.75	0.39	0.47	0.50
Consumption	0.69	0.81	0.84	0.84
Investment	0.67			
mach. & equip.	0.70	0.58	0.64	0.61
Hour	0.84	0.68	0.74	0.76
Trade balance	0.21	0.58	0.61	0.59

The empirically motivated specification of independent exogenous processes correspond to P^I. The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1990:QI to 2005:QIV. National accounts are seasonally adjusted. All variables are in logarithms, except for the trade balance to GDP ratio, and detrended with the Hodrick-Prescott filter ($\lambda = 1600$). Hours are only available from 1992:QI. ϵ stands for standard deviation of shock. In all specifications $\epsilon^\gamma = 0$.

2.6.2.2 Interest rate induced processes

Interest rate induced processes of productivity and/or collateral formation further strengthen the role of interest rate shocks in the CCSOE. Table 2.7 displays the second moments for the three specifications suggested in the previous Section. Interest rate induced productivity and collateral can act as an additional mechanism to further transmit shocks and to augment the economy's overall volatility. They mainly contribute by making the effects of interest rate shocks more dramatic, and they do so within the propagation and growth persistence mechanisms already in place at the core of the model, as propelled by purely independent shocks.

To ascertain which specification is the most appropriate or realistic is not simple. Table 2.8 compares the proportions of output variability attributable to interest rate

TABLE 2.8. Real Macroeconomic Variability Explained by Interest Rate Shocks.

Specifications of exogenous processes	$St.dev.(Y)$ explained by interest rate shock (%)		
	minimum	maximum	average
Independent, P^I	8	40	24
Induced collateral, P^C	11	45	28
Induced productivity, P^P	20	59	39
Induced collateral & productivity, P^{CP}	23	63	43

$St.dev.(Y)$ refers to the standard deviation of output.

TABLE 2.9. Additional Volatility Derived from Interest Rate Shocks.

Specification of exogenous processes	$\frac{St.dev.(Y)}{St.dev.(Y^I)}$	$\frac{St.\ dev.(C)}{St.\ dev.(Y)}$
Independent, P^I	1	0.60
Induced collateral, P^C	1.02	0.60
Induced productivity, P^P	1.14	0.64
Induced collateral & productivity, P^{CP}	1.18	0.64

$St.dev.(Y^I)$ refers to the standard deviation of output with the independent P^I specification of the exogenous process.

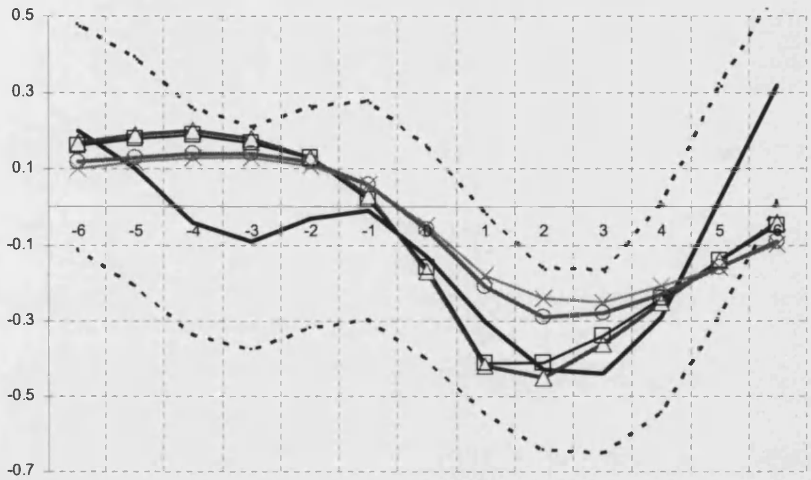
shocks, in the presence of productivity shocks, that result from the independent and induced specifications of the exogenous processes. The VAR exercise (see Table 2.2) suggests that interest rate shocks can determine from 23% to 37% of the output variability. All proposed specifications lead to simulated shares of output variability that are consistent with the empirically estimated range.

Table 2.9 reveals the potential of different specifications of interest rate induced processes in magnifying fluctuations. The induced specifications can account for an additional proportion of 18% of the real macroeconomic volatility. At the same time, productivity induced specifications can augment the relative variability of consumption. Overall, the weaker impact of induced collateral results from the fact that it has poorer propagating properties than productivity.

2.6.3 Serial correlation with interest rates

The four empirically motivated specifications (P^I, P^C, P^P and P^{CP}) of the exogenous processes generate simulated serial correlations between output and interest rates that match the empirical correlations of unconditional data both qualitatively and quantitatively. Figure 2.3 depicts these cross-correlations. As expected in an environment of sustained and significant effects of interest rate shocks over realistic business cycle horizons, the correlations over time are in agreement with the hump-shaped pattern of both estimated and simulated output responses, respectively in Figures 2.1 and 2.2.

FIGURE 2.3. Serial Correlations Between Lagged GDP and Interest Rates.



Empirical and simulated corr(r_{t+j}, y_t). Variables are HP-filtered. Solid (black) lines represent empirical unconditional correlations, with their 95% confidence intervals shown in dotted lines. The model's simulated correlations with independent shocks (P^I) are marked with crosses. The alternative model's correlations, with interest rate induced processes are marked with circles for the P^C case, with squares for the P^P case, and with triangles for the P^{CP} case. The vertical and horizontal axes represent correlations and j quarters, respectively.

2.7 Understanding the Model

The CCSOE model focuses on (international) financial and macroeconomic aspects that are absent in standard SOE models: first, net foreign liabilities are permanently constrained; and, second, the credit constraint is dynamically subject to the accumulation of capital. Let me recall that, in addition to capital being a factor of production, it also serves as collateral and thus has a financial value. Thus, following an adverse (temporary) interest rate shock, investment and consumption expenditures fall, reducing the economy's reliance on foreign savings. These effects are clear from the resource constraint. However, they are subject to the impatience and credit constraint assumptions. The economy has an incentive to operate through gradual cuts in these expenditures, spreading the adjustment over time. Such an incentive comes precisely from the use of capital as collateral in order to sustain foreign financing and to smooth consumption. Nevertheless, such a delayed adjustment imposes further costs of financing over contractions. It eventually results in more prolonged and aggravated recessions.

Capital's dual role as collateral and a factor of production imposes a premium between the marginal product of capital and the interest rate, which triggers the propagation mechanism associated with more prolonged and aggravated recessions. This is implicit in the interplay of the non-standard FOCs with regard to capital and liabilities - Equations (2.10) and (2.11), respectively. On the one hand, an additional multiplier, representing the value of collateral, appears in the Euler Equation (2.10) governing consumption growth dynamics, as shown in Kocherlakota (2000), Arellano and Mendoza (2002) and Chari et al. (2005). On the other hand, the same term enters the Euler Equation (2.11) governing capital accumulation. Deprived from adjustment costs and with $\sigma = 1$, the two equations result in the following:

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{R_{t+1}}{1-\varphi_t} \tag{2.10'}$$

$$\lambda_t = \beta E_t \lambda_{t+1} \left[\frac{Z_{t+1} f_K(K_t, L_{t+1}) + 1 - \delta}{1 - \gamma_t \varphi_t} \right] \tag{2.11'}$$

By substituting out the multiplier in Equations (2.10') and (2.11'), we have:

$$\lambda_t = \beta E_t \frac{1}{1-\gamma_t} \lambda_{t+1} \left[Z_{t+1} f_K(K_t, L_{t+1}) + 1 - \delta - \gamma_t R_{t+1} \right] \tag{2.12}$$

Through the intermediation of collateral's value in the two previous conditions, Equation (2.12) is a combined or extended intertemporal Euler condition. Note that, crucially in Equation (2.12), the interest rate is negatively correlated with consumption growth, in sharp contrast to the positive correlation conventionally observed in standard SOE models. Shocks to the interest rate lead to recessions, with negative growth persistence. The economy reacts to such shocks by a sluggish response in capital. Therefore, the presence of a premium between the marginal product of capital and the interest rate is implicit in Equation (2.12). Following adverse interest rate shocks, the premium recovers from below its steady state value and later overshoots this value, just before stabilizing. Recessions and recoveries are roughly associated with premium both below and above its steady state level, respectively. Therefore, consumption and output respond therefore in an (inverted) hump-shaped form.

It can be shown through Equation (2.12) that intertemporal propagation processes can be directly affected by shocks to productivity, interest rate and collateral. A temporary shock to productivity further propagates due to the collateral parameter. Note in Equation (2.12) that consumption growth is proportional to $(1-\gamma_t)^{-1}$. This term gives the amplitude of the growth rate and, consequently, the pattern of adjustment following shocks. $\gamma \rightarrow 1$ would imply a prompt adjustment, while $\gamma \rightarrow 0$ would lead to a minimum rate of adjustment. Only intermediary values of γ $(0 < \gamma < 1)$ give sluggish and pronounced adjustments.

The Euler equations of the CCSOE models nest the intertemporal consumption substitution problems of standard business cycle models of both closed-economies and SOEs, as extreme special cases. The latter is derived when the multiplier converges to zero ($\varphi_s \rightarrow 0$); that is, when collateral formation has no value. Note that, in this case, Equations (2.10) and (2.11) conform to: $1 = \beta E \frac{\lambda_{t+1}}{\lambda_t} [Z_{t+1} f_K(K_t, L_{t+1}) + 1 - \delta]$ and $1 = \beta E \frac{\lambda_{t+1}}{\lambda_t} R_{t+1}$. The permanent equivalence (no premium) between interest rate and marginal product of capital is implicit: $R_{t+1} = Z_{t+1} f_K(K_t, L_{t+1}) + 1 - \delta$. Such equivalence is only consistent with Equation (2.12) if the economy had the ability to use 100% of its capital as collateral ($\gamma \rightarrow 1$). Approaching this limit, the dynamics of the CCSOE model become closer to that of standard SOE models. At the limit, it would be deprived of its characterizing credit friction features. Conversely, approaching $\gamma \to 0$ leads to a dynamics convergent with RBC models, where exchanges with the world economy do not take place.

The frictionless credit conditions of standard SOE models, resulting in an automatic equivalence between interest rate and marginal product of capital, appear to be behind the "neutrality" of exogenous world real interest rates that they exhibit. In comparison to the CCSOE model, the standard models are only able to produce recoveries. Moreover, those recoveries reveal poor propagation, since they simply tend to mimic the dynamics of the exogenous interest rate process. Such a lack of propagation and growth persistence is overcome by the CCSOE framework thanks to its stronger and richer intertemporal consumption substitution and capital adjustment dynamics, which are rendered inter-twined and inter-connected by the role of capital as collateral.

Now we can understand the fact that within the credit constrained framework, the rest of the world economy would behave similarly to a closed-economy RBC model. Note that, in equilibrium, international assets should be dictated by: $B_t = -B_t^*$, where B_t^* stands for the the net liabilities of the rest of the world. Still, for the simplest case (with no adjustment costs and $\sigma = 1$), it can be shown that $\gamma_t^* = \frac{-B_t^*}{K_t^*} = \gamma_t \frac{K_t}{K_t^*}$. The smaller the economy, relative to the rest of the world, the lower γ_t^*. In such a case, interest rate shocks have an increasingly negligible role.

2.8 Robustness

2.8.1 Shock persistence

In the baseline simulations, the choice of the autoregressive coefficients for both productivity and interest rate shocks is dictated by the unrestricted VAR coefficients ($\rho^z = 0.27$ and $\rho^r = 0.72$). The restricted VAR with the exogenous interest rate would suggest a marginally higher ρ^r, close to 0.80, and the RBC literature usually attributes a higher value to ρ^z. Raising the autoregressive coefficients requires lower standard deviations for the shocks in order to match the overall volatility of the macroeconomic series and their serial correlation with the interest rate. While a higher ρ^z might somehow weaken the role of pure interest rate shocks and reduce the relative volatility of consumption in explaining business cycle fluctuations, a higher ρ^r would have the opposite effects. The moments shown in Tables 2.5 and 2.6 illustrate these effects.

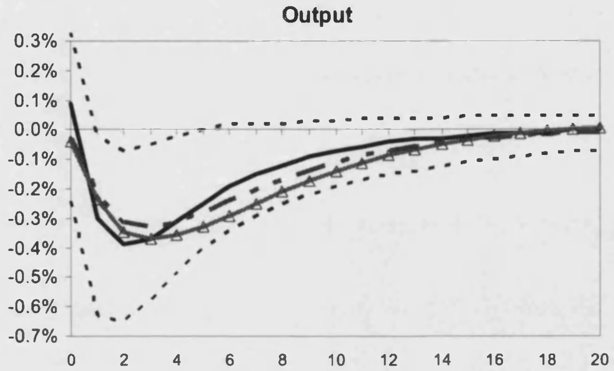
2.8.2 Collateral formation parameters

In a CCSOE model, collateral formation parameters are key to determining the steady state levels of consumption and investment. At the same time, they can also alter the dynamics of these variables. Higher values for either σ or γ strengthen the economy's capacity to take the benefit of collateral formation and, therefore, expose it to more amplified volatility in investment and consumption relative to output. Relative excess in the volatility of consumption is a feature of the CCSOE model that is observed in emerging economies. Conditional on sharing the features of a CCSOE, emerging economies that have a stronger collateral formation - either by domestic merits or by international endorsement - might reveal larger volatility in consumption.

2.8.3 Functional form of utility

I opt for a general utility specification, mixing features of both GHH and KPR preferences, although it is actually closer to the former, as $b = 0.15$. A higher (lower) value for b would diminish (augment) the overall volatility of the economy and also the relative volatility of consumption. Underlying both of these effects are the reduced (expanded) intertemporal effects and growth persistence of shocks. Figure 2.4 shows responses to interest rate shocks under the specification with induced productivity & collateral formation (P^{CP}). There, I contrast the baseline response (line marked with triangles) with the alternative response under $b = 0.20$ (dotted line). Higher b fosters labour's sensitivity to wealth effects. Distancing from GHH preferences and approaching KPR preferences enhances the short term responsiveness of labour and, consequently, of output. GHH preferences lead to deeper and more protracted recessions.

FIGURE 2.4. Wealth Effects and Preferences.



This Figure shows the effects of higher b in the utility within the induced productivity & collateral formation specification of the exogenous processes (P^{CP}). The vertical axis shows output deviations from steady state. The VAR response is the solid line. The simulated model responses are marked with triangles, for $b = 0.15$, and a dotted line, for $b = 0.20$. Units on the horizontal axis are quarters.

2.9 Conclusion

This Chapter highlights the main empirical regularities that characterize the role of real interest rate shocks in determining business cycles of Brazil, as a representative example of emerging economies. More importantly, I consistently develop a credit constrained small open economy (CCSOE) model which comprehensively matches most of these regularities.

Based on vector autoregression analyses, I argue that the real interest rates that emerging economies face in international markets, which are countercyclical and lead cycles, not only work as key transmitters of exogenous global credit shocks, but also as major drivers of real macroeconomic fluctuations. Real interest rate shocks help to explain the excessive volatility of output and the higher relative volatility of consumption in emerging economies. They cause hump-shaped responses of output and consumption, as well as of investment and trade to GDP ratio. These responses might reflect strong intertemporal propagation mechanisms which are able to prolong and aggravate recessions.

In contrast to standard SOE models, including extensions with working capital constraints, the CCSOE model exhibits considerable propagation of interest rate shocks. The effects of these shocks are sustained and significant over business cycle frequencies. They augment macroeconomic volatility, beyond the effects of productivity shocks. The CCSOE model successfully produces hump-shaped responses of output and consumption. It potentially magnifies the variability of consumption relative to output. The model also replicates second moments, and does so in a more realistic way than conventional models especially with regard to the specification of shocks. It systematically matches the correlations between output and interest rates at different lags, namely over recessions. Furthermore, it manages to avoid some of the recurrent anomalies of SOE models, particularly with respect to investment and trade moments.

The CCSOE model fundamentally relies on an impatience assumption and a permanently binding endogenous credit collateral constraint on foreign liabilities. Therefore, it stresses the role of international credit frictions, which impose an enduring discipline on the country's international financial exposure, at least over business cycle horizons.[26] It also emphasizes some systematic reliance on foreign credit, perhaps due to insufficient financial development in some emerging economies.

The essence of the model resides in the interplay between two non-standard intertemporal Euler equations, governing capital dynamics and consumption growth. They provide considerable growth persistence to the propagation of interest rate shocks. The economy responds to such adverse (temporary) shocks by curtailing investment and consumption in accordance with persistent declines in the stock of capital, which serves as a factor of production and collateral. Subject to such incentives, accruing from the dual role of capital, foreign financing and consumption are smoothed. The economy reacts to adverse shocks on a prolonged basis, thereby aggravating recessions.

The Chapter consistently shows that endogenous credit constraints can persistently render an open economy vulnerable to international financial shocks transmitted via the real interest rate. Therefore, it shares some of the concerns expressed in Caballero and Krishnamurthy (2001), Gertler et al. (2003), Aghion et al. (2004), and Aoki et al. (2006).

Furthermore, the CCSOE model is a tractable framework to quantitatively address the macroeconomic implications of international financial frictions in SOEs. This approach, which contrasts to or simply supplements that of Aguiar and Gopinath (2007), treats cycles as transitory fluctuations around a stable growth path. Consistent with empirical evidence, in particular with regard to the identification and propagation of global credit shocks, the CCSOE model reconciles emerging economy regularities - e.g. their overall excessive volatility and countercyclical real interest rates, among other distinct features - with macroeconomic theory. This is possible thanks to a combination of an aggregate financial propagator and international credit shocks.

Future research might seek to explicitly integrate an endogenous country spread into the credit constrained small open economy (CCSOE) framework. In the next Chapter, I suggest a model of this kind, which allows to differentiate shocks to the country spread from those to international interest rates. Another challenge relates to the consideration of additional endogenous transmission mechanisms of global credit shocks that could explain the impact of real interest rate on total factor productivity, the exchange rate and terms of trade.

[26] Such frictions can be somehow complementary to, or consistent with, the home bias puzzle in international debt and equities.

2.A Appendix: Data

All Brazilian quarterly series are available at IPEAData (www.ipeadata.gov.br), the on-line macroeconomic database of the *Instituto de Pesquisa Pura e Aplicada* - IPEA. The national account series are originally from the *Instituto Brasileiro de Geografia e Estatística* (IBGE) - www.ibge.gov.br. Further details of the data are the following:

Output. Real GDP from the IBGE National Accounts. The series was expressed in natural logarithmic of available seasonally adjusted series.

Hours. Industrial hours from the *Confederação Nacional das Industrias* (CNI). The series was expressed in natural logarithmic of available seasonally adjusted index.

Consumption. Total consumption from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Durables. Production of consumption durable good from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Investment. Total fixed capital investment from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Machine and equipment. Total investment in machine and equipment from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Trade balance to GDP ratio. The series was calculated by the author as a ratio of net export to GDP. Official foreign trade statistics are produced by the Ministry of Development, Industry and Foreign Trade - Ministério do Desenvolvimento, da Indústria e do Comércio Exterior (MDIC).

Country spread. EMBI JP Morgan Plus index for Brazil. The series is available from Datastream. US inflation and 3-month nominal interest rates are available from the FRED database of the Federal Reserve Bank of St Louis.

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3

Country Spreads as Endogenous Credit Constraints in Emerging Economy Business Cycles

3.1 Introduction

Thanks to the strength of its intertemporal propagation mechanism, the model in Chapter 2 provides a significant and lasting role for independent shocks to the real interest rate that small open economies (SOEs) face in international markets. Nevertheless, it does not deal with the endogenous implications of interest rate changes, which are posited as being solely derived from exogenous disturbances. Furthermore, it does not differentiate between shocks to the country spread and shocks to the other component of the country's real interest rate, namely an international benchmark real interest rate.

This Chapter completes the gap and suggests a different interpretation of foreign credit constraints on emerging economies which complements that of Chapter 2. This interpretation is primarily based on the macroeconomic role and business cycle implications of country spreads. These spreads are a major component of emerging economy real interest rates, affecting the external financing conditions of both sovereign and private borrowers. I argue that these spreads are not only a key source of emerging economy business cycles, but they are also evidence and part of an endogenous credit constraining mechanism, through which shocks propagate into the domestic economy. Therefore, distinguishing features of emerging economy business cycles result from the combination of a financial accelerator, which manifests itself through country spreads, and shocks that directly affect real interest rates, such as global liquidity shocks and other exogenous credit disturbances. These sources supplement other independent sources of fluctuations, especially productivity shocks of a temporary or a permanent nature (e.g. Aguiar and Gopinath, 2007).

I propose a dynamic stochastic general equilibrium model to address the dynamic interconnections between the country spread and domestic fundamentals, through the workings of an endogenous constraint on foreign credit. As a result, shocks considerably propagate into the economy. In particular, credit shocks aggravate macroeconomic downturns, progressively reducing the country's access to foreign capital as well as investment and consumption expenditures. Credit shocks of realistic proportions explain most of the excess in macroeconomic volatility that emerging economies display in comparison to advanced ones. They cause considerable growth persistence in real aggregates and explain, in addition to other features, the counter-cyclical nature of interest rates (and country spreads) and the relatively high volatility of consumption. On a complementary basis, the Chapter suggests that country spreads exhibit some endogenous moderate persistence. The latter is fostered by the endogenous constraint and is robust to different specifications of the model's parameters and to the underlying exogenous processes.

The model is one of a SOE, with a single and homogeneous good. It differs from the model in Chapter 2, in that it incorporates a formulation of the country spread as a state variable within an endogenous credit constraint on foreign borrowing. This formulation is consistent with empirical analyses that suggest country spreads depend on macroeconomic fundamentals and are exposed to exogenous credit disturbances in international capital markets.[1] In fact, country spreads have been significantly above zero over successive periods of contractions and recoveries in most emerging economies. Moreover, they have remained so even after investment grade status is attained. A positive country spread and a permanently binding constraint are consistent with the hypothesis that the SOE is relatively impatient. The constraint is enough to close the SOE model under conditions similar to those described in Chapter 2.[2] In this Chapter, I add investment adjustment costs to control the excessive volatility of investment, which recurrently manifests in SOE models.[3] Disturbances to the model arise from

[1] See Eichengreen and Moody (1998), Hartelius et al. (2008), Sarquis (2008), Uribe and Yue (2005).

[2] Closing the model by such an assumption is an alternative to other modalities examined by Schmitt-Grohé and Uribe (2003). This approach ensures that the SOE framework has more realistic properties than those documented in Mendoza (1991), in particular with regard to the effects of real interest rate shocks.

[3] Investment adjustment costs have been considered by various authors (e.g. Christiano et al., 2005, and Jaimovich and Rebelo, 2006). Here, they attain the same purpose of capital adjustment costs, widely used in small open economy models. They also provide investment with hump-shaped dynamics, while not affecting the dynamics of output and other variables.

three independent sources: (a) productivity, (b) benchmark (US) real interest rate, and (c) exogenous component of the spread.

Calibrated to the Brazilian economy, the model successfully reproduces stylized facts of emerging economy business cycles. Credit shocks, either to the benchmark risk-free interest rate or to the exogenous component of the country spread, can have pronounced and prolonged effects, with the ability to collectively account for 30% to 50% of the macroeconomic variability. These shocks contribute to the excess of consumption's variability relative to output. Responses of output, consumption and investment to both kinds of credit shocks share similar hump- or V-shaped dynamics. Shocks to the benchmark international rate propagate further through their transmission via the country spread, while shocks to the country spread display higher standard deviations than those of the benchmark risk-free international rate. These distinctive features of credit shocks afford them equivalent explanatory power when accounting for the variability of macroeconomic aggregates and changes in the country's interest rate. Similar to other spreads in financial markets (Collin-Dufresne et al., 2001), country spreads display some persistence over realistic business cycle frequencies, which can be due to both endogenous and exogenous factors. Of the domestic variables, short term foreign debt can play a key role in the propagation of credit shocks, since it has the ability to induce country spread changes.

The dynamics of the propagation mechanism rely on the accumulation of capital and debt, coupled with endogenous changes in the country spread. It operates via transmission of exogenous disturbances into the economy, as well as via feedback effects from the latter into the spread. The spread dynamics reflect variations in the costs of foreign credit that may be exogenously and endogenously driven. Such variations are consistent with changes in the marginal benefit of holding foreign debt. Following adverse credit shocks, the economy has an incentive to reduce the stock of debt, whose financing costs are magnified by the rise in country spread and by the further propagation of this into the real economy. Nevertheless, the fall in debt is accompanied by curtailing consumption and investment, and by a decline in output. Since the spread and borrowing costs ultimately depend on output and debt, capital and debt do not fall all at once as in standard models. They decline rather progressively and in tandem. Accordingly, output and hours persistently decrease, thereby aggravating the recession in a hump-shaped pattern. Recovery only begins after debt successively falls, allowing the country spread to return to steady state levels. Therefore, the model provides intertemporal disturbances with singular strength. Although transitory, credit shocks have pronounced, persistent and significant effects over business cycles. Favourable shocks to productivity lead to analogous credit incentives and propagation into the economy. They provoke both macroeconomic expansions and progressive falls in debt and spreads.

This Chapter significantly differs from recent studies that incorporate financial frictions into small open macroeconomic models and focus on business cycle implications of the country spread (e. g. Neumeyer and Perri, 2005; Uribe and Yue, 2006; and Mendoza and Yue, 2008). Instead of positing working capital constraints, I assume an endogenous credit constraint on foreign borrowing that works in an open economy environment similar to the collateral and balance-sheet approaches of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997).[4] The formulation of the spread as a state variable that is built into the credit constraint in the form of an external financial premium resembles the one used in Gertler et al. (2003). However, the modelling strategy and purpose are very distinct. First, I merely focus on the real side of the financial accelerator, abstracting from monetary and exchange rate channels. Second, I assume the spread is a premium that the economy faces in international capital markets and is not a purely domestic one. The premium applies to the aggregate economy. More importantly, the constraint is grounded on the interaction between domestic fundamentals, the spread and exogenous credit conditions. It establishes interplays between the benchmark international (US) interest rate and the country's real interest rate, and more fundamentally between the latter and the domestic return on capital.

This Chapter distinctively highlights the wedge between the intertemporal marginal rate of substitution in consumption and the rate of return on capital. This wedge represents the bulk of the propagation mechanism. It does not automatically respond to exogenous variables, in that it does not replicate their dynamics. Instead, it undergoes a further transmission of its own that strengthens the model's amplification and propagation. The crucial business cycle dynamics are mainly driven by the combination of a financial accelerator and credit shocks that affect the interest rate (the country spread), while coexisting with and being independent from productivity shocks. Without resorting to other (*ad hoc*) mechanisms, this SOE model enhances the role of intertemporal

[4] The consideration of such kinds of constraints has gained special interest in sudden stop models, as reviewed by Mendoza (2006).

disturbances (Christiano and Davis, 2006; Primiceri et al., 2006). It shows from a SOE business cycle accounting perspective (Chari et al., 2005) that intertemporal wedges can be as important as efficiency or labour wedges.

Section 3.2 presents empirical evidence and regularities. Section 3.3 describes the model. Section 3.4 deals with calibration. Section 3.5 shows and discusses the main qualitative and quantitative results and implications of the model. Sections 3.6 to 3.10 discuss specific issues and the robustness of the results. Section 3.11 concludes.

3.2 Country Spreads as Credit Constraints

In order to characterize the sources of shocks and their propagation via the country spread, I focus on the empirical regularities of Brazilian quarterly data from the second quarter of 1994 through the fourth quarter of 2005. These regularities coincide with the evidence documented for many emerging economies over similar periods.[5] As a major issuer of both sovereign and private debt among emerging economies, Brazil has persistently faced a high country spread. It averaged 706 basis points, with a standard deviation of 297 points, as measured by the country's EMBI Plus index over the period of analysis.[6] Brazil's volatilities of output and real interest rate have approximately been twice those of the US.

3.2.1 Country Spread, Domestic Output and Foreign Debt

Figure 3.1 shows the (unconditional) serial correlations of country spread (s_t) with lagged GDP (y_{t+j}) and with lagged short term foreign debt (b_{t+j}). The correlations are calculated from logged and HP-filtered data. Equivalent serial correlations of the real interest rate (r_t), in place of the spread (s_t), are depicted in Figure 3.2. The real interest rate is the sum of the country spread (s_t) and the benchmark risk-free real interest rate (r_t^*). The latter is calculated as the difference between the nominal rate of US 3-month Treasury bonds and the corresponding expected US inflation.[7]

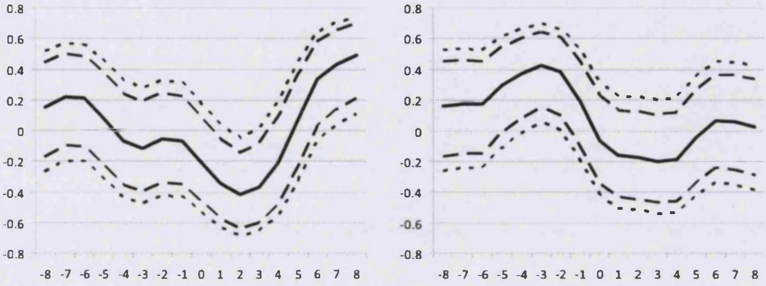
Figures 3.1 and 3.2 provide evidence that the country spread and the real interest rate lead the cycle in a countercyclical way, and that changes in short term debt help to predict movements in the country spread and the real interest rate. Credit tightening adversely affects output over 3 quarters after the shock (at the 98% confidence level). The economy only appears to recover after 5 quarters. Conversely, a rise in the foreign debt level leads to a significant appreciation of the country spread and the real interest rate after 2 to 5 quarters (at the 98% confidence level). There is also some indication that an expansion in output might lead to a rise in the spread. Overall, these phenomena suggest there is a constraint permanently restricting the economy's access to foreign

[5] See e.g. Uribe and Yue (2006).

[6] Even after it attained investment grade status on its sovereign bonds in the first half of 2008, Brazil has been subject to spreads above 200 basis points - a level that is well within the confidence interval for the period of analysis (1994-2005).

[7] Expected inflation is calculated by estimating an autoregressive process with 8 lags.

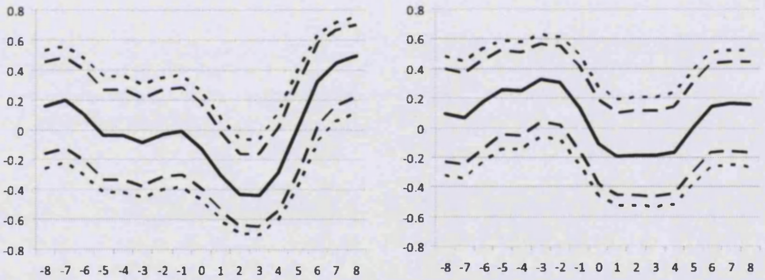
FIGURE 3.1. Serial Correlations: (i) between Country Spread and Output; (ii) between Country Spread and Foreign Debt.



(i) $Corr(s_t, y_{t+j})$ (ii) $Corr(s_t, b_{t+j})$

Correlations are displayed as solid lines. Dotted lines represent 95% and 98% confidence intervals. Units on the horizontal axis are quarters (indexed by j).

FIGURE 3.2. Serial Correlations: (i) between Interest Rate and Output; and (ii) between Interest Rate and Foreign Debt.



(i) $Corr(r_t, y_{t+j})$ (ii) $Corr(r_t, b_{t+j})$

Correlations are displayed as solid lines. Dotted lines represent 95% and 98% confidence intervals. Units on the horizontal axis are quarters (indexed by j).

credit, over business cycle horizons. This permanent feature seems to operate at varying intensities, *pari passu* with the spread.

The very similar correlations obtained for the real interest rate (r_t) and the country spread (s_t) result from the fact that the spread is responsible for the bulk of the magnitude and variability of the interest rate. They also suggest the existence of a common propagating mechanism which has significant effects over business cycle fluctuations. These facts reinforce the hypothesis that country spreads can work as an endogenous credit constraint, in particular in the sense that the economy's ability and costs to access foreign credit depend on its own performance and accumulated foreign debt.

I use short term foreign debt as the proxy for the foreign debt variable for various reasons. It comprehends foreign debt contracts of private and public borrowers that are meaningful over business cycle frequencies, as their maturities are restricted up to 4 quarters (360 days). Short term contracts are less affected by contractual commitments and other rigidities over these frequencies. Long term debt markets for emerging economies are less liquid and have limited participation of private borrowers.[8]. The most relevant foreign financial transactions over business fluctuations, such as trade finance and access to foreign credit to finance domestic projects, are concentrated in short term debt contracts, especially in the case of bank lending to merging markets (Henry, 2007). Broner et al. (2007) argue for instance that bond issuance by emerging economies are oriented towards the short term due to high risk premia charged by creditors on long-term debt, especially over crisis episodes.

3.2.2 Further Evidence from a VAR

I conduct a VAR exercise representing a simple SOE economy, which includes a vector of exogenous variables (m^*), the country spread (s) and a vector of domestic variables (m). The unrestricted VAR is represented below, except for the inclusion of constants and time trends, as well as a shift dummy to account for the drastic shift in the US business cycle and correspondingly in the US monetary policy and global liquidity from 2001:QI.[9]

$$\begin{bmatrix} m_t^* \\ s_t \\ m_t \end{bmatrix} = C \begin{bmatrix} m_{t-1}^* \\ s_{t-1} \\ m_{t-1} \end{bmatrix} + u_t.$$

The US real GDP growth and the US real interest rate enter the vector m^*, so to differentiate the sources of exogenous shocks associated to global credit factors from those associated to the real activity in the world economy. It helps in better identifying real liquidity shocks. Moreover, it represents real foreign forces that affect the SOE not only via foreign demand, but also via changes in productivity and terms of trade. In this latter sense, the inclusion of the US real GDP strengthens the results associated with the credit shocks. They remain mostly unaltered regardless of the consideration of that variable.

[8]Furthermore, a considerable part of Brazil's and other emerging countries' long-term foreign debt was contracted and/or renegotiated by sovereign borrowers before the period of analysis (1994-2005). The inclusion of long-term debt would eventually distort the dynamics brought about by a richer environment over the period of analysis with: private borrowers playing a prominent role, especially in short term borrowing; and secondary markets allowing borrowers to benefit from a more decentralized credit supply.

[9]The causality, impulse responses and variance decompositions are robust to the exclusion of time trends and/or of the shift dummy.

The domestic vector m includes: output (y), hours (h), consumption (c), investment (i) and short term foreign debt (b). The shift dummy enters the US variables and the country spread equations. The Brazilian real variables enter the VAR in log-transformed levels.[10] The foreign debt variable, originally in US dollars, is deflated by the US CPI and enters the VAR in logs. The country spread and the US real interest rate are given in percentages. Additional details of the data are described in Appendix 3.A. The VAR is set with only one lag on the basis of information criteria tests.[11]

Alternative variable specifications in both m and m^* do not alter the major implications of the VAR analysis. As in Chapter 1, the inclusion of trade balance, exchange rate and terms of trade in m do not affect the leading role the country spread and the US interest rate play over business cycle frequencies. In particular, the spread is not dependent on these variables; quite on the contrary in that it leads them all. In place of short term foreign debt, total foreign debt would not modify its causal linkage to spread, although it would weaken the linkage from spread to debt. The total debt ratio reacts slowly to shocks, and its reaction can be anticipated by the short term debt. This is another reason for using only the short term variable as a proxy for the country's foreign debt.

VAR Granger causality tests and variance decompositions support the hypothesis that the country spread is more disturbed by shocks to its own and shocks to international variables (namely the US interest rate) than by domestic shocks, despite the existence of an effect on the spread driven by foreign debt. Granger causality tests, under the unrestricted VAR, are shown in Table 3.1. With 1% confidence, causality occurs from the US and/or the country spread to the macroeconomy. With 5% confidence, a causality is suggested from the US variables to the country spread and to the macroeconomy. Reverse causalities, that originated from the macroeconomy, could not be rejected at the 10% confidence level.

Restricting the analysis to the SOE case, I assume the US variables are exogenous processes and set $C_{1,2} = C_{1,3} = 0$. I do not impose restrictions on the Brazilian variables. This unrestricted VAR leads to the same qualitative and quantitative results as

[10] Unit root tests (with constant and time trend) fail to support the hypothesis that the Brazilian real aggregates follow I(1) processes, in contrast to the US real output, which therefore enters the (US) exogenous block in differences.

[11] Allowing a maximum of 4 lags for the Brazilian variables, Final Prediction Error, Hannan-Quinn and Schwartz tests suggest 1 lag. The Akaike test indicates 4 lags. Therefore, the results are robust.

TABLE 3.1. Granger Causality Tests.

H_0 Granger tests:			p-values:
Variables	Cause	Variables	
Δy^* , r^*	$\Rightarrow$	s , m	0.0194
Δy^* , r^* , s	$\Rightarrow$	m	0.0002
s	$\Rightarrow$	m	0.0002
m	$\Rightarrow$	s	0.0955

Tests on the basis of the unrestricted VAR, allowing Brazilian variables to affect US variables.

those of recursive VARs. This equivalence is particularly strong when s is ordered last, after the m vector. For simplicity, I report only the unrestricted results.

Table 3.2 shows variance decompositions under the unrestricted VAR over 20 quarters. About 50% of the variability in the country spread results from exogenous shocks to itself, while around 33% could be explained by US interest rate disturbances. Combined together, these credit shocks account for 83% of the spread variability and over 30% of the variations in output, hours, consumption and investment. Of all the domestic variables, consumption singles out as being the most dependent on credit shocks. About 42% of its variability could be attributed to exogenous spread and US interest rate shocks. The former (24%) seems to have a slightly stronger effect than the latter (18%), especially if we compare their corresponding shares (14% and 22%, respectively) in explaining output variability. Overall exogenous disturbances to the spread are as important as those to the US interest rate with regard to understanding business cycle fluctuations.[12] The foreign debt ratio is the only domestic variable that appears to have some effects on changes in the country spread, explaining 9% of its variability.

The VAR estimated impulse responses in Figure 3.3 show the causal linkages between the country spread and the foreign debt. They reassure us about the existence of a credit constraining mechanism connecting them. The same mechanism, as I posit, is behind the propagation of shocks into the economy, as suggested by other VAR estimated responses to the US interest rate and country spread shocks - shown in Figures 3.4 and 3.5.[13] They feature growth persistence - in line with recessions and recoveries - in output, hours, consumption and investment dynamics. They reveal variations in

[12] Overall, the Brazilian evidence coincides with cross country evidence of emerging economies. In a panel VAR including seven countries (Argentina, Brazil, Ecuador, Mexico, Peru, Philippines and South Africa), Uribe and Yue (2006) find that, on average, about 30% of movements in aggregate activity may be explained by disturbances in the US real interest rate and country spreads.

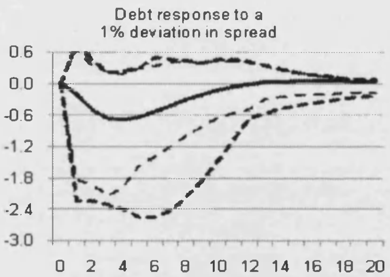
[13] Figures 4 and 5 include responses of trade balance to GDP that are obtained from a VAR that adds this additional variable. Impulse responses and variance decompositions of all the other variables remain intact.

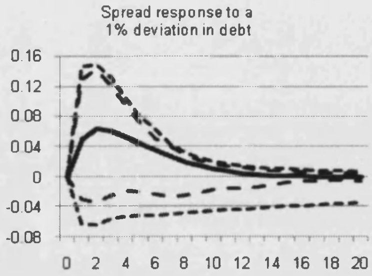
TABLE 3.2. VAR Variance Decompositions.

Dependent variables:	Explanatory variables and/or "sources" of shocks							
	International		Spread	Domestic				
	Δy^*	r^*	s	y	h	c	i	b
s	7	**33**	**50**	0	0	0	1	9
y	27	**22**	**14**	33	0	1	0	2
h	43	**26**	**4**	21	4	1	0	1
c	12	**18**	**24**	20	1	19	1	5
i	17	**18**	**20**	29	1	1	11	3
b	3	**6**	**14**	2	1	8	5	62

The variance decompositions (%) are estimated for 20 quarters from a VAR that includes a constant, time trend and the US shift dummy for US variables and the country spread.

FIGURE 3.3. VAR Impulse Responses: Debt and Spread.





Estimated responses are displayed as solid lines, accompanied by dotted lines representing 95% and 98% confidence intervals, which are obtained by standard (Efron) bootstrappped method. Units on the horizontal axis are quarters.

between V-shaped and hump-shaped patterns.[14] The responses to exogenous spread shocks generate slightly earlier troughs and recoveries than those of the US interest rate. They all indicate that credit variables are effectively countercyclical and leading cycles. As shown in Figures 3.4 and 3.5, consumption is more responsive than output, particularly in the case of country spread shocks. At the same time, its variation over business cycles remains persistently affected by such shocks, when compared to other macroeconomic variables. Therefore, there is some empirical evidence to posit that the spread, both as a source and as a transmitter of shocks might account for the high volatility of consumption relative to output among emerging economies.[15]

[14]Calvo et al. (2006) provide a discussion on the nature of possible V-shaped recessions that arguably share some of the features reported here.

[15]As shown in Table 4, in Brazil there is an excess in the standard deviation of total consumption relative to output. In comparison to advanced economies, such a relative deviation remains high even when it is for non-durable consumption.

The relatively faster responses to spread shocks and the significant response of country spread to US interest rate shocks suggest the country spread can work as a transmitter and propagator of shocks into the macroeconomy. In summary, both variance decompositions and impulse responses indicate that country spreads, beyond their impact on the cost of external financing, are also acting as a "financial accelerator", contributing to the determination of business cycles in emerging economies.

3.3 The Model Economy

3.3.1 Basic Features of the Model

The model economy has a single homogeneous good and is populated by a single representative agent. It is a small open economy that holds net foreign liabilities B_t at the end of each period. The economy pays a variable gross real interest rate R_t on the liabilities it holds against the rest of the world. Such a rate is the product of an exogenously determined international benchmark risk-free real interest rate, R_t^*, and a (partially) endogenously determined country spread, S_t, so that: $R_t \equiv R_t^* S_t$, where $R_t \equiv 1 + r_t$, $R_t^* \equiv 1 + r_t^*$, $S_t \equiv 1 + s_t$ and R, R^* and S are their corresponding steady state values.

I assume that the representative agent is relatively impatient, as in Chapter 2. It is not only less patient than the world economy's counterpart, it is also always willing to borrow abroad up to the limit of a certain foreign credit constraint.[16] Therefore, the economy's discount factor is lower than the rest of the world's, $\beta < \beta^*$, and also $\beta R < 1$. Coupled with such a type of constraint, the relative impatience gives the model steady state properties that preclude the use of typical assumptions to render SOE models stationary (Schmitt-Grohé and Uribe 2003). There is a permanent premium between the domestic return on capital and the cost of foreign borrowing.

The representative agent maximizes his life-time utility,

$$U = E_t \sum_{s=t}^{\infty} \beta^{s-t} u(C_s, H_s), \tag{3.1}$$

where

$$u(C_s, H_s) = \frac{(C_s - aCH_s^{\theta})^{1-\eta} - 1}{1 - \eta} \tag{3.1a}$$

and

$$L_s + H_s = 1 \tag{3.1b}$$

where L and H stand for leisure and hours worked.

[16]Impatience hypotheses haven been used in closed-economy models, such as Kiyotaki and Moore (1997) and of Carlstrom and Fuerst (1997). Paasche (2001) also posits such a hypothesis in an international setting. Moreover, from an emerging or developing economy perspective, it is in line with heterogenous cross-country empirical evidence, which indicates a positive correlation between β and wealth, as in Becker and Mulligan (1997).

The above setting of preferences is widely used in SOE models and follows Greenwood et al. (1988), where η is the coefficient of relative risk aversion and θ is the parameter associated to the elasticity of labour supply.

With a given production technology, the agent accumulates capital and faces not only a resource constraint, but also a credit constraint associated with the country spread.

The resource constraint is represented as follows:

$$C_t \leq Z_t F(K_{t-1}, H_t) - I_t \left[1 + \Omega \left(\frac{I_t}{I_{t-1}} \right) \right] + B_t - R_{t-1} B_{t-1} \tag{3.2}$$

The function $\Omega(\,)$ represents investment adjustment cost. It has the following steady state values: $\Omega(1) = \Omega'(1) = 0$ and $\Omega''(1) = \pi^i$. The latter parameter π^i only affects the dynamic properties of the model, without interfering with its steady state conditions. Investment adjustment costs have been proposed in business cycle literature (e.g. Christiano et al., 2005, Jaimovich and Rebelo, 2006) such to induce inertia in investment and improve the dynamics of the model. I use investment adjustment costs not only to enhance the dynamics of investment, but also as a means to control the excessive volatility that is typically observed in Small Open Economy business cycle models. The production function, $F()$, is Cobb-Douglas and therefore:

$$F(K_{t-1}, H_t) = K_{t-1}^{\alpha} H_t^{1-\alpha} \tag{3.3}$$

Capital accumulation is affected by a depreciation rate, $\delta \in [0, 1]$, and is given by:

$$I_t = K_t - (1 - \delta) K_{t-1} \tag{3.4}$$

3.3.2 Country Spread as an Endogenous Constraint

The constraint is viewed as a credit pricing mechanism that reflects the value of collateral or balance sheet (e.g. Kiyotaki and Moore, 1997). It also reveals a sort of a credit rationing mechanism (Stiglitz and Weiss, 1981). Both mechanisms are intermediated by the country spread, in particular by its tightening or loosening effects in credit price and credit supply. Given the credit supply conditions, the representative agent faces the constraint as in the form of a "monopsonistic contract", by which he is able to endogenously consider the connection between credit supply and the macroeconomy, namely between the spread and its endogenous and exogenous determinants. Without being microfounded, the constraint is simply written in a reduced form as follows:

$$S_t = S_{t-1}^{\sigma} R_{t-1}^{*\tau} \left(\chi \frac{B_{t-1}}{Z_t F(K_{t-1}, H_t)} \right)^d \epsilon_t \tag{3.5}$$

Equation 3.5 posits an endogenous relationship between the country spread and the foreign debt ratio to GDP. Moreover, the spread is affected by the US real interest rate (R_{t-1}^*), reflecting liquidity in global financial markets, and by an exogenous component (ϵ_t).[17] The spread may also be subject to some "additional endogenous persistence" ($\sigma > 0$), beyond the one endogenously implied by the debt-output ratio. Persistence is a well documented characteristics of asset prices, specifically of changes in spreads (Collin-Dufresne, 2001).[18]

Various studies posit a similar *ad hoc* formulation of the external premium (Gertler et al., 2003). Instead of formulating the spread on the basis of a negative correlation with net worth, similar to Gertler et al. (2003), I use the debt-output ratio. Such a ratio has been regarded as one of the principal drivers of country spreads. It is consistently present in rating assessments of country risk and international debt contracts. It might be indicative of the borrowing capacity or ability of an emerging economy to pay.

Overall, the constraint might disturb the economy for various reasons: changes in macroeconomic fundamentals (e.g. Eichengreen and Moody, 1998), global liquidity, and other financial or borrowing conditions that, beyond the macroeconomy, might have an impact on country spread. The latter could stem from international financial contagion or common sources at the core of global credit markets beyond those affecting international liquidity (González-Rozada and Yeyati, 2008; Sarquis, 2008).

[17] The impact of overall global liquidity on country spreads, as well as on other categories of segmented debt markets, has been empirically and systematically observed. Uribe and Yue (2005) and Hartelius et al. (2008) have documented a positive impact of the US interest rates on emerging market spreads.

[18] Country spread persistence is clearly present in the Brazilian evidence and of other emerging economies. An important question in this regard relates to the extent by which such persistence is "endogenous" or exogenously provoked by persistence of the underlying shocks.

3.3.3 Shocks and Exogenous Processes

The model is potentially subject to three exogenous processes that can each be disturbed by specific shocks: (a) productivity, Z_t ; (b) reference interest rate, R_t^*; and (c) exogenous component of the country spread, ϵ_t. These processes follow a vector autoregressive form:

$$x_t = Px_{t-1} + \varepsilon_t \ , \tag{3.6}$$

where $x_t = \begin{bmatrix} z_t & r_t^* & e_t \end{bmatrix}'$, $z_t = \ln Z_t$, $r_t^* = \ln R_t^*$ and $e_t = \ln \epsilon_t$. The vector ε_t $= \begin{bmatrix} \varepsilon_t^z & \varepsilon_t^{r^*} & \varepsilon_t^e \end{bmatrix}'$ gives a log linear representation of the disturbances to the exogenous processes, which are uncorrelated. P is assumed to be diagonal:

$$P = \begin{bmatrix} \rho^z & 0 & 0 \\ 0 & \rho^{r^*} & 0 \\ 0 & 0 & \rho^e \end{bmatrix}$$

3.3.4 First Order Conditions

The problem results in maximizing a Lagrange expression, with the following related equation multipliers: λ_t, q_t and μ_t. The latter is associated with the binding of the endogenous credit constraint. Instead of representing the shadow price of capital as collateral, as in Chapter 2, it acts herewith as a measure of the marginal net benefit of holding foreign debt, once one discounts the effects of the spread on servicing the debt. Six first order conditions derive from the maximization problem:

$$-u_H(C_t, H_{t,}) = \lambda_t Z_t F_H(K_{t-1,} H_t) + d(1-\alpha)\mu_t \frac{S_t}{H_t} \tag{3.7}$$

$$\lambda_t = u_C(C_t, H_t) \tag{3.8}$$

$$q_t = \lambda_t \left[1 + \Omega\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}}\Omega'\left(\frac{I_t}{I_{t-1}}\right)\right] - \beta E_t \left(\frac{I_{t+1}}{I_t}\right)^2 \Omega'\left(\frac{I_{t+1}}{I_t}\right)\lambda_{t+1} \tag{3.9}$$

$$\lambda_t = \beta E_t \left(R_t \lambda_{t+1} + d\mu_{t+1}\frac{S_{t+1}}{B_t}\right) \tag{3.10}$$

$$q_t = \beta E_t \left[Z_t F_K(K_t, H_{t+1})\lambda_{t+1} + (1-\delta)q_{t+1} + \alpha d \mu_{t+1} \frac{S_{t+1}}{K_t} \right] \tag{3.11}$$

$$\mu_t = \beta E_t \left(R_t^* B_t \lambda_{t+1} + \sigma \mu_{t+1} \frac{S_{t+1}}{S_t} \right) \tag{3.12}$$

The endogenous credit constraint has both direct and indirect impacts in the mechanisms brought about by first order conditions (3.7) to (3.12). Equations (3.7) and (3.8) govern the consumption-leisure marginal rate of substitution and the marginal product of labour. The ratio of the aforementioned defines the labour wedge (Chari et al., 2006; Shimer, 2009) and is affected by the endogenous credit constraint. This is deduced by the presence of multiplier μ_t on the right side of Equation (3.7). In the absence of the constraint, where $d = 0$, the ratio would equal one, as conventionally implied by most SOE models.[19]

Equation (3.9) determines the shadow price of investment. This price would be constant ($q_t = 1$) if there were no investment adjustment costs. Despite these costs, investment is mainly driven by λ_t. Therefore, it depends on the dynamics behind the Euler conditions, (3.10) and (3.11), that control the intertemporal optimization problem.

Equations (3.10) and (3.11) differ sharply from the standard ones, in that they both contain the multiplier of the endogenous credit constraint (μ_t). This feature is common to models with endogenous credit constraint.[20] Furthermore, Equation (3.12) controls the dynamics of the endogenous credit constraint multiplier and therefore may strengthen the intertemporal propagation in line with the Euler conditions (3.10) and (3.11). It states that the benefit of holding debt in this period equals the discounted marginal first-order impact of the spread on the aggregate resources of the next period due to debt repayment, plus the discounted benefit from carrying the debt over into the next period. The latter is adjusted by the contribution of the presumed inherent autocorrelation of the spread, and would vanish if it was nonexistent ($\sigma = 0$). The two terms on the right side of (3.12) impact the multiplier via a feedback from the macroeconomy, implicit in the endogenous constraint, and via a purely inherent persistence of the spread. Shocks reduce the multiplier by prompting a progressive fall in debt.

[19] See for instance Schmitt-Grohé and Uribe (2003).

[20] See Kiyotaki and Moore (1997) for a model of a closed economy with heterogenous agents, and Sarquis (2008) for a model of a small open economy facing an aggregate constraint.

Together, conditions (3.10)-(3.12) result in non-trivial mechanisms. For different reasons, both favorable productivity shocks and adverse credit shocks lead to a tightening of the constraint, measured by a fall in the multiplier (reduction of foreign debt), and provoke a rise in the marginal product of capital. Credit shocks drive consumption, capital and debt in the same direction due to their intertemporal propagation. The downturn is further aggravated by the persistence of the spread. Such a persistence is warranted, regardless of an inherently presumed autocorrelation in the spread. Productivity shocks drive the economy through the efficiency and labour wedges. However, these disturbances propagate even further because of credit frictions and implied intertemporal effects. For instance, favorable shocks produce more persistent output dynamics by allowing the economy to reduce its debt holding. A fall in debt during this period results in a reduction in the spread in the next period. This process persists, while a fall in the spread stimulates investment, which is eventually reinforced through a recovery in foreign borrowing. Therefore, the economy can experience a more prolonged and persistent expansion following productivity shocks. The recovery in foreign debt occurs more rapidly after a productivity shock than a credit shock.

The model is fully described by Equations (3.2)-(3.11), and also by the specification of the underlying exogenous processes. I solve the model by the method of logarithmic linearisation (Uhlig, 1999).[21]

3.3.5 Propagation

To further clarify the essence of the model's propagation mechanisms, we should look at the dynamic interactions behind Equations (3.10)-(3.12). For simplicity, I abstract from investment adjustment costs.[22] Substituting out the multiplier μ in Equations (3.10) and (3.11) yields the following combined Euler condition:

$$\lambda_t = \beta E_t \lambda_{t+1} \left[\frac{Z_t F_K(K_t, H_{t+1}) + 1 - \delta - \alpha \frac{B_t}{K_t} R_t^* S_t}{1 - \alpha \frac{B_t}{K_t}} \right] \tag{3.13}$$

The combined Euler condition is similar to, but more comprehensive than, the one derived in Sarquis (2008). It establishes a non-standard negative relationship between

[21] The Matlab code containing the loglinearized equations can be provided by the author. The simulations use Uhlig's toolkit of Matlab codes for analyzing nonlinear dynamic stochastic models.

[22] Neither capital nor investment adjustment costs alter the main implications for output dynamics in the model.

consumption growth and the country's real interest rate. Adverse shocks to the US interest rate or the exogenous component of the country spread can lead to persistent negative growth before the economy recovers to equilibrium levels. Furthermore, the endogenous term (B_t/K_t) in Equation (3.13) reinforces the propagation of shocks, thereby forcing the economy into earlier recessions and recoveries. In Chapter 2, this term is fixed, representing the collateral formation parameter, and can only be directly altered by exogenous disturbances. Here, any shock ends up inducing endogenous changes in (B_t/K_t). Coupled with the specification credit shocks, these endogenous changes govern the intertemporal wedge. This wedge can be defined as the difference between the marginal of consumption substitution and the return on capital. Therefore, it is given by W_{t+1} in Equation (3.14), which restates Equation (3.13):

$$\lambda_t = \beta E_t \lambda_{t+1} R^K_{t+1} W_{t+1} \tag{3.14}$$

where

$$R^K_{t+1} \equiv Z_{t+1} F_K(K_t, H_{t+1}) + 1 - \delta \tag{3.15}$$

$$W_{t+1} \equiv \frac{1}{1 - \alpha \frac{B_t}{K_t}} \left(1 - \alpha \frac{B_t}{K_t} \frac{R^*_t S_t}{R^K_{t+1}} \right) \tag{3.16}$$

An adverse credit shock of any type has an immediate negative effect on the wedge. As it can be shown from Equation (3.16), $\frac{\partial W_{t+1}}{\partial R^*_t} < 0$ and $\frac{\partial W_{t+1}}{\partial \epsilon_t} < 0$. A fall or a rise in the wedge implies that the intertemporal variation in consumption (adjusted by the coefficient of relative risk aversion) has to decrease or increase more than the return on capital. Note that: $E_t \left[\eta(c_{t+1} - c_t) - r^k_{t+1} \right] = E_t w_{t+1}$. The fall in the wedge is met by falls in debt and investment expenditures, as well as by a rise in the current account. The term (B_t/K_t) in the wedge encourages the economy to engage in debt reduction in a persistent way so as to offset the persistent impact of adverse shocks on the wedge. Due to the intertemporal wedge, consumption dynamics can be less smooth than those obtained in standard macroeconomic models. Similar to output, capital and debt, it can reveal a V- or hump-shaped pattern, experiencing negative growth immediately after adverse shocks and recovering relatively fast after troughs.

The multiplier is implicit in the wedge. Adverse credit shocks lead to falls in debt and in the multiplier, while the country spread persists above the steady state even if shocks are purely temporary. As the multiplier keeps falling, it indicates the need to further reduce foreign debt holdings. While the through in output and consumption is attained and the economy starts to recovery, the country spread return to equilibrium. Over this process, the economy can potentially experience cycles, in that it undergoes a non-monotonic convergence towards equilibrium.

On the whole, the model's propagation is caused by the dynamics of foreign debt ratio and country spread, that is by the interaction of balance sheet and asset prices, in analogous terms to a debt-deflation mechanism (Fisher, 1933).[23] It can also generate cycles, as described by Kiyotaki and Moore (1997) in a closed-economy framework. Here, regardless of the shock nature, the responses of debt, capital, output and spread relate to considerable adjustments in asset prices, equity and foreign debt returns. Also with regard to the debt-deflation mechanism, the model is different from models that focus on emerging economy sudden stops.[24] Distinctively, by assuming a permanent constraint, I seek, as in Chapter 2, to address regular business cycle dynamics and, therefore, to explain cyclical, rather than occasionally excessive, output drops and capital outflows.

It is worth noting that the credit constraint parameters do not interfere directly with the core of the intertemporal propagation, as implied by the combined Euler equation (3.13) or the wedge described by Equation (3.16). For instance, the additional persistence of the country spread, σ, only affects the intertemporal dynamics by its interference with the spread process.

[23] Besides quantity effects, price effects arise in the model more acutely than in the CCSOE model of Chapter 2. Therefore, we could say that the debt-deflation mechanism is stronger and more explicit in this Chapter than in Chapter 2.

[24] See Mendoza (2006) for a review of these models.

3.4 Calibration

3.4.1 Parameters

The baseline parameters and steady state values for the interest rate, country spread and macroeconomic "big" ratios are shown in Tables 3.3 and 3.4. I set these values based on available data and empirical estimates for Brazil, complemented when appropriate by the equilibrium conditions of the model, including the credit constraint. The Brazilian average annualised real interest rate was around 8% for the sample period 1994:QII-2005:QIV. Therefore, $R = 1.0175$ on a quarterly basis. The steady state rates for the country spread and the US real rate are: $R^* = 1.0035$ and $S = 1.0164$.

TABLE 3.3. Baseline Parameter Values.

Symbol	Description	Value
	Rates and discount	
R	Brazil real interest rate	1.0175
R^*	US real interest rate	1.0035
S	country spread	1.0140
β^{-1}	subjective rate of discount	1.0383
β	discount factor	0.9631
	Utility function	
θ	elasticity of labour supply = $\frac{1}{1-\theta}$	1.0
η	coefficient of relative risk aversion	10
h	hours	0.2
a	utility parameter	3.6984
	Technology	
α	capital share	0.38
$1-\alpha$	labour share	0.62
	Capital accumulation	
δ	depreciation rate	0.027
π^i	investment adjustment cost	0.5

The coefficient of relative risk aversion, η, is also set at inferior values, such as 5, 2.5 and 1, in the next Sections.

The reported net foreign debt to annual GDP ratio averages 0.207 for the sample period. The short term debt is about 14.4% of the total foreign debt. Therefore, the quarterly ratio of short term debt to GDP is around 0.119.[25] Accordingly, the steady state B/Y ratio is set at 0.12. Alternative ways to measure the total debt to GDP ratio can give ratios of the net short term debt to GDP that fluctuate around 0.12. For comparative analysis I also simulate the model with B/Y set at 0.07 and 0.18. Higher debt ratios reduce the excessive volatility of debt, investment and trade balance,

[25] Note that the quarterly ratio is four times that of the annual ratio, where B is a stock variable and Y a flow variable.

while requiring less presumed persistence in the way credit shocks affect the aggregate economy. However they induce prolonged recessions and very slow recoveries in response to credit shocks.

The subjective discount (β) is set at 0.9631. First, this value technically ensures a permanent binding of the constraint, since $\beta R = 0.98 < 1$. Second, it is in line with estimates found for developing economies, as discussed in Chapter 2. For Brazil, estimates of β are around 0.90 annually (0.974 quarterly), and are at much lower levels than those typically found for the US (and other developed economies), adding further empirical support to the hypothesis of relative impatience. This hypothesis corresponds to a persistent willingness to access and to use all available foreign credit, thus resulting in the permanent binding of the foreign credit constraint.

Another parameter that I specify beforehand is the constant coefficient of relative risk aversion, γ, which corresponds to the inverse of the elasticity of intertemporal substitution. It is set at 10 in the baseline simulations, while lower values (5, 2.5, 1.5 and 1) are also considered. Although it is often assigned at a lower range, between 1 and 3, there does not appear to be any definitive agreement about what is actually reasonable (Cochrane, 2005), especially if we consider the equity premium puzzle and look at estimations based on microeconomic data (Schechter, 2007). Macroeconomic models that address the role of uncertainties and risks consider a much broader range for the relative risk aversion coefficient (e.g. Abel, 1990; Reinhart and Végh, 1995). Yoshino and Santos (2007) estimate that Brazil has the highest coefficient of relative risk aversion and the lowest utility discount factor of the US and six emerging economies.[26]

In order to specify technology parameters, calculations based on income shares usually give developing countries an excessively higher capital share (α) than those found for developed economies.[27] For Brazil, the statistics would produce a capital share grater than 0.40. To correct for the capital bias, I use a capital share which is close to the upper limits of conventional values, $\alpha = 0.38$. I set the capital depreciation rate at 2.7% per quarter: $\delta = 0.027$.

The parameter that gives the curvature of the investment adjustment cost, π^i, is fixed at 0.5, which is at the lower range of recent studies.[28] A higher π^i in the model

[26]Their results are consistent with Brazil having a coefficient of relative risk aversion which is 9 times bigger than the estimate for the US.

[27]A higher proportion of informal labor is one of the reasons usually cited for the under statement of labour income in official statistics.

[28]See for instance Christiano et al. (2005) and Jaimovich and Rebelo (2006). They report π^i ranging from 0 to just over 2.5.

would further prolong the trough and recovery, especially beyond observed empirical responses of investment to credit shocks.

Given α, δ and B/Y, the other ratios of the economy are set in accordance with equilibrium equations. The capital ratio is derived from the steady state equilibrium first order conditions of capital, debt and investment:

$$\frac{K}{Y} = \frac{\alpha\left[\beta + (1-\beta R)\frac{B}{Y}\right]}{1-\beta(1-\delta)}$$

Accordingly, I set $K/Y = 5.8309$ (quarterly basis). The capital ratio in Brazil has been estimated at different values, with most estimates being below typical values used for the US or for industrialized SOEs, such as Canada. Regarding the latter, Mendoza (1991) and subsequent applied studies of SOE models set it at 8.8 quarterly (2.2 annually). Given δ, the corresponding investment rate is 15.74% of the GDP, which is very close to the actual rate.[29] Given the steady state interest rate, the other ratios follow, such as C/Y and the trade balance to GDP, as indicated in Table 3.4. This Table also shows corresponding ratios that would apply for simulations with higher B/Y set at 0.12, in place of 0.07. Actually, the higher debt to GDP ratio does not significantly affect the steady state equilibrium conditions. However, it can attenuate the excessive volatility of debt in the model.

I use the conventional settings of $H = 0.2$, and attribute $\theta = 1$. Therefore, the parameter a equals 3.6984 by the equilibrium first order conditions in consumption, hours, debt and spread. In contrast to the literature, the latter two conditions affect the parametrisation regarding the elasticity of labour supply.

TABLE 3.4. Macroeconomic Ratios of the Model.

B/Y	K/Y	C/Y	I/Y	X/Y
0.12	5.8369	0.8403	0.1576	0.0021

3.4.2 Exogenous Processes

3.4.2.1 Persistence

I use the following *baseline* autoregressive coefficients and standard deviations, represented in the diagonal matrix P_0 below, to specify the persistence and standard

[29]From the national accounts at annual current prices, the investment rate is calculated at 16.96% of the GDP.

deviation of the shocks in the three exogenous processes underlying productivity, the US real interest rate and the country spread:

$$P_0 = \begin{bmatrix} \rho^z & 0 & 0 \\ 0 & \rho^{r^*} & 0 \\ 0 & 0 & \rho^e \end{bmatrix} = \begin{bmatrix} 0.69 & 0 & 0 \\ 0 & 0.63 & 0 \\ 0 & 0 & 0.00 \end{bmatrix}$$

The coefficients of the P_0 matrix are guided by VAR coefficient estimates, especially in the case of the US interest rate. The latter is estimated at 0.633 (with a standard deviation of 0.085) in the VAR spread equation with the US shift dummy.[30] The autoregressive coefficient for productivity is set at 0.69, which is line with the VAR's estimated coefficient of lagged output in the output equation.[31] By firstly setting $\rho^e = 0$, I am suppressing any possible persistence in the exogenous component of the spread. Therefore, I am allowing for the model, under equilibrium conditions, to endogenously determine the persistence of the variable. The VAR indicates some persistence in the country spread, as the lagged coefficient is estimated at around 0.69.[32]

3.4.2.2 Standard deviation of shocks

The standard deviations of the shocks are also guided by the VAR and they are set at 0.53% for ε_t^z, 0.5% for $\varepsilon_t^{r^*}$and 1.7% for ε_t^e in the benchmark model. The last two standard errors are in line with the range suggested by the VAR estimates with and without the US shift dummies: 0.49% to 0.54% for $\varepsilon_t^{r^*}$ and 1.69% to 1.74% for ε_t^e. The exogenous innovation in the country spread is about 3 times more variable than the disturbances to the benchmark (US) interest rate.

The standard deviation of the productivity shock (0.53%), which is not estimated in the VAR, is chosen to match the overall empirical volatility of output. Interestingly, with the specifications of both persistence and deviations of the exogenous shocks, I am allowing for productivity shocks to propagate concurrently with the credit shocks. Thus, it is possible to check whether productivity not only accounts for a large share of the macroeconomic variability, but if it also dominates and eventually dampens the

[30] If the shift dummy is suppressed, the estimated coefficient would be 0.798 (with a standard deviation of 0.079).

[31] The VAR estimated autoregressive coefficients for other domestic variables (hour, consumption and investment) do not seem to suggest the presence of more persistent exogenous productivity processes than the one estimated for the output.

[32] See Tables 3.16 and 3.17 with estimated VAR coefficients in Appendix 3.B.

effects of the credit shocks, which are specifically perpetuated through the constraint, over realistic business cycle frequencies.

3.4.3 Credit Constraint Parameters

Thanks to the model's equilibrium conditions, I only need to specify two of the four parameters (σ, τ, d and χ) of the country spread equation. I start by selecting σ so as to match the amplitude of the output response to the shock in the exogenous spread. Interestingly, the choice of σ (0.62) is very close to, and is slightly more conservative than, the estimated persistence of the country spread in the VAR (0.69). I also set τ at 0.53 in order to match the amplitude of the output response to the shock in the US real interest rate. Given σ and τ, I find $d = 0.011$. It derives from model restrictions arising from the first order conditions in debt and spread: $d = (1 - \beta R)(1 - \beta\sigma)/\beta^2 R$. Given d, σ and τ, the value of χ (12.5892) is determined merely by the steady state property of the S equation.

The baseline model is set as stated above, with *maximum* endogenous persistence of the country spread in the credit constraint. I also specify the model under parameter conditions in which there is a *minimum* persistence of this kind, in order to evaluate the scope for possible exogenous persistence in the spread, driven by a non-zero lagged coefficient in the exogenous component of the spread. Note that, in line with the VAR estimation, we should expect: $0 < \rho^e < 0.69$. At the extreme, the choice of the parameters starts by setting a realistic τ that is higher than previously chosen, that is $\tau > 0.53$. Setting $\tau = 1.6$ and $\sigma = 0$ is sufficient to match the amplitude of the output response to the US rate shock, as long as ρ^{r^*} is set at 0.70, instead of 0.63. The value 1.6 is within the upper limit of the confidence interval estimated for the lagged US real interest rate in the country spread equation (see Tables 3.16 and 3.17 in Appendix 3.B).[33] With minimum σ at 0, ρ^e is set at 0.64, matching the amplitude of the variable following an exogenous spread shock.

Intermediary models would combine pairs of σ and τ, with $0 < \sigma < 0.60$ and $0.53 < \tau < 1.6$. For higher values of σ, less persistent exogenous processes are required in both the US interest rate and the spread. The amplification in the model intensifies with σ. Two possible *intermediary* configurations for the endogenous persistence are

[33] The previously chosen τ is in line with the alternative VAR estimation for the lagged coefficient of the US rate in the country spread equation.

TABLE 3.5. Parameters in the Credit Constraint.

Symbol	Description of components	Models			
		Baseline	Alternatives		
		Maximum	*Minimum*	*Intermediary*	
σ	spread persistence	**0.60**	**0.0**	**0.37**	**0.46**
τ	US interest rate	0.53	1.6	1.2	0.92
d	debt to GDP ratio	0.0089	0.0212	0.0136	0.0118
χ	additional parameter	12.5892	12.3086	11.6214	11.9634

Each specification of σ implies a specific set of τ, d and χ to match output responses according to data and to the conditions imposed by the structure of the model.

examined, as described in Table 3.5. Consistent with the criteria of matching the output responses, they are obtained by setting for instance $\sigma = 0.37$ and $\rho^e = 0.44$, and $\sigma = 0.46$ and $\rho^e = 0.33$, while holding $\rho^{r^*} = 0.63$. Intermediary models can rely on moderate autocorrelation in both the endogenous and the exogenous component of the spread.

3.5 General Results

3.5.1 Model Responses

Figures 3.4 and 3.5 display model responses to US interest rate shocks and to exogenous spread shocks, respectively. Each Figure depicts simulated responses under two specifications of the model: with *maximum* and *minimum* additional endogenous persistence. The latter corresponds to the case requiring a combination of no inherent (endogenous) autocorrelation in country spread and (moderately) persistent shocks to the exogenous component of the spread. The former reflects the baseline model with purely transitory shocks. Responses under intermediary specifications lie within those with *maximum* and *minimum* endogenous persistence, which are respectively marked with circles and crosses along the VAR responses and confidence intervals.

The model responses to US interest rate shocks are, to a great extent, within the corresponding confidence interval of the empirical response, with the exception of the debt response. In particular, the responses of output, consumption and hours illustrate the model's ability to generate recessions, with hump-shaped dynamics. The output and consumption responses appear to match their empirical counterparts both qualitatively and quantitatively. These responses seem to match the paces at which slowdowns and recoveries are empirically observed. All of these features provide reassurance about the model's ability to be used as a framework for assessing the business cycle implications of US interest rate shocks. In the model, the troughs tend to occur about one quarter after those empirically observed. The model's simulated responses of the spread also match their empirical counterparts to a great extent. The amplitude of the responses is better matched by the specification with *minimum* endogenous persistence, while the baseline specification (*maximum* endogenous persistence) ensures greater and more realistic persistence.

The model responses to spread shocks are also consistent with empirical recessions, revealing negative growth persistence. The troughs in output and consumption are attained, compared to the responses to US rate shocks, slightly later than in the VAR responses. A possible explanation for such a discrepancy might be attributable to further transmission channels, associated with the spread, which are not addressed in this Chapter. As shown in Chapter 1, fast capital outflows, coupled with exchange rate depreciation, might result from adverse country spread shocks.

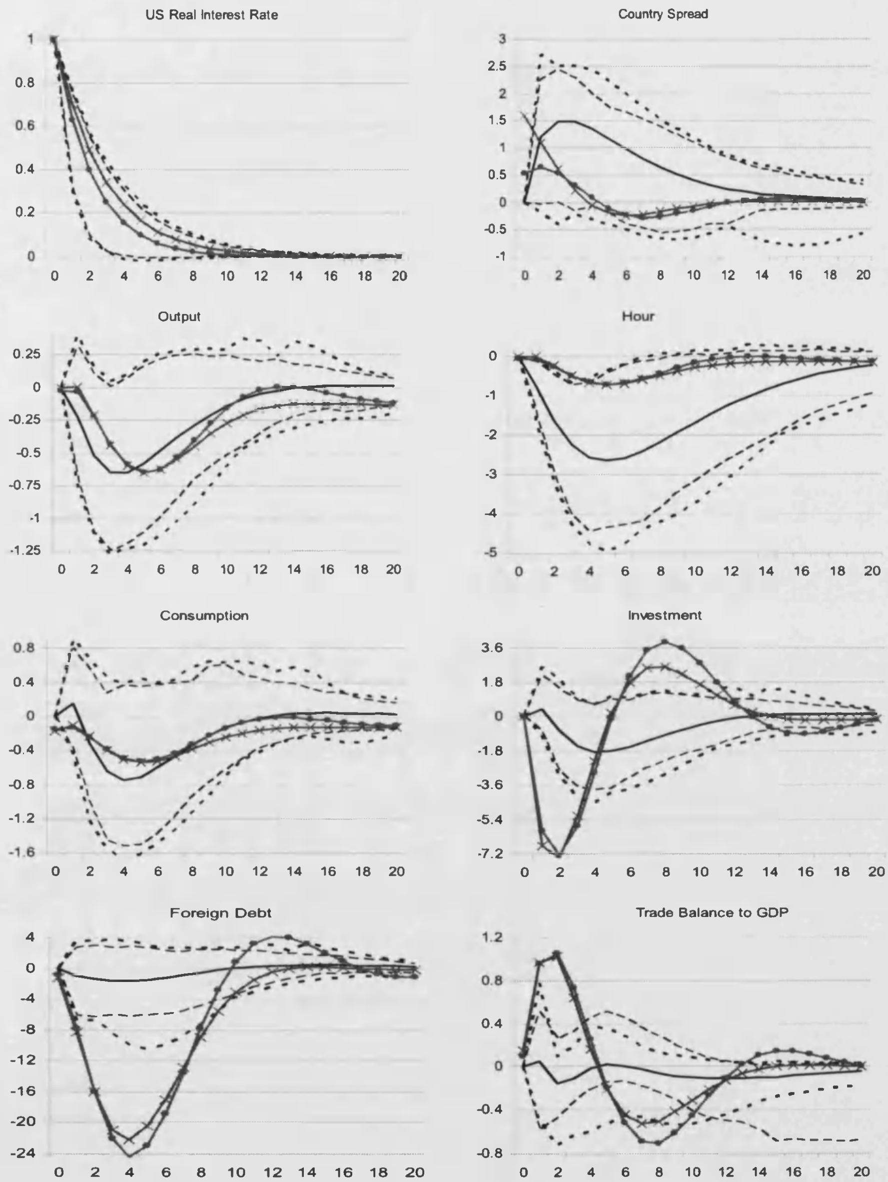
By and large, the model exaggerates the responses of debt. They are more dramatic than those empirically documented. Four comments can be made with respect to such a gap. First, the model does not consider additional transmission channels, such as those associated to monetary effects and changes in relative prices (e.g. exchange rate or terms of trade). The introduction of rigidities and allowing for a detrimental depreciation in relative prices in face of adverse shocks could improve the debt adjustment process. Second, the model could be reinterpreted so to incorporate a broader definition of the country's net international liability position. If net assets held by foreigners in stock exchanges (both domestically and abroad[34]) are taken into account, we would verify dramatic (short term) capital outflows and sharper falls in net liabilities. These changes, together with exchange rate movements, can be caused by credit shocks and eventually impair the country's costs of borrowing via the spread (Calvo, 1998; Calvo and Mendoza, 2000; Sarquis, 2008).[35] Of course, such a reinterpretation might eventually require an extension of the model to enable differentiation between the two forms of international external finance. Third, the excessive volatility of debt can be controlled within the model by alternative calibration methods. Reducing τ and σ can lead to less dramatic falls in debt. The same would apply to the persistence of the exogenous processes. Following these procedures output undergoes smaller contractions, measured by the amplitude at troughs. Finally, independently from or in combination with the above, higher steady state values for the debt to GDP ratio can also smooth debt responses.

Partly due to the characteristics of the model's simulated debt responses, investment and net exports react faster and more pronounced than empirically suggested. However, the model responses in investment reveal significant serial autocorrelation (see Table 3.6). Such a realistic feature is also present in the CCSOE model in Chapter 2, but it tends to be absent from most SOE business cycle models. Investment responses could perhaps be improved by resorting to "time to build". This and other *ad hoc* mechanisms are avoided not only to keep the model simple, but also to focus on its key propagating mechanisms (with relevant qualitative and quantitative implications) in a very transparent way.

[34]Most emerging economies also resort to external finance via equities issued abroad, for instance at the London and New York Stock Exchanges.

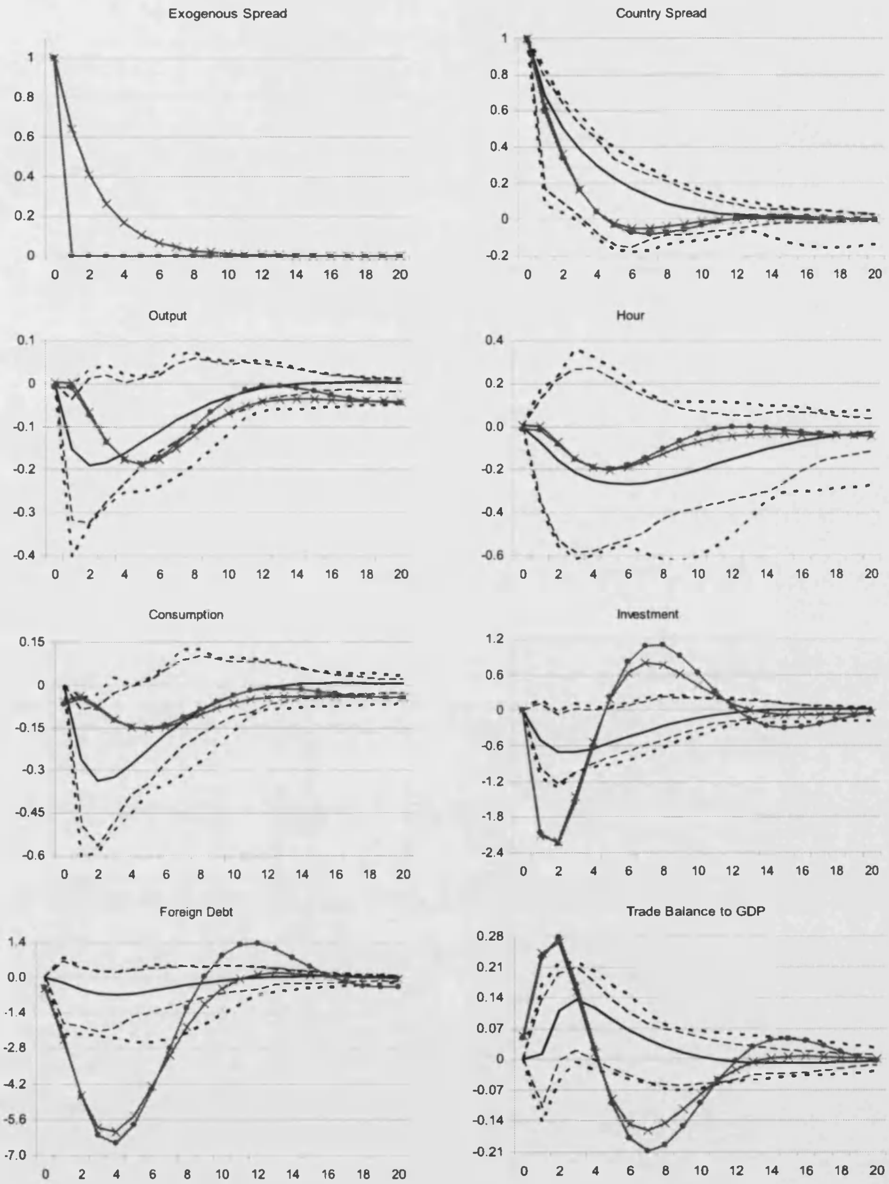
[35]The effects are more pronounced during sudden stops, but they are recurrent facts of emerging economy business cycles.

FIGURE 3.4. Responses to US Interest Rate Shocks.



Model responses with maximum and minimum endogenous persistence are marked with circles and crosses. VAR responses (solid lines) are accompanied by 95% and 98% (standard) bootstrapped confidence intervals (dotted lines). The units of the vertical and horizontal axes are percent and quarters, respectively.

FIGURE 3.5. Responses to Exogenous Spread Shocks.



Model responses with maximum and minimum endogenous persistence are marked with circles and crosses. VAR responses (solid lines) are accompanied by 95% and 98% (standard) bootstrapped confidence intervals (dotted lines). The units of the vertical and horizontal axes are percent and quarters, respectively.

3.5.2 Second moments

Tables 3.6 and 3.7 document the standard deviations and serial autocorrelations of Brazilian data, and of the model under different specifications. The model matches the overall volatility in output with realistic and independent shocks to productivity, the US interest rate, and exogenous component of the country spread. The suitability of the credit shock specifications is corroborated by their respective standard deviations. The model also replicates the variability of consumption, investment and trade to GDP. The standard deviation of foreign debt is higher in the model than in the data, since the model exacerbates the debt response to credit shocks (Figures 3.4 and 3.5). The variability of the country spread and interest rate are also replicated and reassure us about the magnitude of the transmission of credit shocks via the spread, as a major component of the country's interest rate.

The model's simulated serial correlations are all positively significant, except in the case of the exogenous component of the spread under the specification of *maximum* persistence. Overall, they correspond to those observed in the data. As Chapter 2, the model is particularly successful in producing significant serial correlations in investment - a feature that is not usually matched in SOE models (Schmitt-Grohé and Uribe, 2003).

The different specifications of the model, from *minimum* to *maximum* endogenous persistence, do not yield different results. Therefore, in all cases, the underlying forces of propagation concentrate behind the endogenous accumulation of debt and capital. Even country spread is driven by the wedge in debt and capital dynamics. Only on a complementary basis can its propagation be enhanced by (very) moderate endogenous persistence. The persistence of the country spread (see Table 3.6) rises for instance by setting intermediary σ, such as 0.37 or 0.46. Higher levels of endogenous persistence require less volatile disturbances, while increasing the variability of investment, debt and trade balance. However, with regard to country spread, *per se* such a relationship is not necessarily monotonic.

TABLE 3.6. Standard Deviations: Estimated VAR and Simulated Model.

	Real data	Simulated models ($\eta = 10$)			
		Baseline	Alternative		
		Maximum	*Minimum*	*Intermediary*	
		$\sigma = 0.60$	$\sigma = 0.00$	$\sigma = 0.37$	$\sigma = 0.46$
Endogenous variables					
Output	1.60	1.59	1.58	1.58	1.58
Hour	3.28	1.60	1.60	1.59	1.59
Consumption	2.34	-			
non durables	1.56	1.26	1.25	1.25	1.25
Investment	5.14	-			
mach. & equip.	10.28	10.00	9.04	9.79	9.88
Foreign debt	12.33	28.1	24.3	25.3	25.97
Trade balance	1.99	1.52	1.33	1.44	1.47
Interest rate	2.59	2.18	2.45	2.56	2.46
Country spread	2.51	1.99	2.15	2.31	2.24
Exogenous processes					
Productivity	-	0.60	0.60	0.60	0.60
US interest rate	0.48	0.55	0.57	0.55	0.55
Spread	1.68	1.64	1.87	1.72	1.67

The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1994:QII to 2005:QIV. National accounts are seasonally adjusted. All variables are logged - except for the trade balance to GDP ratio, country spread and interest rate - and detrended with the Hodrick-Prescott filter ($\lambda = 1600$).

TABLE 3.7. Autocorrelation: Estimated VAR and Simulated Model.

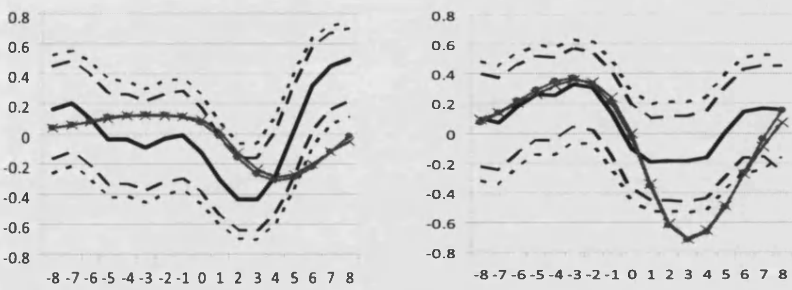
	Real data	Simulated models ($\eta = 10$)			
		Baseline	Alternative		
		Maximum	*Minimum*	*Intermediary*	
		$\sigma = 0.60$	$\sigma = 0.00$	$\sigma = 0.37$	$\sigma = 0.46$
Endogenous variables					
Output	0.69	0.56	0.55	0.55	0.55
Hour	0.84	0.56	0.55	0.55	0.56
Consumption	0.71	0.56	0.55	0.55	0.55
Investment	0.69	0.80	0.76	0.75	0.76
Foreign debt	0.74	0.90	0.90	0.89	0.90
Trade balance	0.41	0.77	0.72	0.72	0.73
Interest rate	0.64	0.54	0.52	0.61	0.61
Country spread	0.66	0.52	0.52	0.61	0.61
Exogenous processes					
Productivity	-	0.54	0.54	0.54	0.54
US interest rate	0.71	0.49	0.55	0.49	0.49
Spread	-0.03	-0.07	0.50	0.33	0.23

Only lag one autocorrelations are shown above. The real data statistics are as in Table 3.6.

3.5.3 *Serial correlations*

Figures 3.6 and 3.7 document unconditional cross correlations of the country interest rate and country spread with lagged output, and with lagged debt. The model under both specifications with *maximum* and *minimum* endogenous persistence replicates the magnitude, sign and dynamic pattern of these correlations. The simulated correlations are derived from realistic parametrisation of the underlying exogenous and independent processes for productivity, US interest rate and exogenous spread. The model is particularly in tune with the countercyclical nature of both the spread and the real interest rate. The model's correlations also reveal the endogenous connection between debt and spread, especially via reverse causation, by which a rise in debt leads to a rise in the spread, of the interest rate, and eventually a contraction. Though it could arguably be pro-cyclical, a rise in debt has dynamic countercyclical implications.

FIGURE 3.6. Serial Correlations: (i) between Interest Rate and Output; (ii) between Interest Rate and Foreign Debt.

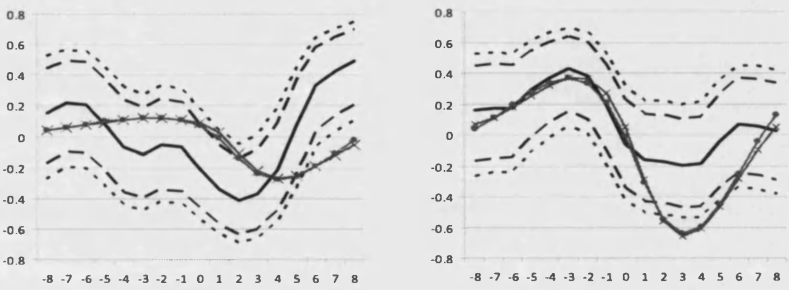


(i) $Corr(R_{t,} Y_{t+j})$ (ii) $Corr(R_{t,} B_{t+j})$

All series are HP-filtered. Solid (black) lines represent empirical unconditional correlations, with 95% and 98% confidence intervals in dotted lines. Model simulated correlations with maximum and minimum endogenous persistence are marked with circles and crosses. The horizontal axis represent j quarters.

Credit shocks appear to be the main determinants of the realistic patterns of cross serial correlations. Figure 3.8 decomposes the correlations that arise separately from each of the three shock sources in the baseline model (with *maximum* endogenous persistence). Only credit shocks ensure that the interest rate leads output in a countercyclical way. Their respective serial correlations, between interest rate and output, correspond to recession patterns that only contrast with the evidence by their prolonged recovery. Consistent with the data, they also lead to correlations that reveal the two causal linkages: the interest rate (country spread) responds upwards to a rise in

FIGURE 3.7. Serial Correlations: (i) between Country Spread and Output; (ii) between Country Spread and Foreign Debt.



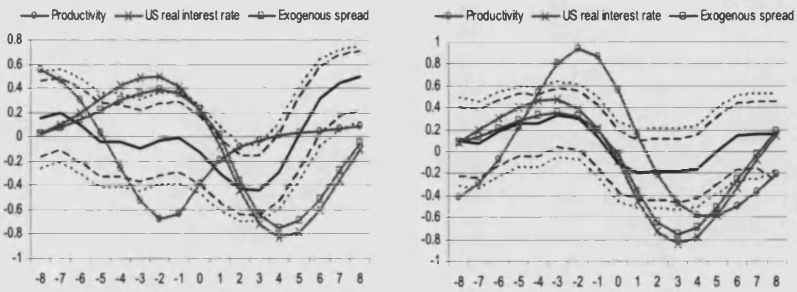
(i) $Corr(S_t, Y_{t+j})$ (ii) $Corr(S_t, B_{t+j})$

See notes for Figure 3.6.

debt, and the latter downwards following rises in the former (country spread). Despite assuring a negative contemporaneous correlation between GDP and interest rate, the effects of productivity shocks are less in tune with the data and cannot be seen as the key drivers of the countercyclical nature of the interest rate.

The model's correlations in Figures 3.6, 3.7 and 3.8 are robust to changes in the coefficient of risk aversion, η. They could slightly alter under different specifications of the exogenous processes. In particular, if we posit a negative correlation between productivity and one of the credit shocks (e.g. Neumeyer and Perri, 2005; Sarquis, 2008), the model could match the actual correlations more closely.

FIGURE 3.8. Serial Correlations: (i) between Interest Rate and Output; (ii) between Interest Rate and Foreign Debt.



(i) $Corr(R_t, Y_{t+j})$ (ii) $Corr(R_t, B_{t+j})$

All series are HP-filtered. Solid (black) lines represent empirical unconditional correlations, with 95% and 98% confidence intervals in dotted lines. Simulated correlations of the baseline model (with *maximum* additional endogenous persistence) are marked with: (a) circles for only productivity shock, (b) crosses for only US real interest rate shocks, and (c) squares for only exogenous spread shocks. The horizontal axes represent j quarters.

3.6 Accounting for Business Fluctuations

Here I look at the variance decompositions among the three independent shocks to productivity, the US interest rate and the exogenous component of the spread. Table 3.8 reports variance decompositions of five endogenous variables: output, consumption, investment, foreign debt and country spread. They are calculated as the variability generated by one or a combination of shocks relative to the variability generated by the three shocks altogether. The first column presents the empirically (VAR) estimated variance decompositions. The maximum percentage that could be explained by a single shock is shown in the second column. The percentage associated to contributions of two shocks follow. The last two columns indicate minimum and mean variance decompositions. The former corresponds to the remaining share of the variability that is not explained by the combination of the other two shocks. The latter are the mean values of maximum and minimum decompositions.

Within the model, the two credit shocks are individually important, with each accounting for a significantly reasonable proportion of business cycle variations. Regarding output, for instance, each of these shocks can be responsible for 5 to 30% of the variable's variability. In combination, the two credit shocks can explain from 9 to 42% of this variability, while productivity and/or other domestic shocks would correspond to 58 to 91%. The credit shocks have similar explanatory power with respect to the variability of consumption. They reveal a stronger role in determining fluctuations in investment and spread. Their implications in terms of the variability of foreign debt look unrealistically excessive. This could be dealt with in the model by the introduction of other frictions, as well as other sources of shocks.

Table 3.9 describes the mean variance decompositions for the specifications with *maximum*, intermediary and *minimum* "additional endogenous persistence", given by σ. The *maximum* column is the same as the last column in Table 3.8. The same statistical procedure as Table 3.8 is applied to derive the mean variance decompositions for other specifications. The results are essentially robust to a wide range of realistic σ from a qualitative and a quantitative standpoint. They reassure us about the model's ability to propagate credit shocks and persistently sustain their effects over realistic time horizons. The model rejects a dominance of productivity shocks that would dampen the effects of productivity shocks over business cycle horizons. Moreover, Table 3.8 indicates that additional endogenous persistence (via σ) enhances, though only marginally, the explanatory power of credit shocks with regard to the fluctuations in output and consumption.

TABLE 3.8. Variance Decompositions: Estimated VAR and Simulated Model.

Dependent variables	**VAR**	**Baseline model** *Maximum* endogenous persistence				
Shock sources:		single or max.	combined US int. rate	combined exog. spread	resulting min.	resulting mean
Output						
Domestic & other	64	91	96	95	58	74
US interest rate	22	31	31	42	5	18
Exog. spread	14	29	42	29	4	17
Consumption						
Domestic & other	58	91	96	95	58	74
US interest rate	18	30	30	42	5	18
Exog. spread	24	29	42	24	4	17
Investment						
Domestic & other	62	35	74	76	6	21
US interest rate	18	66	66	94	24	45
Exog. spread	20	67	94	67	26	46
Foreign debt						
Domestic & other	18	30	76	71	5	17
US interest rate	6	70	70	95	29	49
Exog. spread	14	65	95	65	24	44
Foreign debt	62	-	-	-	-	-
Country spread						
Domestic & other	4	8	29	96	0	4
US interest rate	33	28	28	100	4	16
Exog. spread	51	96	100	96	71	83

For the VAR, all sources of variability, except those due to shocks to the US interest rate and the exogenous spread, are domestic and other sources. The baseline model ($\sigma = 0.60$) includes three sources of shocks: (a) to productivity, (b) to the US interest rate, and (c) to the exogenous spread. Maximum shares correspond to the proportion of the variation of a specific variable that could be explained by only a single independent shock. Minimum shares represent the remaining proportion that, by suppressing the aforementioned single independent shocks, can not be explained by the other two independent shocks acting concurrently. Means are averages of the minimum and maximum shares.

TABLE 3.9. Variance Decompositions: Alternative Models.

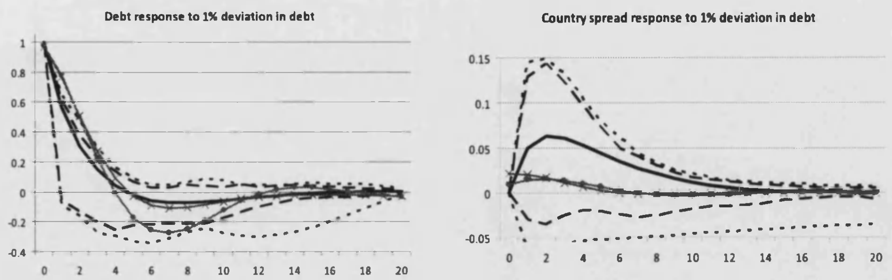
Dependent variables sources of shocks:	**VAR**	Simulated models Baseline *Maximum* $\sigma = 0.60$	Alternative *Minimum* $\sigma = 0.00$	*Intermediary* $\sigma = 0.37$	$\sigma = 0.46$
Output					
Domestic & other	64	74	76	75	75
US interest rate	22	18	16	17	17
Exog. spread	14	17	16	16	16
Consumption					
Domestic & other	58	74	76	76	75
US interest rate	18	18	16	16	17
Exog. spread	24	17	16	16	16
Investment					
Domestic & other	62	21	21	20	20
US interest rate	18	45	45	44	44
Exog. spread	20	46	46	48	48
Foreign debt					
Domestic & other	18	17	16	17	17
US interest rate	6	49	49	48	49
Exog. spread	14	44	45	46	45
Debt	62	-	-	-	-
Country spread					
Domestic & other	4	4	4	4	4
US interest rate	33	16	28	24	20
Exog. spread	51	83	71	76	79

The model with $\eta = 10$ includes three sources of shocks: (a) to productivity, (b) to the US interest rate, and (c) to the exogenous spread. Model shares correspond to means of the minimum and maximum shares. See note of Table 3.8.

3.7 The reverse causation

The model features reverse causation from the macroeconomy to the country spread. The debt variable is key in this process. Figure 3.9 shows the VAR and simulated responses of debt and country spread to a 1% temporary disturbance to the level of debt. Subject to such a shock, the model matches the empirical debt response well, in particular the pace of the endogenous persistence of the variable. It also produces a rise in the country spread, consistent with the empirical response. However, the model does not match the larger amplitude of the point estimates and their hump-shaped form. On the other hand, it should be noted that the model is somehow successful in generating some persistence in the spread's response. The limitations of the model in matching all the features of the spread reverse dynamics are associated with the excessive responsiveness of debt to credit shocks.

FIGURE 3.9. Responses of Debt and Country Spread to a One Percent Deviation in Foreign Debt.



Model responses with maximum and minimum endogenous persistence are marked with circles and crosses, respectively. VAR responses (solid lines) are accompanied by 95% and 98% (standard) bootstrapped confidence intervals (dotted lines). The units of the vertical and horizontal axes are percent and quarters, respectively.

3.8 Persistence and propagation of country spread

The model reproduces to some extent the additional spread variability that should originate endogenously. The empirical estimates of the standard deviations of the country spread and of its exogenous component, respectively at 2.51% and 1.69% (as reported in Table 3.6), are a reference for the model's ability to replicate the spread dynamics. They imply that an additional 48% (2.51/1.69 = 1.48) of the variability should result from endogenous mechanisms of amplification and propagation, as well as from the (exogenous) contribution of shocks other than those to the exogenous component of the spread.

Table 3.10 compares the added standard deviation of the country spread across different combinations of σ and η. Instead of adjusting τ and ρ^e so to match output variability and responses to credit shocks, I simply fix these parameters at the values to which they are calibrated under the specifications with $\eta = 10$. Therefore, the specifications with *maximum* and *intermediary* additional persistence have exactly the same underlying processes of productivity and US interest rate. The superior performance of the *intermediary* models still holds. Since I do not adjust τ and ρ^e across different η, the additional persistence is stronger the higher the coefficient of relative risk aversion.[36] Lower η requires greater persistence of exogenous processes to ensure this matching. Despite having stronger intertemporal consumption substitution effects, it reduces the economy's aggregate volatility.

TABLE 3.10. Standard Deviaton of Country Spread Relative to the Exogenous Component.

Additional endogenous persistence (σ):	Simulated models				
	$\eta = 10$	$\eta = 5$	$\eta = 2.5$	$\eta = 1.5$	$\eta = 1$
Maximum					
$\sigma = 0.60$	1.216	1.214	1.209	1.204	1.199
Intermediary					
$\sigma = 0.46$	1.339	1.334	1.326	1.316	1.305
$\sigma = 0.37$	1.342	1.336	1.326	1.314	1.301
$\sigma = 0.31$	1.332	1.326	1.316	1.303	1.289
Minimum					
$\sigma = 0.00$	1.153	1.148	1.137	1.125	1.112

The Table shows the ratio of the standard deviation of the country spread relative to the standard deviation of the exogenous component of the spread.

[36]The reverse results if I adjust the parameters to match the output dynamics.

According to Table 3.10, the model (with $\eta = 10$) maximizes its ability to generate such additional variability under *intermediary* specifications, namely for σ at 0.37 and 0.46. Under these specifications, the model adds over 33% into the variability of the spread. The model with *minimum* endogenous autocorrelation, that is with no "additional endogenous persistence" ($\sigma = 0$), reveals the worst performance. It has the most significant exogenous persistent, but eventually lacks in endogenous persistence, as first observed in Table 3.6. At the other extreme, the baseline model with *maximum* endogenous autocorrelation or additional persistence reveals more limited amplification than the intermediary ones, although it is the one that ensures the strongest self-explanatory power for the spread (see Table 3.8).

On the whole, three important conclusions can be drawn from the analyses. First, we cannot refute some exogenous persistence of the country spread. It would be associated with global credit and financial factors that persistently and directly affect the exogenous component of the spread, such as those identified in Chapter 1 and by González-Rozada and Yeyati (2008). Second, the combination of exogenous and endogenous persistence maximizes the propagation and additional variability of country spread. Third, the overall endogenous persistence of the spread mainly results from the financial accelerator, which drives the interaction of spreads with fundamentals. The contribution of the financial accelerator is independent from the dependence of the spread on its past values (σ), although it is reinforced by the latter.

3.9 Risk aversion and consumption

Table 3.11 illustrates that the lower the coefficient of relative risk aversion (η), the higher the volatility of consumption is relative to output. In the neutral case ($\eta = 1$), consumption is as volatile as output. This potentially high volatility of consumption relative to output is not found in both closed-economy and SOE business cycle models (e.g. Greenwood et al., 1988; Mendoza, 1991). Table 3.12 compares variance decompositions of the baseline model with different η at 10, 2.5, 1.5 and 1. It shows that lower η increases the explanatory power of intertemporal disturbances, especially shocks to the exogenous component of the country spread, with regard to the variability of consumption. Investment is also affected in the same way, particularly by country spread shocks. These results essentially rely on the strength of the intertemporal substitution of consumption, which is further magnified by the financial accelerator. They do not depend on other features of the model, such as the specification of the endogenous and/or exogenous components of the spread.

TABLE 3.11. Risk Aversion and Standard Deviatons.

Variables	**Real data**	**Baseline model** *maximum* endogenous persistence			
		$\sigma = 0.60$ $\eta = 10$	$\sigma = 0.62$ $\eta = 2.5$	$\sigma = 0.64$ $\eta = 1.5$	$\sigma = 0.66$ $\eta = 1$
Endogenous variables					
Output	1.60	1.59	1.61	1.64	1.68
Hour	3.28	1.60	1.62	1.64	1.71
Consumption	2.34	-	-	-	-
non durables	1.56	1.26	1.31	1.44	1.67
Investment	5.14	-	-	-	-
mach. & equip.	10.28	10.00	10.29	10.89	11.68
Foreign debt	12.33	28.07	32.31	37.56	44.50
Trade balance	1.99	1.52	1.70	1.94	2.29
Interest rate	2.59	2.18	2.20	2.23	2.26
Country spread	2.51	1.99	2.02	2.05	2.08
Exogenous processes					
Productivity	-	0.60	0.60	0.60	0.60
US interest rate	0.49	0.55	0.55	0.55	0.55
Spread	1.69	1.64	1.64	1.64	1.64

The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1994:QII to 2005:QIV. National accounts are seasonally adjusted. All variables are logged - except for the trade balance to GDP ratio, country spread and interest rate - and detrended by the Hodrick-Prescott filter ($\lambda = 1600$). Only σ, among the model's parameters, is adjusted to match the amplitude of output responses to credit shocks for different η values.

TABLE 3.12. Risk Aversion and Variance Decompositions.

Dependent variables and shock sources:	VAR	Baseline model *maximum* endogenous persistence $\eta = 10$			$\eta = 2.5$		
		min.	max.	mean	min.	max.	mean
Output							
Domestic & other	64	58	91	74	56	90	73
US interest rate	22	5	31	18	5	31	18
Exog. spread	14	4	29	17	5	31	18
Consumption							
Domestic & other	58	58	91	74	53	88	70
US interest rate	18	5	30	18	5	30	18
Exog. spread	24	4	29	17	7	36	21
Investment							
Domestic & other	62	6	35	21	6	33	19
US interest rate	18	24	66	45	24	65	44
Exog. spread	20	26	67	46	27	69	48
Foreign debt							
Domestic & other	18	5	30	17	3	26	15
US interest rate	6	29	70	49	27	68	47
Exog. spread	14	24	65	44	27	69	48
Foreign debt	62	-	-	-	-	-	-
Country spread							
Domestic & other	4	0	8	4	0	7	4
US interest rate	33	4	28	16	4	28	16
Exog. spread	51	71	96	83	71	96	83

For the VAR, all sources of variability, except those due to shocks to the US rate and the exogenous spread, are from domestic and other sources The baseline model (σ = 0.60) includes three sources of shocks: (a) to productivity, (b) to the US interest rate, and (c) to the exogenous spread. Maximum shares correspond to the proportion of the variation of a specific variable that could only be explained by a single independent shock. Minimum shares represent the remaining proportion that, by suppressing the mentioned single independent shocks, can not be explained by the other two independent shocks acting concurrently. Means are averages of the minimum and maximum shares.

3.10 Debt ratio

Setting different values for the debt to GDP ratio does not alter the qualitative results of the baseline model, with $B/Y = 0.12$. The most relevant alterations obtain with regard to the speed of recovery, which is faster the lower the debt ratio. This is exemplified by the output responses to credit shocks, shown in Figure 3.10, for three different debt ratios: 0.07 (low ratio), 0.12 (baseline) and 0.18 (high ratio). The calibration for each case follows the same method previously described starting from the baseline specification, with a high coefficient of relative risk aversion ($\eta = 10$) and *maximum* endogenous persistence ($\rho^e = 0$). I use the same parameters specified in Table 3.3. The macroeconomic ratios and coefficients in the credit constraint vary according to specific debt ratios, as reported in Table 3.13. In all cases, σ is set so to match the (VAR) observed amplification of the output responses to country spread shocks.[37]. The persistence coefficients are higher the lower the debt ratio.

TABLE 3.13. Parameters and macroeconomic ratios for different debt ratios.

	Baseline model	**Alternative models**	
		Low debt ratio	High debt ratio
Debt ratio			
B/Y	0.12	0.07	0.18
Macroeconomic ratios			
K/Y	5.8369	5.8309	5.8442
C/Y	0.8403	0.8413	0.8391
I/Y	0.1576	0.1574	0.1578
X/Y	0.0021	0.0012	0.0032
Utility parameter			
a	3.6984	3.6900	3.7085
Country spread			
σ	0.60	0.65	0.56
τ	0.53	0.65	0.43
d	0.0089	0.0079	0.0098
χ	12.5892	19.7791	8.8946

The parameters shown in this Table reflect changes made to the baseline model, keeping $\eta = 10$. Parameters σ and τ are set in the alternative specifications with low and high debt ratios in order to match the amplitude of output responses to the credit shocks.

Figure 3.10 shows that higher debt ratios lead to sluggish recoveries. At the same time, as depicted in Figure 3.11, they moderate the responses and volatility of foreign debt. Table 3.14 suggests that such a moderation comprehends most macroeconomic

[37]According to the choice of σ, τ is set to match the output response to the US interest rate shock.

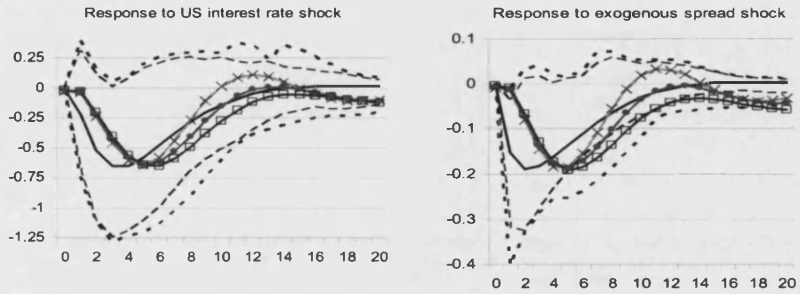
aggregates, with the exception of consumption, relative to output. The standard deviation of consumption relative to output augments marginally from 0.786 to 0.79, moving the debt ratio (B/Y) from 0.07 to 0.18. Of course, such a gap would be higher, if σ and τ were fixed and not adjusted in each simulation so as to match output responses. Table 3.15 indicates that the variance decompositions are robust to changes in the steady state debt ratio. On the whole, the debt ratio seems to be particularly relevant for the adjustment of the timing and amplitude of the debt dynamics. However, it cannot alter the essence of the overall macroeconomic dynamics.

TABLE 3.14. Standard deviations for different debt ratios.

	Real	Baseline model		
	data	$B/Y = 0.12$	$B/Y = 0.07$	$B/Y = 0.18$
Endogenous variables				
Output	1.60	1.59	1.62	1.58
Hour	3.28	1.60	1.64	1.59
Consumption	2.34	-	-	
non durables	1.56	1.26	1.28	1.25
Investment	5.14	-	-	
mach. & equip.	10.28	10.00	11.51	9.31
Foreign debt	12.33	28.07	54.25	17.32
Trade balance	1.06	1.52	1.82	1.347
Interest rate	2.59	2.18	2.37	2.07
Country spread	2.51	1.99	2.17	1.90
Exogenous processes				
Productivity	-	0.60	0.60	0.60
US interest rate	0.49	0.55	0.55	0.55
Spread	1.69	1.64	1.64	1.67

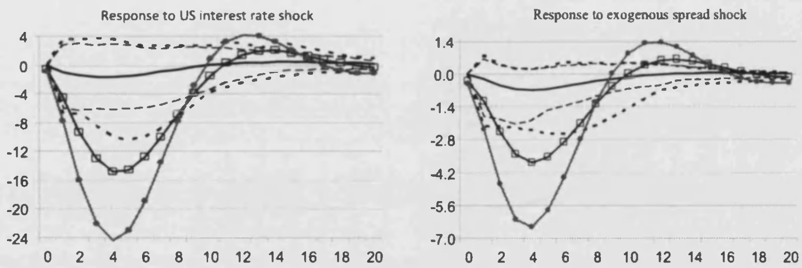
The real data statistics are population moments calculated by the author based on original quarterly series for Brazil from 1994:QII to 2005:QIV. National accounts are seasonally adjusted. All variables are logged - except for the trade balance ratio to GDP, country spread and interest rate - and detrended with the Hodrick-Prescott filter ($\lambda = 1600$).

FIGURE 3.10. Responses of Output to US Interest Rate and Exogenous Country Spread Shocks.



Model responses with *low* ($B/Y = 0.07$), *baseline* ($B/Y = 0.12$) and *high* ($B/Y = 0.18$) debt ratios are marked respectively with crosses, circles, and squares. VAR responses (solid lines) are accompanied by 95% and 98% (standard) bootstrapped confidence intervals (dotted lines). The units of the vertical and horizontal axes are percent and quarters, respectively.

FIGURE 3.11. Responses of Foreign Debt to US Interest Rate and Exogenous Country Spread Shocks.



Model responses with baseline and high debt ratios are marked respectively with circles, and squares. VAR responses (solid lines) are accompanied by 95% and 98% (standard) bootstrapped confidence intervals (dotted lines). The units of the vertical and horizontal axes are percent and quarters, respectively.

TABLE 3.15. Variance decompositions for different debt ratios.

Dependent variables and shock sources	VAR	Baseline model *maximum* endogenous persistence $B/Y = 0.12$ min.	max.	mean	$B/Y = 0.18$ min.	max.	mean
Output							
Domestic & other	64	58	91	74	58	91	75
US interest rate	22	5	31	18	5	30	18
Exog. spread	14	4	29	17	4	29	16
Consumption							
Domestic & other	58	58	91	74	58	91	75
US interest rate	18	5	30	18	5	30	18
Exog. spread	24	4	29	17	4	29	17
Investment							
Domestic & other	62	6	35	21	7	36	21
US interest rate	18	24	66	45	24	66	45
Exog. spread	20	26	67	46	25	67	46
Foreign debt							
Domestic & other	18	5	30	17	6	33	19
US rate shocks	6	29	70	49	30	71	51
US interest rate	14	24	65	44	21	62	41
Debt	62	-	-	-	-	-	-
Country spread							
Domestic & other	4	0	8	4	0	6	3
US interest rate	33	4	28	16	3	22	12
Exog. spread	51	71	96	83	77	97	87

For the VAR, all sources of variability, except those due to shocks to the US interest rate and the exogenous spread, are domestic and other sources. The baseline model ($\sigma = 0.60$) includes three sources of shocks: (a) to productivity, (b) to the US interest rate, and (c) to the exogenous spread. Maximum shares correspond to the proportion of the variation of a specific variable that could be explained by only a single independent shock. Minimum shares represent the remaining proportion that, by suppressing the aforementioned single independent shocks, can not be explained by the other two independent shocks acting concurrently. Means are averages of the minimum and maximum shares.

3.11 Conclusion

This Chapter shows that country spreads can play a central role in the design of SOE business cycle models, from both a qualitative and a quantitative perspective. The spread relates to an external financial premium that emerging economies face in international financial markets. Though not derived from microeconomic foundations, this premium is built into an endogenous constraint on foreign credit that permanently binds due to an emerging economy's relative impatience. The constraint works as a financial accelerator (Bernanke and Gertler, 1989; Kiyotaki and Moore, 1997; and Gertler et al. 2003). It endogenously depends on the short term foreign debt to GDP ratio, and exogenously on international liquidity and other global factors that disturb emerging markets. Facing such a constraint on foreign credit, the economy reacts in a monopsonistic way so as to internalize the intertemporal macroeconomic effects.

The calibrated model matches most of the empirical regularities of Brazil (1994 to 2005), which are common to many emerging economies. Over 35% of output variability and over 40% of consumption variability can be attributed to shocks to the US real interest rate, and to the exogenous component of the country spread. Simulated output and consumption dynamics are in line with recession and recovery patterns, with hump-shaped responses to country spread and interest rate shocks. These two sources are equally important in explaining business fluctuations, and one does not exhaust the effects of the other. Their underlying processes display some different characteristics with respect to standard deviation and persistence, but they both benefit from propagation via the endogenous credit constraint. The excessive volatility of consumption relative to output can result from these sources, in particular from the exogenous component of the spread.

The proposed model has a permanent financial accelerator mechanism that contrasts with models based on working capital constraints (Mendoza and Yue, 2008, Neumeyer and Perri, 2005, and Uribe and Yue, 2006). Credit shocks propagate through intertemporal wedges between the marginal rate of substitution in consumption and the rate of return on capital, as well as between the latter and the interest rate. As in Chapter 2, modelling an SOE facing endogenous constraints on foreign credits appears to give a more general implication to arguments in support of a greater role for intertemporal wedges (Primiceri et al., 2006; Christiano and Davis, 2008) in business cycle accounting (Chari et al., 2005).

Furthermore, the model may help to clarify the nature of country spread persistence, a feature common to other spreads in financial markets (Collin-Dufresne, 2001). A combination of endogenous and exogenous forces may be responsible for such persistence. The exogenous forces relate to moderate or weak persistence in global credit markets - affecting for instance liquidity, uncertainties or risk appetite.[38] Endogenous forces derive from some inherent autoregressiveness in the spread, but mainly from the endogenous forces brought about by the financial accelerator. While ensuring feedback from the macroeconomy into the spread as a state variable, the latter enhances the intertemporal substitution effects.

Extensions could also focus on ways to quantitatively improve the amplitude of debt dynamics and, to a lesser extent, trade and investment dynamics. Other transmission channels, such as those associated with monetary policy and international relative prices, which are in turn affected by country spreads, might be explored to avoid excesses in the debt responses. Other sources of disturbances, e.g. investment and preference shocks, or frictions directly affecting the foreign debt adjustment, could be explored.

[38] See Chapter 1.

3.A Appendix: Data

All Brazilian quarterly series are available at IPEAData (www.ipeadata.gov.br), the on-line macroeconomic database of the *Instituto de Pesquisa Pura e Aplicada* - IPEA. The national account series are originally from the *Instituto Brasileiro de Geografia e Estatística* (IBGE) - www.ibge.gov.br. Further details of the data are as follows:

Output. Real GDP from the IBGE National Accounts. The series was expressed in natural logarithmic of available seasonally adjusted series.

Hours. Industrial hours from the *Confederação Nacional das Industrias* (CNI). The series was expressed in natural logarithmic of the available seasonally adjusted index.

Consumption. Total consumption from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Durables. Production of consumption durable goods from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Investment. Total fixed capital investment from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Machine and equipment. Total investment in machine and equipment from the IBGE National Accounts. The series was expressed in natural logarithmic of the available seasonally adjusted index.

Foreign debt. Short term and total foreign debt levels in US dollars are provided on a quarterly basis by the Central Bank of Brazil - www.bacen.gov.br. The series was deflated (US CPI) and expressed in natural logarithmic.

Debt to GDP ratio. Author's estimate by use of World Bank's annual series of short term and total foreign debt and GDP in PPP (US dollars).

Trade balance to GDP ratio. Author's calculation of the ratio of net export to GDP on the basis of official foreign trade statistics originally produced by the Ministry of Development, Industry and Foreign Trade - *Ministério do Desenvolvimento, da Indústria e do Comércio Exterior* - www.mdic.gov.br.

Country spread. EMBI JP Morgan Plus index for Brazil. The series is available from Datastream.

US CPI, inflation rate and 3-month nominal interest rate are available from the FRED database of the Federal Reserve Bank of St Louis.

3.B Appendix: VAR Coefficient Estimates

TABLE 3.16. Unrestricted VAR Coefficients with a US Shift Dummy.

	dY^*_t	R^*_t	S_t	Y_t	H_t	C_t	I_t	B_t/Y_t
dY^*_{t-1}	0.318	0.03	-2.078	2.073	3.287	0.952	0.856	-1.197
	(0.137)	(0.437)	(1.991)	(1.026)	(1.651)	(1.271)	(3.196)	(8.647)
	{0.021}	{0.945}	{0.297}	{0.043}	{0.046}	{0.454}	{0.789}	{0.890}
	[2.311]	[0.069]	[-1.043]	[2.019]	[1.991]	[0.749]	[0.268]	[-0.138]
R^*_{t-1}	-0.019	0.633	1.2	-0.223	-0.725	0.148	0.39	-0.995
	(0.026)	(0.085)	(0.422)	(0.195)	(0.308)	(0.248)	(0.612)	(1.691)
	{0.457}	{0.000}	{0.004}	{0.254}	{0.019}	{0.551}	{0.524}	{0.556}
	[-0.743]	[7.433]	[2.845]	[-1.142]	[-2.352]	[0.596]	[0.637]	[-0.588]
S_{t-1}	---	---	0.687	-0.152	-0.073	-0.259	-0.507	-0.216
			(0.102)	(0.047)	(0.072)	(0.063)	(0.15)	(0.429)
			{0.000}	{0.001}	{0.309}	{0.000}	{0.001}	{0.615}
			[6.736]	[-3.218]	[-1.017]	[-4.138]	[-3.381]	[-0.503]
Y_{t-1}	---	---	0.188	0.691	1.367	0.745	2.16	0.729
			(0.430)	(0.211)	(0.318)	(0.283)	(0.671)	(1.937)
			{0.661}	{0.001}	{0.000}	{0.008}	{0.001}	{0.707}
			[0.438]	[3.283]	[4.305]	[2.637]	[3.217]	[0.376]
H_{t-1}	---	---	-0.004	-0.036	0.778	-0.092	-0.204	-0.254
			(0.056)	(0.027)	(0.04)	(0.035)	(0.085)	(0.242)
			{0.943}	{0.180}	{0.000}	{0.010}	{0.016}	{0.294}
			[-0.072]	[-1.342]	[19.267]	[-2.593]	[-2.411]	[-1.048]
C_{t-1}	---	---	-0.26	-0.064	-0.447	0.337	-0.719	0.836
			(0.212)	(0.104)	(0.157)	(0.140)	(0.332)	(0.958)
			{0.219}	{0.541}	{0.004}	{0.016}	{0.030}	{0.383}
			[-1.230]	[-0.611]	[-2.852]	[2.409]	[-2.166]	[0.873]
I_{t-1}	---	---	-0.018	-0.008	-0.091	-0.071	0.416	-0.169
			(0.100)	(0.049)	(0.074)	(0.066)	(0.158)	(0.455)
			{0.861}	{0.874}	{0.224}	{0.288}	{0.008}	{0.710}
			[-0.176]	[-0.158]	[-1.217]	[-1.063]	[2.641]	[-0.372]
B_{t-1}/Y_{t-1}	---	---	0.049	0.015	0.018	0.002	0.051	0.565
			(0.028)	(0.013)	(0.020)	(0.018)	(0.042)	(0.121)
			{0.079}	{0.256}	{0.375}	{0.914}	{0.224}	{0.000}
			[1.758]	[1.136]	[0.888]	[0.108]	[1.216]	[4.684]

The unrestricted VAR includes a constant, a time trend, as well as a shift dummy for the US variables to account for the US business cycle switch from 2001:QI. Estimated coefficients are accompanied by the following statistics: (Std. Dev.), {p - Value}, and [t - Value].

TABLE 3.17. Unrestricted VAR Coefficients without a US Shift Dummy.

	dY^*_t	R^*_t	S_t	Y_t	H_t	C_t	I_t	B_t/Y_t
dY^*_{t-1}	0.306	-0.184	-0.257	2.24	3.673	1.077	1.428	-1.681
	(0.137)	(0.482)	(1.949)	(1.030)	(1.675)	(1.275)	(3.228)	(8.618)
	{0.026}	{0.703}	{0.895}	{0.030}	{0.028}	{0.398}	{0.658}	{0.845}
	[2.226]	[-0.382]	[-0.132]	[2.175]	[2.193]	[0.845]	[0.442]	[-0.195]
R^*_{t-1}	-0.01	0.798	0.677	-0.223	-0.726	0.147	0.388	-0.993
	(0.022)	(0.079)	(0.382)	(0.196)	(0.314)	(0.249)	(0.620)	(1.681)
	{0.648}	{0.000}	{0.076}	{0.254}	{0.021}	{0.554}	{0.531}	{0.555}
	[-0.456]	[10.134]	[1.773]	[-1.141]	[-2.312]	[0.592]	[0.626]	[-0.590]
S_{t-1}	—	---	0.813	-0.133	-0.03	-0.245	-0.444	-0.269
			(0.097)	(0.046)	(0.071)	(0.063)	(0.150)	(0.424)
			{0.000}	{0.004}	{0.669}	{0.000}	{0.003}	{0.525}
			[8.380]	[-2.885]	[-0.428]	[-3.909]	[-2.952]	[-0.635]
Y_{t-1}	—	---	-0.069	0.654	1.281	0.717	2.032	0.837
			(0.439)	(0.209)	(0.322)	(0.284)	(0.680)	(1.916)
			{0.876}	{0.002}	{0.000}	{0.011}	{0.003}	{0.662}
			[-0.157]	[3.128]	[3.979]	[2.527]	[2.989]	[0.437]
H_{t-1}	—	---	0.058	-0.027	0.799	-0.085	-0.173	-0.28
			(0.055)	(0.026)	(0.040)	(0.035)	(0.085)	(0.240)
			{0.287}	{0.310}	{0.000}	{0.017}	{0.042}	{0.242}
			[1.065]	[-1.016]	[19.837]	[-2.394]	[-2.032]	[-1.171]
C_{t-1}	—	---	-0.149	-0.047	-0.41	0.349	-0.664	0.789
			(0.217)	(0.103)	(0.159)	(0.140)	(0.336)	(0.948)
			{0.492}	{0.647}	{0.010}	{0.013}	{0.048}	{0.405}
			[-0.687]	[-0.459]	[-2.575]	[2.485]	[-1.973]	[0.833]
I_{t-1}	—	---	0.024	-0.002	-0.077	-0.066	0.437	-0.187
			(0.103)	(0.049)	(0.076)	(0.067)	(0.160)	(0.450)
			{0.818}	{0.971}	{0.311}	{0.321}	{0.006}	{0.678}
			[0.231]	[-0.037]	[-1.013]	[-0.991]	[2.734]	[-0.415]
B_{t-1}/Y_{t-1}	—	---	0.08	0.02	0.028	0.005	0.066	0.553
			(0.027)	(0.013)	(0.020)	(0.018)	(0.042)	(0.119)
			{0.003}	{0.134}	{0.160}	{0.767}	{0.116}	{0.000}
			[2.930]	[1.498]	[1.404]	[0.297]	[1.570]	[4.631]

The unrestricted VAR includes a constant and a time trend. Estimated coefficients are accompanied by the following statistics: (Std. Dev.), {p - Value}, and [t - Value].

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