On Booms and Busts in Latin American Economies

Mariano Andrés Cena

Dissertation submitted for the degree of

Doctor of Philosophy in Economics at

The London School of Economics and Political Science

July 2012

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 other than where I have clearly indicated that it is the work of others.

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

Mariano Andrés Cena

Abstract

This thesis deals with one obsession: the role of external factors in generating boom-bust cycles in Latin American countries. In the first chapter, I employ a Markov switching model to statistically validate the claim that the region is currently experiencing a combination of unprecedented favourable external conditions: high commodity prices and low global real interest rates. Based on this evidence, I introduce a model of a resource-rich small open economy with financial frictions in which external conditions switch stochastically between two regimes: "windfall" and "shortfall". The model is calibrated to Argentina to study how changes in external conditions give rise to boom-bust cycles. I contribute to the current debate on the desirability of controls on capital inflows by studying, from a positive perspective, the effects of introducing a regime contingent tax rate on debt holdings. I conclude that the welfare effect, albeit always very small, is determined by the strength of the domestic financial frictions. The third chapter attempts to empirically evaluate the model by performing an event study. I assess the ability of the model to reproduce the behaviour of the economy during a five-year window period centered around the Great Recession of 2008/09. To capture the external environment following Lehman Brothers' collapse, I introduce a regime switch in global financial conditions: normal and panic periods. I conclude that the model captures remarkably well the dynamic in this period and that its main weakness is the inability to reproduce the large swings observed in asset prices. The second chapter presents and studies a novel mechanism through which low-frequency fluctuations in foreign interest rates can generate different boom-bust patterns in an internationally borrowing constrained small open economy: intertemporal spillovers via collateral markets. When interest rates are low, the presence of a binding international borrowing constraint creates an intertemporal wedge that spills over into the intertemporal equation for capital due to its dual role as physical capital and financial collateral. As a result, in economies where the main source of collateral is reproducible capital, the spillover effect resembles an investment subsidy and fluctuations are smooth since there are no valuation effects. In contrast, when non-reproducible capital is posted as collateral, the disturbance resembles a financial service dividend and the interest rate fluctuations cause ample swings in macro aggregates due to their strong impact on asset valuations. It is my belief that in these chapters, I have contributed to our understanding of medium-run macroeconomic fluctuations in "semi-peripheral" countries.

A Gracielita; porque se la bancó.

Acknowledgements

During the last years this PhD has, in many aspects, been my life. Not surprisingly, the list of people that have helped me and to whom I have become indebted during this period is potentially very long. Risking regrettable omissions, here is an honest attempt at an abbreviated account.

Let's begin with the advisors, Bernardo Guimaraes and Albert Marcet before their departure to their home places and Gianluca Benigno thereafter. Bernardo helped me during my first years, a period in which I had plenty of ideas but did neither have the technical tools to put them into models nor the understanding of how scientific method was applied in economics. His patience during this time was remarkable. Albert provided support at a point in time when I was losing perspective and was becoming less passionate about pure academia. Albert understands this game; he listened to me with attention and guided me towards wrapping up the projects I had been working on. Over the years, Gianluca guided me in the field of international finance, providing great advice and support for my ideas. He definitely helped me improve the final outcome.

There would not have been a thesis without valuable comments from seminar participants, so let's acknowledge that this study has benefited greatly from seminar participants at LSE. I am especially indebted to Michael McMahon, Rachel Ngai, Silvana Tenreyro, Kevin Sheedy, Gianluca Benigno, Albert Marcet, Bernardo Guimaraes, Nobuhiro Kiyotaki, Alex Michaelidis, Alwyn Young, Francesco Caselli and Chris Pissaridis for their encouragement and feedback.

Even though I have benefited immensely from the general intellectual environment at LSE, I benefited even more from the interaction with some of my fellow students with whom, over time, I developed strong bonds. Fernando Aragon, Stefan Penczynski and Bin Xu are among those that have enriched my experience over these years. With Jochen Mankart I spent hours and hours in endless conversations discussing, in between macchiatos, almost everything we could think about concerning macroeconomic issues. I am deeply grateful for what I learnt from him. Like Borges with Ireneo Funes, I was lucky to come across Giovanni "El Memorioso" Ko, a unique warm individual capable of explaining everything about anything without making you feel ignorant. I will sorely miss our conversations. Further evidence that luck is definitely unevenly distributed in this world is my friendship with Konrad Burchardi. Over these years, I enjoyed his inner struggle between a German Apollonian heritage and a Mediterranean Dionysian soul. I am convinced that this feature will serve him well through life.

Let's not forget about those that, although physically in my Pampas, contributed enormously to my experience in London. Thanks Pato and Quiro for being there, always ready to listen and talk. Of course, thanks to Gracielita and Flor for their love and support.

Finally, I am indebted to my “Chiqui” for her love and, specially, her patience during these years: gracias Meli! What a pity that Carlitos, Nilda, Tito, and Erci couldn’t make it until the end; I wouldn’t be here if it weren’t for you dearest. Emita, Lorenzón and the ones to come, thankfully, remind me that the Earth spins.

Contents

List of Figures

List of Tables

Preface

This thesis deals with one obsession: the role of external factors in generating boom-bust cycles - periodic structural changes in macroeconomic dynamics - in Latin America, and in particular, Argentina. In view of some pundits, a "double-tailwind" scenario - a combination of low global interest rates and high commodity prices - is currently propelling forward the major South American economies and planting the seeds of the next bust (crisis for the pessimists). This has stirred up the debate about the appropriateness of introducing some form of capital inflow restrictions as a way of isolating domestic economies from the quandaries of external conditions, but the absence of a formal framework on which to ground the analysis makes this debate futile. In the first chapter I contribute to this debate threefold: First, I statistically validate the claim that the region is experiencing a "double-tailwind" scenario. For this purpose, I employ the Expectation Maximization algorithm to separately estimate two Markov switching processes, one for the ex-ante real U.S. interest rate (financial tailwind) and the other for the price of the commodity exporting bundle (terms of trade tailwind). The results confirm both the non-linear nature of external shocks and the unique external favourable conditions over the last few years. Second, I introduce a model of a natural resource-rich small open economy (receiving an endowment of tradable goods) with financial frictions (an intratemporal one in the form of a working capital constraint at the firm level and an intertemporal one in the form of an elastic debt risk premium) that operates in an environment with two global stochastic regimes (affecting commodity prices and global interest rates). I label the regime representing the current environment "windfall" and the one forecasting conditions once the situation returns to normality "shortfall". Then, I simulate a calibrated version of the model and show that a switch to "windfall" produces a boom with similar characteristics to those recently observed in the data. In a sensitivity analysis, I discuss the critical role played by the elasticity of substitution in consumption in characterizing the dynamic transition after a regime switch and, as a consequence, I highlight the deficiencies of the standard one-good model.

Finally, I extend the framework to study the dynamic, ergodic and welfare consequences of introducing a 1% tax rate on debt holdings contingent on the "windfall" global regime. Although the exercise is not optimally designed given that it is impossible to do that in such a complex model, it is realistic (has been implemented by Brazil and Colombia) and policy makers consider this tax to be a general-purpose instrument as defended by Jeanne (2011). In a nutshell, the main finding is that the tax rate effectively smoothes out boom-bust cycles and permanently reduces external indebtedness, but its welfare impact, i.e. what really matters, is very small and driven by the strength of the intratemporal distortion. That is, the stronger the domestic financial frictions, the more costly is the policy, since the delayed benefits from lower interest rates do not offset the current costs - in terms of foregone output - that the effective increase in interest rates introduces during the booming phase. Thus, there are two lessons to be drawn from this exercise: First, the welfare effects of the policy are minimal in this framework. Thus, I hypothesize that to generate significant welfare changes, it is necessary to either endogeneize a costly financial crisis or introduce some technological externalities possibly connected to the real exchange rate or the level of net debt. Second, in economies plagued by domestic financial inefficiencies, the policy can exacerbate other distortions with costly effects. More work is definitely needed in this respect.

The second chapter of this thesis is an attempt at contributing to our understanding of the channels/mechanisms through which low frequency movements in world interest rates can generate extremely diverse boom-bust patterns in an internationally borrowing constrained small open economy. In this study, I present and study a novel mechanism: intertemporal spillovers via collateral markets. To build my results, I start from the simple small open economy model and assume that the exogenous world interest rates can take on two values, low and normal, following a Markov chain. Further, I assume that to access foreign funds, relatively impatient domestic agents must post domestic capital as collateral. I solve the model with a global solution method and only focus my attention on equilibria where the borrowing constraint is weakly binding when interest rates are normal and strongly binding when they are low. As a result, in the latter case, an intertemporal distortion (wedge) in the Euler equation for bonds arises, as agents would be willing to borrow more at the current rates. As agents incorporate into their valuations the new financial service provided by capital, this wedge spills over into the Euler equation for capital modifying the total return on the domestic asset. Consequently, the larger the financing capacity of domestic capital, the less insulated from the vagaries of external financial conditions the economy is. But, most importantly, when the financing capacity is high, the characteristics of the boom-bust episodes are solely determined by the physical properties of the asset that serves as collateral. In effect, in an economy where only reproducible capital serves as collateral, the cycles are smooth as the intertemporal spillover resembles an "investment subsidy" that causes slow increases in borrowing capacity as a result of a capital deepening process. Quite the opposite, when only non-reproducible capital (land in resource rich economies) serves as collateral, interest rates switches produce abrupt swings in the domestic conditions. Indeed, in these economies, the intertemporal spillover resembles a "financial service dividend" affecting domestic asset prices. Therefore, when the interest rates increase, for example, as borrowing becomes less profitable, the "financial service" valuation component of the asset price plummets, thus triggering a sudden fall in borrowing capacity that forces a large downward correction in domestic absorption, as is typically the case in economies prone to sudden stops. I conclude by presenting two related lessons for emerging economies: first, that the collateral channel can be a powerful transmission mechanism from foreign financial conditions to domestic markets and, second, that the characteristics of the assets that serve as collateral are of importance because, crucially, they determine the vulnerability of the economy to sudden shifts in the external financial conditions. I consider this a promising area of research, both theoretically and empirically.

The main goal of the third chapter is to empirically evaluate the model introduced in chapter one. For this purpose, I perform an event study assessing the ability of the framework to reproduce the behaviour of the Argentinean economy during a five-year window period centered around the Great Recession of 2008/09. I choose this period because the sequence of non-linear shocks that hit the economy was out of the ordinary: in mid-2006, the commodity prices began skyrocketing - some to record highs - fuelling a domestic boom. This external environment was suddenly interrupted in September 2008 when Lehman Brothers collapsed. In a brief period of time, the commodity prices plummeted and a financial panic swept over the world, triggering a jump in spreads and a short lived recession in the country. Less than a year later, the commodity prices and financial conditions began improving quickly, which lead to a rapid economic recovery to the pre-crisis trend levels by the end of 2010.

To be able to capture the sequence of shocks described, I minimally extend the framework and introduce the possibility of a regime switch in financial conditions. The financial environment following the Lehman Brothers collapse is now captured by the financial "panic" regime, which is modelled as a simultaneous exogenous increase in the country risk premium and a tightening of the firms' financial friction. Then, I stochastically simulate the extended framework and evaluate its ability to reproduce the behaviour of a selected group of variables during this five-year window period.

My findings can be summarized as follows: the model does a remarkably good job in tracking the evolution of consumption, output, industrial production, total debt yield and the trade balance. It reproduces qualitatively well, but falls short quantitatively, in terms of investment, total imports and asset prices. Particularly unsatisfactory is the inability of the model to reproduce the large swings in asset prices observed during this period.

Based on this study, I conclude that the literature needs to move forward and incorporate regime breaks into its modelling toolkit. I also argue that the weakness of the model in terms of asset price behaviour is endemic to this class of framework. Therefore, I discourage researchers from using this type of framework to address economic questions in which asset prices are the main subject of study or critical to the final outcome; none of which is the case in this investigation.

1 The Economics of Contingent Capital Inflows Taxation: A Study of the "Double Tailwind" South America

1.1 Introduction

Latin America, in particular the natural resource-rich South America, is booming and euphoria seems to be gaining momentum. The lamenting days of the Prebisch-Singer hypothesis of a secular terms of trade deterioration for primary goods exporters seem to have passed. Even an institution like the Inter-American Development Bank seems overoptimistic, proclaiming that in the new global economic order, the region is likely to enjoy unique favourable external conditions which provide a fertile ground for what could be called the "Latin America decade" (Moreno 2011).[1]

The exceptionality of the current global environment lies in the fact that two key external conditions have recently aligned in the best possible way for the region, creating what the International Monetary Fund (IMF), among many, has labelled a "double tailwind" scenario (see Eyzaguirre et al. 2011). On the real side, historically high world prices for commodity goods - the main source of exports in the region - have boosted income and dramatically improved external solvency. On the financial side, helped by the sustained period of very low real interest rates in advanced countries and reduced levels of risk-aversion from international investors, the conditions have become very lax.

But a simple analysis of the fundamentals behind the current external "bonanza" reveals the latent risk of a rapid deterioration. On the commodity price front, the explanations for the recent spike in commodities prices range from artificially low interest rates, the dynamism of Asian demand, the rise of biofuel production, negative supply shocks to the financialization of commodity markets.[2] The truth is that whatever the reasons, a fundamental analysis suggests that a slower world income and population growth and a quick catch-up of supply will soon reverse this trend. Recent forecasts by the World Bank (Commodity Outlook June 2011) indicate that it might not take long before this materializes, since the latest prediction indicates that all commodity markets will begin a downward movement phase in 2012. On the financial front, a combination of political and legal constraints in advanced countries

[1]Similarly, *The Economist* dedicated a special report devoted to the analysis of the potential for what could be defined as a "Latin America Decade".

[2]In a recent paper, Tang and Xiong (2010) explore the questions of why and how financial commodity markets have become so important during the last decade. The authors believe that the creation of commodity indexes might have reduced market segmentations, allowing for a greater diversification and increasing funds chanelled to these type of investments. In their view, these forces created a new asset class and are partially responsible for the substantial rise in commodity prices.

(the U.S. in particular) has pushed these economies towards an exclusive reliance on an extremely loose monetary policy. While this unconventional monetary policy remains in place, emerging markets will keep benefiting from the positive financial spillovers. The risk lies in the fact that once a strong recovery takes place or signs of inflation gain momentum, the unconventional stimulus will unwind promptly.

These individual risk factors are compounded by the fact that a *synchronized deterioration* on both fronts is the most likely scenario given their tight macroeconomic interconnection. In effect, Frankel (2008) considers that the reason behind the recent spikes in commodity prices is the rapid reduction of the real interest rate that has weakened the incentives to extract exhaustible resources since the opportunity cost of physical storage has been reduced. In his view, this in turn is fueling the speculation in commodity futures and increasing prices.[3] Consequently, if the interest rates return to historical values, commodity prices will suffer a sudden and sharp downward correction. Caballero, Farhi and Gourinchas (2008a, 2008b) provide an alternative explanation. In their view, the global macroeconomic equilibrium is characterized by a chronic shortage of safe assets due to a rising income in developing nations, unmatched by their ability to generate sound assets. As a result, low real interest rates for safe assets and bubbles popping up and bursting across different markets tend to be the norm.[4] In such a fragile coordination equilibrium, there is a latent risk that the commodity prices bubble bursts in case investors suddenly turn glum. In this event, as investors flee to safe-haven U.S. assets, the cost of capital for emerging markets will skyrocket and the commodity prices will plummet.

From a historical perspective, the experience of the late 1970's and early 1980's also helps bring into question the prospects of a "Latin America decade". Low real interest rates and high commodity prices during the late 1970's fed a regional boom that proved to be unsustainable when the conditions changed. In effect, after the increase in U.S. real interest rates at the beginning of Volcker's appointment as chairman of the Federal Reserve, the commodity prices plummeted and in less than two years, the major countries in the region were externally insolvent. What followed was a protracted period of debt renegotiation and stagnation in the so-called "lost decade" of the 1980's.

Given the perceived risks involved with the current scenario, the domestic debate about how to handle the present windfall and sail these unchartered waters without repeating old mistakes has opened up. In some countries, the instinctive answer has

[3]Frankel's argument is based on Hotelling's rule that states that the price of non-renewable resources should grow continuously at a rate that converges to the interest rate as the costs incidence in the final price decreases over time.

[4]The authors provide a metaphorical interpretation of the sequence of events at the world scale in the last twenty years. In their view, the first bubble was located in emerging markets in the 1990's; when these markets burst, the bubble moved to the U.S. tech sector, later on to the U.S. housing market and is now in the oil and commodities markets.

been to resort to the imposition of capital inflows restrictions, with policy makers and politicians alike arguing that these measures are just another tool that makes it easier to lean against the wind and insulate the economy from the shocks of the international context.[5]

The international community, in the form of the Group of Twenty (G20), attending to the reasons behind this policy implementation, but mainly recognizing the risks that a disorganized implementation might cause, endorsed the use of "temporary" capital controls under the umbrella of macro-prudential policies (see the G20 2010 final declaration and the 2011 document). Soon afterwards, in an unprecedented policy prescription change, the IMF set the guidelines for these interventions, officially supporting "the use of temporary capital account restrictions to prevent risky boom-bust dynamics" (see Ostry et al. 2010 and 2011).[6]

Not surprisingly, the debate about the desirability of capital controls has been reignited and is gaining momentum both in policy circles and academia (see Levy-Yeyati 2011 and Jeanne, Subramanian and Williamson 2012). From the point of view of an emerging economy, there are two critical aspects to this debate: effectiveness and efficiency.[7] The effectiveness debate has become less intense over time as a result of the overwhelming empirical evidence demonstrating that capital controls are costly to circumvent. Evidence from the Chilean (see De Gregorio et al. 2000) and Argentinean (see Levy-Yeyati et al. 2004, 2008 and 2009) experience shows that controls are a successful instrument for introducing a wedge between domestic and international rates (at least in countries with less sophisticated capital markets).[8] The results are less robust if the concept of effectiveness is broadened to incorporate whether controls modify aggregate flow levels or have compositional effects.[9]

The jury is still out on the efficiency question, since the progress seems stalled

[5]Brazil and Colombia imposed market based restrictions, while Argentina's barriers are less transparent.

[6]The new vision states that this kind of policies should be considered as a last resort and should be introduced "only when other options for dealing with the inflows have already been deployed or are infeasible"(see Ostry et al. 2010 and 2011).

[7]From a global perspective, there is a justified collective concern, since a disorganized imposition of capital controls at the individual level could divert flows to countries with open capital accounts, exacerbating booms in this group and opening up the possibility of retaliation if the policy is interpreted as a beggar-thy-neighbour.

[8]De Gregorio et al. found that the 90-day UF-US dollar forward discount and the interest rate differential, a measure of the deviation from the covered interest parity, were always in the range of the tax rate imposed by the Chilean government. For Argentina, the study found that after the introduction of quantitative restrictions on capital flows, there was a significant increase in the price difference between the same asset traded in New York and Buenos Aires. This last result confirms that even though restrictions can always be circumvented, the price for this might be very high; effectively imposing a wedge.

[9]For example, Clements and Kamil (2009) document that the Colombian experience with Unremunerated Reserve Requirements (URR) between 2007 and 2008 was ineffective in reducing aggregate flows. Indeed, these authors claim that controls only had a compositional impact, as portfolio equity flows and non-FDI borrowing diminished substantially. Nonetheless, this type of studies should be taken with caution as capital controls are endogenous to the surge in inflows; hence, their effects are very difficult to identify econometrically.

given the methodological difficulties in tackling the question in a comprehensive manner. For some prominent skeptics (see Forbes 2003, 2004 and 2007), capital controls benefits are at best elusive, and most certainly have negative consequences since they mainly introduce frictions in the economy that distort the optimal allocation of resources. Forbes (2007) finds that the main effect of Chile's market based capital controls was to increase the financial constraints for small and mid-sized firms. A mixed assessment of the issue is provided in Gallego, Hernandez and Schmidt-Hebbel (1999) who consider that controls bring gains from higher degrees of monetary independence and reduced indebtedness, but that these have to be weighted against their costs in terms of lower investment and growth. Advocates rationalize the use of controls either theoretically, resorting to simple models where a unique financial friction calls for an optimal policy to remedy the market failure (see Jeanne and Korinek 2011) or, more pragmatically, directly take it for granted that emerging markets are plagued by market imperfections that lead agents to build up excessive external fragilities during the upward phase of the cycle (see Jeanne et al. 2011). In this latter approach, it is understood that in theory, each externality calls for a tailored form of intervention. Nonetheless, for the sake of implementability, these authors consider that "a simple tax on inflows has good properties as a general-purpose instrument to tackle all the externalities present".

This chapter attempts to explore the implications of the current environment for a typical South American economy. Specifically, I evaluate the "double-tailwind" scenario that is propelling forward the major South American economies and introduce a general equilibrium model to quantitatively evaluate the impact of this benign environment and to study the effects of introducing a debt contingent taxation policy. This is done sequentially, that is: I first statistically evaluate the claim of a "double tailwind" external scenario employing a Markov regime switching structure. Once the claim has been validated, I introduce a model of a natural resource-rich small open economy with two financial frictions - an intratemporal one and an intertemporal one - where the stochastic environment is characterized by a Markov switching regime. Then, I simulate this framework to learn about boom-bust dynamics purely driven by the switches in external conditions. Finally, I extend the framework to study the dynamic, ergodic and welfare consequences of the debt taxation policy.

To evaluate the external scenario, I employ the Expectation Maximization (EM) algorithm, as put forward by Hamilton (1990), to estimate two independent univariate Markov switching autoregressive models of order one (MS-AR(1)): one for the ex-ante U.S. real interest rate and the other for the price of a commodity exporting bundle. I follow Di Sanzo (2009) and construct a likelihood ratio test with a residual-based bootstrapping algorithm to test for the hypothesis of nonlinearity. I reject linearity in both series, finding overwhelming support for the proposed two-regime

Markov switching models. I employ the forward filter described in Hamilton (1994) and the backward algorithm developed by Kim (1994) to estimate smoothed probabilities and make inferences about the regimes at each point in time. The regime classification results are conclusive: in the last twenty years, only the last four years have real interest rates and commodity prices aligned in the most favourable way.[10] I call the present configuration the "windfall" regime, as opposed to a "shortfall" regime where real interest rates and commodity prices have returned to historical averages.

I incorporate uncertainty in the model in a simplified form: commodity prices follow a two-state Markov switching AR(1) process as in the data and the U.S. real interest rates just take one value per regime. The production structure is built on the framework presented by Lim and McNeils (2008) and is closely connected to the dependent economy model presented in Agenor and Montiel (1996). A representative household/entrepreneur offers/uses an intermediate domestic input, reproducible capital, non-reproducible capital and labour, to produce a non-tradable intermediate consumption good. Each period, entrepreneurs receive a fixed domestic endowment of domestic manufacturing and commodity goods that must be exported. Domestic entrepreneurs use the proceeds from this endowment to buy a foreign good that serves as an input in the production of the final consumption good or as a final investment good to build reproducible capital. A competitive final sector uses a constant elasticity of substitution (CES) technology to bundle both intermediate goods - domestic and imported - to produce the final consumption good. The two financial frictions complete the setup: first, a working capital constraint at the firm level, in the spirit of Neumeyer and Perri (2005), that negatively connects interest rates to the supply of the economy and has the ability to capture the distortive effects of taxes on debt holdings in a stylized way. Second, a debt-elastic country-premium increasing in the ratio of aggregate debt to expected commodity prices, in the spirit of the pioneering work of Harberger (1976, 1980) that critically guarantees that atomistic agents overborrow, relative to a Central Planner, by failing to internalize the dependence of the interest rate on their individual debt decisions.

A global solution method (Policy Function Iteration) is employed to solve a version of the model reasonably calibrated to Argentina on a quarterly basis. To study the macroeconomic effects of the current external conditions and the potential consequences of their reversal, I stochastically simulate the model for a sufficiently long period of time and create long series of artificial data. Then, I select all seven year sub-series that fulfill the following criteria: the first year external conditions must be in the "shortfall" regime (pre-boom), in the fifth quarter there must be a

[10] My initial aim was to go further back in time to include data from the 1970's and 1980's, but it proved to be very difficult to find data to construct a homogeneous series of the dynamic bundle of commodity exports for the countries of the region.

switch to the "windfall" regime and this regime must remain in place between three to four years (current boom), to finally return to the "shortfall" regime in the last two to three years (future bust).

The working of the model shows that booms arise naturally after a switch to the "windfall" regime. The break creates a positive income shock as the relative price of the commodity endowment is increased. This export windfall can be channeled by domestic residents in two ways: either they increase their purchases of foreign goods for domestic absorption or they reduce net foreign debt. Although the latter seems logical given the usual precautionary motives, these incentives are largely offset by the sharp contraction in interest rates that the simultaneous fall in the risk-free rate (exogenous) and the risk premium (endogenous) entails. Thus, absent strong debt cancellations, the market clearing conditions imply that there is an import boom. In effect, as agents increase their consumption of the foreign good, this automatically puts upward pressure on the real exchange rate (measured as the relative price of the domestic good) since non-tradable domestic production responds slowly. Given that the stochastic regime is expected to remain in place for some consecutive periods, this price effect substantially improves the expected return of domestic investment, thus fostering a capital deepening process that contributes to the rise in imports. Better financial conditions lessen the firms' intratemporal financial constraint in an effect akin to a positive technological shock, thus expanding domestic goods production and reinforcing the incentives to invest. Capital adjustment costs force agents to build capital slowly, hence the transition to a "higher" stochastic steady state takes time. In the process, the economy sustains ever higher levels of output, investment and consumption (both domestic and foreign goods), asset values keep increasing, the real exchange rate moderately appreciates, the interest rates are lower and total debt increases mildly initially (to finance the boom while exports are still increasing) but slowly starts falling soon afterwards. The opposite dynamics (the bust phase) takes place once the external conditions switch back to the average conditions.

I further exploit the flexibility of the framework to investigate the role played by the elasticity of substitution in consumption in shaping the boom-bust cycle pattern that a country experiences. For this purpose, I compare the benchmark economy (an elasticity of 0.45 as estimated for Argentina by Gonzalez-Rozada et al. 2004) against a highly elastic economy (an elasticity of 5) with the objective of representing the one-good workhorse model frequently used in the literature. The comparative dynamics shows that in the benchmark economy, shocks produce relatively larger swings in non-tradable prices, investment returns and asset valuations. As a result, with this characterization, boom-bust episodes in investment and asset prices become the norm, while in the economy with a high elasticity of substitution, the adjustment mainly takes place through variations in foreign goods consumption with a reduced impact on the domestic non-tradable sector. The main lesson I draw from these results is that the literature should not rest its results on the assumption that a technological shock in a one-good model captures reasonably well the effects of terms of trade shocks in developing countries, especially if policy analysis is the objective of the study.[11]

The final contribution of this chapter is to investigate the effects of a regime contingent debt taxation policy. The goal in this respect is primarily positive and the instrumentation is based on the current Brazilian policy of taxing short-term capital inflows at a fixed rate.[12] The presence of the two financial distortions brings empirical realism to the evaluation. It guarantees that the tax policy operates like a general purpose instrument, given that it attempts to remedy the overborrowing caused by the aggregate debt country premium while, at the same time, it inevitably distorts production and investment, as emphasized by capital control detractors, through its impact on the working capital financial friction.

In the simulations, I assume that the government unexpectedly (if it were expected, agents would discount this and start reducing debt holdings in advance) introduces a 1% tax rate on debt holdings in the event of a switch to the "windfall" regime and keeps the tax rate contingent on this regime thereafter.[13] Comparative transitional dynamics during identical boom-bust episodes between the simulation without taxes and the one with taxes reveals that the policy is an "efficient" instrument to smooth out boom-bust cycles. The policy ahieves this result through a subtle intertemporal mechanism: the wedge between the effective interest rate -including taxes- and the market one during the boom, reduces non-tradable production and indebtedness. In the bust phase, the inherited lower leverage position permanently reduces the risk-premium, thus generating a relative rise in domestic production since the firm's intratemporal friction becomes less distortive. This interesting mechanism, absent in the literature analysis, reveals the difficulties that a proper evaluation of capital inflows taxation policy entail.

The key and final question that remains to be answered is whether the policy improves welfare. The short answer is that it barely modifies welfare and that the sign of the welfare change depends on the strength of the intratemporal distortion. Indeed, I simulate three economies that only differ in the degree of strength of the intratemporal friction, labelling them the no-distortion case, the benchmark case and the strong-distortion case. In each case, I calculate the consumption equivalent that would leave households indifferent to the introduction of taxes. My findings reveal that the policy increases welfare in the economy with no distortion (equivalent to a 0.23% increase in consumption) while it reduces welfare by a similar amount

[11]For example, by underestimating the swings in asset prices after a regime switch, the workhorse model minimizes the potential risks associated with banking regulation and supervision.

[12]The Argentinean policy has the same objective, but is not so well defined and changes frequently.

[13]I have completely ignored any credibility or time-consistency consideration in the analysis.

in the economy with strong distortions. The simple reason for this outcome is that absent the static distortion, the increase in the effective interest rate during the boom does not reduce the output; hence, the economy benefits from tackling the overborrowing distortion. In contrast, when the static distortions are relevant, as claimed by those opposing capital inflows taxation, the costs in terms of the foregone output during the boom cannot be offset by the benefits from future lower interest rates (even when accounting for higher future output).

As a robustness check, I also explore varying the tax rate and modifying the tax schedule by introducing a zero-across-regimes tax rate. Although these exercises produce minor changes, the previous findings remain in place. The overall policy lesson I draw from all these exercises is that in a realistic environment, the welfare effects of capital inflows taxation are at best elusive and, clearly, involve very subtle intertemporal trade-offs that are normally absent in the analysis. In general, my findings are in line with the conclusions drawn in Benigno et al. (2010, 2011) that emphasize that ex-ante macro prudential measures, in the form of debt taxation, do not improve welfare in this framework.

The remainder of the chapter is organized as follows. In section 1.2, I discuss papers connected to this study. In section 1.3, I test the hypothesis of a double tailwind and present some data on Argentina and a group of South American countries to characterize the current boom. Section 1.4 outlines the model environment. Section 1.5 presents in detail the stochastic environment and the driving forces in the model. In section 1.6, I briefly discuss the global solution method used to solve the model. Section 1.7 calibrates the model to the Argentinean economy. In section 1.8, I simulate the model, study boom-bust episodes and perform some sensitivity analysis. Section 1.9 studies the economics of contingent capital inflows taxation. The final section 1.10 concludes the chapter. In the appendix, I present all algorithms regarding the Markov switching estimation, the equations employed to solve the model and describe the algorithm that implements the global solution method.

1.2 Related Literature

The model introduced in this chapter belongs to a broad strand of the literature that studies aggregate fluctuations in emerging markets. Specifically, it belongs to the subset that deals with non-linear dynamics using equilibrium stochastic models. This literature has used two different approaches to introduce highly non-linear dynamics into the models. The first mechanism, recently employed by Mendoza (2010), relies on the presence of an international collateral constraint. Normally, after a sequence of negative linear shocks, the constraint suddenly binds and agents are forced to partially repay their debts, generating abrupt adjustments in the domestic economy. The other mechanism is more direct: non-smooth adjustments are introduced by assuming non-linear shocks - regimes breaks - in some underlying exogenous variable. Aguiar and Gopinath (2007) take this approach to modelling cycles in emerging markets by postulating the existence of stochastic trend growth breaks. The model introduced in this chapter belongs to this second strand of the literature. The stochastic structure presented in the model adapts the structure developed in Gruss and Mertens (2010) to a context in which terms of trade constitute the main source of shocks, instead of domestic interest rates as studied by these authors.

In terms of the production structure, the framework could be considered as a modified version of the dependent economy model discussed in Agenor and Montiel (1996). The key characteristic of the dependent economy model is the existence of two different sectors, one producing a home non-tradable good and the other an international tradable good. In the canonical version, capital and labour are in fixed supply and labour is assumed to be perfectly mobile between sectors. Under that configuration, the endogenous response to terms of trade shocks comes from the allocation of labour between sectors. In contrast, in the framework developed in this chapter, the endogenous response to the same type of shocks results in changes in the stock of physical capital, since the labour supply is constant. The logic behind the decision that capital instead of labour is a variable input is explained by the goal of studying the medium-run effects of terms of trade shocks through their impact on capital accumulation decisions. Finally, for the sake of classification, the production structure of this model could also be considered as belonging to the class of natural resource-rich economies, as studied in Lim and McNeils (2008), where the international good is exogenously modelled.

The academic interest in term of trade shocks faded away during the late 1990's as a result of a long period of stable commodity prices. However, the recent spike in commodity prices has brought the attention back to this source of shocks. This renewed interest has primarily materialized in the form of empirical analysis (see Izquierdo et al. 2008 for a broad study covering Latin America), but there have not been any new developments on the modelling front. Indeed, Mendoza's (1995) contribution could still be regarded as the most comprehensive and updated theoretical piece of work. In his three-sector model, domestic firms endogenously produce exportable, importable and home goods. As such, the model allows the author to study the effects of terms of trade shocks in all sectors of the economy. The main weakness is that in order to be able to simulate the model, the author needs to assume that capital is fixed in the home good sector and is perfectly mobile between the exportable and importable sectors. Although these assumptions limit the role of investment in the economy, it is a reasonable simplification in light of the goal of studying the relationship between terms of trade shocks and high frequency business cycle fluctuations. In contrast, the aim of the model introduced here is to contribute to our understanding of the role of low frequency movements in commodity price cycles in generating medium-run boom-bust cycles. Under this longer horizon, capital accumulation becomes critical.

The study also belongs to a large body of literature that studies the interactions between interest rates shocks and financial frictions as a source of fluctuations in the fluctuations of emerging markets. Representative papers in this strand of the literature are Neumeyer and Perri (2005), Uribe and Yue (2006), Gruss and Mertens (2010), Garcia-Cicco et al. (2010) and Mendoza and Yue (2011). The common denominator between these representative papers and the current approach is the assumption, validated by a vast empirical literature, that interest rate shocks contemporaneously affect the supply side of the economy. As a result, I share with these papers the modelling device of assuming a financial working capital constraint at the firm level. I depart from these authors by assuming that the country risk-premium is endogenous, modelled as an increasing function in the ratio of external indebtedness to expected commodity prices. This rich formulation, built in the spirit of the pioneering work of Harberger (1976, 1980), has not been sufficiently well explored in this strand of the literature. One of the main benefits of this formulation is that it brings realism into the analysis since the ergodic properties of interest rates in the economy are determined by endogenous borrowing decisions. As such, the model is uniquely suited to study the long-term dynamic effects of external debt taxation.

Finally, this work is connected to the large body of literature studying capital inflows taxation in emerging markets. The empirical literature on this topic is immense; Edwards (1999), De Gregorio, Edwards and Valdes (2000), Forbes (2004, 2005 and 2007), Levy Yeyati, Schmukler and Van Horen (2008, 2009) and Clements and Kamil (2009) to name a few, find that taxes on inflows effectively increase the domestic interest rates. But when the question is expanded to evaluate the effects on total inflows, the real exchange rate, growth and, most importantly, welfare, the evidence is not conclusive given the difficulties in identifying these effects econometrically (see Gallego and Hernandez 2003, for example). Attempts to study optimal interventions theoretically always rely on very simple models embedded with a particular financial friction that calls for a policy to remedy the market failure. Jeanne and Korinek (2011) study Pigovian taxation as a form of optimal intervention.

In this work, I do not study optimal interventions. Instead, I follow Reinhart and Todd (2002) who study numerically the dynamic and welfare consequences of a temporary tax rate on debt holdings in an environment designed to produce inefficient levels of foreign borrowing. Like them, I assume that the underlying distortion that justifies the intervention is that the social cost of external borrowing exceeds its private cost due to the fact that atomistic agents do not internalize the impact of their borrowing decisions on the price of debt. In the Reinhart and Todd setup, there is neither uncertainty nor production, hence the taxes only affect consumption and interest rates but without any dynamic impact either on output or investment decisions. As a result, in their simplified framework, capital inflows taxation, if correctly implemented, improves welfare because it corrects the overborrowing distortion without imposing any cost.[14] In contrast, this setup introduces an intertertemporal trade-off since taxes also distort output and investment decisions; hence the conclusions are a priori unwarranted.

1.3 A "Double Tailwind" External Scenario?

In this section, I explore the data and statistically evaluate the claim that the current external conditions can be categorized as a "windfall" regime: a unique historical combination of very low real interest rates and high commodity prices. To proceed, I treat the two series as independent stochastic processes since it substantially simplifies the analysis. I model each variable as a univariate Markov switching autoregressive process of order one. I first test for non-linearity in both data generating processes and then use the smoothed probabilities to make the inference about regimes.

1.3.1 U.S. Real Interest Rate

Several authors have tested for regime shifts in the U.S. real interest rate over time. Using a quarterly sample covering 1961-1986, Garcia and Perron (1996) find three different regimes: a "medium" regime with a mean of 1.4% between 1961 and 1973, a "low" regime with a mean of -1.8% between 1973 and 1981 and a "high" regime with a mean of 5.5% between 1982 and 1986. In a similar fashion, I search for evidence of two regimes in the ex-ante real interest rates between 1990-Q1 and 2011-Q2. I choose the starting date of the series to coincide with the resumption of voluntary financing to the region after the successful Brady debt renegotiations.[15] To construct the series, I use quarterly U.S. 1-year Treasury bill rate data and subtract expected inflation data from the University of Michigan Survey of Consumers. I model the series as a Markov Switching Intercept Autoregressive process of Order 1 (MSI-AR(1) following Krolzig (1997) as follows:

$$r_\tau = u_{s_\tau} + \rho_r r_{\tau-1} + \sigma\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0,1) \tag{1}$$

[14] Since the tax policy is not designed to be optimal in their exercise, the authors acknowledge that the small benefits that they found could easily be reversed if they were to choose tax rate values that are further away from what an optimal policy would dictate. In simple words, there are tax rate values for which the policy reduces welfare.

[15] The Brady bonds issuances of 1989 were a market-based solution to the sovereign defaults of the early 1980's. Creditors converted their illiquid bank loans into standardized bonds that started to be traded in financial markets.

where r_τ is the ex-ante real interest rate, $u_{s_\tau}/(1-\rho_r)$ is the unconditional mean (regime conditional though), σ is the standard error and s_τ is the regime at time τ.

To obtain maximum likelihood estimates of the parameters, I employ the Expectation Maximization (EM) algorithm as proposed by Hamilton (1990). I calculate filtered and smoothed probabilities applying Hamilton's (1994) forward filter and Kim's (1994) backward algorithm, respectively. From the smoothed probabilities, I make inferences about regimes (classify regimes). To test for nonlinearity, I construct a residual-based bootstrapping algorithm following Di Sanzo (2009). In Appendices A.3 to A.7, I develop the statistical inference procedure and explain the main algorithms in detail.

Table 1 summarizes the results of the maximum likelihood estimation. A p-value of 0 allows me to reject the null hypothesis of a single-regime model in favour of the alternative hypothesis of a two-regime process. The estimation clearly distinguishes between two different regimes: one with a positive conditional mean of 2.46% and the other with a negative conditional mean of −2.31%. The interest rates are persistent with the estimated $\rho_r = 0.87$ and, on average, the regimes are expected to switch every three to four years during the sample covered.

Figure 1 depicts the ex-ante real interest rate series (circle dotted solid red line, right axis) plotted against the filtered probabilities (dashed blue line, left axis) and smoothed probabilities (grey area, left axis) of being in the low real interest rate regime. The graph provides a simple economic interpretation of the regime classification outcomes: in normal times, real interest rates are in the positive mean regime but switch to the negative real interest rate regime during U.S. recessions as a result of the Federal Reserve Board aggressive monetary stimulus. The grey areas shading the 1991, 2001 and 2007 recession periods support this interpretation, although a simple visual inspection shows that the model encounters some difficulties in making inferences about regimes during the first recession. I calculate the Regime Classification Measure (RCM) proposed by Ang and Bekaert (2002) and find a value of 23.4, confirming that there is some lack of precision in classifying regimes during the first recession of the sample.[16] This problem disappears once we move closer to the present period. The most plausible explanation for the difficulty in classifying regimes is that the AR(1) process cannot deal with the downward trend in U.S. real interest rates observed during the sample period. Nonetheless, the estimation provides overwhelming statistical support for the existence of two regimes that can

[16]The values are calculated according to the following formula:

$$RCM(S) = 100S^2\frac{1}{T}\sum_{\tau=1}^{T}\left(\prod_{s=1}^{2}\hat{\xi}_{s,\tau|T}\right) \tag{2}$$

where $\hat{\xi}_{s,\tau|T}$ is the smooth probability of being in state s at time τ and S is the total number of regimes. A value of 0 shows perfect classification and values closer to 100 show a very poor identification of regimes.

easily be understood as a result of the U.S. economic cycles.

In terms of regime classification, the smoothed probabilities confirm that the financial pillar of the "double tailwind" scenario has been in place since the last quarter of 2007. Indeed, from that quarter onwards, the average real interest rate has been -2.87%; reason enough to explain why this period can be considered to have unprecedented favourable external financial conditions.

1.3.2 Commodity Prices

By all verbal accounts, a positive break in the behaviuor of commodity prices took place at some point between 2006 and 2007. I test whether the data validates this narrative employing an exports commodity basket price index calculated by the Argentinean Central Bank covering 1992-Q1 until 2011-Q2.[17] First, I specify a MSI-AR(1) as follows:

$$p^x_\tau = v_{s_\tau} + \rho_{p^x} p^x_{\tau-1} + \sigma\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0,1) \tag{3}$$

where p^x is the real price of the exporting commodity bundle and $\frac{v_{s_\tau}}{1-\rho_{p^x}}$ is the unconditional mean in regime s.

Table 2 reports the estimated parameters (columns MSI regime) for this specification. I reject the null hypothesis of a linear process against the alternative of two regimes. In the estimated model, when prices switch to the high price ("windfall") state, they are expected to double their value and, on average, tend to remain high for only one year. Figure 2a depicts the price series (right-hand axis) and the inference probabilities (left-hand axis measures the probability of a windfall regime). It shows that in the late 2006, commodity prices switched to the high price regime, then felt drastically during the Credit Crunch of 2008, thus making regime inference difficult during this short period, and have then swiftly recovered since 2010-Q1.

This specification clearly fails to capture the increase in price volatility that has taken place in the last few years. As explained by Caballero et al. (2008b), in an unstable high-valuation world prone to the emergence of bubbles, large corrections in asset prices constitute the norm. Hence, it seems natural to test whether volatility is also regime dependent. Besides, from a historical perspective, it is well known that it is very difficult to stochastically characterize the behaviour of commodity prices, as Angus Deaton famous quote succinctly exemplifies: *"What commodity prices lack in trend, they make up for in variance"*. Thus, for the sake of completeness, I explore the alternative of introducing a heteroscedastic regime-dependent error term and

[17]The dynamic basket is calculated with data from the World Bank "pink sheets" database. Unfortunately, data is available only from 1992-Q1.

estimate an MSIH(heteroscedastic)-AR(1) model as follows:

$$p^x_\tau = \upsilon_{s_\tau} + \rho_{p^x} p^x_{\tau-1} + \sigma_{s_\tau}\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0,1) \tag{4}$$

where the difference as compared to the previous specification is that the standard error σ_{s_τ} is now also regime dependent.

The results are summarized in the last two columns in Table 2 (the columns labelled MSIH) and in Figure 2b. In this case, the likelihood ratio test also rejects the hypothesis of a linear AR(1) model, once more supporting a two-regime specification with the following characteristic: there is a historical regime where prices and volatility are low, and the current regime where prices are high (almost twice as high) and volatility is higher (three times more volatile as measured by the standard deviation). Under this configuration, the Argentinean commodity basket switched to the high ("windfall") regime during 2006-Q2 and has remained there since after. The drawback of this estimation is that it unrealistically underestimates the possibility of a switch to the low-price regime (see the transition matrix in Table 2) because that switch has never taken place in the data.

I extend the analysis to a select group of South American countries comprising Brazil, Chile, Colombia, Ecuador and Peru (henceforth SAC-5) to show that this is a regional event. The data in this case comes from the Inter-American Development Bank "Latin Macro Watch Data Tool". The index is an unweighted average of the five countries and covers 1996-Q1 until 2011-Q2.[18] Table 3 and Figure 3 present all estimation results. To summarize this in a nutshell, the price movements have been more impressive for this group since Chile and Peru are among the largest metal exporters in the world and metal commodities have outperformed agricultural commodities, the main source of Argentinean exports.

To sum up, the estimations find conclusive support for the claim that Argentina and the region are currently experiencing an unprecedented "double tailwind" external scenario. It is necessary to go all the way back to the late 1970's to find a period with similar favourable conditions.

1.3.3 A Quick Anatomy of the Blessing Effects: Flying High

Although I leave the attempt to empirically validate the model to the third chapter, in this brief section I highlight some stylized facts connecting commodity prices and economic performance in the region (extensively documented by the Inter-American Development Bank).[19] In each individual graph in Figure 4, I display the evolution

[18]I have not been able to extend the sample coverage back in time due to the lack of data on exporting commodity baskets.

[19]Empirical work by Izquierdo et al. (2008) concludes that after 2003, the terms of trade have become the most relevant external factor to explain growth and economic activity in the countries of the region.

of the real price of the commodity exporting bundle (right-hand axis) alongside the evolution of the logarithm of a variable (left-hand axis) that is endogenous in the model. The graphs in the first (second) column contain data from Argentina (SAC-5). A simple visual inspection confirms that the positive break in terms of trade around 2005/2006 coincides with the positive break in trend growth for all selected quantities: consumption, output, total imports, investment and industrial production.[20]

The information in Figure 5 is focused on the evolution of three key prices reproduced by this model: asset prices (proxied by the stock market), the real exchange rate (vis-à-vis the U.S.) and the EMBI (emerging markets bond index) spread. Although there are idiosyncratic stories behind the evolution of some of these variables, in particular in Argentina and Ecuador with their dramatic downfalls in the early 2000's, the general emerging picture can be summarized as follows: 1) Asset prices (in real terms) have tracked the impressive improvement in commodity prices. They suffered a strong downward correction in the aftermath of Lehman's bankruptcy but have fully recovered since then. 2) The real exchange rate in all countries has also tracked the evolution of commodity prices and has been appreciating sharply since 2004.[21] 3) Debt yields in all countries have co-moved negatively with commodity prices, more strongly in those countries that do not have a recent default event, like Argentina and Ecuador.

1.4 The Model

In this section, I introduce the basic structure of a framework that captures the economic environment described. The model departs from the baseline one-good neoclassical small open economy in some dimensions that can be summarized as follows: (i) Each period, domestic agents receive a fixed endowment of manufacturing and natural resource goods that have to be exported. Manufacturing goods are always traded at a fixed price of one relative to import goods, while the natural resource good price p^x fluctuates stochastically. Hereafter, I will denote by X the total value of exports. (ii) Consumption (C) is a composite good of a non-tradable domestic produced good (c_h) and an imported one (c_f). (iii) The technology for producing the domestic good uses four inputs: an intermediate domestic input (m), labour (h), reproducible capital (k) and non-reproducible capital (l). (iv) Only import goods can be used to build domestic capital; hence, total imports are given by

[20] It is worth noticing that Argentina's 2002 default took place when commodity prices were at their minimum and that the economy's strong subsequent recovery was accompanied by a rapid improvement in the terms of trade.

[21] Logically, Argentina has not returned to the unsustainable pre-crisis real exchange rate level. Nonetheless, the exchange has also been steadily appreciating during this period.

the sum of gross investment (x) and foreign goods consumption (c_f).[22] (v) Domestic firms are subject to an intratemporal financial friction, in the spirit of Neumeyer and Perri (2005), that takes the form of a working capital constraint on intermediate inputs purchases. (vi) Households have access to a one-period non-contingent discount bond denominated in units of the import good. (vii) Competitive foreign creditors charge a risk premium in their lending operations that is increasing in aggregate leverage - defined as the ratio of aggregate debt to the expected price of the natural resource good - in the spirit of Harberger (1976, 1980). Formally, I use a logistic function to endogenize a "perceived" probability of debt payments confiscation π^{def} assigned by foreign agents based on the expected leverage ratio. ($viii$) The basic uncertainty structure is a two-state Markov regime switching process that characterizes two global external regimes based on the level of commodity prices and the U.S. risk-free interest rate. For the sake of clarity, before fully characterizing the stochastic structure, I next present the model in detail. I devote section 1.5 to describe the stochastic environment.

1.4.1 Households

The economy is populated by identical, infinitely lived households that inelastically supply one unit of labour $h = 1$ to the market and consume the composite good C_τ. The household preferences can be summarized by:

$$U = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{C_\tau^{1-\sigma} - 1}{1-\sigma} \tag{5}$$

where $\beta \in (0,1)$ is the discount factor and $\sigma > 0$ defines the curvature of the utility function.

As in Lim and McNeils (2008), the household sector also includes entrepreneurs that receive the export good endowment, buy import goods that are either competitively bundled into the final consumption good by firms or used as investment x_τ to build physical capital.

Export goods have to be sold every period in the international market at the spot price. This assumption rules out the possibility of storing these goods or engaging in future contracts.[23] I denote by $\bar{X}$ the total quantity of export goods endowed per period and by $\zeta \in (0,1)$ the fraction of these goods that are natural resources. With no production costs, the households/entrepreneurs at time τ receive dividends from export sales equal to the value of total invoices $X_\tau = [p_\tau^x \zeta + (1-\zeta)]\bar{X}$. In section 1.7, I will calibrate $\bar{X}$ to approximate non-tradable production in the economy and

[22] Burstein 2006 supports this assumption. He extensively documented that the share of import capital goods in fixed capital formation in Latin American is higher relative to that of other regions.

[23] See Caballero (2003) for an in-depth analysis of the reasons behind the underutilization of price hedging opportunities in commodity exporting countries.

$\zeta\bar{X}$ to represent exports of primary (non-manufactured) goods.

Households also receive a wage w_τ for the labour services provided to domestic firms and a gross return r_τ^k and r_τ^l per unit of reproducible capital k_τ and non-reproducible capital l_τ rented to these firms. While the stock of land is fixed in the economy, reproducible capital can be accumulated according to the following law of motion:

$$k_{\tau+1} = x_\tau + (1-\delta)k_\tau - \Psi(k_{\tau+1} - k_\tau) \tag{6}$$

where x_τ is gross investment, $\delta \in (0,1)$ is the depreciation rate and the last term represents capital adjustment costs. As explained in Fernandez-Villaverde et al. (2011), these adjustment costs have become commonplace in the business cycle models of small open economies because they contribute to reduce the excessive investment expenditures volatility that the models produce in response to plausible real interest rate fluctuations. I assume that these costs satisfy $\Psi(0) = \Psi'(0) = 0$. As is standard, the functional form chosen reads:

$$\Psi(k_{\tau+1} - k_\tau) = \frac{\phi}{2}\left(\frac{k_{\tau+1}}{k_\tau} - 1\right)^2 k_\tau \tag{7}$$

where the parameter ϕ controls the intensity of these costs.

Non-reproducible capital is introduced as an input in the production process of domestic goods to be able to model a domestic asset and endogenize a forward looking asset price that responds to domestic market conditions. To this end, I assume that land is infinitely divisible and that there exists a frictionless market for land where agents can trade this asset at a price of q per unit.

In period τ, households/entrepreneurs receive the proceeds from selling the endowment abroad and all sources of income provided by domestic firms. They can invest in three types of assets: a one period discount foreign bond denominated in units of the import good d_τ, reproducible capital k_τ and non-reproducible capital l_τ. The values of $d_\tau > 0$ denote a net debtor position in international markets by domestic residents. The households' sequential budget constraint in period τ is then given by:

$$p_\tau C_\tau + x_\tau + d_\tau + q_\tau l_{\tau+1} = X_\tau + w_\tau h + r_\tau^k k_\tau + (r_\tau^l + q_\tau)l_\tau + \pi_\tau + R_\tau^{-1} d_{\tau+1} \tag{8}$$

where p_τ is the price of the composite consumption good, R_τ is the international interest rate faced by domestic households and π_τ denotes any type of profits that the households might receive from the firms (always zero in equilibrium).

The budget constraint in (8) reflects two critical issues of this type of economies. First, the limited external insurance opportunities faced by the households, as they receive a stochastic endowment income and only have access to one-period discount uncontingent bonds. Second, a kind of "liability dollarization" (see Eichengreen et al. 2006 for a description and an empirical study of the concept), as financial instruments are denominated in units of tradable goods while domestic production generates non-tradable goods.

Finally, the representative household is subject to a non-Ponzi game condition:

$$\lim_{s\to\infty} \mathbb{E}_\tau \frac{d_{\tau+s+1}}{\prod_{s=0}^{n} R_{\tau+s}} \leq 0 \tag{9}$$

that simply rules out the possibility that the households set a scheme of unlimited borrowing.

The optimization problem of the households consist of choosing contingent plans C_τ, x_τ, $k_{\tau+1}$, $l_{\tau+1}$ and $d_{\tau+1}$ to maximize expected lifetime utility (5) subject to the sequential budget constraint (8), for given prices and endowment p_τ, w_τ, r_τ^k, R_τ, q_τ and X_τ, for the initial values k_t, d_t and land holdings l. Letting λ_τ denote the Lagrange multiplier associated with (8), the dynamic optimization problem optimality conditions are (8) holding with equality and:

$$C_\tau^{-\gamma} = \lambda_\tau p_\tau \tag{10}$$

$$\lambda_\tau R_\tau^{-1} = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}\right] \tag{11}$$

$$q_\tau \lambda_\tau = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}(r_{\tau+1}^l + q_{\tau+1})\right] \tag{12}$$

$$\lambda_\tau \left(1 + \phi \frac{k_{\tau+1}}{k_\tau} - \phi\right) = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}\left(r_{\tau+1}^k + 1 - \delta + \frac{\phi}{2}\left(\frac{k_{\tau+2}}{k_{\tau+1}}\right)^2 - \frac{\phi}{2}\right)\right] \tag{13}$$

Equation (10) defines the marginal utility of a unit of consumption of the composite good. Since the foreign good is the numeraire, on the right-hand side, the marginal utility of a unit of tradable (as represented by λ_τ) has to be multiplied by the price of the composite good. Equation (11) is the intertemporal Euler condition determining the allocation of bonds; it equates the marginal benefits and the marginal costs of borrowing R_τ^{-1} units of the import good in period τ. Equation (12) is a standard first-order condition for an asset; it establishes that the present value of a unit of land is given by the expected discount value of tomorrow's dividends and resale price. Finally, equation (13) is the intertemporal Euler condition that determines the allocation of capital into the domestic good sector; it accounts for the fact that agents internalize that their investment decisions affect future capital adjustment costs.

1.4.2 Production Non-tradable Good

To produce this good, domestic firms use a constant-returns-to-scale technology requiring four inputs: an intermediate domestic input m_τ, capital k_τ, land l_τ and labour h_τ services. Hence, defining $Y_{h,\tau}$ as gross production of the domestic good, we have:

$$Y_{h,\tau} = F\left(m_\tau, k_\tau, l_\tau, h_\tau\right) \tag{14}$$

As in Uribe and Yue (2006), I assume production to be subject to a financing constraint that imposes domestic firms to hold an amount χ of a non-interest bearing asset as collateral for their intermediate input expenditures. The simplest "modelling trick" to deal with the production of this intermediate domestic good (m) is to assume that production in the domestic good sector is "roundabout" (see Basu 1995).[24] Alternatively, I could have assumed that this intermediate good is an import good as in Mendoza (2010). My modelling choice has two advantages over the alternative structure: i) I can consider production of this domestic intermediate input as a proxy variable for industrial production in the quantitative evaluation and, more importantly, ii) I shut down the relative price channel present in Mendoza's framework to focus my attention on the more relevant - in terms of capital controls - financial friction channel. In Mendoza's framework, a relative price change between domestic and foreign goods, ceteris paribus, resembles a negative (positive) technological shock during bad (good) times, thus exacerbating boom-bust dynamics. Thus, in terms of boom-bust dynamics, my assumption could be considered as a conservative choice.

Returning to the collateral constraint formulation, if I denote the price of intermediate inputs as p_h (since it is a domestic good), the total intermediate expenditures at market values can be expressed as $p_h m$; hence, the working capital constraint at time τ takes the following form:

$$\frac{\chi_\tau}{R_\tau} \geq \kappa_m p_{h,\tau} m_\tau \tag{15}$$

The specification of this commonplace friction can be denoted as the *cash-in-advance convention*, by which firms must hold non-interest-bearing foreign assets to cover a fraction κ_m of the intermediate inputs. Uribe and Yue (2006) use the *shopping time convention* by which firms need to have the working capital $\kappa_m p_{h,\tau} m_\tau$ at the end of the period. Qualitatively, there is no difference between these two formulations since they serve the same purpose: to introduce a wedge in labour demand. Nonetheless, quantitatively there is a minor difference since in the first case the wedge is $\kappa_m(R_\tau - 1)$ whereas in the second one the wedge is $\kappa_m\left(\frac{R_\tau-1}{R_\tau}\right)$.

The representative firm's debt position, denoted by $d^F_{\tau+1}$, evolves according to

[24] Production is "roundabout" in the sense that intermediate goods m are made by costlessly transforming the final production good Y. The domestic production sector can be considered as composed of many identical firms that produce domestic goods that serve both as inputs into the production process of the other firms and as final goods. See Comin and Gertler (2003) for a detail explanation and application of this production structure.

the following law of motion:

$$\frac{d^F_{\tau+1}}{R_\tau} = d^F_\tau - p_{h,\tau}Y_{h,\tau} + p_{h,\tau}m_\tau + w_\tau h + r^k_\tau k_\tau + \pi_\tau + \chi_\tau - \chi_{\tau-1} \tag{16}$$

Proceeding in a similar fashion as in Uribe and Yue (2006), I define total net liabilities $(d^F_{\tau+1} - \chi_\tau)$ at the end of period τ as $a_{\tau+1}$. Then, expression (16) can be rewritten as:

$$\frac{a_{\tau+1}}{R_\tau} = a_\tau - p_{h,\tau}Y_{h,\tau} + w\tau h + r^k_\tau k_\tau + \pi_\tau + p_{h,\tau}m_\tau + \chi_\tau \left(\frac{R_\tau - 1}{R_\tau}\right) \tag{17}$$

Since, by assumption, interest rates are always positive, optimizing firms will always find it optimal to hold non-bearing assets at the minimum level, that is $\frac{\chi_\tau}{R_\tau} = \kappa_m p_{h,\tau} m_\tau$. Thus, replacing this last result in the budget constraint (17), I eliminate χ_τ to finally get:

$$\frac{a_{\tau+1}}{R_\tau} = a_\tau - p_{h,\tau}Y_{h,\tau} + w_\tau h + r^k_\tau k_\tau + \pi_\tau + p_{h,\tau}m_\tau \left[1 + \kappa_m(R_\tau - 1)\right] \tag{18}$$

The firms discount the future using the pricing kernel $\beta^{\tau-t}\frac{\lambda_{\tau+1}}{\lambda_\tau}$ that corresponds to the preferences of the representative household that owns them. Their problem is to choose state contingent sequences for k_τ, l_τ, h_τ, m_τ and $a_{\tau+1}$ in order to maximize the present discounted value of the expected profits distributed to the households;

$$max \quad \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{\lambda_\tau}{\lambda_t} \pi_\tau \tag{19}$$

subject to the budget constraint (18) and a non-Ponzi-game borrowing constraint of the form:

$$\lim_{s\to\infty} \mathbb{E}_\tau \frac{a_{\tau+s+1}}{\prod_{s=0}^{n} R_{\tau+s}} \leq 0 \tag{20}$$

and taking prices and the households' kernel as given. The set of first-order conditions for the firm's problem include (11), (18), the no-Ponzi holding with equality, and:

$$p_{h,\tau}F_h\left(m_\tau, k_\tau, l_\tau, h_\tau\right) = w_\tau \tag{21}$$

$$p_{h,\tau}F_k\left(m_\tau, k_\tau, l_\tau, h_\tau\right) = r^k_\tau \tag{22}$$

$$p_{h,\tau}F_l\left(m_\tau, k_\tau, l_\tau, h_\tau\right) = r^l_\tau \tag{23}$$

$$F_m\left(m_\tau, k_\tau, l_\tau, h_\tau\right) = 1 + \kappa_m(R_\tau - 1) \tag{24}$$

Equations (21) to (23) are the firms' factor demand for labour, reproducible capital and non-reproducible capital. They are almost identical to the standard one-sector model demands; they differ in the fact that firms sell a product with a relative price given by $p_{h,\tau}$ instead of one. Equation (24) is the factor demand for the intermediate input. It shows that the working capital constraint introduces a wedge between the value of the marginal product of the input and its relative price. The intensity of the distortion is increasing in the fraction of input expenditures that must be held in non bearing assets (κ_m) and the opportunity cost per unit held ($R_\tau - 1$). A positive opportunity cost guarantees that the supply side of the economy responds to the conditions in financial markets in the same period, without delay, a well established stylized fact in this strand of the literature (see Garcia and Uribe 2010 for an evaluation of financial frictions in emerging market models.).

As explained in Mendoza and Yue (2011), any real-valued process $\{a_{\tau+1}\}_{\tau=t}^{\infty}$ which satisfies (17) and (20) will be optimal. This is the case because the firms use the pricing kernel of the households and net liabilities enter the objective function linearly; hence firms do not engage in precautionary savings. Thus, without lost of generality, I assume that the firm starts out with a zero net debt position $a_\tau = 0$ and, hence, maintains this value at all times.

1.4.3 Production Final Consumption Good

Entrepreneurs run the domestic firms that produce the aggregate consumption good C_τ. The technology for this is a CES production function that takes non-tradable consumption goods $c_{h,\tau}$ and tradable consumption goods $c_{f,\tau}$ as the inputs of production. Thus, as in Schmitt-Grohe and Uribe (2011), the composite good is given by:

$$C_\tau = \left(\eta^{\frac{1}{\theta}}(c_{h,\tau})^{\frac{\theta-1}{\theta}} + (1-\eta)^{\frac{1}{\theta}}(c_{f,\tau})^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{25}$$

where the parameter η represents the share of domestic goods in aggregate consumption and $\theta > 0$ is the elasticity of substitution between domestically produced goods $c_{h,\tau}$ and internationally produced goods $c_{f,\tau}$.

These "bundlers" operate in perfectly competitive inputs and final product markets. Their objective is to choose output C_τ and inputs $c_{h,\tau}$ and $c_{f,\tau}$ in order to maximize profits:

$$\pi_\tau = p_\tau C_\tau - p_{h,\tau}c_{h,\tau} - p_{f,\tau}c_{f,\tau} \tag{26}$$

where the intermediate input prices of non-tradable and tradable goods are $p_{h,\tau}$ and $p_{f,\tau}$, respectively.

A solution to this problem is obtained from equation (25) and the following first-order conditions:

$$c_{h,\tau} = \eta(\frac{p_{h,\tau}}{p_\tau})^{-\theta}C_\tau \tag{27}$$

$$c_{f,\tau} = (1-\eta)(\frac{p_{f,\tau}}{p_\tau})^{-\theta}C_\tau \tag{28}$$

Perfect competition guarantees zero profits in equilibrium; thus the consumer price index p_τ is simply the minimum cost to attain one unit of the composite good. Since the foreign good acts as the numeraire in this economy, the composite good price level can be expressed as:

$$p_\tau = \left[(1-\eta) + \eta(p_{h,\tau})^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{29}$$

1.4.4 Equilibrium

A competitive equilibrium for this model is a set of infinite sequences for allocations C_τ, $c_{h,\tau}$, $c_{f,\tau}$, x_τ, $k_{\tau+1}$, $l_{\tau+1}$, $d_{\tau+1}$, m_τ, $a_{\tau+1}$ and prices w_τ, r^k_τ, r^l_τ, p_τ, $p_{h,\tau}$, q_τ such that households and firms solve their respective problems given the initial conditions (k_t, d_t), non-reproducible capital holdings l and endowment X, for a given sequence of p^x_τ and R_τ, and labour, assets and all goods markets clear. The market clearing conditions in the domestic and the tradable goods markets are:

$$Y_{h,\tau} = c_{h,\tau} + m_\tau(1 + \kappa_m(R_\tau - 1)) \tag{30}$$

$$c_{f,\tau} + x_\tau + nx_\tau = X_\tau \tag{31}$$

respectively, where nx_τ is the value of net exports given by $(d_\tau + d^F_\tau) - (d_{\tau+1} + d^F_{\tau+1})R^{-1}_\tau$.

1.5 Uncertainty Structure

For the sake of simplicity, I assume that the external environment can be stochastically characterized by a two-state Markov chain; each state representing a global regime. I dub as "windfall" regime the scenario that depicts the current conditions of high commodity prices and low real interest rates, and I label "shortfall" regime the scenario where both variables are at their historical levels. This simplification keeps the solution tractable while still capturing the basic upside and downside external risks that this type of economies has faced over time. Formally, I denote S_τ as the global regime state space that takes the following values in each regime:

$$S_\tau = \begin{cases} s_\tau = 0 & \text{in the "shortfall" regime} \\ s_\tau = 1 & \text{in the "windfall" regime} \end{cases} \tag{32}$$

and evolves according to the following transition probabilities $Pr(s_\tau = j | s_{\tau-1} = i) = p_{ij}$ for i, j that take the values of 0 and 1. The transition matrix probability is denoted by $\mathbb{P}$. In the simulation exercises, I assume that $\mathbb{P}$ is given by the estimated transition matrix Π' for the Argentinean commodity prices in the MSI-AR(1) case (as estimated in section 1.3).[25]

1.5.1 Commodity Prices

In this world, commodity prices follow an AR(1) process with regime intercept switching given by:

$$p^x_\tau = [s_\tau v_{wi} + (1 - s_\tau)v_{sh}] + \rho_{p^x} p^x_{\tau-1} + \sigma\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0, 1) \tag{33}$$

where $v_{wi}/(1 - \rho_{p^x})$ and $v_{sh}/(1 - \rho_{p^x})$ are the unconditional means in the "windfall" and "shortfall" regimes, respectively, σ is the standard deviation and μ_τ is white noise.

1.5.2 Risk-Free Rate

I model the other pillar of the "double-tailwind" environment in a very simple way: I directly assume that the U.S. real interest rate only takes one value per regime. Clearly, this assumption might be considered as a strong over-simplification, but it serves well the purpose of capturing the essence of each financial regime estimated in section 1.3.1, while keeping the dimensionality of the state space manageable. Formally,

$$r^f_\tau = s_\tau r^f_{wi} + (1 - s_\tau)r^f_{sh} \tag{34}$$

where r^f_τ is the ex-ante real interest rate in the U.S. at time τ, and r^f_{wi} and r^f_{sh} are the values in the "windfall" and "shortfall" regimes, respectively.

1.5.3 Country Risk-premium

The emerging markets literature has developed three approaches to modelling country spreads. The first, denoted as the *independent country risk approach*, assumes that spreads are exogenous to the model. In these cases, exogenous global factors (risk aversion, liquidity shocks, contagion effects, etc) that are independent of local conditions drive the risk premium (see Uribe and Yue 2006 and Fernandez-Villaverde et al. 2011). A second alternative, known as the *induced country risk approach*, assumes that the country risk is associated with fundamental shocks to the economy. In a seminal paper, Neumeyer and Perri (2005) model this premium using a reduced form where the spread is a decreasing function of expected productivity. Finally, in the *endogenous country risk approach*, the pricing of bonds is the outcome of the interaction between competitive lenders and a Central Planner that optimally

[25] As explained, in the heteroscedastic estimation, there is no switch from high commodity prices to the low commodity price regime during the sample length and, accordingly, the 'windfall" regime is a quasi-absorbing state. To avoid this unrealistic feature, I pick the homoscesdastic estimation that provides a more realistic picture of the changing nature of the external environment.

chooses whether to repay or default given the state of the economy and the costs associated with the event of default (see Arellano 2008 and Yue 2010 for models with productivity shocks). In this strand of the literature, in a model driven by terms of trade shocks, Cuadra and Sapriza (2006) established that the default risk is increasing in debt holdings and decreasing in the value of exports, as the former increases the incentives to behave opportunistically, while the latter reduces them.

Within the limits imposed by the induced country risk modelling approach, I propose a reduced form for the risk premium based on the results of the endogenous country risk approach and supported by the empirical findings. Following Kumhof and Ranciere (2011), I assume there to be a large mass of competitive risk-neutral foreign investors that are willing to lend to the economy at a spread ϵ_τ over the risk-free rate. As in Neumeyer and Perri (2005), I justify the introduction of this spread by assuming that there is a "perceived" probability π_τ^{def} that the domestic government will confiscate a fraction $(1-\nu)$ of the payments to foreign lenders at the end of the period τ. Although the event never takes place in reality, this assumption is sufficient to rationalize the pricing behaviour of competitive lenders. In this reduced form, the probability of confiscation π_τ^{def} is increasing in leverage, defined as the ratio of aggregate external debt holdings to the expected price of commodity exports $\frac{d_{\tau+1}}{\mathbb{E}(p_{\tau+1}^x)}$. As a result, the properties of the probability of confiscation conform to the findings in Cuadra and Sapriza (2006).[26]

As in Kumhof and Ranciere (2011), I choose a logistic functional form to govern this probability, which reads:

$$\pi_\tau^{def} = \frac{exp\left(\phi_0 + \phi_1\left(\frac{d_{\tau+1}}{\mathbb{E}(p_{\tau+1}^x)}\right)\right)}{1 + exp\left(\phi_0 + \phi_1\left(\frac{d_{\tau+1}}{\mathbb{E}(p_{\tau+1}^x)}\right)\right)} \tag{35}$$

and guarantees that for a suitable choice of parameters, the probability is increasing in aggregate debt d and decreasing in the expected price of commodities $\mathbb{E}p^x$ (Figure 7 shows the calibrated form).

Foreign investors risk neutrality and zero "perceived expected" profits imply that the following condition must hold:

$$\frac{1}{R_\tau} = \frac{1}{1 + r_\tau^f + \epsilon_\tau} = \frac{1 - \pi_\tau^{def}}{1 + r_\tau^f} + \frac{\pi_\tau^{def}\nu}{1 + r_\tau^f} \tag{36}$$

which states that the current value of a discount bond is given by the present "expected" recovery value.

[26] Given the representative agent assumption in the model, individual debt holdings are equal to aggregate debt holdings.

Rearranging in (36), I pin-down the country risk-premium for a discount bond,

$$\epsilon_\tau = (1 + r_\tau^f)\frac{(1-\nu)\pi_\tau^{def}}{1 - \pi_\tau^{def}(1-\nu)} \tag{37}$$

The parameterization in section 1.7 guarantees that the spread is convex and increasing in leverage. From a purely empirical perspective, there is ample econometric support for this reduced-form specification. Indeed, Hilscher and Nosbusch (2010) find that for a large group of developing countries, even after controlling for a wide array of global and idiosyncratic factors, indebtedness (measured as debt to GDP) and terms of trade have significant power to explain sovereign risk premium movements.

1.5.4 Real Interest Rate

The gross real interest rate faced by domestic residents in international markets (R_τ) is the sum of an international risk-free real rate (r^f) plus the country premium (ϵ), thus:

$$R_\tau = 1 + r_\tau^f + \epsilon_\tau \tag{38}$$

To conclude this section, two properties of the domestic interest rate are worth highlighting: First, it can have discrete jumps following a regime switch since both of its components, the risk-free rate and the country risk premium, adjust discretely in the same direction. Second, it is endogenously determined in the model by the household's investment decisions. Hence, policies that modify borrowing decisions have an impact on the equilibrium interest rate. Notice that this a substantial difference to the approach taken by Neumeyer and Perri (2005), since in their framework, there is no feedback from borrowing decisions to interest rates.

1.6 Numerical Solution

The setup developed in this chapter is not suitable for applying widespread perturbation methods because of the non-linear uncertainty structure. In an environment with stochastic breaks, the only alternative is to resort to global solution methods to solve the model.

As explained by Kumhof and Ranciere (2011), a model with three continuous state variables (reproducible capital, external borrowing and commodity prices) and one binary state ("shortfall" and "windfall" regime) can be solved by functional iteration on a discretized state space. In particular, I iterate on the policy and pricing functions as first developed by Coleman (1990). This class of algorithm has become increasingly popular among researchers with an interest in simulating highly non linear economies that are subject to "big" shocks or breaks. Davig and

Leeper (2006, 2007), Gruss and Mertens (2010), and Kumhof and Ranciere (2011) are among those papers that deal with non-linear shocks in this way.

The method aims at finding a fixed point in the policy functions for each grid point in a discretized state space. In a nutshell, to find the solution, the researcher chooses a set of conjectured decision rules and pricing functions and uses them to solve the model in the equilibrium conditions, iterating until the decision rules are fixed at each grid point, given a fixed tolerance criterium. As suggested by Barillas and Fernandez-Villaverde (2007), to reduce the computational burden and increase the efficiency, the policy functions are set following the method of endogenous grid-points in Carrol (2006).

To obtain a discrete approximation to the Markov switching process for commodity prices, I use the quadrature method proposed by Tauchen and Hussey (1991) over a grid of 31 equidistant nodes. Figure 6 depicts the ergodic distribution of the discretized process for the parameterization of the model. I follow Kumhof and Ranciere (2011) and use the policy functions computed by DYNARE for a first-order approximation of a model as my initial guess for the policy functions. The uncertainty structure is simplified in the DYNARE version. I first estimate a model with a linear shock for which the standard deviation of commodity prices has been substantially lessened. This reduces the curvature of the policy functions and hence the first guess over the grid space is more accurate given its more linear structure. With this guess in hand, I solved the model globally for the same level of uncertainty. The secret is to find a robust solution for this reduced level of uncertainty. Once this critical step has been achieved, I use homotopy in the direction of the desired structure of uncertainty. Each new solution is used as the initial guess for the next estimation. To check that the model has good convergence properties, I follow two ad-hoc procedures: First, I graph the policy functions to see if at the edges of the state space, the optimal choices are inside the state space (that is, inside the grid limits). I found that this simple visual inspection easily detects whether the simulations will converge or diverge. Second, I perturb the equilibrium decision rules in different directions and check whether the model converges to the same equilibrium in each regime.

The appendix A.9 explains the algorithm solution and the implementation in full detail.

1.7 Calibration

To numerically evaluate the model, I calibrate it at a quarterly frequency using data from Argentina as shown in Table 4. As is standard practice in the small open economy literature, I set the parameter governing the intertemporal elasticity of substitution $\sigma = 2$.

I assume a CES production function as the non-tradable sector gross output:

$$Y_{h,\tau} = Z[\omega^{1-\rho} m_\tau^\rho + (1-\omega)^{1-\rho}(k_\tau^\alpha l_\tau^\gamma h_\tau^{(1-\alpha-\gamma)})^\rho]^{\frac{1}{\rho}}$$

where Z measures the level of total factor productivity and ω is the intermediate domestic input weight in production. I set Z to normalize the steady-state level of the domestic good net output at unity, while fixing the labour supply at one.

As in Neumeyer and Perri (2005), I set the labour share in the non-traded sector $(1-\alpha-\gamma)$ at 0.62, for which there is ample empirical evidence. The share of land in production γ is set at a minimal value of 0.01. As in Gruss and Mertens (2010), the share of intermediate goods ω in production is fixed at 0.40, a value close to the share of intermediate goods consumption arising from the input-output matrix. Given the absence of any estimate for the elasticity of substitution between the intermediate good and the other factors of production, I set this value $(1-\rho)^{-1}$ at 1 as in Mendoza (2010). I have checked that the results are not very sensitive to this value within a reasonable range (I tried values between 0.2 and 5).

I choose the depreciation parameter δ at 0.038 to match the average investment-output ratio in Argentina of 19.1% for the last ten years. In this context, since capital is only used to produce non-traded goods I match this ratio for the non the non-tradable production sector. This means that in the steady state investment to total output ratio is lower in the model than in the actual data, since in the model a fraction of output is an endowment good X. With this assumption I guarantee that the production function in the non-tradable sector and the depreciation parameter do not differ from the standard choices in this strand of the literature.

I set the tradable consumption share parameter η in the consumption aggregator at 0.20. Investment goods are 100% tradable by construction in the model.[27] With these two final assumptions, the share of tradable component in total absorption will be around 30.6% in the neighbourhood of the steady state (that is, when the relative price of the non-tradable good is $p_h = 1$).[28] This value is in the range of those recently used in the literature for Argentina. Schmitt-Grohe and Uribe (2011) calculate the share of tradable output in total output over the period 1980-Q1 to 2010-Q4 to be approximately 0.26. Using data that covers almost a century, Garcia (2008) calculates this value at 0.32. I calibrate the endowment X such that it guarantees a domestic price p_h of 1 in the "windfall" non-stochastic steady state.

[27]See Burstein, Eichenbaum and Rebelo (2005) for an empirical study that shows that investment goods have a large proportion of imported capital in emerging markets.

[28]In the model, the ratio of tradable absorption to total absorption is defined by $\frac{x+c_f}{x+pC} = \frac{x+c_f}{x+c_f+p_h c_h}$. To obtain the actual share, we evaluate the equation for $p_h = 1$, use the targeted investment ratio $\frac{x}{c_h} = 0.191$ to substitute for investment, and use the consumption calibration share $c_h = 0.25 c_f$ to substitute for c_f. After replacing, we find: $\frac{x+c_f}{x+c_f+c_h} = \frac{0.191c_h+0.25c_h}{0.191c_h+0.25c_h+c_h} = \frac{0.441}{1.441} = 0.306$, as claimed.

Setting $X = 0.47$ guarantees this outcome.[29]

The next step is to assume which fraction of endowment that is subject to commodity price fluctuations. In this respect, Argentina's primary goods exports are in the order of 25% out of total exports that account for 20% of output. Thus, primary goods exports are approximately 5% of output. To match this value, I set the share of the natural resource good ζ in the total endowment at 0.16. This implies that the size of the commodity shock is in the order of 4.5% of total output after some years. To obtain this result, just multiply the share of natural resource exports in output (5%) times the estimated commodity price increase (see section 1.3.2) in the "windfall" regime (approximately 90%).

In the business cycle literature, the values for the capital adjustment cost ϕ range from lower limits of 8 to high values of 40 (for example, Neumeyer and Perri (2005) use these two values and a middle case with 25.5). Although this investigation is not centered around business cycle fluctuations, but rather on medium-run boom-bust dynamics, for the sake of discipline, I choose this parameter to be in line with the parameterization used in the literature that matches the volatility of investment to the data. Nonetheless, the reader should take into consideration that in a model with regime switches and time horizons as studied here, this parameter mainly affects the cumulative response of investment to regime switches rather than the volatility of investment along a trend. I set ϕ to be 24 for the simple reason that it is the average value between the extremes and very close to the middle case presented in Neumeyer.

The parameter of elasticity of substitution in consumption determines the response of the domestic price ("the real exchange rate") to relative consumption changes between import and domestic goods. This property becomes critical to the functioning of the model, because it determines the response of domestic investment and consumption to fluctuations in the availability of foreign goods. Given its macroeconomic importance, there is a rich literature that deals with the estimation of this parameter. Gonzalez Rosada et al. (2004) estimates this parameter at $\theta = 0.45$ for Argentina, with time series ranging from 1993-Q1 to 2001-Q3. The robustness of this result has recently been confirmed by Akinci (2011) who estimates a value of 0.43 for a group of developing nations using more updated data. Thus, I set this value in the baseline model at 0.45. Then, I perform a sensitivity analysis setting the parameter $\theta = 5$ to explore and understand the differences between both configurations. I consider that this comparison sheds some light on the po-

[29]The conditional ergodic mean distribution of the domestic price p_h is around 0.95 in the simulations. The reason that this mean is below the target of 1 -the value in the non-stochastic steady state- is that under uncertainty, a precautionary savings motive leads domestic agents to increase the stock of capital, higher production of non-tradables and higher use of tradables to investment means that the share of tradables in consumption goes down. If this is the case, the price of non-tradable goods, relative to the tradable ones, goes down.

tential deficiencies of the one-good sector models (represented by the model with high elasticity of substitution), particularly with respect to compositional effects in absorption following a terms of trade shock.

To pick a value for the parameter governing the firms' financial constraint, I follow Mendoza's (2010) methodology given the absence of official data on this. I calculate total credit to private non-financial firms as a share of GDP at 16% and try to match this value. Given that the share of intermediate inputs in gross non-tradable output is 0.40, a value of $\kappa_m = 1$, guarantees that measured in annual terms, the stock of this debt is around 16% of annual non-tradable net output. This final figure is close to the implicit values obtained by Neumeyer and Perri (2005) that choose $\kappa_w = 1.25$ and by Uribe and Yue (2006) that choose $\kappa_w = 1.2$, for financial constraints linked to the wage bill instead of intermediate goods expenditures.

The only relevant aspect of the calibration of the risk-free rate is the absolute jump between regimes. I base this calibration on the results of subsection 1.3.1 and set $r^f_{wi} = 0\%$ in the "windfall" regime and $r^f_{sh} = 4.75\%$ in the "shortfall" regime. These values guarantee that in the event of a regime switch, the risk-free rate has the same correction as in the data.

There are four remaining parameters that need to be calibrated: the recovery rate $(1 - \nu)$, the subjective discount factor (β) and the two parameters that shape the logistic function (ϕ_0, ϕ_1). Sturzenegger and Zettelmeyer (2005) calculate the historical recovery rates to be close to 0.57, but their figures for the Argentinean default of 2001 are half of this value, thus I set $1 - \nu = 0.28$. To calibrate (ϕ_0), I assume that there is almost no risk premium for a zero net debt position; thus, I set this value at $\phi_0 = -6.25$ (close to Kumhof and Ranciere 2011). In order to calibrate the two other parameters, I try to match two targets in the "shortfall" regime: an average debt-to-output ratio of 25% and an annual real domestic interest rate of 12.3%. The debt-to-output ratio is within the range of the updated version of the dataset constructed by Lane and Milesi-Ferretti (2007) for Argentina over the last fifteen years. For the real interest rate calculations, I follow Schmitt-Grohe and Uribe (2011) and only consider quarters where Argentina was not under default, since spreads of defaulted instruments are not indicative of real interest rates. A value of $\beta = 0.963$ and of $\phi_1 = 2.25$ produce simulations that match these targets. Figure 7 displays the calibrated probabilities of confiscation in each regime as a function of total indebtedness.

A final comment is in order. In common with the *endogenous spread approach*, the model has the unresolved issue (see Pouzo and Presno 2010) that for empirically plausible values for the default probability (the consensus for Argentina is 3% annually), the model delivers very low spreads. In that literature, the cost paid to match default frequencies to historical levels is an unrealistic low real interest rate, which gets values close to 5.5% annually (see Arellano 2008). Facing this trade-off, I choose to match real interest rates since default probabilities are just a modelling trick to endogenize interest rates. As a result, the calibration generates realistic domestic interest rates but at the cost of delivering "unrealistically" high default probabilities (ranging from 1.5% to 3.0% quarterly depending on the regime).

1.8 Model Exploration: Will this Time be Different?

In this section, I quantitatively simulate the model to investigate its dynamic properties. Although I mainly devote Chapter 3 to empirically validate the setup with an ad-hoc approach based in numerical simulations, the exercises in this section are not only an attempt to study the dynamic properties of the model but also a preliminary attempt to offer empirical validation to the framework.

I pursue three specific goals in this section: First, to evaluate how far a calibrated switch to the "windfall" regime can go in terms of generating a boom of the type recently observed in Argentina and described in section 1.3. In this process, I also try to shed some light on the dynamic adjustment that will potentially take place once the current benign environment ceases. Second, to study the transmission mechanisms and the general equilibrium feedback effects that a regime switch produces in this framework, with particular attention to the intertemporal adjustment in the current account. Third, to study the role played by the elasticity of substitution in consumption in shaping the macroeconomic properties of the domestic economy. As a byproduct, I highlight the potential limitations of the prototypical one-good model.

To identify potential boom-bust cycle episodes, I simulate the economy for 200000 quarters to create artificial data. Then, I select seven-year (28 quarters) series according to the following rule: during quarters $\tau-4$ to $\tau-1$, the world must be in the "shortfall" regime. At quarter τ, a switch to the benign environment takes place and the conditions must remain in place for at least three years (quarters τ to $\tau+11$). During the following year, the regime must switch back (quarters $\tau+12$ to $\tau+15$). From quarter $\tau+16$ onwards, the external conditions cannot be favourable. In a nutshell, the simulated episodes start with a year of low prices and high interest rates, followed by a boom phase of 3 to 4 years, concluding with a bust phase of 2 to 3 years, for a total period of 7 years. I found 1047 of these episodes.

Figure 8 displays the transitional dynamics of the main variables of the model. In each of the 12 graphs, the solid line shows the average value of a variable over all episodes and the shaded area demarcates where 90% of the simulations lie. I set $\tau = 1$ and draw a vertical line in the quarter before the first regime switch takes place ($\tau = 0$). The horizontal axis shows time measured in quarters and the vertical axis shows levels (normalized to one in the quarter previous to the beginning of the boom) for all stock and flow variables. Interest rates, the probability of default and net return on capital are all measured in absolute values without any normalization.

1.8.1 The Impact of a Regime Switch

The regime switch brings about a sharp reduction in interest rates (see row 1, column 2 of Figure 8), similar to the one observed in the countries of the region during the boom years (see Figure 5 column 3). On top of the fall in the international benchmark risk-free rate, there is a sharp compression in the risk premium originating in the reassessment by foreign creditors of the perceived probability of "confiscation" (see row 1 column 3). Both effects contribute to the borrowing costs going down to around 1.5% (quarterly) initially; to further continue moving downwards, ceteris paribus, as the persistent increase in commodity prices reduces the leverage ratio.

The fall in the domestic interest rate lessens the financial friction at the firm level. The effect of this on the production side is akin to a positive productivity shock, since it reduces the distortion created by the working capital constraint. As a result, intermediate input usage, a reasonable proxy for industrial production, goes up by 3% in the first period without any feedback or cumulative effects (see row 2, column 3) and continues to increase thereafter (Figures 4i and 4j show the data for Argentina and SAC-5, respectively). Non-tradable output increases with the reduction in the distortion.

On the exporting front, commodity prices start climbing to reach a final increase of approximately 90% (see the ergodic distribution of prices in Figure 6) after three years. With commodities calibrated at 16% of the total endowment, this implies a cumulative increase in total exports of 15% after three years. Thus, the magnitude of the endowment windfall is around 4.5% of the initial net output after some years. Notice that this calibrated shock is quite conservative in comparison to data for any country in the region. For instance, if I were to include agricultural manufacturing products in the Argentinean commodity exporting bundle, total commodity related exports would jump to 39% of total exports (from 25% for commodities alone). For other countries with less diversified exports, like Peru and Chile, this number is even more conservative. In Chile, for example, exports are 30% of GDP, of which more than 50% are accounted for by a single metal, cooper, the price of which has more than doubled since 2008.

At the aggregate level, the economy has three alternatives to dispose of the extra exports income generated by the endowment "windfall": i) to increase the imports of foreign consumption goods, ii) to increase the imports of investment goods to build capital in the non-tradable sector and iii) to reduce debt. Indeed, domestic residents optimally choose to increase consumption demand since they experience a positive, relatively permanent, income shock. Since domestic goods production is quite inelastic in the short run (fixed labour supply), the bulk of the increase in consumption initially comes from a rise in imports of foreign consumption goods. As a result, tradable consumption jumps close to 7% at $\tau = 1$ (see row 3, column 3) while the non-tradable consumption increase is constrained by the 1.2% (see row 3, column 3) improvement in non-tradable supply. This positive dynamic continues while domestic agents' income keeps improving, and by the end of year 3, domestic and foreign goods consumption are up by almost 5% and 15%, respectively.

The relative scarcity of non-tradable goods, combined with a low elasticity of substitution in consumption, results in a price correction of almost 10% initially (see row 3, column 1), replicating, at least qualitatively, the pattern of real exchange rate appreciations lately observed in all countries in the region (see Figure 5 column 2). As these conditions are expected to remain in place for some time (see Table 2), the expected net return on domestic investment jumps close to 20% above its previous value (see row 2, column 1). In terms of the return to investment, this general equilibrium price effect is akin to a 10% technological shock, and creates the incentives for an investment boom in the non-tradable sector. Indeed, investment initially jumps by more than 20% and remains 30% above the previous steady state value during the transition to the "windfall" stochastic steady state (see row 2, column 2). In this respect, the model rationalizes, without resorting to the existence of implausible technological shocks, the capital deepening process that Argentina and the SAC-5 have been experiencing from the onset of the commodity boom, as documented in Figures 4g and 4h, respectively.

Higher export prices, a reduction in the financial frictions in the intermediate sector, an increase in the stock of reproducible capital and the appreciation of the real exchange rate, all together contribute to the increase in domestic output at the market value by almost 20% by year three (see row 4, column 1). This is a remarkable figure considering that the initial export shock is only 4.5% of output. Asset prices increase around 15% in the first period, without any feedback or cumulative effects (see row 4, column 2). The increase in the return on domestic capital, mainly due to the real exchange rate appreciation, and the increase in the stochastic discount factor due to the contraction in interest rates, explain the instantaneous jump in asset valuations. Although a pale figure if the benchmarks are the stock markets in Argentina and the region (see Figure 5), it is an impressive number for a DSGE model of an open economy.

In terms of total borrowing, the behaviour of the model seems to conform to the Obsteld-Razin-Svensson (ORS) effect.[30] The rapid increase in debt in the first

[30] This effect is part of a long tradition of research that tries to understand the impact of terms of trade shocks in the trade balance. In the early 1950's, within a Keynesian framework, Harberger (1950) and Laursen and Metzler (1950) claimed that positive shocks to terms of trade should be associated with an improving trade balance, giving birth to the Harberger-Lausen-Metzler (HLM) effect. More than thirty years later, at the introduction of the intertemporal approach to the current account paradigm, Obstfeld (1982) and Svensson and Razin (1983) challenged this view.

quarters (see row 4, column 3) has a natural explanation based on the intertemporal approach to the current account principles: as agents foresee a future of abundance ahead and decide to increase consumption and investment while exports have not yet fully reached their new steady-state level, they use the international financial markets to temporarily tap this shortfall. Once this gap has been successfully bridged, the ORS effect - given that the shock is temporary - indicates that agents devote more resources to cancelling debt. In effect, a second look at the debt figure (see row 4, column 3) confirms that domestic agents engage in net debt repayments after five to six quarters from the onset of the boom.

A comment regarding the ORS effect is in order. In the empirical literature on emerging markets, researchers test this effect (see Barone 2009 for example) ignoring the effects of terms of trade shocks in interest rates and beyond. As a result, their identifications cannot capture the full effects of terms of trade on borrowing decisions. This point has recently been given attention by Uribe (2011) who claims that any correct identification process must rely on a formal model as the general equilibrium implications are rich and extended. Although this issue is beyond the scope of this investigation, the structure of this model is perfectly suited to explore this point quickly. To this end, I simulate (not shown) the economy for different parameter values. The main conclusion is that the robustness of the ORS result is very sensitive to capital adjustment costs and the impact of terms of trade shocks on the risk-premium, among other parameters.[31] In effect, when interest rates decrease sharply (marginally) following a positive and persistent terms of trade shock, agents can increase (reduce) borrowing if adjustment costs are low (high). Thus, a simple re-parameterization shows that Uribe's concerns are justified, as reductions in interest rates can offset precautionary saving incentives.

To complete the picture, the bust phase begins at some quarter during year 4 (quarters $\tau+12$ to $\tau+15$) and by year 7, almost all accumulated gains are reversed. Given the symmetry of the model, there is no need to describe this phase in detail, just to point out that the appearance of a soft landing is the result of assuming that switches take place in any quarter during year 4.

A final analysis for the sake of robustness. The model satisfies the main empirical regularities documented in the literature for emerging markets (see Neumeyer and Perri 2005). In particular, both consumption and output are negatively correlated with real interest rates, and these lead the cycle. The main regularity that fails to be accounted for is that model consumption and output standard deviations (0.050 and 0.051, respectively) are almost identical, which is not the case in the data where

In the new framework, the effect mainly depends on the perceived persistence of the shocks. For instance, for highly persistent shocks, the trade balance can even respond in an opposite way as agents borrow to accumulate capital faster.

[31] The other critical parameter is the elasticity of substitution in consumption. I devote the next subsection to its analysis.

consumption is 1.25 times more volatile than output. The simple explanation for this outcome is that in this model, 80% of consumption are composed of non-tradable goods which, by definition, implies a perfect comovement between consumption and output.

1.8.2 The Role of the Elasticity of Substitution in Consumption: Shaping the Cycle?

As pointed out, the behaviour of non-tradable prices has rich general equilibrium implications that are worth considering. For this purpose, I simulate alongside the benchmark economy ($\theta = 0.45$) another elastic economy ($\theta = 5$) that could be seen as resembling the prototypical one-good model in the literature.

Figure 9 displays the dynamics in both environments. At a first glance, it is obvious that in the elastic economy, agents engage in a foreign consumption binge (jumps up 17% in comparison to 7% for the benchmark case) as both types of goods are easily substituted away and hence, the aggregate consumption bundle price does not go up strongly (see row 3, column 3). This, in turn, implies that profitability in the non-tradable sector is not substantially modified, relatively reducing the investment incentives (see row 2, column 2) and the asset prices correction (see row 4, column). Thus, in this economy, the adjustment to the "windfall" conditions mainly takes place through an increase in the consumption of the import good. In contrast, in the benchmark economy, the consumption bundle becomes more expensive in terms of tradable goods; hence the asset prices corrections are larger and the imports are mostly devoted to building capital rather than increasing the consumption of foreign goods. Borrowing initially increases in both economies, to then start falling later once the commodity prices are closer to their new conditional mean (see row 4, column 4). Borrowing increases less in the benchmark economy, as capital adjustment costs preclude agents from building capital quickly.[32]

I conclude this section by drawing attention to one interesting property of the model: it endogenously generates a very strong negative correlation (-0.91 in the simulations) between the cost of borrowing and the net return on domestic capital (compare row 1 column 2 with row 2 column 1). In effect, following a switch to the "windfall" ("shortfall") regime, the return on debt falls (increases) by more than 100 basic points on a quarterly basis while, in contrast,the return to domestic investment increases (falls) by approximately the same amount. I consider this property to be economically relevant since it captures a real-world phenomenon that can be the root cause of external insolvency problems to come. Indeed, high commodity prices in natural resource rich countries are normally followed by increases in the consumption of import goods. This, in turn, modifies relative prices tilting investment

[32] Once more, this result is sensitive to the parameterization.

towards non-tradable activities. Laxed external conditions allow domestic agents to finance this investment boom with cheap foreign resources. When external conditions deteriorate, reality bites again, as non-tradable investments are of no value to repay foreign creditors.

1.9 The Economics of Inflows Taxation

The previous section illustrated how changing conditions in the external environment generate ample boom-bust cycles in natural resource-rich developing nations. From this simple fact, many government officials and pundits conclude that it is beneficial to insulate domestic conditions from external shocks. Under this narrative, capital inflow controls are justified for the sake of avoiding large cyclical swings in economic aggregates. But the lack of understanding and evaluation of the dynamic effects of this policy is noticeable. My contribution in this final section is to shed some light on the effects of this type of policies to try to assess whether they are worth implementing.

1.9.1 The Theoretical Rationale for Introducing Taxes in the Model

The pioneering works of Stiglitz (1982), Greenwald and Stiglitz (1986) and Geanakoplos and Polemarchakis (1986) have established that if markets are incomplete or agents do not behave competitively, the decentralized market allocation is not constrained efficient in general.[33] Based on this theoretical finding, the literature specialising in emerging markets has formalized models where a type of market incompleteness - possibly combined with a financial market imperfection - creates a financial externality that guarantees inefficient borrowing by domestic agents. In the strand of the literature that studies overborrowing in emerging markets, the most extended formalization assumes that agents can only trade non-contingent bonds denominated in units of the tradable good - a form of market incompleteness - and that there is a borrowing constraint that depends on the price of a non-tradable good - a form of market imperfection in a multiple good economy.[34] In this environment, domestic agents fail to internalize the effect of their borrowing decisions on the price of the non-tradable good in states of the world where the constraint is

[33] There are some particular exceptions to this general result. For example, consider a representative agent economy with incomplete markets and a single good. In this setup, the market allocation is constrained efficient because there is neither trade in equilibrium nor relative prices; hence, the Central Planner's choice does not differ from the decentralized market allocation. Stiglitz was the first to notice that this peculiar market configuration has interesting effects in terms of the First Welfare Theorem.

[34] Technically, the assumption of multiple goods does not necessarily imply that there are two different types of goods in the economy. Clearly, the presence of a non-tradable good would suffice for this result, but it could also be the case that an asset that provides the legal rights to the stream of future tradable good dividends serves this purpose. Effectively, what is needed for the externality to arise is that the price of the good in the borrowing constraint fluctuates endogenously.

binding. This situation creates a financial externality that leads agents to borrow inefficiently. Benigno et al. (2010, 2011) provide an in-depth study of the conditions under which domestic agents overborrow or underborrow relative to the constrained efficient level.[35]

In the model of this chapter, there is also a financial externality that generates inefficient borrowing from domestic agents. In this case, the financial externality leads to overborrowing in equilibrium. The financial externality arises in this case because domestic agents fail to internalize the effect of their borrowing decisions in the cost of borrowing. As a result, in equilibrium, atomistic agents undervalue the social cost of borrowing. Thus, although the result of a different modelling 'trick', a financial externality is the cause behind inefficient borrowing in this chapter and the next. Nonetheless, there is an important caveat. When the externality is introduced via a borrowing constraint in a model with exogenous interest rates, as in the models studied by Benigno et al. (2010, 2011) and in chapter 2 of this thesis, the planner's intervention is global Pareto optimal. In contrast, with the configuration of this chapter, the intervention is not globally Pareto optimal since it improves domestic agents' welfare but reduces that of foreign creditors.[36]

The nature and consequence of the financial externality can easily be illustrated. To facilitate the exposition, I follow Uribe (2007) and assume that the domestic interest rate only depends positively on aggregate debt. In a nutshell, the domestic interest rate takes the form $R_\tau = R(B_{\tau+1})$ with $R' > 0$ and B denoting aggregate debt.[37] As I have shown, in the decentralized equilibrium, the standard Euler equation for bonds at time τ is given by:

$$\lambda_\tau \left[\frac{1}{R(B_{\tau+1})}\right] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}\right] \tag{39}$$

A Central Planner instead, when directly choosing the aggregate debt level $B_{\tau+1}$, also internalizes the effects of her decision on the price of borrowing R_τ. As a result, the Euler equation in the constrained efficient economy is:

$$\lambda_\tau \left[\frac{1}{R(B_{\tau+1})} - \frac{B_{\tau+1} R'(B_{\tau+1})}{R(B_{\tau+1})^2}\right] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}\right] \tag{40}$$

The next step is to evaluate equations 39 and 40 in the steady state. Denoting

[35] In chapter 2 of this thesis, I introduce a model that features a permanently binding borrowing constraint linked to an asset price. I use the model to show that the financial externality does not only cause inefficient borrowing but, more more importantly, it can also create the conditions for large boom-bust cycles in the economy.

[36] In the specialized literature, it is common practice to evaluate the policy in terms of its impact on the welfare of domestic agents without pointing out that the intervention is not globally optimal and, hence, could create some difficulties with foreign lenders.

[37] Notice that the domestic interest rate also depends on the stochastic state. This omission is immaterial for the overborrowing result. It simply helps keeping the equations simpler.

the steady-state aggregate debt level in the economy with atomistic borrowers by B^{*} and in the economy with a central planner by B^{**}, it must be the case that the following equality holds in the steady state:

$$\frac{1}{R(B^{*})} = \frac{1}{R(B^{**})} - \frac{B^{**}R'(B^{**})}{R(B^{**})^{2}} \tag{41}$$

Finally, acknowledging that in equilibrium $B^{**} > 0$ and $R'(B^{**}) > 0$, it is straigthforward to deduce that $B^{*} > B^{**}$. This inequality proves that agents in the decentralized equilibrium (relatively) overborrow. This is the case because the Central Planner internalizes that marginal increases in borrowing levels increase the borrowing costs; hence it borrows less than the representative agent.

1.9.2 Regime Contingent Debt Taxation

Knowing the exact nature of the market failure that generates overborrowing does not guarantee that the researcher can derive analytically what the planner's optimal policy would be. Indeed, the price of operating with a realistic model is that it becomes too complex to isolate the effects of a policy since there are too many general equilibrium feedback effects. For this reason, and in the spirit of realism, I tackle the question from a positive perspective, basing my analysis on the evaluation of a policy similar to the one currently being implemented in Brazil. In a nutshell, the Brazilian policy mainly consists of taxing particular inflows at selected tax rates - ranging from 2% to 6% annually - during periods of high capital inflows.[38]

To be able to implement this policy in this model, I introduce a government sector in a highly stylized way. In this minimal governmental setup, fiscal expenditures are fixed at zero and the government does not hold any assets or issue any debt instrument. The assumption is that the authorities follow a simple policy rule that sets a tax rate $\tau^{d}_{\tau} = 1\%$ (4% annually) on debt issuances as follows:

$$\tau^{d}(s_{\tau}) = \begin{cases} 0 & \text{if } s_{\tau} = 0 \\ \tau^{d} & \text{if } s_{\tau} = 1 \end{cases} \tag{42}$$

The fiscal authority runs a balanced budget by automatically rebating all tax revenues to domestic agents via lump-sum t^{d}_{τ} transfers. As a result, the government budget constraint in period τ takes the following form:

$$t_{\tau} = \tau^{d}(d^{F}_{\tau+1} + d_{\tau+1}) \tag{43}$$

[38] The WEO 2010 reports that Brazil increased the tax on external inflows from 4% to 6% in October 2010 as a measure to discourage foreign investments in the local fixed-income market. Earlier in 2011, the tax rate on external short-term borrowing by firms was raised to 6% and the maturity threshold from 90 to 720 days.

where $d^F_{\tau+1}$ and $d_{\tau+1}$ represent debt holdings of the firms and the households, respectively, and t_τ total transfers.

1.9.3 The Dynamic Effect

To realistically assess the effects of the tax policy, it is necessary to take into consideration the transitional effects created by the imposition of the tax rate, in particular the costs - in terms of foregone consumption - associated with net debt cancellations.[39] To capture this effect, I select the same boom-bust episodes of section 1.8 and assume, for each boom-bust cycle, that the government *unexpectedly* introduces the tax policy at the onset - the first period - of the boom. Figure 10 displays the transient dynamics for two economies. Simulations of the model where taxes have been introduced (labelled "taxation" economy) are represented with solid lines and those of the model without taxes (labelled "benchmark" economy) with dashed ones.[40]

Delving into the analysis, the graph displaying the effective interest rates (row 1, column 2) reveals the dynamic trade-off that the policy creates: it increases the effective interest rate during the initial boom and reduces it during the bust and thereafter. The interest rate goes down after the boom phase because households reduce their debt holdings (row 3, column 3) due to the increase in borrowing costs during the boom phase. As the leverage goes down, so does the probability of default (row 1, column 3), and also the "perceived" risk-premium. The presence of this intertemporal effect reveals the benefits of using a dynamic and stochastic framework like that of this chapter.

The simulations illustrate a novel and unexplored aspect of this policy. By reducing the interest rates during the bust phase, the policy produces a subtle outcome: it transfers non-tradable goods intertemporally from the abundant regime to the scarce one, thus smoothing domestic production.[41] Notice that this effect only takes place due to the presence of the intratemporal friction at the firm level. Thus, this result illustrates the main drawback of simpler models that can be solved analytically: they cannot account for the rich general equilibrium feedback effects that the policy creates. Indeed, in this model, the contingent tax rate tightens the firms' collateral constraint during the boom but softens it during the bust, thus smoothing intermediate input production in the process (row 3, column 2). This, in turn, stabilizes non-tradable consumption and production (see row 3, column 2).

One important outcome of the policy is that it reduces the rise in the domestic

[39] The welfare analysis would clearly be misleading if I were to omit the cost of the initial foregone consumption that net debt cancellations impose.

[40] In these simulations, for the sake of better comparison, I decide to leave all variables in levels - that is, not normalized - so that the reader can see the magnitudes in the changes that the tax induces.

[41] Possibly, this is the effect that advocates have in mind when defending this type of policies.

asset price during the boom. Indeed, by increasing the effective interest rate during the boom phase, the tax reduces the stochastic discount factor and moderates the jump in the asset valuation in good times (see row 4, column 2). In the simulations, by year two, the price of land is up by 6% in the model with taxes as compared to the 12% increase in the benchmark model. This finding highlights the potential role that capital controls can play as a macro-prudential tool in the regulation of banks in resource rich emerging markets, in particular, when considering that a large chunk of domestic financing in these countries is channelled through banking systems that rely heavily on collateral-based lending (see Caballero 2001).

The effect on the domestic good (see row 3, column 1) requires some explanation because it seems counterintuitive that the tax policy appreciates the real exchange rate (the domestic good price goes up) both in the boom and the bust phases. The reason for this is simple: In the initial phase, domestic prices go up because the tax policy reduces domestic goods production, via the intratemporal friction, proportionally more than foreign goods consumption. In the downward phase, the tax policy increases foreign goods consumption, via a lower debt level and lower interest rates, proportionally more than domestic goods consumption. This result is clearly model specific and depends on the calibration. Nonetheless, a lesson to be drawn from it is that in the presence of financial frictions, it is not so straightforward to disentangle how controls affect the real exchange rate.[42] Thus, if the objective of introducing the policy in the first place was to permanently undervalue the real exchange rate, as suggested by Jeanne (2011b), this can possibly only be achieved by a combination of constant foreign asset purchases by the government and controls on inflows.

1.9.4 The Ergodic Effect

It is also interesting to study the impact of the tax policy in the long run. For this purpose, I simulate both economies for 100000 consecutive periods, I discard the first 50000 periods and then I estimate kernel densities for each global regime. Figure 11 displays the ergodic regime conditional distributions. Top Figures 11a and 11b show the long-run distributions of aggregate consumption and output, respectively. In terms of volatility reduction, the results are not particularly impressive or interesting, with a standard deviation of aggregate consumption and output going down by approximately 16% and 9%, respectively.[43] The main effect of the policy in terms of consumption is that the ergodic distribution in the "shortfall" regime shifts to the right as a result of permanently lower interest rates.

[42] Not surprisingly, the empirical evidence is very weak in this respect. See IMF 2010.

[43] The aggregate consumption standard deviation goes down from 5.21% to 4.32%. Notice that these figures are in line with the calculations in Neumeyer and Perri (2005) that report, for example, a value of 4.22% for Argentina. These values remain very high in comparison with the 1.37% for small developed nations as documented by these authors.

Figures 11c and 11d in the middle panel plot the ergodic distributions of households' debt holdings and the market interest rate, respectively. In this case, it is clear that the policy achieves a permanent reduction in leverage by approximately 10% on average. As a result, the interest rates are permanently lower in the taxation economy since the "perceived" probability of confiscation shrinks. Figure 11e in the bottom panel shows that taxation increases capital accumulation. This increase is stronger in the "shortfall" regime, mainly because permanently lower interest rates reduce the intratemporal distortion; thus increasing the marginal productivity of capital. Figure 11f confirms the permanent fall in asset prices, in particular in the "windfall" regime.

The general assessment is that the policy effectively reduces indebtdeness in the long run. It is tempting to argue that the economy becomes less prone to crisis as a result, since leverage, risk premium and asset prices are permanently lower in the economy with taxes. Nonetheless, a crisis event is not an outcome of this model; hence, the conclusion is not guaranteed by this framework.

1.9.5 The Welfare Effect

The final and key question that needs to be addressed is whether the policy improves domestic welfare. A priori, the answer to this question is not self evident. On the one hand, we know that the benchmark economy is not constrained efficient since private agents undervalue their "monopsony" power. Thus, the policy goes in the direction of improving welfare. On the other hand, as explained, the policy is not optimally designed and interferes - in a subtle intertemporal way - with the intratemporal distortion at the firm level. Thus, I explore the issue numerically. Although the analysis precludes any normative evaluation, my simulations show that under a reasonable calibration, the welfare effect crucially depends on the strength of the static distortion.

To establish this result, I calibrate three cases that only differ in the strength of the static distortion: the benchmark case with $\kappa_m = 1$, a no distortion case with $\kappa_m = 0$ and a strong distortion case with $\kappa_m = 2$. I follow Aoki, Benigno and Kiyotaki (2007) and define the welfare effect of contingent debt taxation by the percentage change in consumption (per period) in the economy without taxes that is required to make households indifferent to the introduction of taxes. The exercise still assumes that the government unexpectedly introduces the policy at the moment of the switch to the "windfall" regime. The model is simulated for each boom-bust episode previously selected in this section for 200 consecutive periods.[44]. Thus, I am, for example, explicitly excluding simulations where the boom lasted only three periods. Clearly this is not correct, as the length of the boom modifies

[44]Notice that this implies that the policy is only evaluated over all boom-bust episodes that fulfill the specified criteria

the effect of the policy. What remains true is that the optimal policy will depend on the expected length of the booms. This type of optimal design is beyond the scope of this investigation. Welfare is calculated as the average discounted utility over all episodes.

In formal terms, I denote μ - called the consumption equivalent - as the welfare variation that guarantees that the following equality holds

$$\mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{((1+\mu)C_\tau)^{1-\sigma}-1}{1-\sigma} = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{(C_\tau^{tax})^{1-\sigma}-1}{1-\sigma} \tag{44}$$

where C_τ and C_τ^{tax} denote consumption at date τ in the economies without taxes and with taxes, respectively.

In general, the welfare impact of the tax policy is minimal in all cases, albeit with opposite signs in the extremes. In effect, in the economy without intratemporal distortions, taxes increase the consumption equivalent by 0.23%, whereas in the economy with strong frictions, the fall is -0.21%. Not surprisingly, welfare remains almost unchanged in the benchmark case.

Visual aid is provided in Figure 12 that displays the evolution of average consumption - across all episodes - in the three economies, both under no taxes (dotted lines) and under taxes (solid lines). A simple comparison of the top Figure 12a - no distortion - and the bottom Figure 12c - maximum distortion - sheds some light on the role played by the intratemporal distortion. Absent any intratemporal friction, the policy intertemporal trade-off in terms of output vanishes, as there are no direct effects in domestic production caused by changes in the effective interest rate. In this case, the tax policy addresses the inefficient overborrowing without introducing further distortions in the economy. On the contrary, when the static distortion is important, the economy initially pays a high cost in terms of foregone output that is not compensated by the future benefits of (relatively) lower interest rates as seen in Figure 12c.

1.9.6 Robustness Analysis: Size and Shape of the Tax Schedule

Given that the evaluation of the policy was based on a numerical example, I extend the evaluation in two dimensions for the sake of robustness. First, I assess how sensitive the results are to changes in the size of the tax rate. Second, I evaluate the effects of introducing a zero-across-regimes tax rate.

In Figure 13a, I compare the evolution of average consumption in the 1% "taxation" economy alongside three other economies, one with no taxes, another one with a reduced tax rate of 0.5% and finally one with a higher tax rate of 1.5%.[45]

[45]Notice that both tax rates are still within the limits of the tax rates imposed by the Brazilian authorities.

The chart simply shows how sensitive is consumption to changes in the tax rate. More importantly, the simulations show that for all cases, the welfare effects remain minimal (in none of the cases is the consumption equilivalent greater than 0.05%). This result confirms two findings of this chapter: First, that the welfare effects of the policy are always minimal. Second, that for the particular calibration of the "benchmark" economy, the long-term benefits of interest rate reductions are almost identically matched by the short-term losses of higher effective interest rates.

With the particular stochastic structure of the model, it seems reasonable to consider that an optimal taxation schedule could be designed to be zero-across-regimes, that is, with taxes set at 1% during the booms and debt sudsidies set at 1% during the bust phases.[46,47] Hence, the new tax policy can be summarized as follows:

$$\tau^d(s_\tau) = \begin{cases} -\tau^d & \text{if } s_\tau = 0 \\ \tau^d & \text{if } s_\tau = 1 \end{cases} \tag{45}$$

Evaluating this economy under the benchmark calibration, Figure 13b shows that consumption now falls by less during the period following the end of the boom as a result of the subsidy. Nonetheless, in the long run, consumption is lower with this tax scheme - in comparison to the 1% tax rate only in the boom phase - because the subsidy induces domestic agents to carry more debt on average, thus increasing long-term interest rate payments. The ergodic distributions in Figure 13c illustrate the long-term effect on debt. A simple visual inspection shows that the subsidy substantially increases the debt holdings in the "shortfall" regime, which translates to higher debt levels also in the "windfall" regime. In terms of welfare analysis, the "zero-across-regimes" tax schedule improves welfare slightly, with the consumption equivalent in this case being 0.07%.

I conclude by pointing out that these exercises show, albeit numerically, that in a realistic policy environment, the welfare effects of capital inflows taxation can be either positive or negative, but certainly quite insignificant. As such, my model confirms two of the main findings of Benigno et al. (2010, 2011): First, that the results are sensitive to the parameterisation and the calibration. Second, that the scope for this type of macro-wide policy interventions is weak because welfare improvements are unwarranted and, in case they are positive, they tend to be quite limited.

1.9.7 Two Stories Absent in this Model: Costly Crises and the "Dutch" Disease

Finally, I have shown that within this framework, macro-prudential policies in the form of taxes on debt holdings have quite limited welfare effects. Thus, given the

[46] Notice that this scheme does not imply zero average tax rates because the expected duration of each global regime is different.

[47] Clearly, these subsidies are financed with lump-sum taxes on the natural good endowment.

apparent attractiveness of this type of policies in some countries, a researcher might wonder what part of the story does this model fail to capture. I consider that there are two possible extensions to this framework that could enrich the environment enough to potentially justify, in terms of welfare, the introduction of this type of policy. A first approach would be to introduce the possibility of an endogenous costly crisis event. In the current framework, there are no crises that inflict a direct loss on the economy; hence, the benefits of reducing leverage only materialise through interest rates reductions. In an extended model where a crisis event - with the probability of occurrence increasing in leverage - destroys capital as in Kumhof and Ranciere (2011) or temporarily reduces productivity as in models of endogenous default, the benefits of a prudential debt policy could be magnified. Indeed, in that case, the expected benefits of the policy would include the gains from reducing the probability of costly crises.

The second possibility could be based on considerations about the negative effects of the "Dutch disease". Countries with open capital accounts, particularly some in South America, have suffered strong real exchange rate appreciations in the face of increasing manufacturing competition from China. This dynamic has led to a relative primarisation of the export basket. In Brazil, for example, the real exchange rate has appreciated by more than 23% in the last two years and commodity exports moved from 40% of total exports in 2006 to 58% in 2010 (see De Negri and Varela Alvarenga, 2010). In a framework with production in the tradable sector, two types of frictions could potentially justify the tax rate to reduce inflows: first, a technological externality through learning by doing in the manufacturing sector in the spirit of Krugman (1987) (see also Wijnbergen 1984 and Corden 1984). Second, indivisibilities in production combined with financial frictions in exporting that could cause an inefficient destruction of exporting firms during the appreciation phase, as in Caballero and Lorenzoni (2008). Nonetheless, in both cases, it would still be debatable whether the policy is effective in depreciating the real exchange rate. Possibly, researchers that push forward this idea have in mind the Chinese policy of continuously buying foreign assets as a way of reducing absorption of tradable goods and depressing the real exchange rate.

1.10 Conclusions

In this chapter, I first established empirically - using Markov switching techniques - that commodity prices and foreign interest rates fluctuate between two global regimes. I labelled these the "windfall" regime and the "shortfall" regime. Then, I introduced a model of a small open economy with a rich natural sector economy where boom-bust dynamics arise naturally as a result of low frequency movements in commodity prices and the world risk-free interest rate. I showed that the framework generates very interesting dynamics and general equilibrium feedbacks that go well beyond the one-good workhorse model. In particular, I have illustrated how the elasticity of substitution in consumption dictates the pattern taken by the boom-bust cycle. I showed that with inelastic values, the appreciation of domestic prices is very strong and, as a consequence, a large chunk of the windfall resources are channelled towards increasing production in the non-tradable sector during booms. In contrast, with elastic values, there is a surge in foreign consumption as final-good producing firms can easily substitute between domestic and foreign goods. This finding has critical implications for policy makers interested in understanding the potential consequences of a commodity price boom.

The model has a very rich uncertainty structure with two global regimes that fluctuate according to an estimated Markov chain. I model export prices - terms of trade - with a Markov switching autoregressive process of order one. Interest rates just take on a different value in each regime. I solve the model with a global technique - Policy Function Iteration - to be able to produce a set of very rich and interesting simulations. First, I use the framework to shed some light on the validity of the Obsteld-Razin-Svensson (ORS) effect when interest rates are debt elastic and shocks are not of a permanent nature. The main finding is that the ORS effect is not granted when the terms of trade and the interest rates are negatively correlated, as is the case with this model and empirically. Indeed, in this environment, agents face two counter-forces: the usual precautionary incentive that pushes agents to save a fraction of the temporary windfall - as expected in the ORS analysis - and the opposite one caused by the reduction in interest rates that pushes agents to advance their consumption to the present - the contribution of this model. I conclude that the ORS is highly sensitive to parameterisation and might not stand so neatly in a richer environment with terms of trade shocks and endogenous interest rates (or if the interest rates are exogenous when correlated with terms of trade shocks).

Finally, I extended the framework minimally to be able to study the economics of contingent debt taxation in an attempt to shed some light, although mainly from a positive perspective, on the effects of the capital inflows policies in some South American countries, e.g. Brazil. I tackle this issue numerically since it is not possible to derive analytically optimal policies given the complexity of the model. Although an elastic debt premium - as introduced by Harberger - guarantees that agents overborrow in equilibrium, this financial externality is not sufficient to justify economic intervention. Among many reasons, the most important one is that there is also a working capital constraint in the model - as in Neumeyer and Perri - that distorts production. Hence, changes in interest rates directly affect the production function via the distortion in the factors market.

By introducing a contingent - on the "windfall" regime - 1% tax rate, I showed that the policy smoothes cycles and permanently reduces external indebtedness.

But when I evaluate the critical aspect of whether the policy improves welfare, I found that the direction in welfare change, albeit minimimally in all cases, critically depends on the strength of the intratemporal distortion connecting effective interest rates with the supply side of the economy. Without this constraint, welfare increases slightly as the policy tackles overborrowing without negatively affecting output. In contrast, when the distortion is important, the initial costs in terms of foregone output dominate the later benefits arising from permanently lower interest rates. I conduct some robustness checks by modifiying the size of the tax rate and by introducing a tax schedule where the tax rate is zero-across-regimes. Albeit with minor differences, the findings remain the same. My results are in line with those of Benigno et al. (2010, 2011) that have shown that there is not much scope for this type of policies for macro-prudential reasons, albeit I recogenize that there are some relevant aspects that my model does not capture.

All in all, I have shown that in a realistic environment, the policy introduces an intertemporal trade-off, in terms of two "competing" financial distortions, that the literature has ignored but that are critical for the outcome. In this sense, these exercises reinforce the idea that this is a topic where it is very difficult to come up with any definite conclusions.

A Appendix

A.1 Tables

Table 1: Markov Switching AR(1) Estimate: US Real Interest Rate

Statistic	Parameter	*MSI* Regime Shortfall	Windfall
Intercept	$u(s)$	-0.305 (0.148)	0.324 (0.213)
Autoregressive	ρ_r	0.868 (0.315)	
Standard deviation	σ	0.464	
Transition matrix	Π'	0.93	0.07
		0.07	0.93
Stationary probability		0.49	0.51
Expected duration		14.7	15.2
Observations		85	
Log likelihood		-52.27	
Log likelihood linear AR(1)		-69.21	
Linearity test(p-value)		0.000	

Notes: The table reports the estimation results of a Markov Switching Intercept Autoregressive process of Order 1 (MSI) for the US ex-ante real interest rate for the period 1Q1990-2Q2011. Standard deviations are between brackets. The linearity test is conducted over 1 000 simulations. Data source: St Louis Fed.

Table 2: Markov Switching AR(1) Estimates: Commodity Prices Argentina

Statistic	Parameter	*MSI* Regime		MSIH Regime	
		Shortfall	Windfall	Shortfall	Windfall
Intercept	$v(s)$	18.87 (5.248)	36.06 (9.748)	14.63 (4.120)	24.05 (11.565)
Autoregressive	ρ_{p^x}	0.767 (0.232)		0.826 (0.196)	
Standard deviation	$\sigma(s)$	8.74		4.94	18.58
Transition matrix	Π'	0.96	0.08	0.98	0.001
		0.04	0.92	0.02	0.999
Stationary probability		0.79	0.21	0.59	0.41
Expected duration		26.7	13.1	46.0	35.2
Observations		77		77	
Log likelihood		-263.0		-253.4	
Log likelihood linear AR(1)		-279.4			
Linearity test (p-value)		0.000		0.000	

Notes: The table reports the estimation results of a Markov Switching Intercept Autoregressive process of Order 1 (columns MSI) and a Markov Switching Intercept and Error (heteroscedastic) Autoregressive process of Order 1 (columns MSIH) for the export bundle price of Argentina for the period 1Q1992-2Q2011. Standard deviations are between brackets. The linearity test is conducted over 1 000 simulations. Data sources: BCRA and World Bank "pink sheets" database.

Table 3: Markov Switching AR(1) Estimates: Commodity Prices SAC-5

Statistic	Parameter	*MSI* Regime		MSIH Regime	
		Shortfall	Windfall	Shortfall	Windfall
Intercept	$v(s)$	16.582 (7.172)	33.369 (16.449)	10.08 (5.597)	19.06 (10.098)
Autoregressive	ρ_{p^x}	0.853 (0.218)		0.91 (0.170)	
Standard deviation	$\sigma(s)$	5.82		4.00	11.45
Transition matrix	Π'	0.95	0.06	0.97	0.01
		0.05	0.94	0.03	0.99
Stationary probability		0.57	0.43	0.01	0.99
Expected duration		21.2	16.7	41.2	++
Observations		61		61	
Log likelihood		-197.6		-191.9	
Log likelihood linear AR(1)		-211.7			
Linearity test (p-value)		0.000		0.000	

Notes: The table reports the estimation results of a Markov Switching Intercept Autoregressive process of Order 1 (columns MSI) and a Markov Switching Intercept and Error (heteroscedastic) Autoregressive process of Order 1 (columns MSIH) for the export bundle price of SAC-5 (South American five: Brazil, Chile, Colombia, Ecuador and Peru) for the period 1Q1992-2Q2011. Standard deviations are between brackets. The linearity test is conducted over 1 000 simulations. Data source: Inter-American Development Bank "Latin Macro Watch Data Tool".

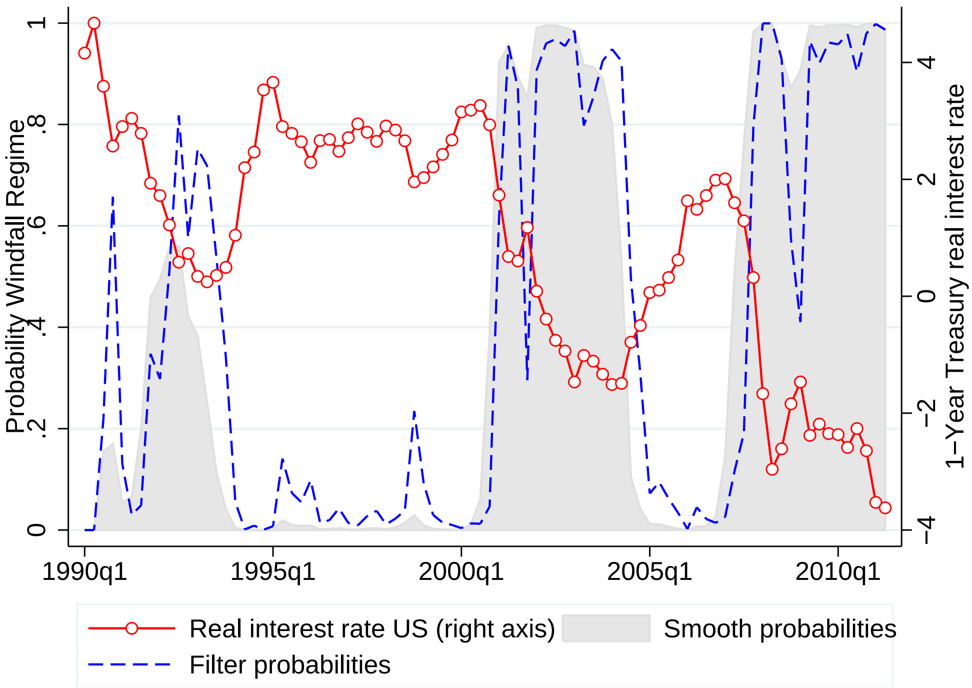
Table 4: Calibrated Parameter Values

	Parameter	Definition	Value	Target/Source/Comments
a)	Preferences			
	σ	Risk aversion	2	SOE convention
	β	Discount rate	0.963	Match avg. interest rate
b)	Consumption			
	η	Share non-tradables in C	0.85	National accounts
	θ	Elasticity substitution	0.45	Gonzalez-Rozada (2004)
c)	Technology			
	α	Share reproducible capital	0.38	labour share set at 0.62
	γ	Share non-reproducible cap.	0.01	
	ω	Share intermediate input	0.40	Input-Output matrix
	δ	Depreciation rate	0.038	Investment-to-GDP ratio
	ρ	Elasticity substitution	0.2	Gruss and Mertens (2010)
d)	Borrowing			
	κ_m	Working cap. requirement	1.0	Follows Mendoza (2010)
	ϕ_0	Normalization zero leverage	-6.25	Romancieri (2011)
	ϕ_1	Sensitivity spread	2.25	Debt to output ratio 25%
	ν	Recovery rate	0.28	Sturzenegger et al. (2005)
d)	Stochastic			
	p_{00} p_{01} p_{10} p_{11}	Transition probabilities	0.96 0.04 0.08 0.92	Own estimations
	$v_{sh}/(1-\rho_{p^x})$	Uncond. mean price low	1.0	
	$v_{wi}/(1-\rho_{p^x})$	Uncond. mean price high	1.91	
	ρ_{p^x}	Autoregressive term	0.818	
	σ	Standard deviation prices	0.063	
	r^f_{sh}	U.S. interest rate shortfall	4.75%	Non-negative values
	r^f_{wi}	U.S. interest rate windfall	0%	

Notes: Non-estimated parameters are selected from relevant papers published in top refereed academic journals.

A.2 Figures

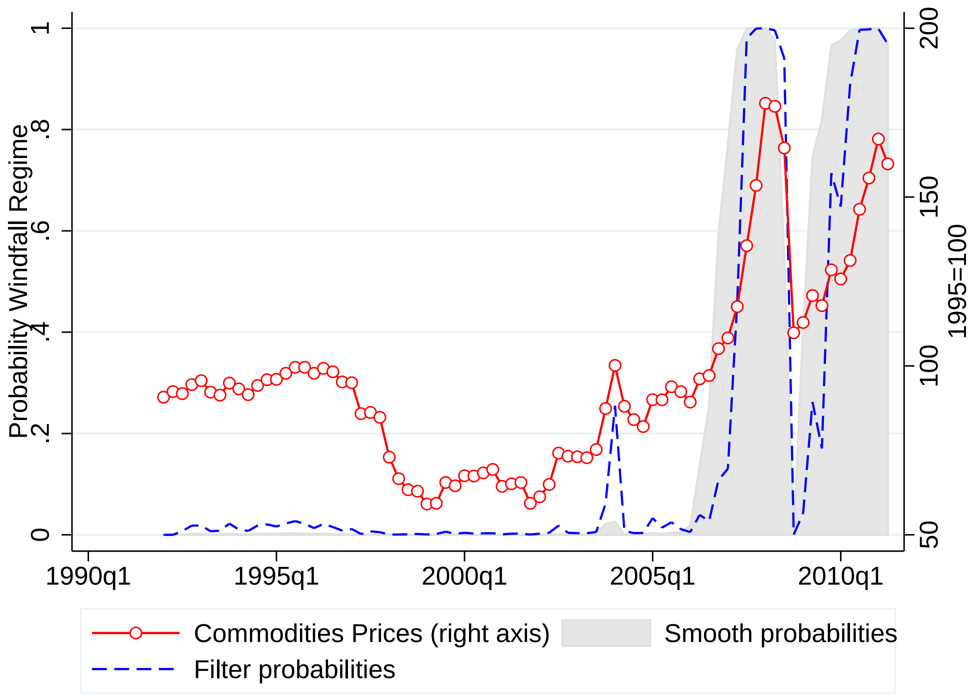
Figure 1: Inference About Windfall Regime: Interest Rates in U.S.



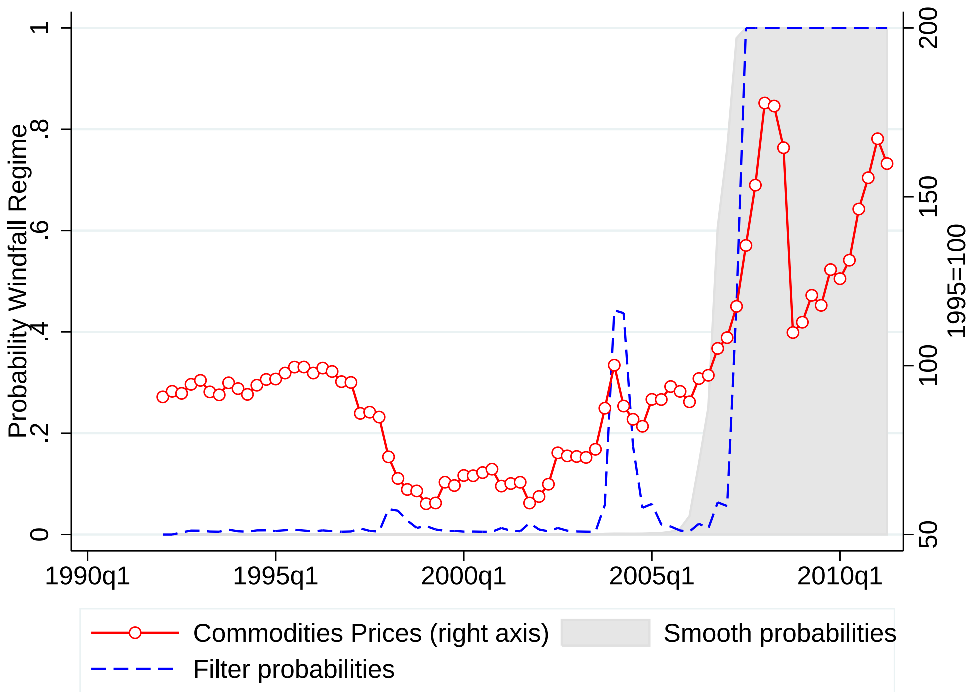
Notes: Figure 1 shows the regime inference outcome for the US ex-ante real interest rate. The lhs axis measures the smoothed (shaded area) and the filtered (dashed line) probabilities of being in the low interest rate regime, respectively. The rhs axis measures the US ex-ante real interest (red line). Filtered and smoothed probabilities are estimated using Hamilton's Forward algorithm and Kim's Backward algorithm, respectively.

Figure 2: Inference About Windfall Regime: Commodity Prices in Argentina

(a) MSI-AR(1)



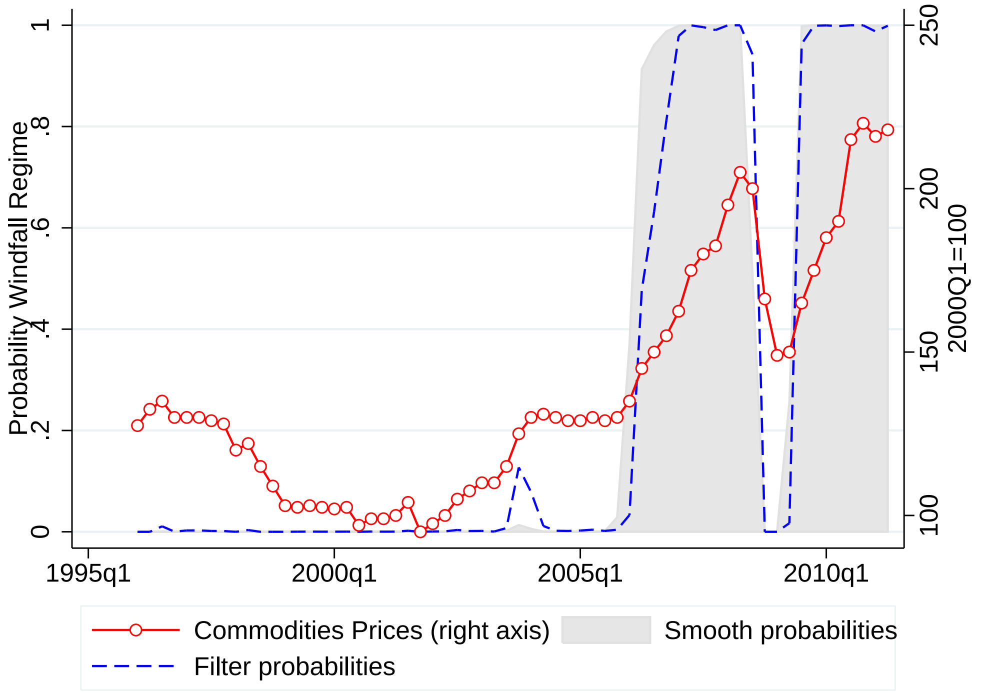
(b) MSIH-AR(1)



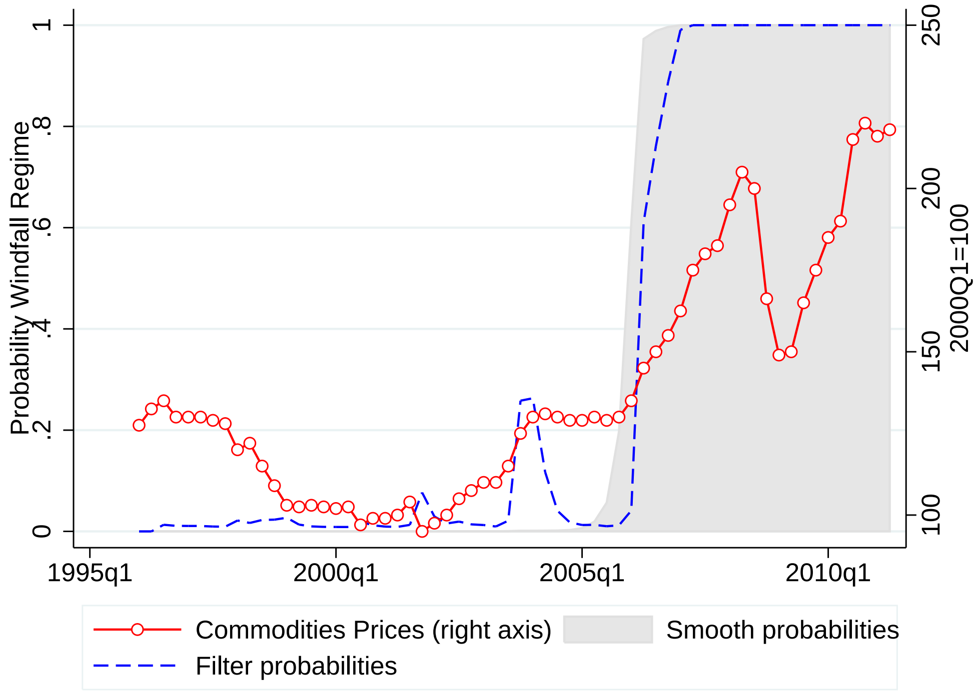
Notes: Figure 2a (2b) shows the regime inference outcome for the export-bundle price of Argentina for the MSI (MSIH) model. The lhs axis measures the smoothed (shaded area) and the filtered (dashed line) probabilities of being in the high commodity price regime, respectively. The rhs axis measures the export-bundle price (red line). Filtered and smoothed probabilities are estimated using Hamilton's Forward algorithm and Kim's Backward algorithm, respectively.

Figure 3: Inference About Windfall Regime: Commodity Prices in SAC-5

(a) MSI-AR(1)



(b) MSIH-AR(1)



Notes: Figure 3a (3b) shows the regime inference outcome for the export-bundle price of SAC-5 for the MSI (MSIH) model. The lhs axis measures the smoothed (shaded area) and the filtered (dashed line) probabilities of being in the high commodity price regime, respectively. The rhs axis measures the export-bundle price (red line). Filtered and smoothed probabilities are estimated using Hamilton's Forward algorithm and Kim's Backward algorithm, respectively.

FIGURE 4: SELECTED QUANTITIES AND EXPORT PRICES: ARGENTINA AND SAC-5

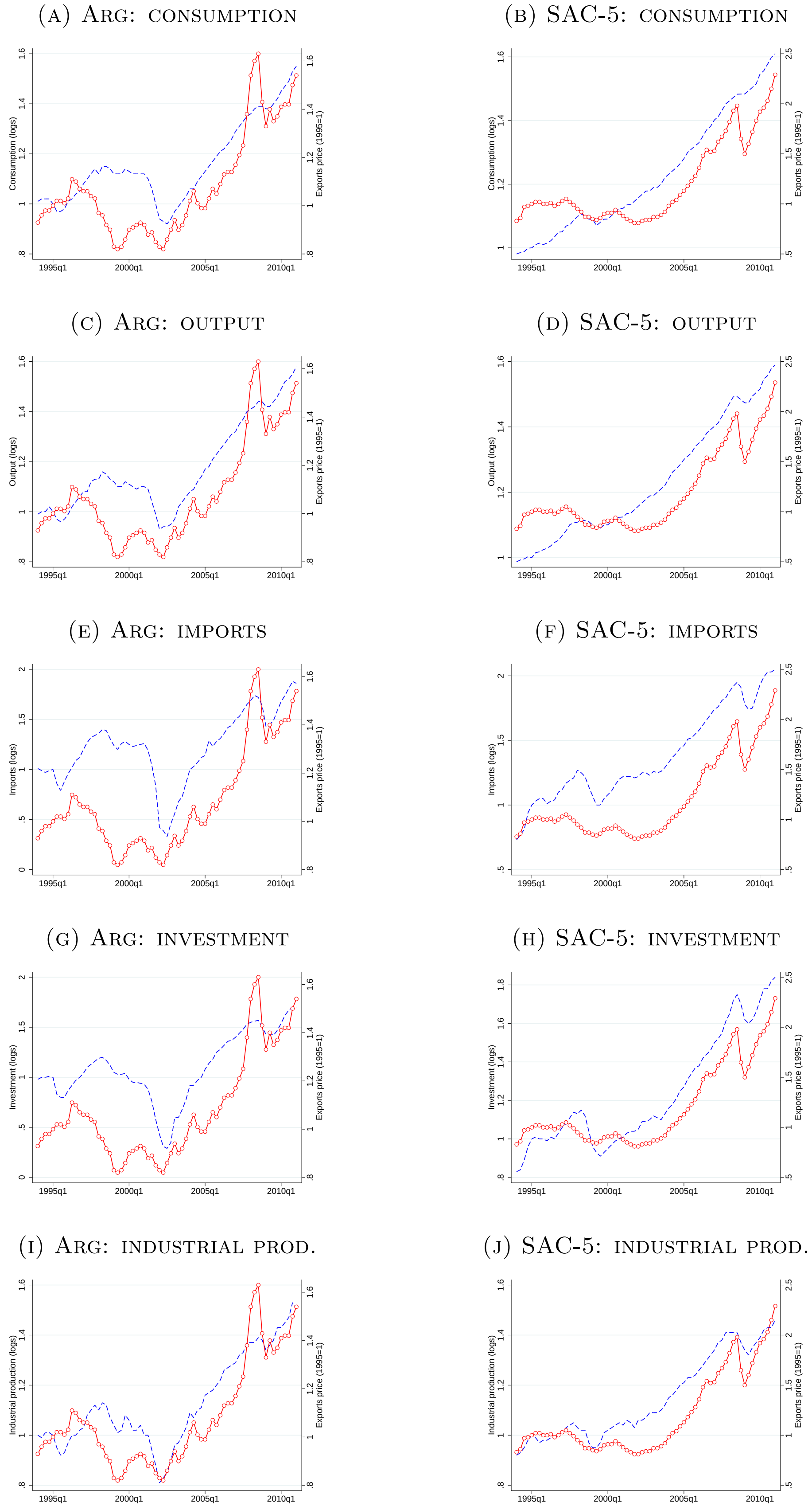
(A) ARG: CONSUMPTION — (B) SAC-5: CONSUMPTION

(C) ARG: OUTPUT — (D) SAC-5: OUTPUT

(E) ARG: IMPORTS — (F) SAC-5: IMPORTS

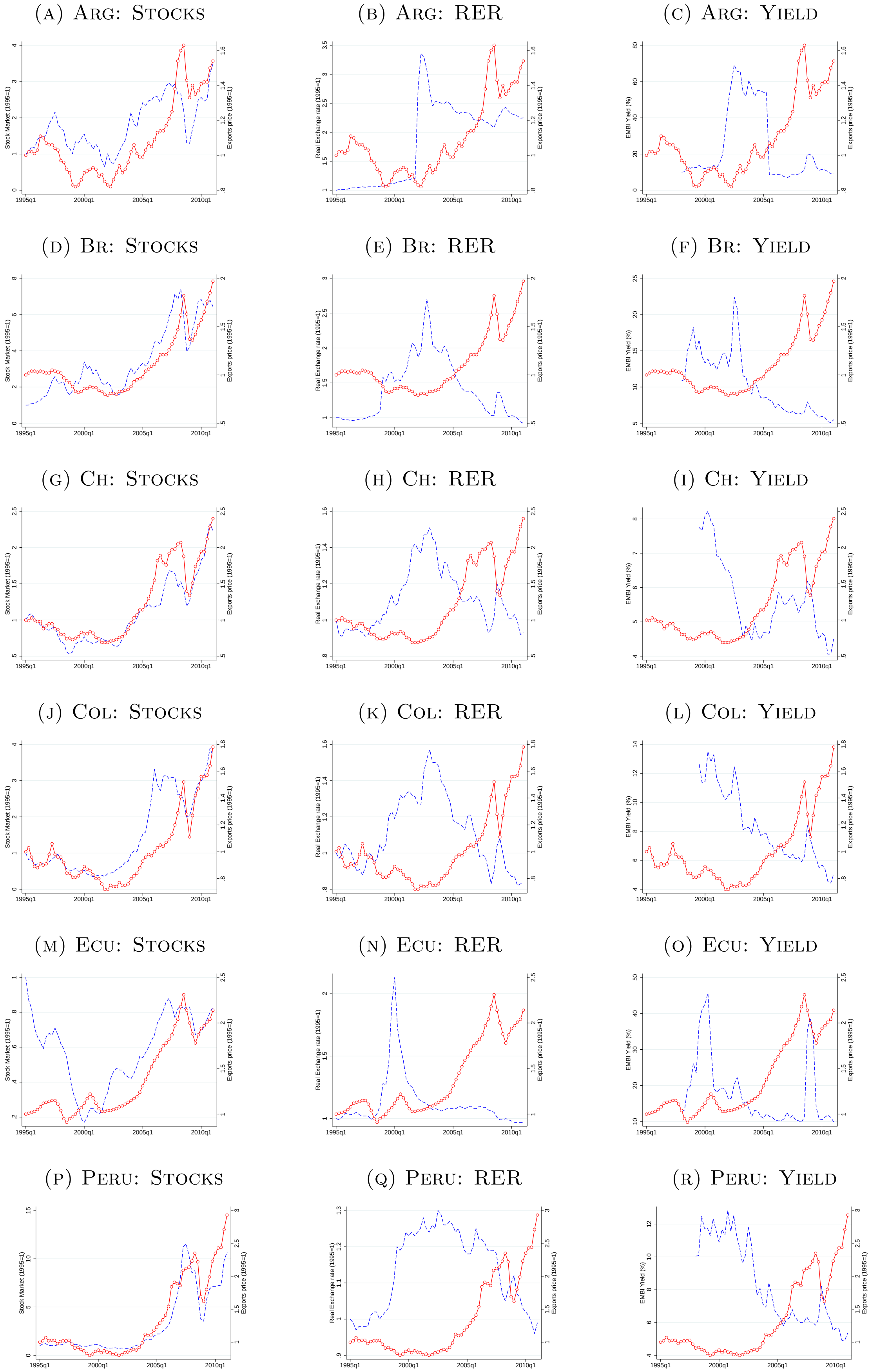
(G) ARG: INVESTMENT — (H) SAC-5: INVESTMENT

(I) ARG: INDUSTRIAL PROD. — (J) SAC-5: INDUSTRIAL PROD.



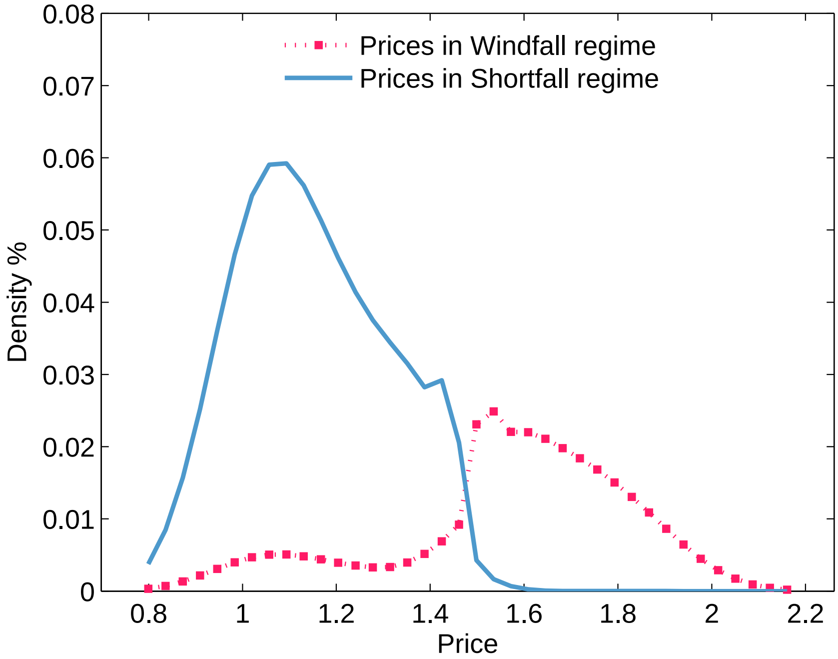
Note: The charts in Figure 4 show for Argentina (left column) and SAC-5 (right column) the time series of a selected (quantity) variable (lhs axis) alongside the export-bundle price series (rhs axis) for the period 4Q1994-2Q2011. Data source: BCRA for Argentina and IDB for SAC-5.

Figure 5: Selected Prices And Export Prices: Argentina and SAC-5



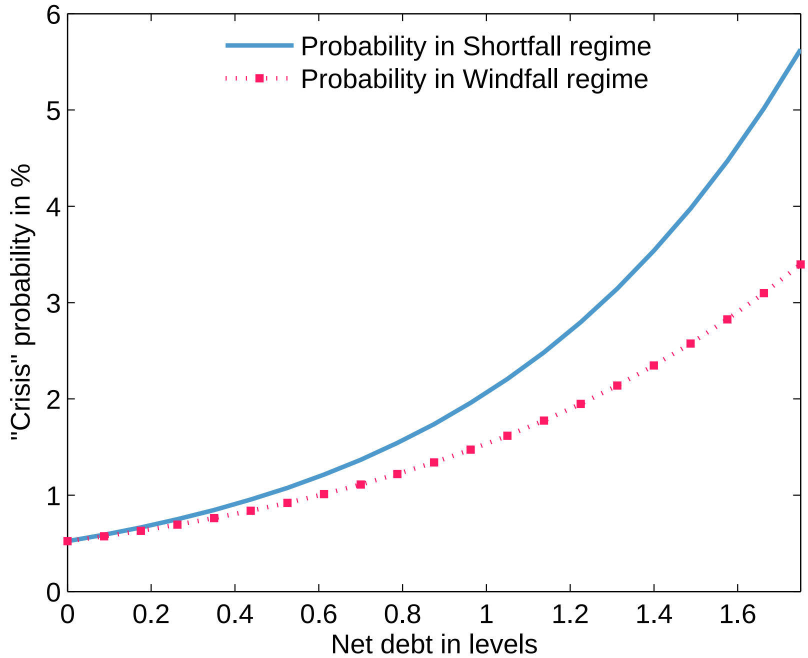
Note: The charts in Figure 5 show for each country (rows) and price variable (columns) the time series of a selected (price) variable (lhs axis) alongside the export-bundle price series (rhs axis) for the period 4Q1994-2Q2011. Data source: BCRA for Argentina and IDB for SAC-5.

Figure 6: Ergodic Distribution Commodity Prices in Simulations



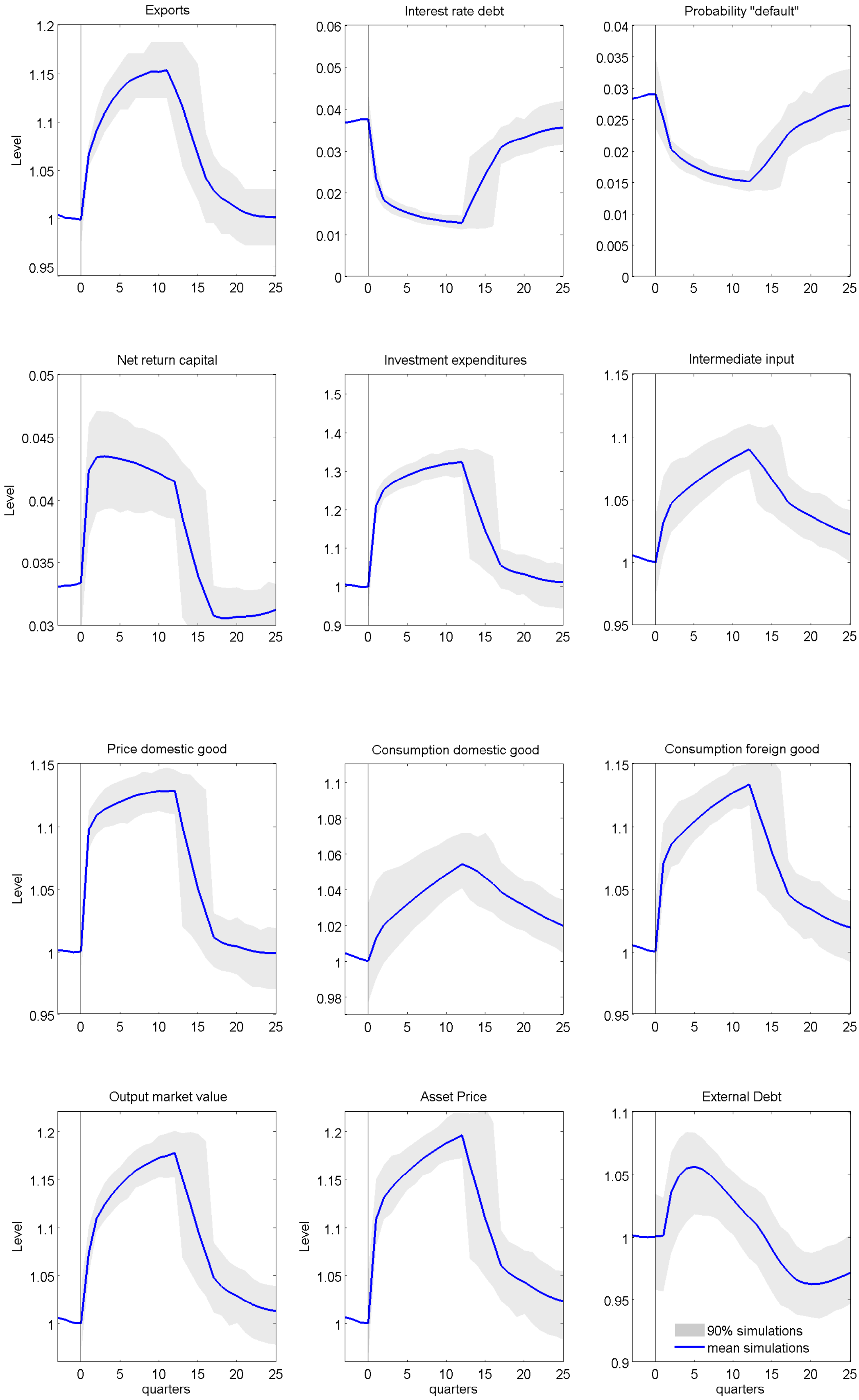
Note: Figure 6 plots the discrete ergodic distributions in each regime of the commodity prices used in the simulations. The discrete approximation to the Markov intercept switching AR 1 process is calculated using the quadrature method proposed by Tauchen and Hussey (1991).

Figure 7: Perceived "Probability" Confiscation Logistic Function



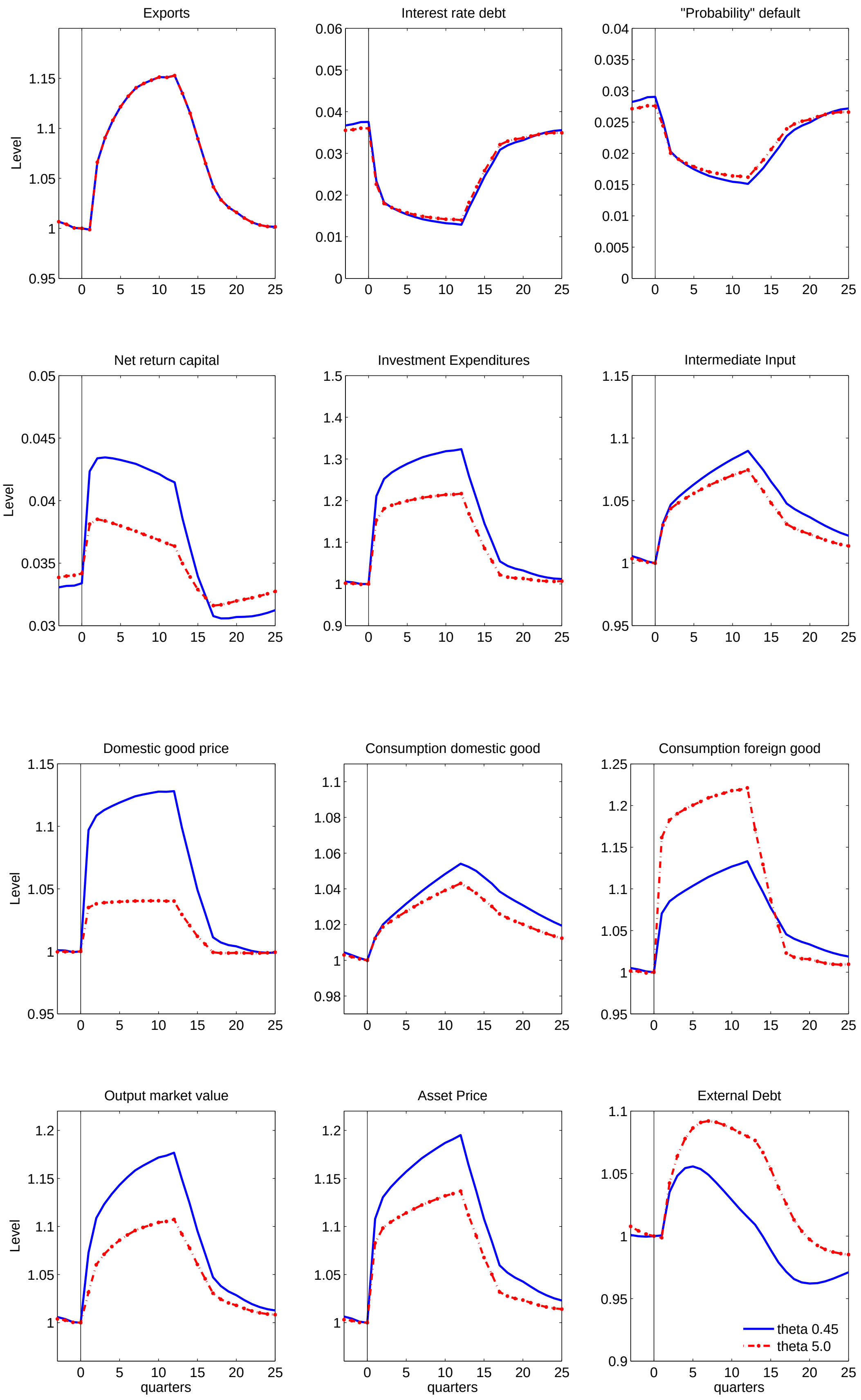
Note: Figure 7 plots the calibrated "perceived" probabilities of confiscation in each regime -evaluated at the mean ergodic export price- as a function of net external debt.

Figure 8: Boom-Bust cycle benchmark case (θ= 0.45)



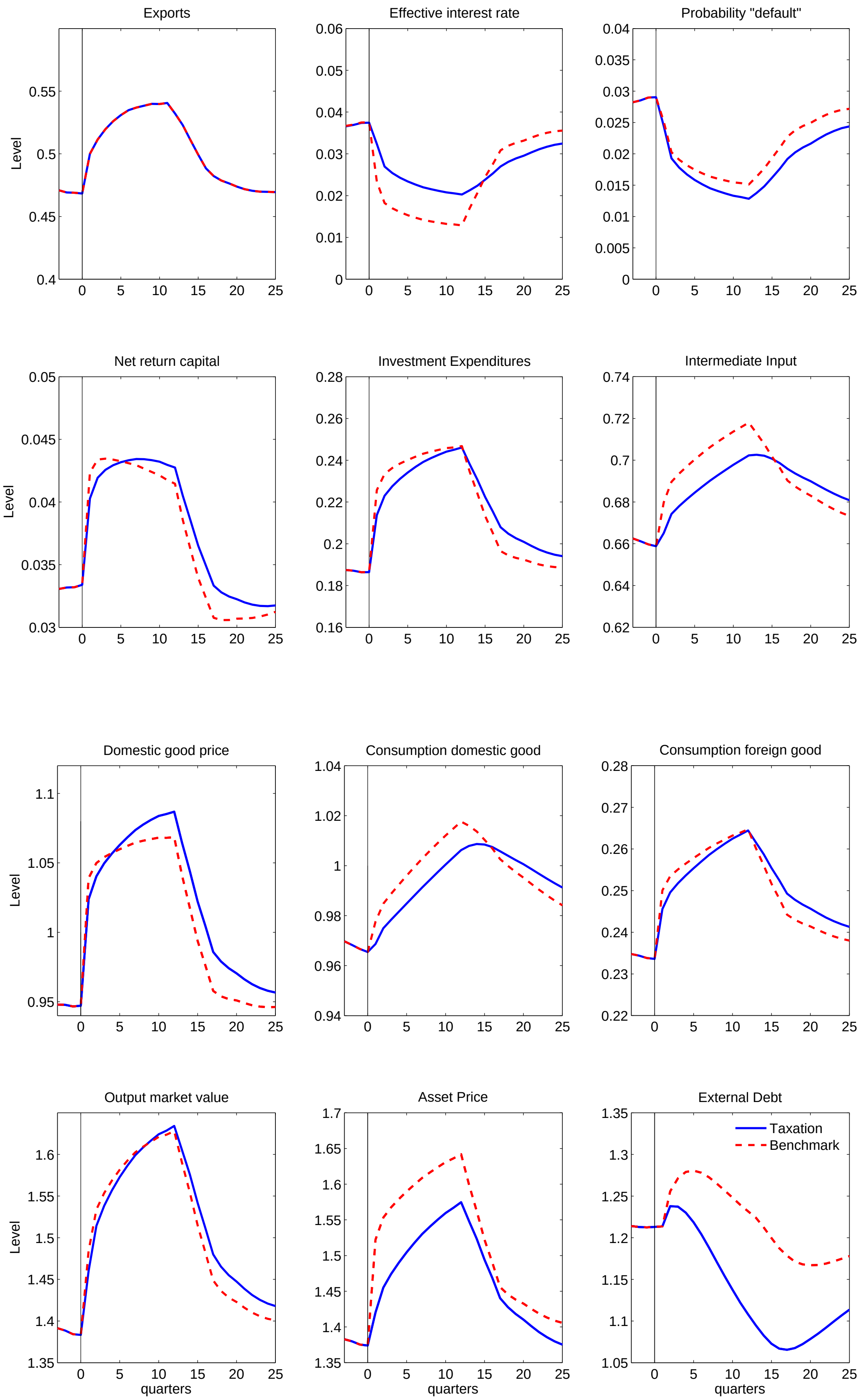
Note: Each chart shows the average value of a variable (solid blue line) over all simulated boom-bust episodes. The gray area denotes where 90% of the simulations lie.

Figure 9: Sensitivity: Benchmark (θ= 0.45) alongside Elastic (θ= 5) case



Note: Each chart shows the average value of a variable over all simulated boom-bust episodes. Solid blue (dashed red) lines correspond to the model with an elasticity of substitution in consumption of 0.45 (5.0).

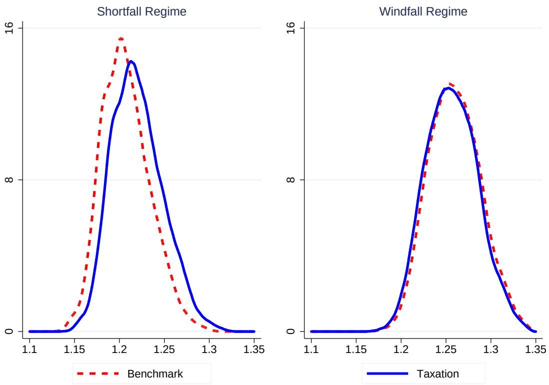
FIGURE 10: SIMULATION: BENCHMARK ALONGSIDE DEBT TAXATION CASE



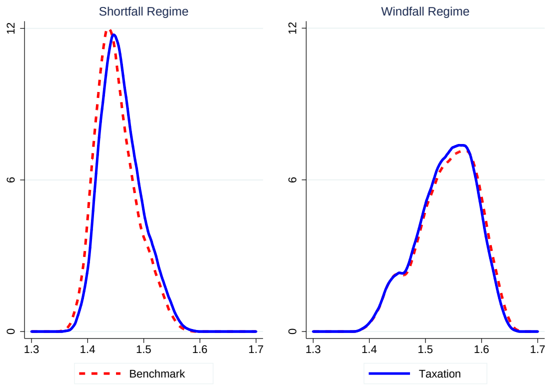
Note: Each chart shows the average value of a variable over all simulated boom-bust episodes. Solid blue (dashed red) lines correspond to the model with a tax rate in the "windfall" regime set at 0% (1%).

Figure 11: Ergodic Distributions Benchmark and Debt Taxation

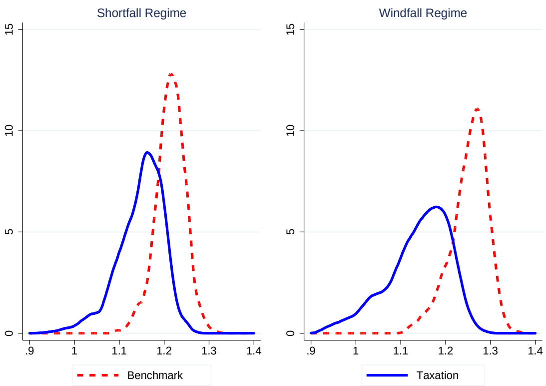
(a) Aggregate consumption



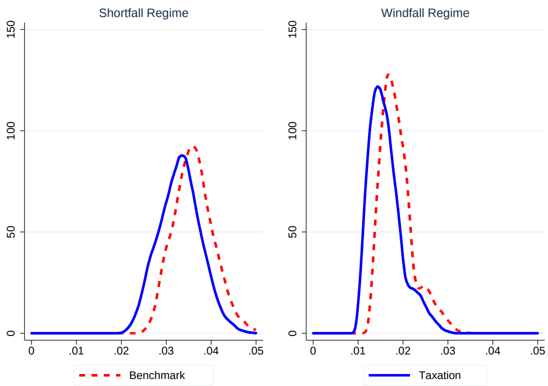
(b) Output



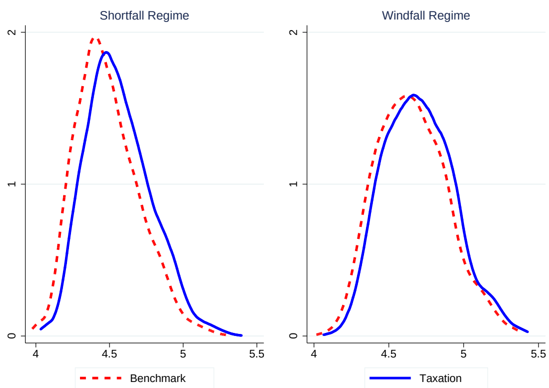
(c) Debt



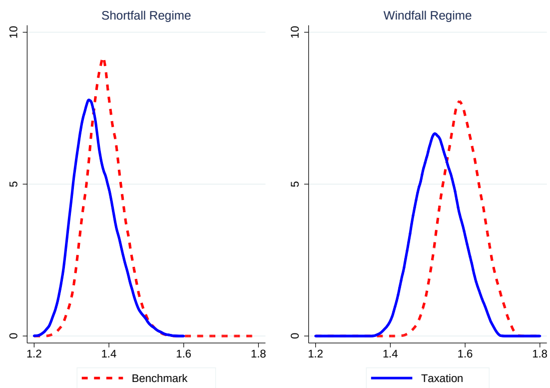
(d) Debt yield



(e) Stock capital



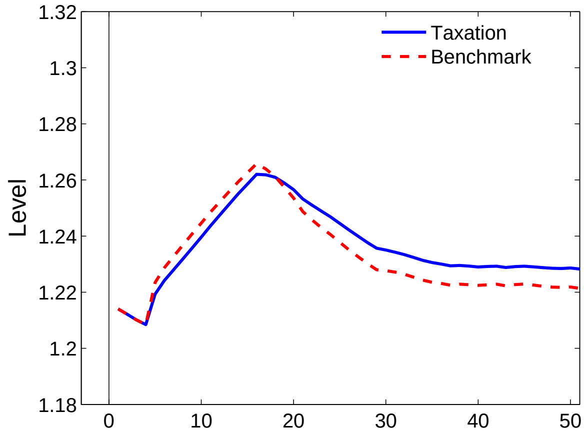
(f) Land price



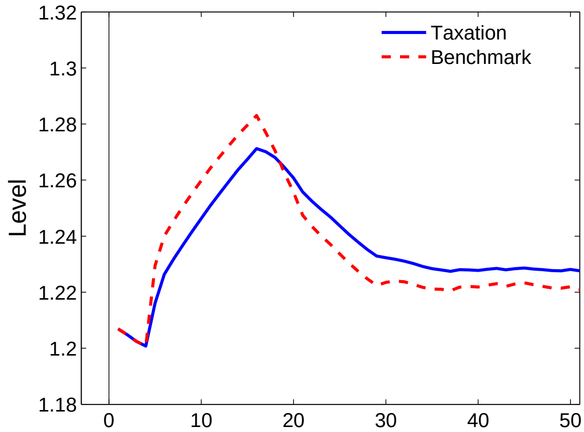
Note: Each chart shows the stationary distribution of a relevant endogenous variable for the model without taxes (blue solid line) and the model with taxes (red dashed line). To estimate the densities, the model is simulated for 10000 periods. After discarding the first 5000 observations, the densities are calculated using Stata's adaptive kernel density estimator.

Figure 12: Intratemporal Friction Sensitivity

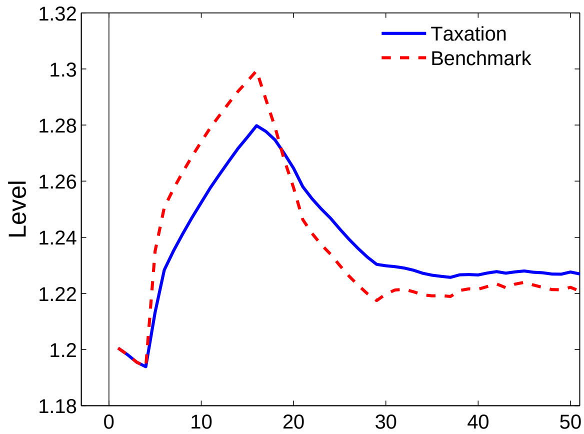
(a) No distortion case $\kappa_m = 0$



(b) Benchmark distortion case $\kappa_m = 1$



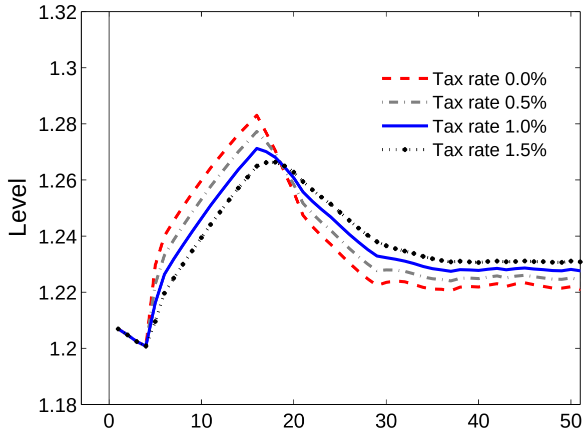
(c) Strong distortion case $\kappa_m = 2$



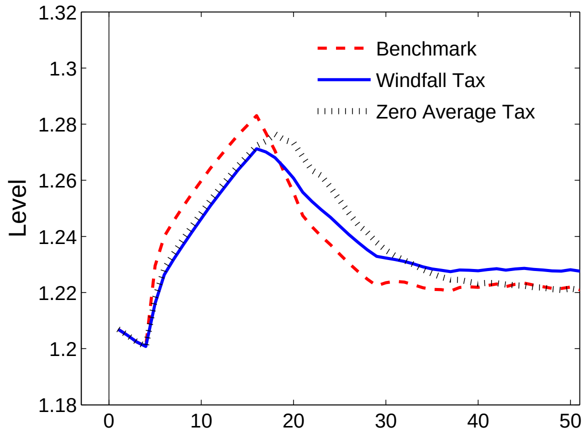
Note: The charts show aggregate consumption dynamics, starting from the onset of a boom, for the model without taxes (solid blue lines) and the model with taxes (dashed red lines) for three different configurations of the intratemporal friction.

Figure 13: Tax Policy Robustness

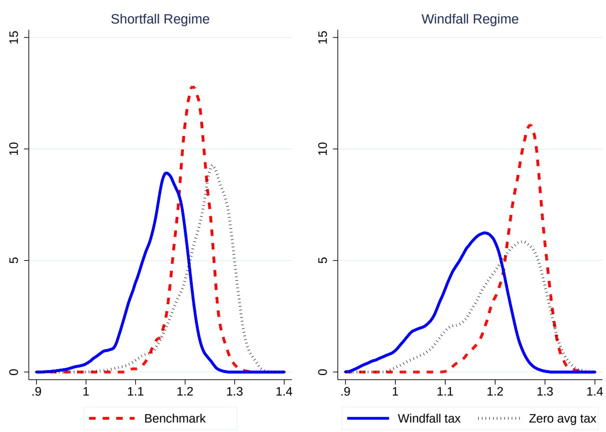
(a) Sensitivity Size Tax Rate



(b) Sensitivity Schedule Tax Rate



(c) The Ergodic Effect on Debt



Note: Figure 13a shows the evolution of average consumption over the selected boom-bust episodes for different levels of the tax rate in the windfall regime. In Figure 13b there are three different tax schedules: no tax, 1% in the windfall regime and a combination of subsidy and tax (zero-across-regimes). Figure 13c plots the ergodic distributions of debt for each tax schedule.

A.3 Theoretical AR(1) Markov Switching Estimator

This appendix details the algorithm used to estimate the Markov switching regime process governing the U.S. real interest rates and the commodity price bundles in the main text. For simplicity, the exposition is confined to the case of two switching intercept regimes only (Markov Switching Intercept model as defined by Krolzig 1997). An extension to frameworks with other parameters being regime dependent is trivial once the main algorithm has been programmed.[48]

The stochastic process under estimation can be summarized as follows:

$$y_\tau = \nu_{s\tau} + \rho y_{\tau-1} + \mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0, \sigma^2) \tag{46}$$

where $s_\tau \in S_\tau = \{1, 2\}$ is described by a transition matrix $\mathbf{\Pi}$ containing the probabilities $p_{ij} = P(s_{\tau+1} = j|s_\tau = i)$ of switching from regime i in period τ to regime j in period $\tau + 1$. Under this configuration the population parameters that need to be estimated can be represented by the vector $\mathbf{\Theta} = (\nu_1, \nu_2, \rho, \sigma, p_{11}, p_{22})'$.

If the regimes were to be known with certainty at each point in time, the model described in (46) would boil down to a dummy variable model that can be directly estimated using standard Maximum Likelihood Estimation (MLE). In that hypothetical case, the log-likelihood would be given by

$$\mathbb{L} = \sum_{\tau=1}^{T} ln(f(y_\tau|s_\tau, \Omega_{\tau-1}; \mathbf{\Theta})) \tag{47}$$

where $f(y_\tau|s_\tau, \Omega_{\tau-1}; \mathbf{\Theta}) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y_T - \nu_{sT} - \rho y_{T-1}}{\sigma}\right)^2}$ is the density of y_τ conditional on the state s_τ and the information set $\Omega_{\tau-1} = \{y_0, y_1, ..., y_{\tau-1}\}$. From the usual first-order conditions, we could get the AR(1) parameter estimates. A separate MLE for the Markov chain would get the remaining parameters.[49]

However, in our case, the current state s_τ is a latent variable that also needs to be estimated by the researcher, adding an extra layer of uncertainty that complicates the estimation process. To see this, notice that the joint density of y_τ and the unobserved regime s_τ can be decomposed as follows,

$$f(y_\tau, s_\tau|\Omega_{\tau-1}; \mathbf{\Theta}) = f(y_\tau|s_\tau, \Omega_{\tau-1}; \mathbf{\Theta}) f(s_\tau|\Omega_{\tau-1}; \mathbf{\Theta}) \tag{48}$$

hence, using (48) we can show that the density of y_τ conditional on $\Omega_{\tau-1}$ is the sum

[48] See Krolzig (1997) for a detail analysis of all possible configurations and their estimation strategy.

[49] A simple MLE for Markov chains shows that $\hat{p}_{ij} = \frac{n_{ij}}{\sum_{j=1}^{2} n_{ij}}$, where n_{ij} is the number of times i followed by j.

of two densities, that is, a mixture of two Gaussian random variables:

$$f(y_\tau|\Omega_{\tau-1};\boldsymbol{\Theta}) = \sum_{j=1}^{2} f(y_\tau, s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta}) \quad (49)$$

$$= \sum_{j=1}^{2} f(y_\tau|s_\tau = j, \Omega_{\tau-1};\boldsymbol{\Theta}) f(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta}) \quad (50)$$

$$= \sum_{j=1}^{2} f(y_\tau|s_\tau = j, \Omega_{\tau-1};\boldsymbol{\Theta}) P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta}) \quad (51)$$

$$= \sum_{j=1}^{2} \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2}\left(\frac{y_\tau - \nu_j - \rho y_{\tau-1}}{\sigma}\right)^2} P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta}) \quad (52)$$

As a result, for a Hidden Markov model, the log-likelihood function becomes:

$$\mathbb{L} = \sum_{\tau=1}^{T} ln(\sum_{j=1}^{2} f(y_\tau|s_\tau = j, \Omega_{\tau-1};\boldsymbol{\Theta}) P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta})) \quad (53)$$

where $P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta})$ is the regime probability.

As is evident from (53), on top of the standard uncertainty from the unknown parameter values affecting the conditional density $f(y_\tau|s_\tau = j, \Omega_{\tau-1};\boldsymbol{\Theta})$, the unobservable regime state term $P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta})$ adds an extra source of uncertainty.

Although is possible to tackle this maximization problem directly with gradient-based methods, an iterative Maximum Likelihood approach based on an application of the Expectation Maximization Algorithm (EMA) developed by Dempster, Laird and Rubin (1977) is usually more robust under poor likelihood surfaces (see Mizrach and Watkins 1999). The algorithm tackles the maximization problem iteratively, dealing with the dual uncertainty problem in two steps within each iteration.

A.4 Inference About Regimes: Smoothed Probabilities Estimator

The exposition and notation follows Hamilton (1990 and 1994) and Krolzig (1997). To form a probabilistic inference about the state at each point in time, we assume that the parameter vector $\boldsymbol{\Theta}$ is known. Let $\hat{\boldsymbol{\xi}}_{\tau|\tau-1}$ be a (2×1) vector whose jth element is $P(s_\tau = j|\Omega_{\tau-1};\boldsymbol{\Theta})$, the so-called **Prediction probability** and let $\hat{\boldsymbol{\xi}}_{\tau|\tau}$ be a (2×1) vector whose jth element is $P(s_\tau = j|\Omega_\tau;\boldsymbol{\Theta})$, the so-called **Filtered probability**. These probabilities are estimated applying Hamilton's (1990) filter that consists of the following forward recursion:

$$\hat{\boldsymbol{\xi}}_{t|t} = \frac{\boldsymbol{\eta}_\tau \odot \hat{\boldsymbol{\xi}}_{\tau|\tau-1}}{\mathbf{1}'(\boldsymbol{\eta}_\tau \odot \hat{\boldsymbol{\xi}}_{\tau|\tau-1})} \quad (54)$$

$$\hat{\boldsymbol{\xi}}_{\tau+1|\tau} = \boldsymbol{\Pi}'\hat{\boldsymbol{\xi}}_{\tau|\tau} \quad (55)$$

where $\boldsymbol{\eta}_\tau$ is a (2×1) vector whose jth element is the conditional density $f(y_\tau|s_\tau = j, \Omega_{\tau-1}; \boldsymbol{\Theta})$ and $\odot$ denotes element-by-element multiplication. To initialize the filter, the researcher can choose $\hat{\boldsymbol{\xi}}_{1|0}$ equal to the ergodic probability of the Markov chain.

This filter recursion delivers estimates $\hat{\boldsymbol{\xi}}_\tau$ for $\tau = 1, ..., T$ based upon information up to time τ, as such, these estimates can be very sensitive to the volatility of the series. If we instead use the whole sample information (all past and future observations), it is possible to improve the quality of the inference.[50] The simplest way of estimating these full-sample probabilities, often denominated **Smooth probabilities**, is to apply Kim's (1993) backward recursion algorithm. Denoting $\hat{\boldsymbol{\xi}}_{\tau|T}$ as a (2×1) vector whose jth element is now $P(s_\tau = j|\Omega_T; \boldsymbol{\Theta})$, the recursion consists of:

$$\hat{\boldsymbol{\xi}}_{\tau|T} = (\boldsymbol{\Pi}(\hat{\boldsymbol{\xi}}_{\tau+1|T} \div \hat{\boldsymbol{\xi}}_{\tau+1|\tau})) \odot \hat{\boldsymbol{\xi}}_{\tau|\tau} \tag{56}$$

where $\div$ denotes an element-by-element division. The process is initialized by realizing that $\hat{\boldsymbol{\xi}}_{T|T}$ is just the last estimate from Hamilton's filter.

A.5 Log-likelihood Function

The conditional probabilities are then replaced by the smoothed probabilities in the likelihood function and taken as fixed when maximizing; thus the log-likelihood function becomes:

$$\mathbb{L}(\boldsymbol{\Theta}) = \sum_{\tau=1}^{T} ln(\sum_{j=1}^{2} f(y_\tau|s_\tau = j, \Omega_{\tau-1}; \boldsymbol{\Theta})\hat{\xi}_{s,\tau|T}) \tag{57}$$

A.6 Expectation Maximization Algorithm for Parameters Estimation

We are now ready to summarize the pseudo-algorithm. It begins with an initial guess for the vector of parameters $\boldsymbol{\Theta}^0$ and then iterates over the following two steps:

1. **E(xpected)-Step**: taking as given the estimated parameters from the previous iteration $\hat{\boldsymbol{\Theta}}^{n-1}$, use the filter and smoothen processes described to estimate the unobserved states $\boldsymbol{\xi}_{\tau|T}$ and replace them in (57).

2. **M(aximization)-Step**: obtain a new estimate of the parameters $\hat{\boldsymbol{\Theta}}^n$ as a solution to the Maximum Likelihood problem (57), where the conditional regime probabilities have been replaced by the estimated smoothed probabilities $\hat{\xi}_{t|T}$ from the E-step. As shown in Krolzig (1997), estimates for the autoregressive

[50] By using the whole sample information, the researcher reduces the chances of misinterpreting an outlier in a given regime for a regime switch.

parameters and the transition probabilities are given by:

$$\hat{\beta} = \left(\left(\sum_{s=1}^{2} (X_s' \Xi_s X_s) \right)^{-1} \sum_{s=1}^{2} (X_s' \Xi_s X_s)^{-1} \right) Y \tag{58}$$

$$\hat{\sigma} = T^{-1} \sum_{s=1}^{2} \hat{\boldsymbol{\xi}}_s \odot (Y - X_s \hat{\beta})'(Y - X_s \hat{\beta}) \tag{59}$$

$$p_{ij}^{n+1} = p_{ij}^{n} \frac{\sum_{\tau=2}^{T} P(s_\tau = j | \Omega_T; \boldsymbol{\Theta}^n) P(s_{\tau-1} = i | \Omega_{t-1}; \boldsymbol{\Theta}^n) / P(s_\tau = j | \Omega_{t-1}; \boldsymbol{\Theta}^n)}{\sum_{\tau=2}^{T} P(s_\tau = j | \Omega_T; \boldsymbol{\Theta}^n)} \tag{60}$$

where $\hat{\beta} = (\nu_1, \nu_2, \rho)$, Y is a $(T \times 1)$ vector, Ξ_s is a $(T \times T)$ diagonal matrix with diagonal values given by the vector $\hat{\boldsymbol{\xi}}_s = (\hat{\xi}_{s,1|T}, ..., \hat{\xi}_{s,T|T})'$ and X_s is a $(T \times 3)$ matrix whose first two columns are ones when the column number is equal to s and zero otherwise.

Once the updated set of parameters $\boldsymbol{\Theta}^{n+1}$ is obtained, return to E-Step until the improvement in the log-likelihood function (57) is less than a pre-established criterion.

A.7 Residual-based Bootstrapping Algorithm for Nonlinearity Test

To partially validate the hypothesis that the Markov switching model is the appropriate representation, a typical test will consider whether the switching parameters are the same in each regime, against an alternative hypothesis that they differ. The problem with this test is that under the null hypothesis, the regime probabilities are not identified; hence the quasi-log-likelihood function is flat with respect to these parameters and the information matrix is singular. A consequence of this *nuisance parameters* problem is that standard likelihood based tests (see Hansen 1996) no longer hold. Several formal tests have been proposed to overcome this difficulty (see Hansen 1992 and 1996, Garcia 1998, Carrasco et al. 2005 and Di Sanzo 2009). I follow Di Sanzo's (2009) bootstrap approach and construct the test with the following steps:

I. Compute the maximum log-likelihood $\mathbb{L}(\hat{\Theta}_0)$ of the linear model AR(1) - under the null - to get an estimate of the parameters $\hat{\Theta}_0$ and the residuals $\hat{\epsilon}_\tau$

II. Estimate the model under the alternative MS-AR(1), compute the log-likelihood $\mathbb{L}(\hat{\Theta}_1)$ and calculate the LR test statistic for the sample

$$LR = 2 \left[\mathbb{L}(\hat{\Theta}_1) - \mathbb{L}(\hat{\Theta}_0) \right]$$

III. Construct the estimated errors $\hat{\epsilon}_\tau$ from the model.

IV. Obtain the bootstrap errors ϵ_τ by re-sampling the estimated residuals $\hat{\epsilon}_\tau$ with replacement.

V. Construct the bootstrap data under the null $\hat{\Theta}_0$ using the following recursion

$$y_\tau = \hat{\nu}_0 + \hat{\rho}_0 y_{\tau-1} + \epsilon_\tau$$

where the initial observation is randomly selected from the data. Repeat this step N-times.

VI. Estimate the model under the null and the alternative and calculate LR^B.

VII. Repeat this step N-times.

VIII. Get the p-value as the fraction of bootstraps LR^B that are greater than the sample LR.

$$p = N^{-1} \sum_{n=1}^{N} \mathbb{I}(LR_n^B > LR)$$

where $\mathbb{I}$ is an indicator function that is equal to one if the condition inside the brackets is true and 0 if false.

A.8 System of Equations of the Model

$$\pi_\tau^{def} = \frac{exp\left(\phi_0 + \phi_1\left(\frac{d_{\tau+1}}{\mathbb{E}(p^x_{\tau+1})}\right)\right)}{1 + exp\left(\phi_0 + \phi_1\left(\frac{d_{\tau+1}}{\mathbb{E}(p^x_{\tau+1})}\right)\right)} \tag{61}$$

$$\epsilon_\tau = (1 + r^f_\tau)\frac{(1-\nu)\pi^{def}_\tau}{1 - \pi^{def}_\tau(1-\nu)} \tag{62}$$

$$R_\tau = 1 + r^f_\tau + \epsilon_\tau \tag{63}$$

$$c_{h,\tau} = F\left(m_\tau, k_\tau, h\right) - m_\tau \tag{64}$$

$$F_m\left(m_\tau, k_\tau, h_\tau\right) = 1 + \kappa_m(R_\tau - 1) \tag{65}$$

$$p_{h,\tau} = \left[\frac{\eta}{1-\eta}\frac{c_{f,\tau}}{c_{h,\tau}}\right]^{\frac{1}{\theta}} \tag{66}$$

$$\frac{d^F_\tau}{R_\tau} = \kappa_m p_{h,\tau} m_\tau \tag{67}$$

$$c_{f,\tau} = X_\tau + \frac{d_{\tau+1} + d^F_{\tau+1}}{R_\tau} - d_\tau - d^F_\tau - k_{\tau+1} + (1-\delta)k_\tau - \frac{\phi}{2}\left(\frac{k_{\tau+1}}{k_\tau} - 1\right)^2 k_\tau \tag{68}$$

$$p_\tau = \left[(1-\eta) + \eta(p_{h,\tau})^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{69}$$

$$C_\tau = \left(\eta^{\frac{1}{\theta}}(c_{h,\tau})^{\frac{\theta-1}{\theta}} + (1-\eta)^{\frac{1}{\theta}}(c_{f,\tau})^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{70}$$

$$C_\tau^{-\gamma} = \lambda_\tau p_\tau \tag{71}$$

$$\lambda_\tau R_\tau^{-1} = \beta\mathbb{E}_\tau\left[\lambda_{\tau+1}\right] \tag{72}$$

$$\lambda_\tau q_\tau = \beta\mathbb{E}_\tau\left[\lambda_{\tau+1}(p_{h,\tau+1}F_l + q_{\tau+1})\right] \tag{73}$$

$$\lambda_\tau(1 + \phi\frac{k_{\tau+1}}{k_\tau} - \phi) = \beta\mathbb{E}_\tau\left[\lambda_{\tau+1}\left(p_{h,\tau+1}F_k + 1 - \delta + \frac{\phi}{2}\left(\frac{k_{\tau+2}}{k_{\tau+1}}\right)^2 - \frac{\phi}{2}\right)\right] \tag{74}$$

A.9 Model Solution Algorithm: Policy Function Iteration

To begin, let us denote the vector of state variables at time τ by $SV_\tau = [S_\tau, p^x_\tau, d_\tau, k_\tau]$, the policy functions for the endogenous state variables by $d_{\tau+1} = D(SV_\tau)$ and $k_{\tau+1} = K(SV_\tau)$, and the rational expectations asset pricing function by $q_{\tau+1} = Q(SV_\tau)$. These functions are approximated over a grid of size $N = n_S \times n_{p^x} \times n_d \times n_k = 2 \times 40 \times 30 \times 30 = 72000$ by piecewise linear functions. The algorithm is implemented with the following steps:

I. Obtain an initial guess $d_0 = D(SV)$, $k_0 = K(SV)$ and $q_0 = Q(SV)$ using the policy functions obtained with a first perturbation by Dynare in a model with a very simple uncertainty structure (a simple AR(1) process for the terms of trade).

II. Given the last estimations $D_{j-1}(SV)$, $K_{j-1}(SV)$ and $Q_{j-1}(SV)$, find $d'' = D_{j-1}(SV)$, $k'' = K_{j-1}(SV)$ and $q'' = Q_{j-1}(SV)$ to apply the Endogenous gridpoint method to the system of equations. From equation (61) until equation (71) operating basically in a sequential order, I obtain: π'_{def}, ϵ', R', m', c'_h, p'_h, d'_F, c'_f, p', C' and λ'.

III. For each node in the grid, I use equations (61) to (63) to calculate R this time.

IV. I am now ready to compute

$$E_D = \beta R \mathbb{E}\left[\lambda'\right]$$

$$E_L = \beta \mathbb{E}\left[\lambda'\left(p'_h F_l\left(m', k', h', l'\right) + q'\right)\right]$$

$$E_K = \beta \mathbb{E}\left[\lambda'\left(p'_h F_k\left(m', k', h', l'\right) + 1 - \delta + \frac{\phi}{2}\left(\frac{k''}{k'}\right)^2 - \frac{\phi}{2}\right)\right]$$

and replace the expectations in equations (72) to (74) to find λ, q and k.

V. From equation (65) get m, then from (64) get c_h. Replace (66) in (69), and use this and (70) to get c_f from (71). Finally, from (67) get d_F and use this to get d from (68). Thus, I have solved the system for this iteration.

VI. Then use k, d, q and k', d', q' to interpolate to find the new iteration results $d'' = D_j(SV)$, $k'' = K_j(SV)$ and $q'' = Q_j(SV)$

VII. If $max(abs[k - k', d - d', q - q']) < tolerance$, jump to the next step, if not return to II.

VIII. I have a solution for this level of uncertainty. If this is not yet at the final level, increase it slowly as in any homotopy process and use the current policy function as the initial guess for the next iteration.

2 Collateral Types and Boom-Bust Cycles Patterns in a Borrowing Constrained Small Open Economy

2.1 Introduction

Latin American countries have been plagued by boom-bust cycles in recent history. Over the last forty years, the major countries in the region have experienced at least two medium-run boom episodes that were followed by a protracted bust episode: the 1975-1981 boom, interrupted by the regional sovereign debt defaults in 1982 and followed by seven lean years in the so-called "lost decade"; and the 1991-1998 boom, abruptly curtailed by the Russian default in August 1998 and followed by four years of capital outflows and weak economic activity (see Calvo 2009 for a thorough description).[51]

In a typical cycle, during the upward phase, macroeconomic indicators move in tandem: financial flows pour in, investment booms, asset prices rally, the real exchange rate appreciates and consumption and output growth are above trend. In the bust phase, as extensively documented by Calvo and Talvi (2005) and Reinhart and Reinhart (2008) among many, the opposite takes place to varying degrees across countries: net positive financial flows are reversed, asset prices give back their gains, the real exchange rate depreciates, output and consumption fall and, in particular, as documented by Cerra and Saraxena (2008), there is a severe and protracted period of low investment levels. In some episodes, the boom comes to an end in such an abrupt manner, triggering a large flow reversal with devastating macroeconomic consequences, that the literature has labelled this particular type of macroeconomic disruption a "sudden stop".[52]

Mendoza and Terrones (2008) analysed these macro credit boom-bust cycles and found that they are uniquely characterized by five stylized facts. First, in developing countries, booms are preceded by large capital inflows but not by productivity gains or financial reforms as is the case for industrial countries. Second, the interest rates are relatively low during the expansionary phase and then, on average, jump 500 basis points one year after the boom peak, as opposed to industrial countries for which the interest rates are more stable and drop after the peak. Third, episodes tend to be highly synchronized within regions and centered around some "big"

[51] It is worth mentioning that in the middle of the second boom, the political events that took place in Mexico in December of 1994 caused a short-lived reversal of flows from Argentina and Mexico that sent both countries into a short lived recession; but without modifying the long-term flow trend. Calvo (2005) considers that the domestic nature of the shock was the main reason behind the rapid resumption of flows once Mexico's transition of power had been completed.

[52] The term was first introduced by Calvo in 1998. See Calvo, Izquierdo and Talvi (2006) for a classification of sudden stops episodes.

events.[53] Fourth, booms are low frequency events with an average duration of about 6 to 7 years. Fifth, not all credit booms end in crises, but most notorious crises in emerging markets followed upon a financial boom.

A tradition of thought in Latin America that dates far back in time states that the main factors behind these low-frequency fluctuations are external developments in the financial "centre". The premise underlying this hypothesis, recently reinvigorated by Calvo and Talvi (2005) and Izquierdo, Romero and Talvi (2008), is that domestic households and firms with irresistible international borrowing opportunities are faced by exogenous improvements in the external financial conditions for "peripheral" countries. Provided that the benign external environment is prolonged (or at least perceived as prolonged) in time, a boom fuelled by low interest rates and capital inflows then follows.[54]

But sooner or later, the story goes, a sudden turn for the worse in global external factors, the usual suspects being risk premia, global liquidity or contagion (see Gonzalez-Rozada and Levy Yeyati 2008 for empirical validation), manifests itself as a shock to the capital account in the "periphery", i.e., an increase in the price and a reduction in the availability of foreign capital.[55] Domestic idiosyncrasies (vulnerabilities) subsequently delineate the characteristics of the unavoidable adjustment process to the negative shock.[56] Thus, in this view, rather than moderating fluctuations in developing countries, they are generated by international financial markets.[57]

This so-called "push" factors view tells a compelling story about cyclical crises in the region. The narrative is appealing because it conforms with many of the stylized facts described, but it has one key weakness: it is not supported by a formal model. Thus, this view fails to formally rationalize how exogenous low-frequency

[53] The "big" events in their study coincide exactly with the two bust episodes described in the initial paragraph. The authors called the one in the 1980's the "Petro-dollar recycling and debt crisis" and the one in the late 1990's the "Sudden Stops".

[54] The literature has found different channels through which low world interest rates affect flows to middle income countries. As discussed in Frankel (2007), one key channel is carry trade and all its previous incarnations. A second channel is the traditional balance sheet channel, through which favourable external conditions increase commodity prices and appreciate the exchange rate, thus improving borrowers' net-worth (see Frankel 2009 and Reinhart and Reinhart 2008). A traditional channel, stressed by Calvo, Leiderman and Reinhart (1993), is portfolio investment seeking higher returns in developing countries. Finally, Dooley and Fernandez-Arias (1996) emphasize that low real rates reduce the default probabilities and risk aversion, thus increasing the perceived repayment capacity.

[55] Diaz Alejandro's (1985) seminal paper described Chile's shock at the onset of the debt crisis in 1982 in a similar fashion "... Chile was also feeling the full force of the international economic crisis and discovering that it was not a "small country" in international financial markets, in the sense of being able to borrow, in either public or private account, all it wished at a given interest rate, even including a generous spread."

[56] Calvo and Talvi consider international trade closedness and liability dollarization as the most relevant vulnerabilites that magnify this type of negative shocks.

[57] See Kaminsky, Reinhart and Vegh (2005) and Smith and Valderrama (2009) for a growing body of empirical research that confirms that capital inflows tend to more often be procyclical than countercyclical.

movements in the cost of borrowing produce boom-bust cycles that on occasions end in an abrupt 'sudden stop" event. This lack of formalization has curtailed our understanding of this type of recurrent events in emerging markets.

In this chapter, I formalize and evaluate this view using a Small Open Economy (SOE) model where I have introduced two special features: low-frequency stochastic movements in the level of the foreign interest rate and a collateral international borrowing constraint - like in Aoki, Benigno and Kiyotaki (2009) - that is permanently binding. These two assumptions create a mechanism for the transmission of foreign interest rate shocks into domestic conditions: *intertemporal wedge spillovers* via collateral markets. As in the model studied in chapter 1, in this setup there is also a financial imperfection - borrowing constraint - creating an externality. In this context, the financial externality increases the return of domestic collateral assets when atomistic agents price the "financial services" provided by the assets. As a result, changes in the return of domestic assets are mainly driven by movements in foreign interest rates. In this environment, the boom-bust pattern that an economy experiences crucially depends on the strength of the wedge spillover - determined by the expected duration of foreign interest cycles and the pledgeability of domestic assets - and on the type of assets that is used as collateral-reproducible or non-reproducible capital.

The mechanism through which the intertemporal wedge emerges and operates in the model is very simple. Consider first a perfect foresight equilibrium and assume that the exogenous interest rate "unexpectedly" falls permanently.[58] The effect of this reduction in the cost of borrowing is akin to an increase in the households' relative impatience when agents are borrowing constrained, as pointed out by Uribe (2007). In effect, in both circumstances, the gap between the shadow interest rate - a hypothetical interest rate that would leave households indifferent to borrowing - and the market interest rate widens. This increase takes place because households now value the marginal unit of borrowing beyond the collateral limit to a larger extent. This positive wedge automatically *spills over* into the Euler condition of capital when it also serves as collateral. This transmission takes place in a decentralized equilibrium because borrowers internalize the dual role played by capital as an input in production and as collateral in financial borrowing. Hence, domestic investment decisions and asset prices are largely affected by conditions in the financial "centre".

To assess the ability of the model to produce plausible boom-bust dynamics, I need to impose the fact that the foreign interest rate fluctuates stochastically between a "low" and a "normal" level, following a symmetric Markov chain. This realistic necessary assumption introduces technical computational complications. That is, although Christiano and Davis (2006) have shown that the wedge spillovers can

[58]The reader should leave aside the intrinsic contradiction of assuming "perfect" foresight and then introducing an "unexpected" shock.

be a powerful quantitative mechanism for the transmission of intertemporal wedge shocks, their analysis was limited to models with smooth linear shocks that can be solved using perturbation techniques. Hence, in my framework, the challenge is significantly harder since I need to implement a solution method capable of dealing with non-linear shocks - the interest rate moves 400 basic points in each switch - calculating the non-negative multiplier in the international borrowing constraint in each state and introducing the spillover effect into the Euler equations of the two types of capital - reproducible and non-reproducible - used in domestic production. In simple words, I need an algorithm not only capable of finding the shadow value of an additional unit of debt but also capable of evaluating how this shadow value modifies the intertemporal conditions for the assets that serve as collateral. The global solution method uniquely suited to deal with this environment is the Parameterized Expectations Algorithm (PEA) introduced by den Haan and Marcet (1990) and later modified by Christiano and Fisher (2000).

With a solution method in place, the model becomes operational after calibrating it to the Argentinean economy on an annual basis. For the external shocks, I assume that foreign interest rate cycles on average last seven years as estimated in Mendoza and Terrones (2008). Although I do not validate the model empirically with a rigorous method, I produce an attempt at validation by simulating the framework for a sufficiently large number of consecutive periods and then selecting all 14 year time series where a complete cycle of seven years of "high" interest rates are followed by seven years of "low" interest rates. The outcome from these simulations of the "benchmark" calibration is used to evaluate the ability of the model to reproduce the dynamics of the main Argentinean macroeconomic aggregates around the time of Russia's default in August 1998.

The general assessment is that the model falls quantitatively short in generating enough action. Nonetheless, it does a reasonably good job in qualitative terms. I take these findings as indirect evidence that the mechanism presented might play a role in a boom-bust episode. The most relevant quantitative failure is in terms of the behaviour of asset prices, since in the data asset prices fell by more than 50% from peak to trough, while the "benchmark" calibration barely generates an 8% asset price swing. The success is due to the ability of the framework to provide a simpler and alternative explanation for the permanent fall in investment, documented after the interest rates have switched back to normal. In the literature, the most familiar argument, exposed by Calvo, Izquierdo and Talvi (2006), considers that after the increase in the cost of debt, firms decide to postpone investment projects in order to rebuild their inside capital since their balance sheets have been weakened and the outside capital cost increased. The alternative, and possibly complementary, explanation provided by this model is that investment falls permanently simply because the investment subsidy vanishes once capital sees its attractiveness as collateral reduced. Thus, a lower return on capital leads to a smaller optimal level of capital in equilibrium.[59]

Then, I move to the most promising outcome of this research project: the association between the type of collateral that is used for pledging and the characteristics of the boom-bust cycle that an economy experiences. For the sake of clarity of exposition, I simulate two polar economies in this respect, one in which only reproducible capital serves as collateral and the opposite in which only non-reproducible capital is pledgeable. My results are interesting and promising. In environments in which agents only use reproducible capital, the intertertemporal wedge spillover resembles an investment subsidy as described in Chari, Kehoe and McGrattan (2007). In this case, switches in the foreign interest rate modify capital accumulation decisions and produce smooth dynamic transitions since there are no price effects affecting budget constraints. Quite on the contrary, in the world in which agents pledge fixed supply assets, regime switches resemble the environment described in Caballero and Krisnamurthy (2006), in which emerging markets volatility is the result of asset price bubbles popping up and bursting stochastically. Indeed, in this economy, switches in the intertemporal wedge generate large swings in asset prices, since the present value of the financial dividend differs substantially between regimes. As a result, given the assumption of a permanently binding international borrowing constraint, the economy adjusts like in the model of bubbles in emerging markets studied by the authors, since switches produce strong domestic absorption movements (current account adjustments) and large asset price swings.

My final conclusion from this investigation is that it is necessary to increase empirical research on the structure of collateral markets in emerging markets. I consider that the rich macro dynamics produced by this framework supports the call of Uribe (2011) to increase our empirical knowledge of these unresearched financial aspects.

2.2 Connection to the Literature

At the empirical level, there is a large amount of research that has tried to identify the role of external factors - the “push” view - in the macroeconomic fluctuations of Latin American countries. The list of papers that confirm the role of global financial conditions as the relevant source of fluctuations in the region is quite extensive. To name some relevant few, Canova (2005) shows that U.S. monetary shocks produce significant fluctuations in the region, but supply and real demand shocks do not. Osterholm and Zettelmeyer (2007) and Izquierdo et al. (2008) find that the level

[59] Clearly, there are other reasons in the model for this, such as the reduction in precautionary savings since there are no downside risks but only upside opportunities in the “normal” interest rate regime. Nonetheless, my point is simply to emphasize that the investment subsidy can be an important force in explaining this stylized fact in middle-income countries.

of economic activity and interest rates in the developed world significantly affects average quarterly growth in the region. Uribe and Yue (2006) estimate a VAR from five countries of the region to disentangle the impact on country spreads of domestic and international factors, and conclude that more than two thirds of the variations in country spreads are driven by external financial conditions.[60] In the same spirit, Gonzalez Rozada and Levy Yeyati (2008) and Longstaff et al. (2010) have separately found that country spreads are highly regionally correlated and are mainly explained by global factors, in particular risk appetite, international liquidity and contagion effects. Longstaff et al.'s (2010) final conclusion gives strong support to the financial "push" factors view explored in this chapter: "... Sovereign credit spreads are generally more related to the U.S. stock and high-yield bond markets, global risk premia, and capital flows than to their own local economic measures".

At the modelling level, the literature has increasingly resorted to interest rate shocks and financial frictions as the main driver behind high-frequency fluctuations in emerging markets. The seminal work of Neumeyer and Perri (2005) includes country risk premium shocks and a working capital constraint to the standard small open economy model to study business cycle fluctuations in Argentina. More recently, Fernandez-Villaverde et al. (2010) introduce stochastic volatility in interest rates and conclude that it is an important factor behind the amplitude and pattern of fluctuations in Latin America. My model shares the prominent role of foreign interest rates in generating fluctuations with these two frameworks, but differs in two critical aspects: First, I instead explore low-frequency fluctuations. Second, my model has a permanently binding international borrowing constraint that produces non-linear dynamics. In this latter aspect, my model is closer to the frameworks used by researchers interested in modelling "sudden stops" dynamics, like Mendoza and Smith (2006) and Mendoza (2010) who employ this constraint to model abrupt non-linear adjustments. The main difference as compared to these two papers is that I model interest rates as the only source of fluctuations, while in the "sudden stop" literature technological shocks are the main source of disturbances, even though the assumption is not supported by the evidence found in Mendoza and Terrrones (2008).[61]

This investigation is also connected with Jeanne and Korinek (2011) that attempts to tackle bust dynamics in a model that uses a domestic asset as collateral in international borrowing. The authors are interested in the negative feedback loop

[60] Argentina, Brazil, Ecuador, Mexico and Peru. They also included the Philippines and South Africa.

[61] Strictly speaking, in Mendoza (2010) there are TFP, terms of trade and interest rate shocks. The reason why the author resorts to three type of shocks is that he needs to generate sudden stops within a framework that also matches the typical second moments of business conditions. Thus, he needs a sudden stop to be an unlikely event, which in this context is a series of consecutive "unlucky" draws of the three random variables. In Mendoza and Smith (2006), the only source of risk is a symmetric two-state Markov chain TFP shock.

that is created on the occasion of a large negative shock by the interplay between the fall in asset prices and a tightening of the collateral borrowing constraint. In effect, in their framework, following a fall in the endowment level, asset prices go down and the tightening of the borrowing constraint reduces borrowing. This, in turn, produces a fall in consumption, further reducing the asset prices and creating a negative feedback loop. Thus, my model shares the fact with their framework that a binding collateral constraint can produce large swings in absorption following a shock. But the similarities stop here, since I do not explore their amplification mechanism and, in my framework, boom-busts mainly arise because agents internalize the dual role played by capital in a constrained economy, whereas in their setup, this effect is completely ignored (probably due to the difficulties in solving the model). Thus, in terms of boom-bust studies, the model presented here is quite unique.

The remainder of the chapter is organized as follows. Section 2.3 documents and analyses the 1991-2002 cycle - with a special emphasis on the period around Russia's default in August of 1998 - for the largest Latin American countries. Section 2.4 introduces the model. Section 2.5 explains in detail how I deal with uncertainty and how the model is solved numerically. In section 2.6, I discuss the calibration issues. Section 2.7 builds the intuition behind the intertemporal wedges spillovers in a simplified setup without uncertainty. Section 2.8 explores quantitatively the ability of a calibrated version of the model to generate empirically plausible boom-bust cycles. Then, in subsection 2.8.2 I study the intimate link between the type of assets that is used as collateral in an economy and the type of boom-bust cycle that the economy experiences. This is done by simulating two polar economies, one in which only capital serves as collateral and the other in which only land has this role. Section 2.9 is a semi-autonomous extension, in which I profit from the structure developed in this chapter to make a small contribution to the literature on "overborrowing" in emerging markets. Section 2.10 concludes the paper, while the appendix details how I apply the Parameterized Expectation algorithm to this model.

2.3 Snapshot of the 1991-2002 Boom-bust Cycle

By the end of the 1980's, after the successful debt restructuring implemented in the Brady Plan, the sovereign debt defaults in the region became things of the past. A side effect of this problem resolution was the development of a liquid secondary market for sovereign bonds. This, in turn, reduced informational frictions and fixed the financial investment costs. According to Calvo et al. (2006), this development was the main driver behind the resumption of private flows into the region in the early 1990's. Around the same time, on the northern hemisphere, particularly in the U.S, the decade saw the beginnings of a secular trend towards lower real interest rates within a financial environment marked by low volatility. These prosperous global conditions were conducive to a surge in net capital flows into the region that effectively ended up stimulating a seven-year regional boom, as concisely summarized in Table 5. In effect, from 1991 until 1997, each major country in the region (Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela) benefited from this benign financial bonanza in which regional average net private inflows were around 2.5% of GDP.[62] As shown by the table, during this upward phase, average yearly output, investment and asset prices growth rates were 4.5%, 11.1% and 7.2% in real terms, respectively, i.e. well above the historical figures.

The first signs of trouble in global financial conditions came with the Asian crisis of 1997. Luckily, the region was relatively unscratched by this major financial event due to the absence of any financial contagion and the weak commercial links with Asia.[63] But the unexpected Russian default in August 1998 was a structural break for Latin America (see every second column in Table 5).[64] Graphically, this break in global financial conditions can be seen in Figure 14a that plots the evolution of the implied volatility of the S&P500 future index (VIX index). It is clear that global risk aversion skyrocketed at the time of the Russian default and remained relatively high thereafter (as compared to the average pre and post crisis values). As claimed in the "push" view, this was not good news for the region.

Indeed, there was an immediate reversal in the net private financial flows (accumulated over the last four quarters) in the region. Figure 14b measures this reversal for Argentina and Figure 14c does the same for an unweighted average of the other six countries (hereafter labelled LAC-6).[65] In less than a year, the entire region went from receiving inflows in the range of 45 billion dollars yearly to experiencing outflows of almost the same magnitude. This implied that from peak to trough, inflows fell by 4.7% as a fraction of GDP, that is, from around 2.4% of GDP to around -2.3% of GDP.

Figures 15a and 15b give a magnitude of the financial shock in terms of the exogenous increase in the cost of borrowing. Indeed, in less than two weeks during August 1998, sovereign bond spreads did, on average, jump by more than 600 basic

[62] Private inflows exclude foreign direct investment flows which tend to be more stable and are less sensitive to global factors such as liquidity or risk aversion (see Smith and Valderrama 2009 for an analysis).

[63] For Chile and Peru, the main exporters of basic metals to Asia, the main effect of the crisis was to decelerate growth.

[64] As analysed in Calvo and Talvi (2005), Mexico's Tequila crisis in 1994-1995 was not a structural break, as it generated a temporary reversal of capital flows - mainly in Argentina and Mexico - that was quickly reversed. These authors conclude that the nature of the shock - domestic political events rather than external factors - is the reason behind the quick recovery of the financial conditions for the region.

[65] Although the initial outflow reversal was more pronounced in LAC-6 than in Argentina, the situation deteriorated for Argentina during 1999, after Brazil had devalued its currency in January.

points. As with financial flows, country spreads also depict a clear cut between the boom and the bust phase, as confirmed by the fact that the region moved from average spreads below 300 basic points at the peak of the boom in 1997 to spreads in the neighborhood of 750 basic points all along the bust phase. Not surprisingly, the increase in the cost of external capital and a massive credit tightening resulted in a drastic across-the-board drop in asset prices. Figures 15c and 15d confirmed the reversal in asset price moves. In effect, in less than a quarter of a year, the asset prices were down by approximately 35% in real terms and ended the year below 50% of the maximum value that they had reached at the peak in 1997. For LAC-6, it took until mid-2003 for asset valuations to regain the losses suffered during the crisis.

The real side of the economy was not immune to this shock and clearly illustrates the scale of permanent shocks that took place in August 1998. As a result of the sheer size of the net transfer of resources from the private domestic sector to foreigners, real per capita seasonally adjusted investment was down by almost 20% at the regional level one year after the default event and only began to recover slowly late in 1999 (see Figure 15f). In Argentina, investment also initially went down sharply but kept falling until the full-blown crisis of December 2001 (see Figure 15e). To provide a magnitude for this adjustment, at the peak of the boom in 1997, the investment to output ratio reached a regional maximum of 23.4% and by 2000, this value was down by 4.5%, close to its level at the beginning of the boom, thus confirming the findinds of Cerra and Saxena (2008). The same figures also show that the impact was less severe in terms of output and consumption, with drops below the 5% mark in all countries, demonstrating that the bulk of the adjustment principally took place in the form of investment level corrections rather than consumption.

After this quick recollection of facts, it seems plausible to consider that the main driver behind this highly synchronized macro boom-bust episode in these countries was to change the financial conditions in the "centre", as argued by the "push" view advocates.

2.4 The Model Environment

The framework is built on the simple growth model of a small open economy developed by Mendoza (1991) and Correia et al. (1995), where I have incorporated some particular features: (*i*) There are two types of capital in the economy, reproducible capital k (indistinctibly called capital in the text) and a natural resource based non-reproducible capital l (that I sometimes call land). (*ii*) There are neither adjustment costs nor investment irreversibilities, thus capital can be transformed back to consumption goods at no cost; hence, its relative is always equal to one. (*iii*) Land is in fixed supply, infinitely divisible and can be sold and bought only by domestic agents in a liquid market for a price of q in terms of the consumption good. (iv) To buy uncontingent one-period discount bonds, foreign creditors require that their purchases have to be fully backed by any type of domestic capital. (v) Domestic firms face a working capital constraint to pay wages. (vi) There is only one source of uncertainty: interest rates that switch between a "normal" level of $R^n = 9.5\%$ (annually) and a "low" level of $R^l = 5.5\%$ following a symmetric two-state Markov chain. (vii) Finally, domestic agents are (relatively) impatient $\beta R^l << \beta R^n <= 1$.[66][67]

2.4.1 Households

A large number of identical, infinitely lived households inhabit the small open economy. Their preferences are represented by the Greenwood, Hercowitz and Huffman (1998) preferences-type (GHH preferences) that is widely used in this strand of the literature :

$$\mathbb{U} = \mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} u(c_\tau - v(h_\tau)) \tag{75}$$

where $c_\tau \geq 0$ denotes consumption, $h_\tau \geq 0$ is the time spent working and the period utility u is a standard continuously differentiable concave utility function that satisfies $u''(\bullet) < 0 < u'(\bullet)$ and $u'(0) = \infty$. The argument of u is the composite commodity $c - v(h)$ that neutralizes the wealth effect on labour supply by making the marginal rate of substitution between consumption and labour supply independent of consumption. This property generates a procyclical supply of labour capable of reproducing business cycle second moments in emerging markets (Correia et al. (1995)).[68] The function $v(h)$ is concave, continuously differentiable and measures the disutility of labour.

Households supply labour, reproducible and non-reproducible capital services, receive factor payments and profits from firms if any, and make consumption, saving and investment decisions. Domestic residents own the stock of capital $k_\tau \geq 0$ and the fixed stock of land $l_\tau = l$ that are rented to the representative firm at a rental rate of r^k_τ and r^l_τ, respectively. We can write the households' period τ flow budget

[66] The impatience hypothesis has been used in an international setting by Paasche (2001) and Aoki, Benigno and Kiyotaki (2007) among many. From a purely theoretical perspective, this could be the outcome of different demographic structures in lenders' and borrowers' societies. It is in line with cross-country empirical evidence that indicates a positive correlation between patience and wealth, as in Becker and Mulligan (1997).

[67] These assumptions guarantee that the stationary distribution of foreign debt holdings is obtained through a model-based approach (see Mendoza 2010 for a description), in contrast to the ad-hoc approaches that impose stationarity by directly picking, for example, the steady-state debt holding (see Schmitt-Grohe and Uribe 2003).

[68] These preferences have also become dominant in the Sudden Stop literature (see Mendoza 2005), since they can reproduce the initial fall in employment once the economy receives a negative income shock.

constraint as follows:

$$c_\tau + i_\tau + d_\tau + q_\tau l_{\tau+1} \leq w_\tau h_\tau + r_\tau^k k_\tau + r_\tau^l l_\tau + \frac{d_{\tau+1}}{R_\tau} + q_\tau l_\tau \tag{76}$$

where the households' sources of funds are labour income $w_\tau h_\tau$, capital rental income $r_\tau^k k_\tau$, land rental income $r_\tau^l l_\tau$, one period noncontingent discount foreign borrowing $d_{\tau+1} R_\tau^{-1}$ and the market value of land holdings $q_{\tau+1} l_{\tau-1}$. Resources are spent on consumption c_τ, investment i_τ, due debt payments d_τ, and purchases of land $q_\tau l_{\tau+1}$.

International financial markets are incomplete and imperfect. First, because foreign borrowing is restricted to one period non-contingent discount bonds $d_{\tau+1}$ at an exogenous interest rate of R_τ. Second, because households are required to fully guarantee their debt obligations by posting any type of domestic capital as collateral. The modelling of this collateral constraint is not micro founded in this setting, but should be understood as a "catch-all" reduced-form that incorporates the many types of financial frictions that plague emerging economies. It is directly imposed as in almost all SOE models (e.g. Mendoza and Smith 2006, Aoki et al. 2007, and Mendoza 2010). In principle, it typifies a situation in which domestic residents cannot pledge uncertain future earnings; instead they need to resort to the use of well founded domestic physical assets, such as capital, residential property or land, to secure borrowing. In particular, I assume that lenders accept only a fraction $\kappa_k \in [0, 1)$ and $\kappa_l \in [0, 1)$ of the end of period value of capital and land, respectively, as a guarantee for future payments.[69] The assumptions imply that the constraint adopts the following form:[70]

$$\kappa_k k_{\tau+1} + \kappa_l q_\tau l_{\tau+1} \geq d_{\tau+1} \tag{77}$$

The assumption that only a fraction of the value of each type of asset can be used as collateral must be interpreted in the light of Krisnamurthy (2003) who shows that introducing a richer set of insurance contracts than those allowed by models in the Kiyotaki and Moore tradition shifts the relevant constraint from an individual level to the total availability of collateral in the economy (see Caballero and Krisnamurthy 1999).

This seems to be a reasonable assumption for an emerging economy with under-developed financial markets, particularly in the light of the strong empirical evidence

[69] This specification describes environments in which contractual enforcement problems or some type of inalienable form of human capital (see Kiyotaki and Moore 1997) prevents foreign lenders from recovering more than a fraction κ of the value of the debtor's assets in case of a contract infringement.

[70] Notice that in the borrowing constraint, I have the current ex-dividend equity price, as opposed to the cum-dividend price in Mendoza's work or the expected price in the work of Kiyotaki and Moore. My choice in this respect is the one that simplifies the calculation of the wedges the most. The ex-ante collateral type is typically used in models that want to generate a negative feedback loop between today's dividend price and borrowing, as in Jeanne and Korinek 2010.

that shows that in these countries, a large chunk of the intermediation of foreign funds takes place through the banking system (see Caballero and Krisnamurthy 1999). Hence, if banks aggregate the available collateral in the economy for foreign borrowing, the constraint is a useful abstraction that encompasses both micro and macro financial frictions. Kocherlakota (2009) provides the best arguments in favor of this type of constraints in macro models: "...it is true that few entrepreneurs literally collateralize their loans using land. However, consider the following chain of transactions...[] Thus, in the real world, there are many layers of paper collateralization that are ultimately grounded in an asset. The model abstracts from these multiple layers".

Consumption goods can be transformed into capital and back at a rate of one to one, so the relative price of capital is always one.[71] The law of motion for capital is thus given by:

$$k_{\tau+1} = i_\tau + (1-\delta)k_\tau \tag{78}$$

where k_τ and $k_{\tau+1}$ denote the beginning and end-of-period stocks of physical reproducible capital, respectively, i_τ denotes period τ gross investment expenditures and $\delta \in [0,1]$ is the depreciation rate.

The household's problem, given the initial conditions (l_t, k_t, d_t) and the process for R_τ, consists of choosing state contingent sequences of $c_\tau, i_\tau, h_\tau, l_{\tau+1}, k_{\tau+1}$ and $d_{\tau+1}$ to maximize expected utility (75), subject to the budget constraint (76), the borrowing constraint (77), and the law of motion for capital (78), for given prices w_τ, r^k_τ, r^l_τ and q_τ. The Kuhn-Tucker first-order conditions of the optimization problem of domestic household's include:

$$v'(h_\tau) = w_\tau \tag{79}$$

$$u'(c_\tau - v(h_\tau)) = \lambda_\tau \tag{80}$$

$$\lambda_\tau \left[\frac{1}{R_\tau} - \mu_\tau\right] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}\right] \tag{81}$$

$$\mu_\tau \geq 0 \tag{82}$$

$$\mu_\tau (d_{\tau+1} - \kappa_k k_{\tau+1} + \kappa_l q_\tau l_{\tau+1}) = 0 \tag{83}$$

$$\lambda_\tau [1 - \kappa_k \mu_\tau] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}(r^k_{\tau+1} + 1 - \delta)\right] \tag{84}$$

$$q_\tau \lambda_\tau \left[1 - \kappa_l \mu_\tau\right] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}(r^l_{\tau+1} + q_{\tau+1})\right] \tag{85}$$

Equation (79) determines the optimal labour supply, stipulating that the disutility of working should be equal to the real wage rate. Equation (80) denotes the marginal

[71]This is a key assumption of this framework because it guarantees a fundamental property: that the price of reproducible capital is always one. It follows that there are no valuation effects in the collateral when only reproducible capital is pledgeable.

utility of consumption. Equation (81) to equation (83) are the conditions with respect to foreign borrowing where μ_τ denotes the Lagrange multiplier associated with the borrowing constraint (77) divided by the multiplier associated with the budget constraint λ_τ. Nonsatiation guarantees that $\lambda_\tau > 0, \forall_\tau$; hence, from equation (81) we can deduce that the borrowing multiplier is non-negative and bounded, $\mu_\tau \in [0, \frac{1}{R_\tau})$. When the constraint is binding, following Uribe (2007), we can define the shadow interest as $\widetilde{R}_\tau = R_\tau/(1 - R_\tau \mu_\tau) > R_\tau$. This non-market interest rate reflects the fact that at the market rate, the household would be willing to borrow beyond the collateral limit.

Condition (84) is the dynamic efficiency equation for capital accumulation. It differs from the standard SOE equation by the fact that agents internalize the dual role of capital and assign a return for the services that it provides as collateral in foreign borrowing. In other words, a binding collateral constraint introduces an intertertemporal distortion in reproducible capital accumulation $\kappa_k \mu_\tau > 0$, that exactly resembles a subsidy to capital accumulation (see Chari, Kehoe and McGrattan 2007).

In a similar fashion, the effect of a binding borrowing constraint spills over into the natural resource condition in the form of a financial service dividend of value $\kappa_l \mu_\tau > 0$ per unit value of "land". Iterating expression (85) forward and imposing a non-bubble condition, we can determine the price of a unit of land and see the impact of a binding borrowing constraint:

$$q_\tau = \mathbb{E}_\tau \left(\sum_{s=0}^{\infty} \left[\prod_{i=0}^{s} \beta^{1+i} \frac{\lambda_{\tau+1+i}}{\lambda_{\tau+i}} \frac{1}{1 - \kappa_l \mu_{\tau+i}} \right] r^l_{\tau+1} \right) \tag{86}$$

It follows from equation (86) that the price of land is the value of the discounted stream of future rents, less heavily discounted in the presence of a binding borrowing constraint.

2.4.2 Domestic Firms

In each period τ, a representative firm entirely owned by the households rents land $l_{\tau-1}$ services, capital services k_τ and labour input h_τ, to produce a final good y_τ according to the production function:

$$y_\tau = F(l_\tau, k_\tau, h_\tau) \tag{87}$$

where there is no technological uncertainty, the function F is assumed to be homogeneous of degree one, increasing in all inputs and concave. All factor markets are perfectly competitive.

Production is subject to a working capital constraint, as first introduced by

Neumeyer and Perri (2005).[72] I assume that domestic firms need to borrow intra-period at market rates from foreign banks to finance a fraction κ_w of the current wage bill. I depart from the literature by assuming that interest rates charged by banks are taxed by the government and fully rebated as a transfer T_τ to the representative household. By doing this, I maintain the direct transmission mechanism linking external financial conditions to labour demand, but avoid imposing the unrealistic additional cost in terms of resource transfers abroad (see Chari et al. 2007) as is the case in Neumeyer and Perri (2005), Uribe and Yue (2006) and Mendoza (2010), where domestic agents pay interest rates to foreigners on both the stock of debt and the working capital positions.[73] [74]

A further clarification regarding this friction is in order. I have included the friction only for the sake of empirical realism, since it guarantees that output responds simultaneously to movements in interest rates, a stylized fact repeatedly validated in the emerging markets literature. Nonetheless, in the calibration, I minimize the effect of this friction to guarantee that this distortion does not play any large role in generating boom-bust episodes. As a result, in the simulations, an interest rate switch produces a contemporaneous change in output of less than 0.25%, i.e. well below the generally accepted values.

Returning to the representative firm, as is standard, it takes prices as given and maximizes profits:

$$\max_{l_\tau, k_\tau, h_\tau, \theta_\tau} F(l_\tau, k_\tau, h_\tau) - w_\tau h_\tau - r^k_\tau k_\tau - r^l_\tau l_\tau - (R_\tau - 1)\theta_\tau \tag{88}$$

subject to the working capital constraint

$$\theta_\tau \geq \kappa_w w_\tau h_\tau \tag{89}$$

At the optimum, firms will never borrow beyond what is required to finance the labour cost, given strictly positive world interest rates; as a result, in equilibrium the working capital constraints will always hold as an equality $\theta_\tau = \kappa_w w_\tau h_\tau$. Using

[72] The success and popularity of working capital constraints in the SOE literature are explained by their ability to introduce a labour wedge between the marginal product of labour and its relative price under GHH preferences. This distortion in the labour demand decisions in equilibrium is manifested as an efficiency wedge that resembles a shock to total factor productivity.

[73] For example, in Mendoza (2010), the labour share represents 66% of output, firms need to finance 26% of the wage bill in advance and the interest rate oscillations are 4%. Thus, when the interest rates increase, the transfers abroad automatically increase by approximately 0.7% of domestic output per year. In Neumeyer and Perri, the interest rates are around 14% and firms need to pay the full wage bill in advance. To my knowledge, no empirical evidence supports the size of these transfers.

[74] For an exhaustive study and criticism of this type of frictions, see Chari, Kehoe and McGrattan 2007.

this result, we can express the optimality conditions of the representative firm by:

$$F'_l(l_\tau, k_\tau, h_\tau) = r^l_\tau \tag{90}$$

$$F'_k(l_\tau, k_\tau, h_\tau) = r^k_\tau \tag{91}$$

$$F'_h(l_\tau, k_\tau, h_\tau) = w_\tau \left(1 + \kappa_w \left(R_\tau - 1\right)\right) \tag{92}$$

These three equations (90 to 92) represent the firm's factor demands and in combination with the assumption of competitive factor markets and constant returns, technology guarantees that profits are zero at all times in equilibrium. Equation (92) shows that the working capital constraint effectively introduces an intratemporal wedge between the marginal product of labour and the real wage rate. This distortion is increasing in the level of interest rates and in the strength of the financial friction κ_w.

2.4.3 Stochastic World Interest Rates

As in Mendoza (2010), I assume that the stochastic process of international interest rates is characterized by a two-point simple persistent rule. Formally, the interest rates R^s follow a Markov chain with state space $S \in \left\{R^n, R^l\right\}$ and symmetric transition probabilities $\mathbb{P}(R_\tau = R_{\tau-1}) = \pi \geq 0.5$. With this specification, the expected duration of each regime is equal to $\frac{1}{1-\pi}$.[75]

Even though this study deals with low frequency fluctuations, it is also technically possible to assume that this stochastic process is the discretized version of an underlying AR(1) process. Indeed, my specification is the two-state Markov-chain approximation to the continuous-valued autoregressive process proposed by Rouwenhorst (1995). As shown in Kopecky and Suen (2010), the autoregressive parameter is $\rho = (2\pi - 1)$ and the standard deviation is $\sigma_\epsilon = 0.5(R^h - R^l)$ under this specification.[76]

As emphasized in the introduction, I am completely silent regarding the true causes behind these interest rate switches. I directly assume that external factors unrelated to domestic conditions are responsible for these fluctuations. Based on the empirical evidence in Gonzalez, Rosada and Levy Yeyati (2008) and Longstaff et al. (2010), the usual suspects are fluctuations in risk aversion, international liquidity or contagion effects.

[75] In formal terms, the expected duration d of any given regime j is given by $E[d_j|S_t = j] = \frac{1}{1-\pi_{jj}}$, for $j \in 1, 2$ and $d_j = T - t$, such that $S_t = S_{t+1} = \cdots S_{t+T} = j$ and $S_{t+T+1} \neq j$.

[76] For those interested in the statistical properties of the method, there is a comprehensive description in Kopecky and Suen (2010). A nice property worth highlighting is that the method always matches the unconditional variance and the persistence of any stationary $AR(1)$ process.

2.4.4 Equilibrium

A competitive equilibrium for this model is a set of infinite sequences for allocations c_τ, i_τ, $k_{\tau+1}$, $l_{\tau+1}$, $d_{\tau+1}$ and prices w_τ, r_τ^k, r_τ^l, q_τ such that households and firms solve their respective problems given the initial conditions (k_t, l_t, d_t), for a given sequence of R_τ, and labour, assets and goods markets clear. The market clearing condition in the goods market implies:

$$c_\tau + i_\tau + nx_\tau = y_\tau \tag{93}$$

where nx_τ is the value of net exports given by $d_\tau - d_{\tau+1}R_\tau^{-1}$. Since, by assumption, in the model, domestic agents do not hold foreign assets and non-residents are not allowed to hold either capital or land, the household's debt position d_τ is what is commonly defined as the net external position in the balance of payments statistics.

2.5 Dealing with Uncertainty in the Model

Solving non-linear rational expectations models presents difficulties because their solutions involve dealing with conditional expectations that depend on future choice variables, future prices and a future realization of stochastic state variables. Nonetheless, a vast array of methods for solving this types of models has been developed over the years. The simplest strategy is to use linear or log-linear approximation methods around the steady state and then obtain (local) approximate solutions. However, the inherent non-linear structure of this model makes this strategy completely inappropriate. The same kind of argument applies to high-order perturbation methods.

A method that could handle non-linearities is value function iteration (VFI). Following Mendoza and Smith (2006), the literature has been able to solve SOE models with potentially binding collateral constraints linked to asset prices by resorting to what the authors define as a "quasi social planner" algorithm, that is to say, by solving the problem like a central planner. The weakness of this strategy is that the planner selects quantities directly, thus internalizing the impact of her decisions on the collateral constraint. The authors acknowledge this drawback, but claim that it has minimal consequences. What they do not recognize, though, is that their claim is correct, provided that the constraint is binding with very low probability and is not so tight. But if this is not the case, the distortion can be sufficiently large to substantially alter the equilibrium values. My results, in contrast, rest on the two opposite properties: the constraint is always binding in my calibrations and its tightness varies substantially with movements in R. For this reason, I have not even attempted to solve the model with this algorithm.

Fortunately, there is a global solution method that can deal with this framework in a very simple way: the Parameterized Expectations Approach (PEA) presented in den Haan and Marcet (1990). It has four properties that make it suitable for solving this model: First, it does not suffer from the curse of dimensionality and, therefore, it can be applied to models with many endogenous variables. Second, it is very easy to apply in models with occasionally/regularly binding constraints, because there is no need to solve separately for the policy and multiplier functions, as it would be with policy function iterations, for example (see Christiano and Fisher 2000). Third, it can be applied to inefficient economies with endogenous collateral constraints, externalities, distortions, etc. Fourth, there is a substantial degree of freedom in choosing the functional form to be parameterized (see Maliar and Maliar 2005). The main drawback is that convergence is not guaranteed and it is not possible to rule out numerical instabilities. To minimize this potential difficulty, I restrict the amplitude of the shocks to manageable values (interest rate fluctuations) in the simulations.

The algorithm aiming at finding accurate approximations of the expectations functions appearing in the first-order conditions using some polynomial or other known functional forms of the state variables. The goal is to obtain the coefficient values that minimize an appropriately defined residual function evaluated at the approximated solutions. The version I use is what is now commonly referred to in the literature as the non-stochastic PEA implementation (see Christiano and Fisher 2000), following the modifications introduced in the original PEA (stochastic implementation) based on the ideas discussed in Judd (1998): instead of using stochastic simulations to obtain the data, the state space is discretized choosing the grid points at which to evaluate the conditional expectations according to the zeros of the Chebyshev polynomials. The benefit of using the actual conditional expectation, rather than the stochastic realization, is that we eliminate sampling noise and linear regression methods can be used to estimate the coefficients. The advantage of choosing the nodes in this form is that we gain in efficiency since the limits of the grid space will be over sampled, putting more weight on the areas where non-convexities could potentially arise and the stochastic steady states reside.

Moving to the actual implementation in this model, the solution requires that the three expectations resulting from the first-order necessary conditions are approximated, one for each stock variable (k, d, l). I denote by Θ, Φ, and Υ the approximation functions for the expectations in the Euler equations for bonds, capital and land, respectively. The coefficients in each approximation are denoted by ϑ_Θ, ϑ_Φ and ϑ_Υ. Since I only have two stochastic states, I approximate one conditional expectation per stochastic state; hence, I denote by superscript s the coefficients corresponding to the stochastic state $s \in S$.

To begin the analysis, assume that for a given grid point - that is a triplet (k, d , R^s) - the international borrowing constraint is slack and, as a result, $\mu_\tau = 0$.

Then, the system of three equations dealing with the expectational approximation functions becomes:

$$\lambda_\tau = R_\tau \Theta(k_\tau, d_\tau; \vartheta^s_\Theta) \tag{94}$$

$$\lambda_\tau = \Phi(k_\tau, d_\tau; \vartheta^s_\Phi) \tag{95}$$

$$q_\tau \lambda_\tau = \Upsilon(k_\tau, d_\tau; \vartheta^s_\Upsilon) \tag{96}$$

A simple visual inspection reveals that this system is not invertible and, hence, a solution cannot be found: the first two functional approximations pin down the same endogenous variable. To solve this problem, I apply the solution offered by Marcet and Singleton (1999). In this case, I introduce a monotone transformation of another endogenous variable on both sides of the Euler equation for bonds. In effect, by dividing both sides by $(1 + d_{\tau+1})$, invertibility is guaranteed since the system now has three endogenous variables and three functional approximations.[77] This transformation implies that the approximation for the Euler equation for bonds is as follows:

$$\frac{\lambda_\tau}{(1 + d_{\tau+1})} = R_\tau \beta \mathbb{E}_\tau \left[\frac{\lambda_{\tau+1}}{(1 + d_{\tau+1})} | R_\tau = R^s \right] \simeq R_\tau \Theta(k_\tau, d_\tau; \vartheta^s_\Theta) \tag{97}$$

Now, consider the alternative case and assume that the international borrowing constraint is binding, that is $\mu_\tau > 0$. In this case, the Euler equation for bonds no longer holds as an equality, hence we “lose” one equation. But this is no problem since we gain one additional equation as the borrowing constraint now holds with equality (see Marcet and Singleton 1999 for a detailed analysis of this type of cases). However, the problems arise in the approximations of the Euler equations for capital and land. The reason is that the presence of $\mu_\tau > 0$ precludes us from finding the solution, as we have an additional unknown variable:

$$\lambda_\tau [1 - \kappa_k \mu_\tau] = \Phi(k_\tau, d_\tau; \vartheta^s_\Phi) \tag{98}$$

$$q_\tau \lambda_\tau [1 - \kappa_k \mu_\tau] = \Upsilon(k_\tau, d_\tau; \vartheta^s_\Upsilon) \tag{99}$$

Intuitively, the problem that we now face is that the spillover effect introduces a different circularity, since it is necessary to know μ to find the solution, but the solution depends on μ.[78]

As explained, the flexibility of the algorithm allows for a reparameterization of both equations in such a way that it is not necessary to know the current multiplier μ_τ to find the solution in the current iteration. To achieve this, I simply move the

[77] In the appendix I explain the technical reason for this choice: guarantees that the Kuhn-Tucker conditions always hold in a solution.

[78] Consider the fact that to know the asset price q, we need to know μ, but the asset price determines borrowing and hence affects μ, which, in turn, modifies q.

terms involving the intertemporal spillovers from the LHS of the equations to the RHS inside the functional expectation to be approximated. In addition, further exploiting the flexibility of the algorithm, I also move the budget constraint current multiplier λ_τ in the land equation to the RHS. With this final modification, the polynomial in the expectational approximation Υ needs to approximate a smooth expectation like q_τ, rather than the more cumbersome $\lambda_\tau q_\tau$. With these changes, the two conditions become:

$$\lambda_\tau = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1} \left(\frac{r^k_{\tau+1} + 1 - \delta}{1 - \kappa_k \mu_\tau} \right) | R_\tau = R^s \right] \simeq \Phi(k_\tau, d_\tau; \vartheta^s_\Phi) \tag{100}$$

$$q_\tau = \beta \mathbb{E}_\tau \left[\frac{\lambda_{\tau+1}}{\lambda_\tau} \left(\frac{r^l_{\tau+1} + q_{\tau+1}}{1 - \kappa_l \mu_\tau} \right) | R_\tau = R^s \right] \simeq \Upsilon(k_\tau, d_\tau; \vartheta^s_\Upsilon) \tag{101}$$

The reader might be wondering if the solution proposed still accounts for the spillover effects introduced by μ_τ? The answer is a definite yes, but it does so via a subtle trick. That is, in each iteration, we take these values as given, but once we find the current solution, we include the spillover effects when we update the expectational functions for the next iteration. On a computational level, the trick involves that for each grid point in iteration j, I solve the model using the expectations calculated with the multipliers found in iteration $j-1$. In other words, the multiplier value obtained at iteration j enters the solution through the calculated conditional expectation of iteration j and will a have direct effect on the solution at iteration $j+1$ through the updated coefficients of the approximating functions. This simple trick breaks the circularity between the multiplier, total borrowing and the two endogenous assets when the international constraint is binding. To my knowledge, this is the first attempt in the literature to implement such a solution.

To conclude, when the borrowing constraint is not binding, the three equations involving expectational functions are active and take the following form:

$$\frac{\lambda_\tau}{1 + d_{\tau+1}} = R_\tau \Theta(k_\tau, d_\tau; \vartheta^s_\Theta) \tag{102}$$

$$\lambda_\tau = \Phi(k_\tau, d_\tau; \vartheta^s_\Phi) \tag{103}$$

$$q_\tau = \Upsilon(k_\tau, d_\tau; \vartheta^s_\Upsilon) \tag{104}$$

In the appendix (B.3) I give full details of some relevant technicalities of the algorithm and also explain the steps to instrument the algorithm.

2.6 Calibration

To introduce some discipline in the evaluation of the model, I calibrate the setup to the Argentinean economy. I set many of the parameters following the literature that attempts to match second-order business cycle moments from the data in emerging markets. By doing this, I exclude the possibility of introducing controversial values given the abundance of studies choosing Argentina as their case study.

To numerically evaluate the model, I first need to make explicit assumptions regarding functional forms and parameter values. I assume a CRRA form for the composite commodity period utility function and the disutility of labour, and a Cobb-Douglas technology for the production of output:

$$u(c_\tau - v(h_\tau)) = \frac{\left[c_\tau - \xi \frac{h_\tau^\theta}{\theta}\right]^{1-\sigma} - 1}{1-\sigma}, \qquad \sigma, \theta > 1 \tag{105}$$

$$F(l,k,h) = A l_\tau^\gamma k_\tau^\alpha h_\tau^{1-\gamma-\alpha}, \qquad 0 < \gamma, \alpha < 1, \quad A > 0 \tag{106}$$

These functional forms are quite standard in the SOE literature. The parameter σ is the coefficient of relative risk aversion (also the inverse of the intertemporal elasticity of substitution) and θ determines the wage elasticity of labour supply.[79]

Table 6 lists the values assigned to each parameter. In the model, one period corresponds to a year.[80] The moment utility and labour curvature parameters are set at $\sigma = 2$ and $\theta = 1.8$. These values are in the range of those typically used in SOE models by several authors (e.g Uribe and Yue (2006), Aguiar and Gopinath (2007), Mendoza (2010) and others).

The labour income share is always underestimated in the official statistics in Latin American countries, possibly due to the high proportion of informal workers in the labour market.[81] As such, researchers have been using values that are close to those used for developed countries. I follow the literature on this and set the labour income share $(1-\gamma-\alpha)$ at 0.64, in line with other studies such as Neumeyer and Perri (2005) which set this parameter at 0.62 or Mendoza (2010) which sets it at 0.66. The labour weight ξ just scales and normalizes the input of hours to approximately 1 in the steady state.

A difficult parameter to calibrate is the share of each type of capital in the production process. In order to find a plausible range for these parameters, I resort to the study by Caselli and Feyrer (2006) that found that in comparable Latin American countries (e.g. Chile, Mexico, Peru and Uruguay), non-reproducible capital payments are very high and could reach up to 45% of total capital income.[82] As this

[79] The elasticity is given by $\frac{1}{\theta-1}$.

[80] A higher frequency choice would make less precise the evaluation of the role played by the multiplier in the borrowing constraint.

[81] The extreme example is Mexico where the share of labour income in GDP is about 1/3 in the official statistics, but estimates from Garcia-Verdu (2005) using data from a survey of households duplicate this figure.

[82] Using data compiled by the World Bank, these authors separated natural capital from reproducible capital to re-calculate the share of output paid to reproducible capital and showed that previous studies were overestimating the marginal-productivity of reproducible capital in natural resource rich countries.

work uses official data to estimate the labour shares, it is also subject to the same methodological criticism. Thus, I take these values as an upper bound in terms of the capital income share.[83] On the other hand, although very volatile, Argentina's average investment-output ratio has been around 18.3%.[84] Thus, if I my objective is to match this ratio without assuming unreasonably high depreciation rates for reproducible capital, a compromise is in order. Henceforth, I set $\alpha = 0.30$, $\gamma = 0.06$ and $\delta = 0.12$ which guarantees that in a non-stochastic steady state with "normal" interest rates, the reproducible capital to output ratio $\frac{k}{y}$ is 1.38, the total capital at market values to output ratio $\frac{k+ql}{y}$ is 1.99 and the investment to output ratio $\frac{i}{y}$ is 18.5%. All these values are within the generally accepted range in the literature. The supply of land is normalized to $l = 1$.

I calibrate the subjective discount factor β to match the average price-dividend ratio of 10.5 observed in Argentina for the period covered from 1985 until 2001 (data from International Finance Corporation Annual Factbooks). This implies choosing $\beta = 0.913$. This value is within the range used in the related literature: Schmitt-Grohe and Uribe (2011) set this value at 0.93, Aghion et al. (2004) and Uribe and Yue (2006) use 0.90, Aoki et al. (2006) use 0.91, and Neumeyer and Perri use 0.89. This value is very conservative as compared to the values used in the quantitative literature that deals with models of endogenous sovereign default.[85]

In the context of the model, it is not an easy task to calibrate the parameters of the Markov process governing interest rates. To explore the range of plausible values, I extended the series of Argentinean quarterly real interest rates constructed by Neumeyer and Perri (2005) until 2009 and found that over a period of 30 years, the range of values goes from minimums close to 4.6% per annum (p.a.) to maximums near 60% p.a..[86] If I discard the crisis events and the years in which the country was technically in default, I found periods of international bonanza, like the years preceding the Russian crisis or the sub-prime meltdown, with interest rates of an historical minimum of 5.1% p.a., and less benign international environment periods when the lower bound is always above 10% p.a., like during the 1980's or following the Russian default. Since I am only using a two-point Markov process and I have

[83] Caselli and Feyrer's work shows the difficulties and the room for potential misleading conclusions that can arise when estimating income shares in countries with large informal sectors. An example of these are the cases of Ecuador and Paraguay, with estimated labour income shares of 45% and 49%, respectively, which are well below the plausible values.

[84] Measured at current prices, the investment rate reached a minimum of 10.35% during the 2002 crisis and set a maximum of 23.1% in 2010.

[85] Aguiar and Gopinath (2006) needed a value of $\beta = 0.8$ to generate empirically plausible default probabilities in a model of Argentina.

[86] The original Argentinean interest rate series constructed by Neumeyer and Perri (2005) can be found at www.perri.net/data/neuperri.xls. I extended the series using the methodology proposed by the authors: the nominal interest rate is the sum of the yield for the 90-day U.S. T-bill plus the corresponding J.P. Morgan EMBI spread. To obtain the real rate, I deflate the nominal rate by U.S. GDP deflator expected inflation. Expected inflation is calculated as the average inflation of the current and the preceding quarter.

imposed the restriction that $R^n\beta = 1$, I am limited to find a "representative" value for the low interest rates scenario. To this end, I decided to follow Mendoza (2011) that argues that 400 basic points constitute a reasonable estimate for interest rate shocks in emerging markets. Thus, given the baseline interest rate of $R^n = 1.095$, the interest rates during international bonanzas is set at $R^l = 1.055$. My final choice is in line with Mendoza (2010), which uses $R^{Low} = 1.066$ and $R^{High} = 1.106$ in a model calibrated to the Mexican economy.[87]

As established in Mendoza and Terrrones (2008), the average duration of a credit boom in emerging markets is between six and seven years. To guarantee that agents in the "benchmark" case expect seven-year booms, I choose $\pi = 0.857$, which also implies a first-order autocorrelation $\rho^R = 0.714$ on an annual basis.[88]

I now turn to the three parameters governing the borrowing constraints. In Argentina, there is no data available on working capital, thus I follow Mendoza's (2010) methodology and calculate total credit to private non-financial firms as a share of GDP at 16%. With this target in mind, I set $\kappa_w = 0.25$ which guarantees that the target is satisfied in the non stochastic steady state. This value is slightly below the ones used at a quarterly basis by Neumeyer and Perri ($\kappa_w = 1.25$) and Uribe and Yue ($\kappa_w = 1.2$). It is worth noticing that the intratemporal wedge is not essential for the results of the chapter, but it adds realism by directly connecting interest rates to the production side.

For the external leverage position, I assume that in the "benchmark" case, external leverage is around 50% of output, a figure well within the historical range for Argentina. In December 1994, the ratio was 34% and by the end of 2001, the months before the default and devaluation, the ratio was close to 50%.[89] Even from a longer historical perspective, these values are also within a reasonable range, since the average ratio between 1983 to 2001 is close to 41% as documented in the Lane and Milesi-Ferreti (2007) dataset.

A difficult task in this calibration is to determine the relative financing capacity between both types of assets as there is no data on the relative pledgeability of reproducible and non-reproducible capital in emerging markets in general, and Ar-

[87] An indirect proof of the volatility and difficulties that arise in choosing real interest rates for an economy like Argentina is the huge dispersion of benchmark values chosen by different authors. For instance: Garcia-Cicco et al. (2009) use $R = 1.085$, Uribe and Yue (2006) $R = 1.11$, Schmitt-Grohe and Uribe (2011) $R = 1.126$ and Neumeyer and Perri (2005) $R = 1.149$

[88] In light of Schmitt-Grohe and Uribe (2011), seven-year durations seem very plausible. Their findings show that interest rates in Argentina have a first-order autocorrelation of 0.953 on a quarterly basis if "abnormal periods" are excluded, implying durations above five years in a two-state symmetric Markov process average. The caveat is that the authors recognize that this value is very sensitive to the exclusion of periods that represent a crisis quarter or when the economy was in default.

[89] Immediately after the devaluation in 2002, the ratio jumped to values above 100%, but I consider that this value is not representative of an equilibrium outcome as confirmed by the latter debt restructuring.

gentina in particular.[90] Thus, without strong empirical support, I assume that the financing capacity of land is twice that of reproducible capital, that is $\kappa_l = 2\kappa_k$. One argument in favour of this assumption is that agency problems might be mitigated by non-reproducible assets, such as land, due to better legislated property rights and more liquid secondary markets in emerging markets. Caballero and Krisnamurthy (1999) explain why real estate property is the asset par excellence in emerging markets). These assumptions imply that $\kappa_l = 0.38$ and $\kappa_k = 0.19$ for the "benchmark" model.

I also evaluate the sensitivity of the model to a reduction in the expected duration of cycles and the pledgeability of collateral, by calibrating a version where $\pi = 0.5$ - cycles are expected to last two years - and κ_l and κ_k are halved - pledgeability falls by 50%. I label this model the "less sensitive case".

2.7 Understanding Intertemporal Wedge Spillovers

For the sake of understanding, let us consider of the model as in a non-stochastic steady state. From the Euler equation for bonds (equation 81) in that stationary environment, it is easy to reexpress the associated (rescaled) multiplier μ as follows,

$$\mu = \frac{1}{R} - \beta$$

which shows that, in terms of consumption goods, the rescaled multiplier measures the net present gain of a unitary increase in the face value of debt: in exchange for $\frac{1}{R}$ resources today, agents repay 1 unit tomorrow with the present value of β. Provided that $R\beta < 1$, the multiplier will be positive ($\mu > 0$) and decreasing in R, as increases in foreign interest rates reduce the benefits of bringing consumption to the present by borrowing.

Domestic agents understand that collateral is required to profit from this borrowing opportunity ($\mu > 0$). Hence, in their valuation of reproducible capital (k), they fully incorporate the service that capital provides. Technically, this implies that the multiplier $\mu > 0$ spills over into the Euler equation for capital, introducing an intertemporal distortion that affects capital accumulation exactly in the same way as does a subsidy to current investment in an economy without impatient borrowers (see Chari, Kehoe and McGrattan 2007 for an analysis of investment wedges). To see this, notice that, in steady state, the equation for capital (84) can be expressed as

$$1 = \beta(r^k + 1 - \delta) + \kappa_k \mu$$

[90] For this reason, Uribe 2011 considers that one of the priorities for future research in the area is empirical and should be aimed at answering what type of assets do foreign lenders accept as collateral.

which differs from a standard Euler equation by the second term on the RHS, that shows that the implicit subsidy per unit of reproducible capital created by the collateral service is equal to the return per unit borrowed (μ) times the leverage per unit of reproducible capital (κ_k).[91] Thus, hereafter I denote ($r^k + \kappa_k\mu - \delta$) as the total net return on capital, which includes the standard net rental rate and the novel "investment subsidy" or "financial service rent". Notice that a simple inspection of the equation confirms that for different steady states, it must be the case that a higher value in $\kappa_k\mu$, for example due to a lower international interest rate R or an increase in financing capacity κ_k, must be compensated by a fall in r^k resulting from an increase in capital depth. For our purpose, it is suffices to notice that international interest rates and domestic capital depth have a negative relationship.

In the case of non-reproducible capital (land), the effect is that the asset incorporates the extra return generated from collateral services into its price. To understand why this takes place, consider, for the sake of the argument, a perfect foresight equilibrium. In that case, we can express the Euler condition for non-reproducible capital (equation 85) as

$$q_\tau = \beta\frac{\lambda_{\tau+1}}{\lambda_\tau}(q_{\tau+1} + r^l_{\tau+1}) + \mu_\tau\kappa_l q_\tau$$

which shows in the second term of the RHS of the equation that the equilibrium asset price exceeds the households' IMRS-based valuation of the associated dividends by the collateral service dividend value. In effect, the ownership of a unit of land enables a household to borrow by $\kappa_l q_\tau$ in this case. As the implicit rent per unit borrowed at τ is given by μ_τ, the unit of land provides a borrowing rent of $\mu_\tau\kappa_l q_\tau$ in period τ. Since atomistic agents in decentralized trading will bid for this service, this collateral dividend creates a premium in the price of land (see Uribe 2007).[92] In the same way as with reproducible capital, I denote ($r^l + \mu\kappa_l q$) as the total return on land, which includes the rental rate and the "financial service rent".

In the steady-state version of equation (85), it is easy to decompose the price of a unit of land into the present value of its rental rate and the present value of its financial dividend rent:[93]

$$q = \frac{\beta r^l}{1-\beta} + \frac{\mu\kappa_l q}{1-\beta}$$

As is also the case with reproducible capital, it is evident from equation 2.7 that the price of land is increasing in pledgeability - financing capacity - κ_l and decreasing

[91] This Euler equation is identical to the one from a prototype economy where there is a subsidy rate $s_i = \frac{\kappa_k\mu}{1-\beta(1-\delta)}$ to investment expenditures.

[92] To my knowledge, J. Detemple and S. Murthy (1997) were the first to show this type of result in a dynamic environment with short selling constraints proportional to the investor's portfolio value.

[93] A necessary and sufficient condition for the price to be bounded in steady state is that $1-\beta > \kappa_l\mu$, since this rules out asset prices going to infinity due to leverage.

in the interest rate R.

2.8 Model Exploration

In this section, I explore the transient dynamic and ergodic properties of the model, with a particular interest in the ability of the framework to generate boom-bust episodes. In all dynamic exercises to be presented, I follow the same procedure. I first simulate the model for 10000 consecutive periods and once this is done I select all 20-period series that fulfill these conditions: during the initial 6 periods, the interest rate must be at the normal value $R = 9.5\%$, then from period 7 until period 13, the interest rate must be at the low value $R = 5.5\%$. From period 14 onwards, the interest rate should remain at the "normal" level of $R = 9.5\%$. By following this rule, I attempt to capture a complete cycle in external conditions that could give raise to a boom-bust episode domestically. When I discuss the ergodic properties of the model, I calculate the stationary distribution of the variables of interest by discarding the first 5000 periods of the simulations and estimating the kernel density of the remaining periods.

2.8.1 A Complete Cycle: "7 years of Plenty and 7 years of Famine"

Figure 16 plots the transitional dynamics of variables for the "benchmark" economy in dotted lines alongside the "less sensitive" economy - two-year expected cycles and a 25% debt ratio - in solid lines. For the sake of clarity, in each chart I denote the period of the initial switch to the low interest rate regime as period 1. The evolution of the exogenous driving force of the model - the foreign interest rate - is displayed in figure 16a.

Following the switch to the low interest rate level in period 7 (in the charts period 1), the borrowing constraint starts binding more tightly since domestic agents are more willing to bring more consumption to the present at this lower intertemporal price but they cannot do this due to the limit in borrowing. This unfulfilled desire increases the shadow value of debt, as measured by μ - the intertemporal wedge - that automatically spills over into the returns of capital and land due to their services as financial instruments. Indeed, in the top figures 16b and 16c, we can see that the total return on capital and land goes up automatically when the external conditions become favourable. The importance of these effects cannot be overstated, as they showed how the return of domestic assets depend on external financial conditions, a condition that has not been sufficiently explored in the literature before. A simple comparison of the response of returns in the "benchmark" and the "less sensitive" economies reveals how important is total pledgeability for creating a strong transmission mechanism.

A side effect of the fall in the interest rates is that the intertemporal distortion at the firm level is lessened and the financing cost of hiring workers goes down. As a result, hours worked (see Figure 16d), real wages (see Figure 16e) and output (see Figure 16f) immediately go up, albeit minimally in these simulations given how this friction was calibrated.

The interesting dynamic effects are due to the intertemporal spillovers. Indeed, higher returns on land that are, on average, expected to remain for seven years explain why asset prices jump 5.1% instantaneously (see Figure 16l). This valuation effect automatically increases the collateral capacity, allowing households to borrow more internationally as shown in Figure 16j. Of these extra resources, a small fraction is devoted to increasing consumption levels as shown in Figure 16h, but its bulk is chanelled to investment (see Figure 16g). In effect, fostered by the higher return on capital, investment goes up by 15% during the first period and remains 13% higher thereafter.[94] As a consequence, from the moment of the switch to the low interest rate regime, the economy begins transitioning towards a new stochastic steady state in which the levels of capital, asset prices (see Figure 16l), hours worked, output, consumption and external indebtedness (see Figure 16j) are all higher. In this new equilibrium, the share of investment in output increases to 21.6% from values of 19.1%.

When foreign external conditions return to “normal” in period 8 (in the chart), the economy begins undoing the gains from the boom phase. Upon the switch, investment permanently plummets, reproducing in some dimensions the drastic fall that took place in the data and was documented by Cerra and Saxena (2008). Overall, a quick look at all charts in Figure 16 reveals that the model reproduces the data of Argentina qualitatively well - and the other Latin American countries - around the time of Russia’s default as documented in Section 2.3. In this qualitative aspect, the model is clearly sucesseful and gives support to the “push” view by showing that low frequency movements in the foreign interest rate can generate boom-bust cycles in internationally borrowing constrained economies. In terms of the transmission mechanism proposed in this framework, the results show that intertemporal wedges can be a force creating boom-bust cycles in these economies.

Quantitatively, though, the model falls short of being realistically accurate as it cannot reproduce the size of many of the adjustments that took place during this period. This is most evident in relation to the model’s inability to reproduce the large swings in asset prices observed in the data - a 35% quarterly fall in the data against an 8% fall in the model.[95] I consider that this drawback is not unique to

[94]It is fair to mention that during the boom, there is a precautionary motive that also contributes to the build up of capital as a buffer stock. Although is not possible to isolate this effect, in the simulations I find that for the levels of risk aversion with which I am working ($\sigma = 2$), the precautionary savings effect is of second-order importance in the decision to accumulate capital when the interest rate is low.

[95]Nonetheless, in the calibration of the next subsection where only land is pledgeable, the asset

this framework and is shared by all DSGE models in this strand of the literature.[96] Possibly, an approach better suited to rationalize these large asset price swings is the learning framework proposed in Adam and Marcet (2011).[97]

2.8.2 Collateral Types and Boom-Bust Patterns

In section 2.7, I discussed how the intertemporal wedge can resemble an investment subsidy or a financial dividend when capital is reproducible or non-reproducible, respectively. I now build on this intuition and explore numerically the connection between collateral types and the boom-bust cycle pattern that an economy experiences. As a way of reinforcing my case, I simulate two polar cases in the collateral type dimension: an "all-land" case in which only non-reproducible capital is pledgeable and an "all-capital" case in which only reproducible capital serves as collateral.[98]

Figures 17b and 17c neatly reveal how the intertemporal wedge spillovers modify the domestic assets return. A simple comparison of both figures illustrates the diametrically opposite effects between the economies. While the total return on capital skyrockets and the total return on land remains insensitive to the change in external financial conditions in the "all-capital" economy, the opposite response takes place in the "all-land" model. In turn, this assymetry results in the two economies having very different macroeconomic properties.

A quick glimpse at the evolution of the main macro aggregates (dashed lines) in the "all-capital" simulation reveals that the main characteristic of this economy is that the cycles are quite smooth. In effect, following a reduction in interest rates, all macro aggregates begin to grow smoothly and steadily as the economy embarks on a capital deepening process. But since this process can only be financed with foreign borrowing to the extent of the increase in domestic collateral, there is no automatic increase in borrowing upon the improvement in external financial conditions (see Figure 17j). In this economy, the fact that collateral is a reproducible asset - with no capital adjustment costs - acts as a stabilizing force that tightly limits the possibility of large fluctuations in domestic absorption, due to the absence of a collateral price

price fluctuations get closer to the actual data.

[96]This is a general weakness of the DSGE models, as they always fail to match the asset price movements. This limitation has recently been criticized in Caballero (2010) which claims that the profession is wrong in only judging models by their ability to match quantities, while completely ignoring prices.

[97]In this setting, Bayesian learning by investors generates empirically plausible low-frequency boom-bust cycles in asset prices as the updating of beliefs can temporary generate a self-reinforcing return optimism loop.

[98]Notice that by assuming zero adjustment costs in capital production, I am considering the limiting (maximum) case in terms of the investment subsidy effect. Indeed, if the capital adjustment costs were to be positive, the net effect of the subsidy would be smaller. It is also fair to acknowledge that if this were the case, the numerical solution would be less reliable due to the additional complexity in the Euler equation for capital.

effect (see Figure 17l).

In contrast, the "all-land" simulation reproduces some of the typical fluctuations that take place in emerging markets, especially during a sudden stop event. Indeed, the simulation shows that in the event of an interest rate switch, there is a 10.2% movement in asset prices (see Figure 17l) that produces a large swing of 7.6% in domestic absorption (see Figure 17i) due to the binding borrowing constraint. As a consequence, for example in period 8 when interest rates go up, investment collapses by 30.1% (see Figure 17g), consumption falls by 2.3% (see Figure 17h) and the current account reversal is around 5.4% of GDP (see Figure 17j). It is worth remembering that this response is well within the range of what is considered to be an average response to this type of events (see Calvo and Izquierdo 2006). In my view, the type of dynamic adjustment generated by this model configuration captures quite well the essence of the message put forward by the advocates of the "push" view. The adjustment that takes place after the large valuation correction in the collateral constraint could easily be interpreted as a *shock to the capital account* in the spirit of Calvo and Talvi's (2009) ideas.

Nonetheless, the simulations also reveal a weakness of this framework: by construction the model produces symmetric responses to opposite (positive and negative) shocks. Although it could be argued that this is empirically plausible, for example if one were to consider the early 1990's when the countries of the region embarked on deep structural reforms (including privatizations) and received large capital inflows that created a sudden domestic boom, I acknowledge this to be a handicap of the setup. The introduction of some sort of capital adjustment costs would help smooth out these large fluctuations at the onset of a boom, but at the cost of risking that it becomes intractable to solve the model numerically.

2.8.3 Pure Speculative Bubbles? The "All-Land" Model Perspective

From a theoretical perspective, the aforementioned weakness might not be so unreasonable, especially considering the connections with the seminal paper on bubbles and volatility in emerging markets by Caballero and Krisnamurthy (2006). In their setup, speculative bubbles emerge due to the absence of an intergenerational asset market allowing youngsters to channel their savings into the high return projects of the old generation. This missing market forces the young generation to store its savings in low return foreign assets. Thus, when a domestic speculative bubble emerges, it creates a bridge between the generations - it creates a financial instrument - that allows intertemporal trade. In this fragile coordination-based equilibrium, asset prices, consumption and investment are high as long as the old generation can sell the bubble to the young. When the bubble bursts stochastically, there is a large current account reversal when young agents start sending their savings abroad. As a consequence, domestic investment collapses and consumption falls. In this environment, there is also symmetry and the opposite movements take place when a bubble pops up.

The "all-land" configuration shares most of the dynamic properties of Caballero and Krisnamurthy's framework. Nonetheless, the frameworks portrait different views of a key aspect: the presence of pure speculative bubbles in emerging markets. In effect, in the authors' view, asset prices in emerging markets truly deviate from their fundamental value for some period of time for speculative reasons. In contrast, in my framework, there is no speculative deviation since asset prices move according to changes in the expected collateral service. Thus, this subtle difference raises a very interesting empirical question: are abrupt corrections in asset prices in emerging markets following changes in central countries interest rates the result of speculative movements or simply corrections caused by the impact on collateral services? And if the latter results are the case, how easy is it to empirically identify this component?[99] The correct answer to this question could save policy makers from the associated costs of engaging in futile battles to prick "non-speculative" bubbles.

The two frameworks also differ in the role they assign to external financial conditions in generating boom-bust cycles. In principle, in Caballero and Krisnamurthy, there is no role for foreign interest rates, while in the model of this chapter collateral valuations only go up when interest rates fall. This property of my model coincides with Ventura's (2011) view that associates the emergence of bubbles in less developed countries with reductions in the interest rates of central countries.

2.8.4 A Quick Inspection at the Stationary Distributions

To conclude, and get a full picture of the long-run effects of intertertemporal wedges, I plot in Figure 18 the conditional (on the stochastic state) kernel estimates of some key endogenous variables for each of the four models simulated ("less sensitive","benchmark", "all-capital" and "all-land"). The first two Figures 18a and 18b in the top panel depict the conditional distributions of the total return on land and reproducible capital in each case. From these figures, it is easy to read how the intertemporal wedge spillovers permanently affect the return of domestic assets. Figures 18c and 18d illustrate how the intertemporal wedge effects modify the stationary distributions of land prices q and the capital stock k. Figure 18c confirms that the price of land is permanently higher and substantially more volatile in the "all-land" simulation than in the "all-capital" one. Figure 18d shows that the "investment subsidy" in "all-capital" simulation stimulates capital accumula-

[99]For example, I have in mind carry trade operations between a low interest rate currency (Japanese Yen) and a high one (Brazilian Real) that increases demand for Brazilian assets as collateral through the banking system.

tion conducing to an average increase in the stock of capital in the economy. For example, relative to the "all-land" simulation, the stock of capital is on average 10% higher in the "all-capital" economy.[100]

Figures 18e and 18f depict the distributions of output and absorption for each simulation. As expected, in the "all-land" economy, given the abrupt changes in domestic absorption following an interest rate switch, we observe that the volatility of absorption is an order of magnitude larger than the one of output. In this case, domestic absorption is 2.53 times more volatile, as measured by the standard deviation, than domestic output. It is worth remarking that this property of the model is a common empirical feature across emerging markets (see Neumeyer and Perri 2005).

Finally, the overall message that can be read from these ergodic distributions is that intertemporal wedges can be a powerful transmission mechanism in borrowing constrained open economies and, more relevantly, that the stationary properties of the system crucially depend on the type of assets that serves as collateral and their pledgeability capacity. The findings of this section validate Uribe's (2011) claim that there is an urgent need to increase the empirical research in this area in order to recollect information on the type of assets that foreign creditors accept as collateral.

2.9 Extension: Over-borrowing or Under-Collateral Supply?

The intertemporal wedge spillover mechanism developed in this framework is another manifestation of the same kind of financial imperfection described in chapter 1. As explained in section 1.9, Geneakoplos and Polemarchkis (1986) and Stiglitz (1982) proved separately that the competitive equilibrium is constrained inefficient in economies with multiple goods and incomplete markets. Over time, these pioneering papers give birth to a large set of papers that exploit these results to analyse different features of constrained inefficient economies. Some of these papers, like Caballero and Krishnamurthy (2001), Gromb and Vayanos (2002), Lorenzoni (2008), Korinek (2009), Benigno et al. (2010, 2011) and Bianchi (2011), also incorporate a financial market imperfection in the form of a collateral constraint linked to a relative price, as I have done in this chapter, to study how the emergence of a financial externality when the constraint binds with positive probability induces atomistic agents to borrow inefficiently.

One of the most popular research avenues that builds on this externality aims at understanding whether this type of externality generates "over-borrowing" in emerg-

[100]The distribution of capital in the "all-land" simulation reveals that precautionary savings also contribute to the capital deepening process when interest rates are low. That is, even though there is no "investment subsidy" in this case (see Figure 18b), capital increases when $R = 5.5\%$ because agents engage in precautionary savings to smooth out the fluctuations in consumption.

ing economies. For this purpose, researchers typically compare the distribution of debt holdings in the competitive equilibrium (CE) against the one in which a Central Planner (CP) internalizes the effect of her debt choices in the price of the collateral constraint. For example, Bianchi (2011) uses a two-goods endowment economy to show that these externalities do not increase the average debt levels to any great extent ("small over-borrowing") but substantially increase the probability of a crisis. In a production economy, Benigno et al. (2010, 2011) show that if labour income is used as collateral, Bianchi's results are overturned for some parameterizations as the CP borrows more than the private agents in the CE.[101]

The model studied in this chapter is clearly connected to these papers because the financial externality is the same, although I use it in a different way since I allow atomistic agents to partially internalize the effect of the financial externality via the wedge spillovers. Nonetheless, atomistic agents in my model do not incorporate the effect of their investment decisions in the price of land (another byproduct of a binding borrowing collateral constraint). Hence, in my framework there is inefficient production of collateral for this reason. That is, not only borrowing is inefficient like in the model of chapter 1, but also collateral investment decisions are inefficient. As a result, I claim that in the decentralized equilibrium agents "under investment in collateral" as discussed in Geneakoplos and Fostel (2008). In other words, in this model an hypothetical CP would maintain higher levels of k relative to the CE because she would internalize the positive impact of k on the price of land q, and accordingly on borrowing capacity.

So, the simple but powerful message I want to convey in this section is that in models in which the CP can only choose borrowing levels, like in Bianchi (2011), it is true that atomistic agents borrow more in absolute levels than what a CP does. Interestingly, this does not have to be the case when the CP also chooses the level of the endogenous variable that serves as collateral, like in Benigno et al. (2010, 2011) or in this model. In these type of models, the planner will also understand that increasing collateral increases borrowing capacity (through the price of land in this model, through labour supply decisions in Benigno et al.). Hence, it is no longer the case that total borrowing always goes down in absolute levels, since the planner modifies both sides of the borrowing constraint (borrowing decisions and collateral decisions). As a result, whether total borrowing increases or not is probably a matter of parameterization -as shown by Benigno et al. (2010, 2011)- because of the two opposing forces: on the one hand, the CP internalizes the negative externalities that increasing borrowing d imposes on the price of land q. But on the other hand, the CP also internalizes that increasing capital k lifts the collateral valuation, thus allowing for more borrowing. Hence, one can only affirm with certainty that in a

[101]Notice that these papers need to resort to the use of numerical simulations to support their claims since analytical results are elusive in this strand of the literature.

decentralized equilibrium there is "under collateral investment".

To show intuitively the arguments and results explained in the last paragraphs, assume that at the start of period τ, the planner freely chooses $d_{\tau+1}$ and $k_{\tau+1}$ but internalizing the impact of her decision on the price of land in the borrowing constraint. As is standard in this type of settings (see Jeanne and Korinek 2010), the CP leaves the pricing of land to the private agents. Hence, the CP chooses $d_{\tau+1}$ and $k_{\tau+1}$, maximizing the same objective function as an atomistic agent but with the sole difference that she understands that the borrowing constraint is given by:

$$\kappa_k k_{\tau+1} + \kappa_l q(k_\tau, d_\tau | s_\tau = s) l_{\tau+1} \geq d_{\tau+1} \tag{107}$$

Then, it is straigthforward to show that the necessary first-order condition for $d_{\tau+1}$ and $k_{\tau+1}$ becomes, respectively:

$$\lambda_\tau \left[\frac{1}{R_\tau} - \mu_\tau \right] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1} \right] - \kappa_l \beta \mathbb{E}_\tau \left[\lambda_{\tau+1} \mu_{\tau+1} q'_d(k_{\tau+1}, d_{\tau+1} | s_{\tau+1} = s) \right] \tag{108}$$

$$\lambda_\tau [1 - \kappa_k \mu_\tau] = \beta \mathbb{E}_\tau \left[\lambda_{\tau+1}(1 + r_{\tau+1} - \delta) \right] + \kappa_l \beta \mathbb{E}_\tau \left[\lambda_{\tau+1} \mu_{\tau+1} q'_k(k_{\tau+1}, d_{\tau+1} | s_{\tau+1} = s) \right] \tag{109}$$

where it is easily seen that the Planner's optimal conditions differ from the decentralized ones in the second terms in the RHS of the equations.

To characterize the CP solution, we need to know the sign of the derivatives of the pricing function $q(k_{\tau+1}, d_{\tau+1} | s_{\tau+1} = s)$ with respect to its two arguments. The answer to this comes from the estimated pricing function that was used to solve the model which shows that $q'_k(k_{\tau+1}, d_{\tau+1}) \geq 0$ and $q'_d(k_{\tau+1}, d_{\tau+1}) \leq 0$ for both s as can be seen, with some dedication, from Figure 19. In effect, the pricing function estimated with the PEA algorithm is increasing in the stock of reproducible capital and decreasing in the stock of external debt. With these intuitive results, I can now characterize the CP behaviour with the help of some proven results in the macro literature.

Looking at equation (108), it is clear that the second term on the RHS is non-negative, since the CP internalizes that an additional unit of debt today reduces the capacity to borrow tomorrow in states with a binding constraint. Technically, this economy resembles a prototype economy where there is a contingent taxation on foreign debt and thus, agents' incentives to borrow go down. If nothing else were to change, total borrowing would be reduced as claimed by Bianchi (2011). Now, looking at the last term in the Euler equation for capital (see 109) it is also the case that the term is non-negative, since the CP internalizes that an extra unit of capital tomorrow increases land prices, thus increasing the borrowing capacity in states with a binding constraint. As shown in Chari, Kehoe and McGrattan (2006), this Euler equation for capital resembles the one of a prototype economy where there is a contingent subsidy to capital accumulation. Since a well-known result in the business-cycle literature is that this type of capital subsidy fosters investment, it is the case that the CP will invest more in reproducible capital than atomistic agents, as it was claimed. Thus, since collateral goes up in the CP model, it is not longer true that total borrowing always goes down. Clearly, the results will depend on the parameterization as shown by Benigno et al. (2010, 2011)

The simple idea exposed in this section explains why policy interventions in this kind of frameworks are always tricky and results are unwarranted as claim in Benigno et al. (2010, 2011). The reason for this is that the financial externality that arises in economies with financial market imperfections that take the form of a collateral borrowing constraint creates general equilibrium feedback effects that are difficult to isolate and evaluate. Even in the simplest cases in which there is no borrowing constraint and the financial externality only depends on the debt level, like in the model of chapter 1, intervention outcomes can be dissapointing as shown in subsection 1.9 for the case of taxes on debt holdings. Thus, when the market imperfection incorporates a collateral constraint of the type study in this chapter, it is even more plausible that an optimal policy intervention is difficult to design and most probably, impossible to implement. In this respect, I share the conclusions of Benigno et al. (2010, 2011) that claim that the scope for macro-prudential policy interventions is weak in cases of borrowing inefficiencies like the ones presented in chapter 1 and this chapter. One feature that this section leaves unanswered is whether there is scope for interventions in the form of subsidies to the accumulation of collateral since I have shown that atomistic agents under invest in collateral. As it is the case with debt taxes to remedy overborrowing, it is my intuition that any policy aimed at stimulating collateral formation would face the same challenges. I recognize that in some cases this can be considered a practical second best outcome, but my findings of chapter 1 make me think that the welfare effects could be very small. In the end, I consider that every effort should be made, primarily, to try to eliminate the causes of imperfections in financial markets.

2.10 Conclusion

One common macroeconomic characteristic of the major Latin American countries is that they experience frequent boom-bust episodes. In view of some prominent economist like Calvo and Talvi, the main drivers of these cyclical fluctuations are external factors; in particular, changing conditions in the financial "centres". In this so-called "push"factors view, financial shocks in the centre manifest as *shocks to the capital account* in the "periphery", i.e., a simultaneous change in the price and availability of foreign capital.

On the empirical front, the exogeneity of the financial conditions has been tested, and the results validate the principal claim of the "push" view: it is now generally accepted that the cost of borrowing for emerging markets is mainly explained by external factors such as risk aversion, global liquidity and contagion rather than domestic conditions as would be suggested by a "pull" factors view. The weakness, though, resides on the theoretical front. That is, even though these authors present a compelling narrative that seems to offer a parsimonious explanation for some historical developments, there is no model backing this conjecture.

I have tried to fill this gap in this chapter. I proposed a transmission mechanism of international interest rates to domestic conditions that goes beyond the direct effect on the cost of debt. The mechanism is based on spillover effects in the intertemporal Euler equations for capital. To generate this, I assumed that foreign lenders demand domestic capital as a guarantee for lending and that local residents would like to borrow beyond their collateral backing at market interest rates. Hence, since capital has a dual role in a borrowing constrained economy, changes in interest rates automatically spillover into capital demand conditions, as is the natural outcome when the financial return component has also been altered.

Then, I studied this mechanism in a dynamic context. For this purpose, I presented a SOE model where foreign interest rates take on two values following a symmetric Markov chain and there are two types of capital - reproducible and non-reproducible - in the economy. I calibrated the model to the Argentinean economy and simulated boom-bust dynamics driven by foreign interest rate cycles. The results can be summarized, in a nutshell, as follows: intertemporal wedges are an important transmission mechanism and contribute to explain the boom-bust cycles in the region. My opinion is that intertemporal wedges should be considered as a complement to other types of mechanisms and financial frictions.

I also explored the implications of varying the relative financing capacity of the two types of capital. The results are novel and highlight an aspect that has been left unattended by the profession: the type of assets that is used as collateral characterizes the cycles pattern. In effect, for economies in which collateral assets can be reproduced, the intertemporal wedge resembles an investment subsidy. In this case, when the cost of borrowing goes down (up), the return to capital goes up (down) and the investment cycles are very smooth. When collateral is in fixed supply, as it would be in an economy in which only land can be pledged, the intertemporal wedge resembles a financial dividend (financial rent). Under this configuration, changes in external financial conditions do automatically have an impact on collateral valuations. In this scenario, a persistent increase in foreign interest rates, for example, potentially generates a large swing in the value of collateral tightening the binding constraint. This does, in fact, resemble a *shock to the capital account* in the domestic economy, since an increase in foreign interest rates results in a strong current account reversal with all characteristics of a Sudden Stop. Thus, this setup confirms the concerns of Uribe (2011) who claims that when modelling borrowing constraints, the profession takes lightly the fact that we do not have any empirical information regarding what types of assets are used as collateral in international borrowing.

Since my model was solved globally, I can easily analyse numerically the properties of the policy function for reproducible capital $k_{\tau+1}$ and the pricing function for non-reproducible capital $q_{\tau+1}$. I use this feature in an ad-hoc way to study how the financial market imperfection present in the model not only creates inefficient borrowing, but also inefficient investment in collateral, in particular under investment. I connect this result to the studies of Benigno et al. (2010, 2011) and conclude that even though there might be some scope for a policy intervention aiming to stimulate collateral creation, welfare changes tend to be minimal in this type of setups. Instead, I argue that every effort should be made to eliminate the causes of imperfections in financial markets.

A general lesson to be drawn from these exercises is that these type of frameworks are incapable of reproducing the large swings in asset prices observed in the actual data. I conclude that this weakness could be critical from a policy making perspective. The general warning is that predictions from this class of models will generally underestimate the scale of the potential asset price fluctuations; a particularly worrying aspect when acknowledging that the typical emerging market depends heavily on collateralized borrowing to access international markets and domestic lending and borrowing are also based on this type of operations.

B Appendix

B.1 Tables

Table 5: Selected Variables During the 1991-2002 Boom-Bust Cycle

	Private Flows (avg % of GDP)		Output (avg yearly % change)		Investment (avg yearly % change)		Asset Price (avg yearly % change)	
Country	91-97	99-02	91-97	99-02	91-97	99-02	91-97	99-02
Argentina	1.96	-2.97	5.55	-3.77	12.23	-11.30	6.42	-11.24
Brazil	1.84	-0.99	2.85	1.96	5.50	1.15	16.28	-4.60
Chile	3.48	-3.18	7.96	2.31	14.38	-1.88	3.52	-2.80
Colombia	2.48	-1.26	4.10	0.50	9.30	-2.20	7.07	-9.30
Mexico	2.43	-0.12	2.53	2.08	6.90	1.80	4.51	-5.43
Peru	5.81	-0.10	5.63	2.07	13.38	-5.70	7.22	-7.34
Venezuela	-0.73	-2.61	3.40	-2.61	16.30	-4.60	5.55	-18.30
Unweighted avg.	**2.47**	**-1.60**	**4.54**	**0.37**	**11.14**	**-3.25**	**7.22**	**-8.42**

Notes: The table reports data of selected variables (Private Flows, Output, Invesment and Asset Prices) for the six largest South American countries for two distinctive periods: the pre-Russia default period (1991 until 1997) and the post-Russia default period (1998 until 2002). Source: IMF, WEO database.

Table 6: Calibrated Parameter Values

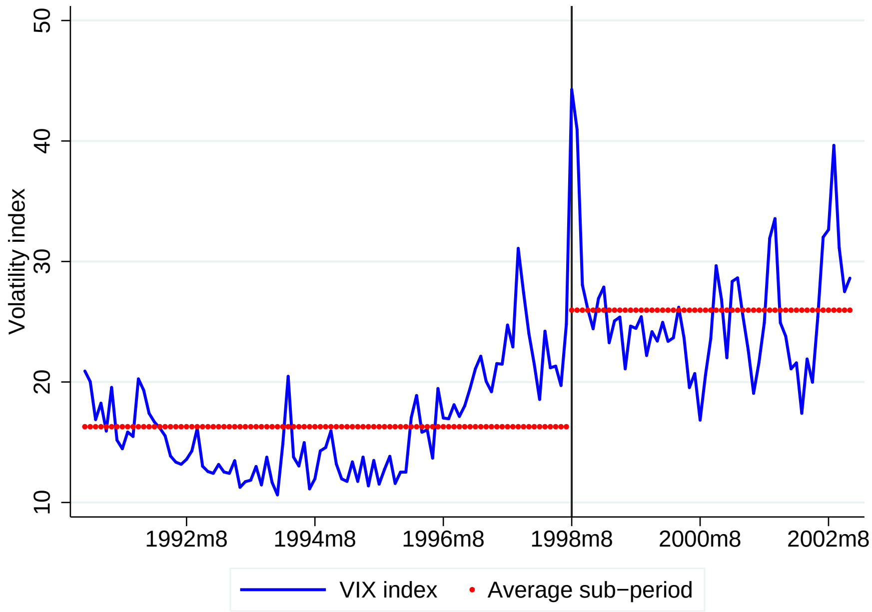
Parameter	Definition	Value	Target/Source
a) Preferences			
σ	Risk aversion	2	SOE convention
β	Discount rate	0.913	Price earnings ratio assets
θ	Labour disutility	1.8	Mendoza (2011)
ξ	Inverse wage elasticity labour	0.83	Normalized labour input
b) Technology			
α	Share reproducible capital	0.30	Labour share set at 0.64
γ	Share non-reproducible capital	0.06	Caselli (2006) natural cap.
δ	Depreciation rate	0.12	Investment-to-GDP ratio
c) Borrowing			
κ_w	Working capital requirement	0.25	Mendoza (2011)
κ_k	Pledgeability K	0.18	Debt-to-GDP Argentina
κ_l	Pledgeability L	0.36	Debt-to-GDP Argentina
d) Interest rate			
R^h	Normal interest rate	0.095	Average normal times
R^l	Low interest rate	0.055	Four percent shock
π	Expected duration boom (bust)	0.857	Mendoza & Terrones (2008)

Notes: The table reports the value of the parameters calibrated.

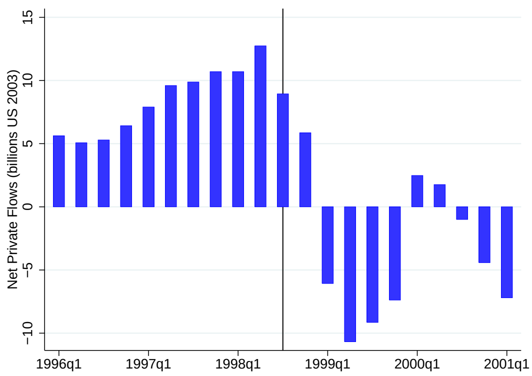
B.2 Figures

FIGURE 14: SNAPSHOT RUSSIAN DEFAULT FINANCIAL SHOCK

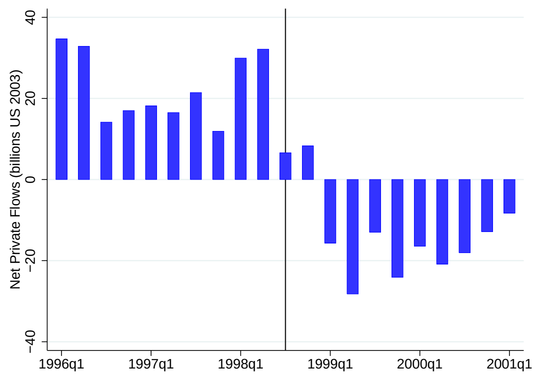
(A) VOLATILITY INDEX (VIX)



(B) ARG.: PRIVATE FINANCIAL FLOWS



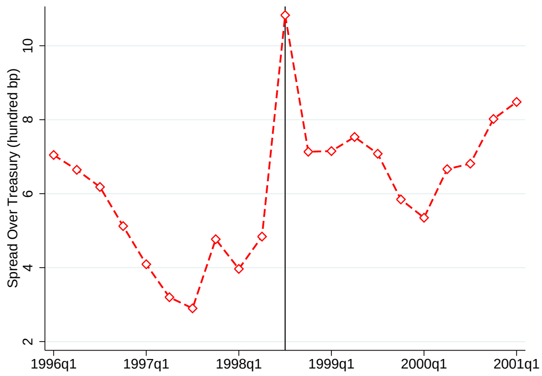
(C) LAC-6: PRIVATE FINANCIAL FLOWS



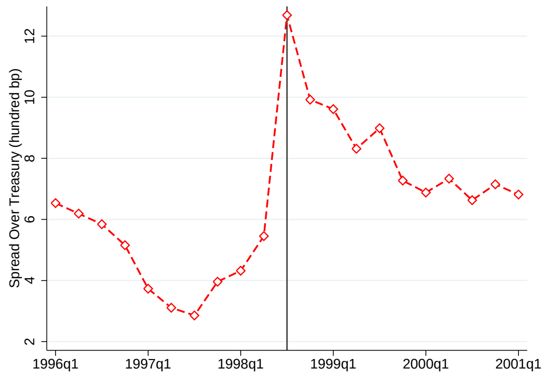
Notes: Figure 14a plots the evolution of the VIX index from 1991 until 2002. Figures 14b and 14c show the cumulated (over last four quarters) net private inflows between 1996-Q1 and 2001-Q1 for Argentina and LAC-6, respectively. The vertical line indicates the time of Russia's default. Source: Bloomberg and IMF, WEO database.

Figure 15: Selected indicators Around Russia's Default: Argentina and LAC-6

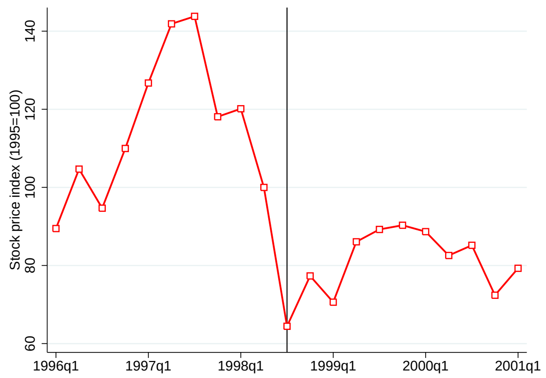
(a) Arg.: Spreads



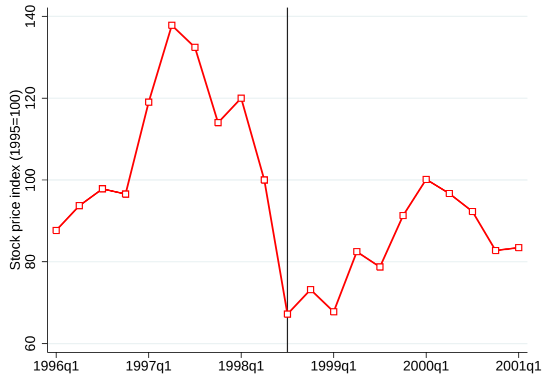
(b) LAC-6: Spreads



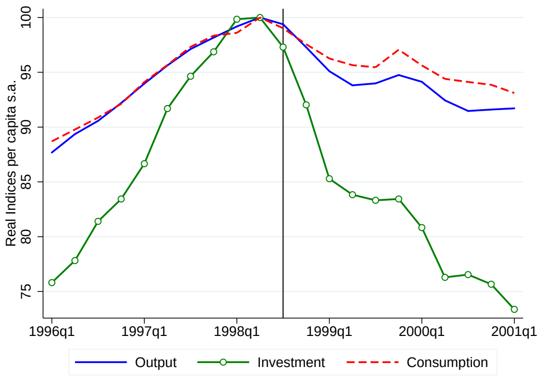
(c) Arg.: Stock Prices



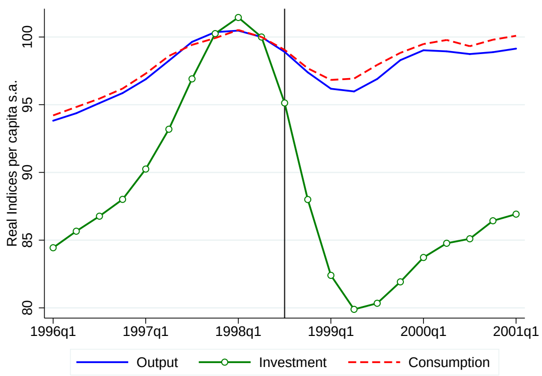
(d) LAC-6: Stock Prices



(e) Arg.: Selected Quantities

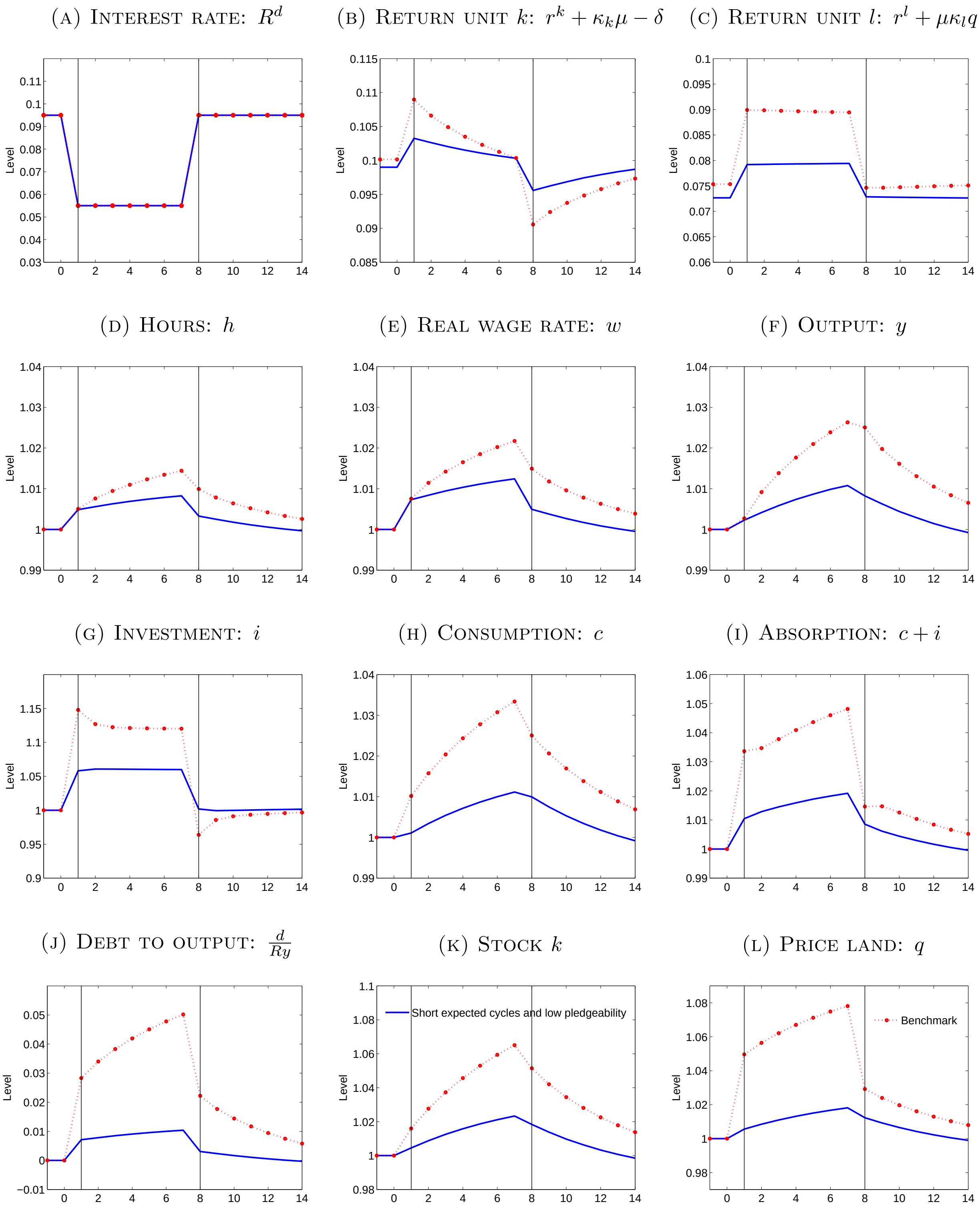


(f) LAC-6: Selected Quantities



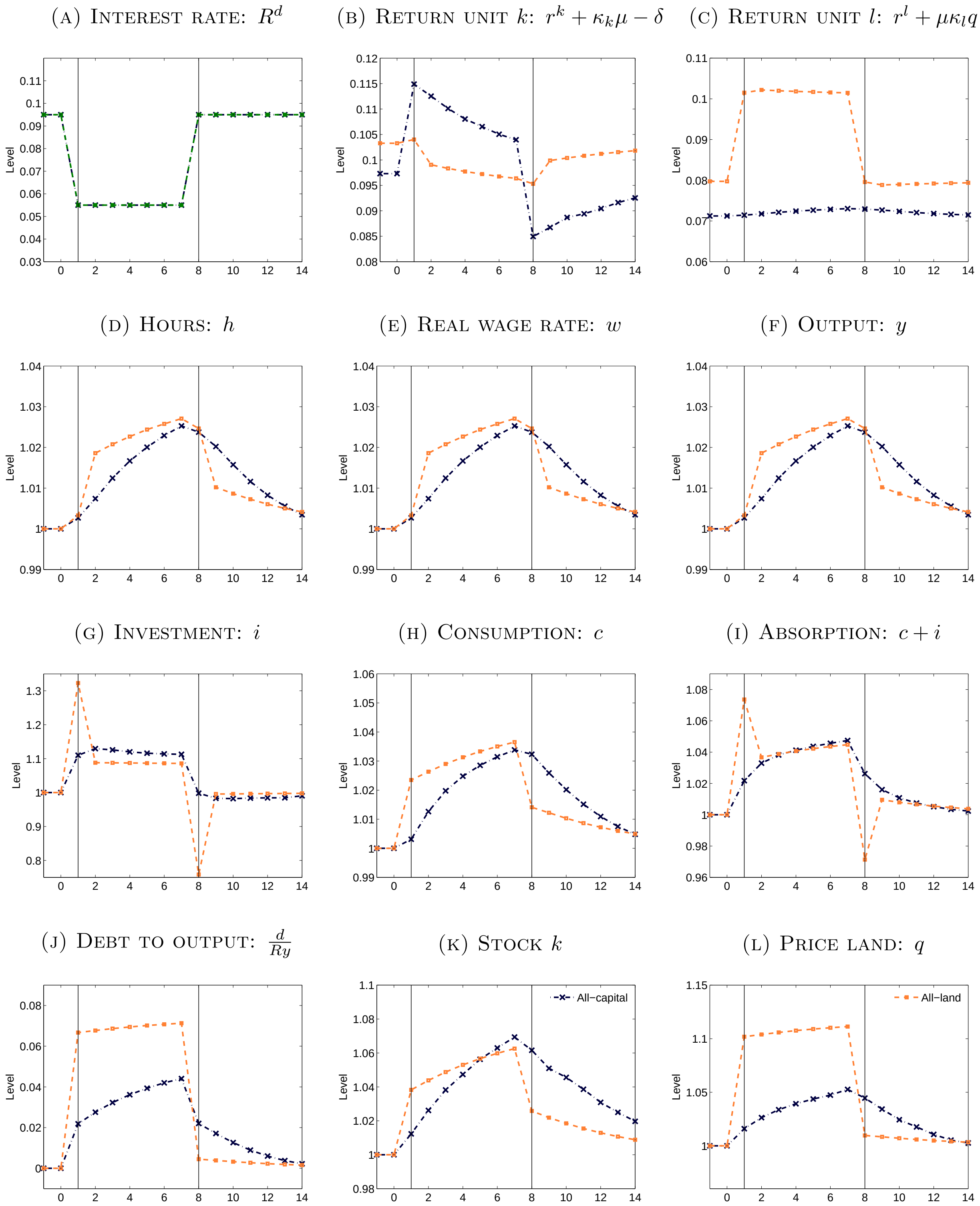
Note: The charts in Figure 15 show the evolution of bond spreads over treasury, stock prices, output, investment and consumption during a five-year window period centered around the time of Russia's default. The left column has the charts with data from Argentina and the right column the charts with data from LAC-6 (unweighted average). Source: IDB.

Figure 16: Boom-Bust Cycle Simulations: Benchmark vs Less Sensitive Case



Note: Figure 16 shows the evolution of all the relevant variables in the simulations of the "less sensitive economy" calibration (solid line) and the "benchmark" calibration (dotted line). The vertical lines indicate the beginning of a boom phase and the beginning of the bust phase, in that order.

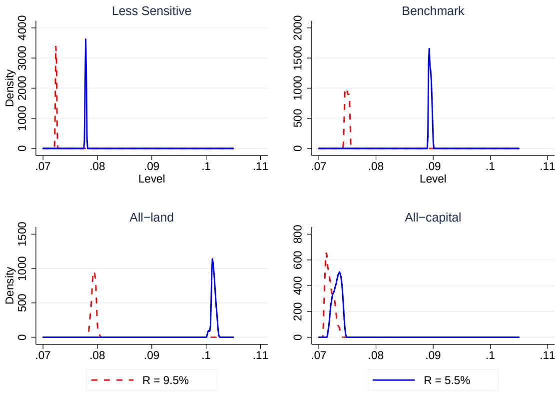
FIGURE 17: BOOM-BUST CYCLE SIMULATIONS: "ALL-LAND" VS "ALL-CAPITAL" CASES



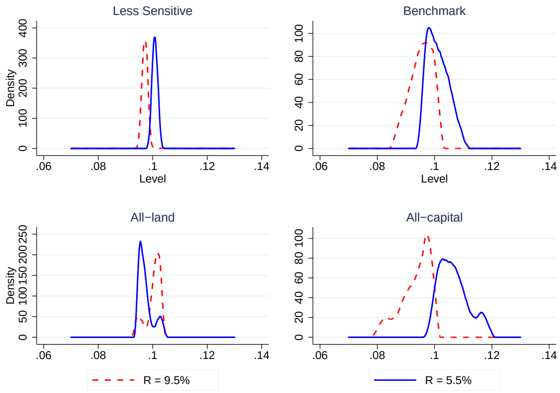
Note: Figure 17 shows the evolution of all the relevant variables in the simulations of the "all-land" calibration (orange line) and the "all-capital" calibration (dark blue line). The vertical lines indicate the beginning of a boom phase and the beginning of the bust phase, in that order.

Figure 18: Conditional Kernel Densities for Selected Endogenous Variables

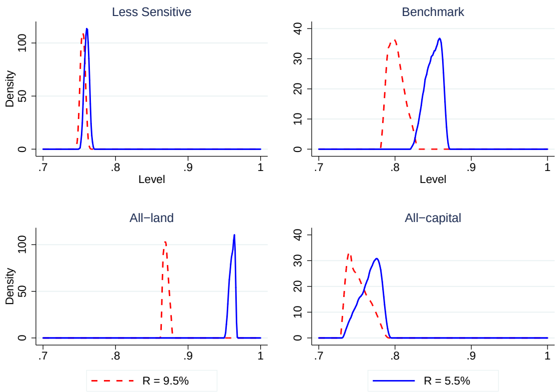
(a) Return unit *land*: $r^l + \mu\kappa_l q$



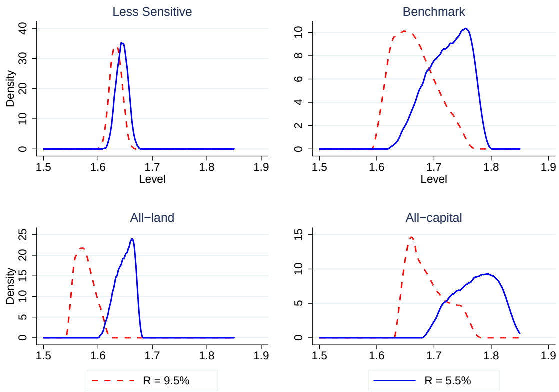
(b) Return unit *capital*: $r^k + \mu\kappa_k$



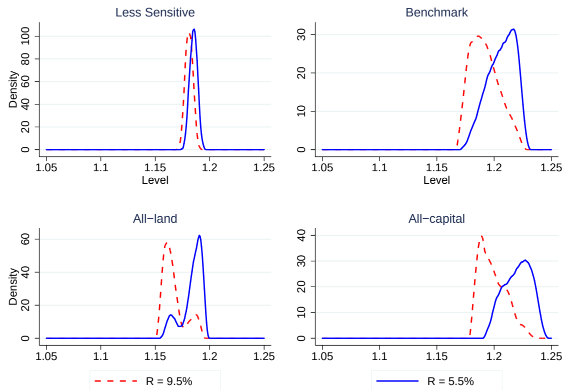
(c) Land price: q



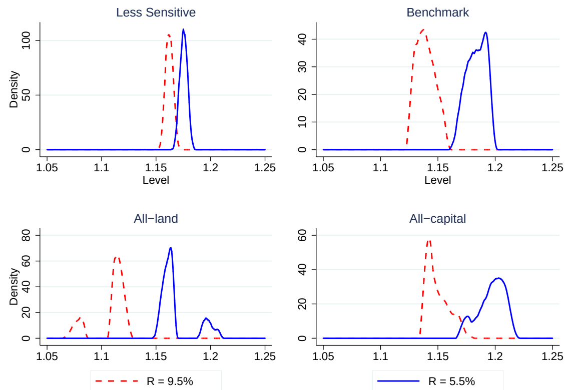
(d) Stock capital: k



(e) Output: y



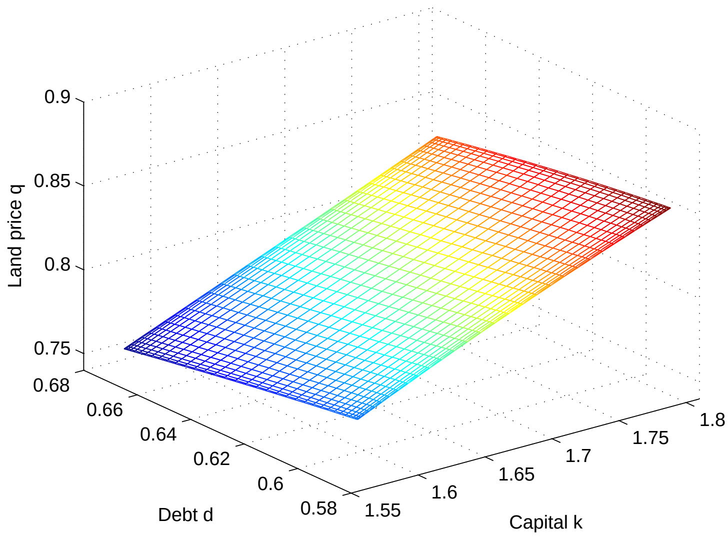
(f) Domestic absorption: $c + i$



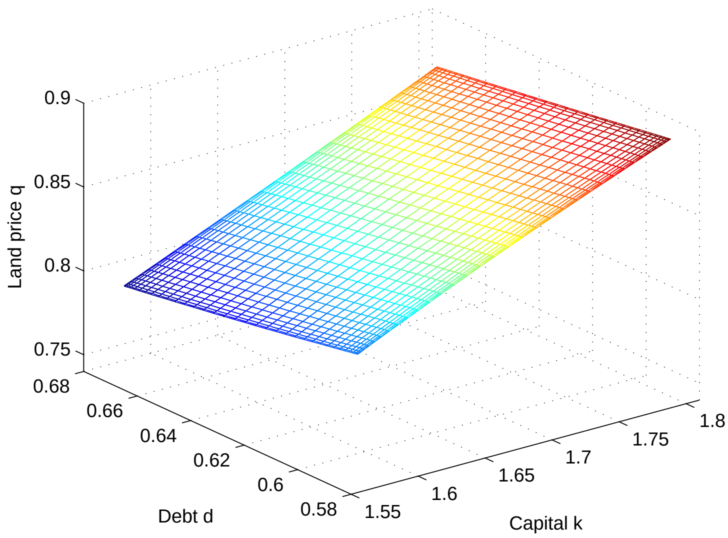
Note: Figure 18 shows the estimated stationary distributions of a selected group of endogenous variables for each model that is simulated in the chapter. The stationary distributions are calculated using Stata's adaptive kernel density estimator from series of 10 000 periods length.

Figure 19: Land Pricing Function on Selected Grid Pairs in Benchmark Case

(a) Price when $R = 9.5\%$



(b) Price when $R = 5.5\%$



Note: Figure 19 shows the estimated pricing functions of land on selected grid pairs of the state variables (k and d) for the two levels of interest rate in the model.

B.3 Model Solution Algorithm: Parameterized Expectations

At first sight, the model appears to have four state variables, but a more careful observation reveals that land (l_τ) is in fixed supply; hence, it becomes irrelevant for the algorithm solution. Of the other three state variables, interest rates (R_τ) can only take on two values while the other endogenous variables - (k_τ) and (d_τ) - have a continuous support. To solve the model, following the Parameterized Expectations approach, I postulate for each discrete state variable an exponentiated polynomial in the two continuous states variables as the functional form for the approximation of the conditional expectations in each stochastic state. In plain and simple words, I use a different polynomial in k and d for each stochastic state R^s and expectational equation.[102]

The parametric form chosen spans the space of positive valued functions; hence, by increasing the order of the polynomial, it is possible to approximate arbitrarily well any function that takes strictly positive values. For each expectation, I estimate the log of the expectation with a polynomial $N = (n_k) \times (n_d)$ in the log of the endogenous states variables, with coefficients in each stochastic state given by ϑ^s. For example, the expectations in equation (100) in state $s \in S$, will be given by

$$\Phi(k_\tau, d_\tau; \vartheta^s_\Phi) = \exp(P_N\left(\ln(k_\tau), \ln(d_\tau); \vartheta^s_\Phi\right)) \tag{110}$$

where P_N is a $N - th$ order polynomial. The number of coefficients when using Chebyshev polynomials is given by the multiplication of the order of the basis function for each state variable. Therefore, if I use a simple first-order basis function for each state variable ($n_k = n_d = 1$), the polynomial will have four coefficients to estimate.[103]

Once I have discretized the state space and made an initial guess ϑ^{init} for the parameters choice, the algorithm is given by the following steps:

1. Given the last estimates for the coefficients of the approximations (ϑ^s_Φ, ϑ^s_Θ, ϑ^s_Υ), compute for each grid point the conditional expectations Φ^s, Θ^s and Υ^s and use them to replace the expectations in the equilibrium conditions following the next steps:

   (a) Assume that the borrowing limit does not bind $\mu_\tau = 0$, then for each grid point $(k_\tau, d_\tau, R^s_\tau)$ solve for the endogenous $k_{\tau+1}$, $d_{\tau+1}$, c_τ, h_τ, q_τ and λ_τ

[102] With three expectational equations and two stochastic states in the model, the total number of exponentiated polynomials employed to solve the model is six.

[103] In this case, the regressors will be a constant term, $\ln(k_\tau)$, $\ln(d_\tau)$, and $\ln(k_{\tau-1}) \times \ln(d_\tau)$.

in the following reduced system:

$$v'(h_\tau) = \frac{R_\tau}{R_\tau + \kappa_w (R_\tau^s - 1)} F_h'(l, k_\tau, h_\tau) \tag{111}$$

$$\lambda_\tau = u'(c_\tau - v(h_\tau)) \tag{112}$$

$$\frac{\lambda_\tau}{(1 + d_{\tau+1})} = R_\tau \Theta(k_\tau, d_\tau; \vartheta_\Theta^s) \tag{113}$$

$$\lambda_\tau = \Phi(k_\tau, d_\tau; \vartheta_\Phi^s) \tag{114}$$

$$q_\tau = \Upsilon(k_\tau, d_\tau; \vartheta_\Upsilon^s) \tag{115}$$

$$c_\tau + k_{\tau+1} + d_\tau + q_\tau l = F(l, k_\tau, h_\tau) + (1 - \delta)k_\tau + \frac{d_{\tau+1}}{R_\tau^s} + q_\tau l \tag{116}$$

If $\kappa_k k_{\tau+1} + \kappa_l q_\tau l > d_{\tau+1}$, the solution for this grid point has been found. Otherwise,the international borrowing constraint is binding and we need to consider the case, $\mu_\tau > 0$.

(b) If $\mu_\tau > 0$ the Euler condition for bond holdings holds only as an inequality; hence we "lose" equation 113 but gain the borrowing constraint equation as an equality:

$$v'(h_\tau) = \frac{R_\tau}{R_\tau^s + \kappa_w (R_\tau^s - 1)} F_h'(l, k_\tau, h_\tau) \tag{117}$$

$$\lambda_\tau = u'(c_\tau - v(h_\tau)) \tag{118}$$

$$\lambda_\tau = \Phi(k_\tau, d_\tau; \vartheta_\Phi^s) \tag{119}$$

$$q_\tau = \Upsilon(k_\tau, d_\tau; \vartheta_\Upsilon^s) \tag{120}$$

$$\kappa_k k_{\tau+1} + \kappa_l q_\tau l = d_{\tau+1} \tag{121}$$

$$c_\tau + k_{\tau+1} + d_\tau + q_\tau l = F(l, k_\tau, h_\tau) + (1 - \delta)k_\tau + \frac{d_{\tau+1}}{R_\tau} + q_\tau l \tag{122}$$

As explained in Marcet and Singleton (1999), to verify that we have found the correct solution for this grid point, one must ensure that the inequality in the Kuhn-Tucker condition is satisfied. In this case, this condition is automatically satisfied by construction (through the trick of dividing the RHS of the Euler for bonds by $1 + d_{\tau+1}$). This can be seen as follows: $\mu_\tau = 0$ was not a solution because it implied that $d_{\tau+1} > \kappa_k k_{\tau+1} + \kappa_l q_\tau l$. Hence, realizing that in the new solution h_τ, c_τ and q_τ will maintain their values (see equations 117, 119 and 120), it is the case that equations 122 and 121 can simultaneously hold if and only if $d_{\tau+1}$ goes down. In that case, the LHS of (113) unambiguously goes up and the inequality $\frac{\lambda_\tau}{(1+d_{\tau+1})} > R_\tau \Theta(k_\tau, d_\tau; \vartheta_\Theta^s)$ is automatically satisfied. I have found the solution for this grid point and can calculate μ_τ.

2. Once I have the model solved for each grid point, I compute the conditional expectations in equations 97, 100 and 101. The Markovian structure of the shock simplifies this step enormously, avoiding any need for a Gauss-Hermite quadrature.

3. I now have the conditional expectation based on the initial expectation function for each grid point. I can now find the implied new values for ϑ by fitting the polynomials to these data points. Given that I have more data points than parameters to estimate, I use a regression method. In particular, I linearly regress the logarithm of the exponentiated polynomial on the logarithm of the three conditional expectations to obtain the implied coefficients given by ϑ^{impl}.

4. I update the parameter vector in the direction of the recent estimated coefficients:
$$\vartheta^{new} = (1 - \Gamma).\vartheta^{init} + \Gamma.\vartheta^{impl} \tag{123}$$
where $\Gamma \in (0, 1)$ determines the weight placed on the new estimates.

5. The iterations are stopped when the difference between any element of ϑ^{init} and its corresponding value in ϑ^{impl} is below a chosen tolerance level (I set it to 10^{-5}).

Other technicalities: to discretize the endogenous state variables, I first find the steady-state values for two economies - normal and low interest rates - without uncertainty. Then, I create a regular grid with deviations of 15% from the average values. I have tried to make the grid as fine as possible. I use 35 nodes for each of k and d, which combined with the two stochastic values for R gives a total grid of 2450 coordinates. I found that the solution is quite accurate with Chebychev polynomials of order 2. A low updating parameter Γ makes the algorithm more stable, minimizing the risks of divergence, but at the cost of speed. I have initially used very low values $\Gamma = 0.05$, once a first robust set of coefficients was found I later increase this value in the sensitivity analysis.

To find the solution up to the required level of uncertainty I used "homotopy". I found that the best strategy to obtain a solution was to first solve a model with very small interest rate fluctuations, and once a robust solution was obtained, to use it as the initial condition for the next estimation in a calibration with larger amplitude fluctuations in foreign interest rates.

3 A Regime Switch Based Event Study of Argentina's Macro Fluctuations Between 2006-2011

3.1 Introduction

The sequence of external shocks that hit Argentina and the largest South American economies between 2005 and 2011 has been out of the ordinary. Early in 2005, in a global context of easy financial conditions, commodity prices started increasing slowly but steadily, blessing the country and the region with a continuous improvement in terms of trade. This mild initial trend gained momentum in late 2006 when primary goods prices speeded up their rate of growth in global markets. But in September of 2008, this apparently ever-increasing tendency came to an abrupt halt. At this point in time, the financial crisis, which was initially attributed to the United States and parts of Europe, intensified and spread across the globe. Between the last quarter of 2008 and the first half of 2009, the world experienced a severe deterioration in global financial conditions, causing the largest annualized fall in output and trade since the days of the Great Depression. During this acute phase of the Great Recession of 2008-09, a double whammy of plummeting commodity prices and a rapid deterioration in financial conditions battered Argentina and the other countries of the region in a similar fashion. Surprisingly, a year later, by the end of 2009, commodity prices were on their way to recover the lost ground while the negative real interest was contributing positively on the financial front. From then onwards, the external factors have continued to improve and remain aligned in the most favourable way for all major South American primary goods exporting countries.

The effects of these external shocks on the macroeconomic performance of the country and the overall region have been notorious and clearcut. Until Lehman Brothers' bankruptcy in September 2008, skyrocketing commodity prices had been fuelling a regional boom. Naturally, the intensification of the crisis proved to be too much of a double negative shock since no emerging economy was capable of escaping intact from the simultaneous negative shocks on the trade and financial fronts that took place in such short timespan, as extensively documented in Blanchard, Das and Faruquee (2010). Nonetheless, as soon as the shocks receded, with no permanent damage inflicted during the crisis, a V-shaped recovery followed. By the end of 2010, the economies had fully recovered the pre-crisis trend levels.

This experience provides a unique kind of natural experiment for evaluating a macroeconomic model, since reality seldom offers such a clearcut sequence of well defined exogenous shocks and macroeconomic adjustments. In this chapter, I take this task and assess the accuracy of the framework proposed in chapter 1 to reproduce the performance of the Argentinean economy during these turbulent years. My goals in this respect are twofold: the narrow one is to simply evaluate how does the model fare in terms of its ability to reproduce the dynamics of some selected macroeconomic aggregates during this period of unprecedented non-linear external shocks. The broad one is to understand the strengths and limitations of this type of framework in order to highlight the areas in which further research or a different approach are needed.

The starting point of this task is the data. Although I only evaluate the model for Argentina, I also explore the data for the five other largest "market-oriented" economies in South America (Brazil, Chile, Colombia, Ecuador and Peru) to highlight the common pattern, in terms of shocks and macro performance, among all selected countries.[104] In the process, I also evaluate whether some well-established stylized facts remain valid during this period. I also discuss some relevant regularities that my framework is capable of reproducing, but that the workhorse single-good model cannot.

To be able to numerically evaluate the model, I develop a stochastic structure that captures the sequence of external shocks described. As in chapter 1, I assume that the price follows a two-state Markov switching AR(1) process for the external shocks of commodity prices. I add realism to the model by further assuming, as in Bacchetta, Tille and van Wincoop (2010), that global financial conditions can also be characterized by two regimes, denoted as "normal" and "panic" regimes, where the latter captures conditions such as in the aftermath of Lehman's downfall. As is standard practice in the empirical literature, I use the VIX index - also known as *The Fear Index* - as a proxy for global panic and estimate a two-state Markov switching AR(1) from this series. I employ the estimated smoothed probabilities to statistically validate the argument that around the time of Lehman's downfall, the world experienced a financial panic regime. Then, I assume that the two Markov chains are independent and consider there to be four global regimes, the outcome of all possible combinations between the price and the financial regimes.[105]

The financial "panic" regime is incorporated into the model, assuming that it triggers a simultaneous increase in the tightness of the firms' working capital constraint and in the foreign creditors' perception of "default" risk probability. This ad-hoc specification captures the main channels through which a global financial meltdown has a negative effect on Argentina (and the other countries of the region): a direct negative effect on economic activity through the tightening of the working capital constraint and an increase in the risk premium with its knock-on general

[104] I exclude Venezuela from the analysis because I consider that domestic politics affect macroeconomic performance in a way that is not captured by the model.

[105] Clearly, the correct strategy would be to jointly estimate the process and then test the independency assumption. I acknowledge this weakness and leave this estimation to further research.

equilibrium effects.

To create the artificial data to which the real observations are to be compared, I simulate the model (calibrated like in chapter 1) for a sufficiently long period of time. Then, I collect all sub-series of six-year length in which the sequence of global regimes exactly matches the sequence of estimated global regimes. In other words, I first make inferences on the global regimes and then impose these conditions on the time series I select from the extended simulation. Thus, I preserve the stochastic nature of the simulations.

I first simulate a model - labelled the "baseline" simulation - where there is no "panic" regime. I illustrate that this configuration fails to reproduce the recession that materializes after Lehman's collapse. To improve upon this result, I further introduce the possibility of a "panic" regime and select all sub-series in which this regime was present in the quarters following Lehman's collapse (according to the estimated regimes). I conclude that this more realistic model fares quite well against the data, especially when considering the non-linear nature of the numerical exercise I am performing. The general assessment is that the endogenous variables evaluated - nine in total - move in the correct direction most of the time and track the data reasonably well. Particularly encouraging is the ability of the setup to reproduce the movements in consumption, output, industrial production and the trade balance. The modle is less accurate in terms of its ability to reproduce movements in investment and total imports. One explanation for this failure is the reductions in investment and imports, particularly during the acute phase of the global crisis, are too large in the data (25% and 40%, respectively).

In terms of prices, the model captures with a reasonable degree of accuracy the evolution of total bond yields (thanks to the panic regime) and the real exchange rate; two key prices in any developing small open economy. The main weakness of the framework is due to its inability to reproduce the stock market value behaviour. In this respect, there is an order of magnitude of difference. While prices more than halved in a short span of time in the data, the maximum fall in the model, even after the introduction of a financial "panic" regime, is approximately 20%. Although it is possible to come up with some modifications that would improve the results in this respect, i.e. such as expanding the number of regimes to include a "disaster" regime à la Barro (2006), as I have sustained in this entire thesis, this failure is an intrinsic property of the asset pricing frameworks currently employed by the literature.

All in all, I conclude that the framework captures reasonably well both the sequence of external events that shocked Argentina during the period under analysis and the economic adjustments generated by the shocks. Considering that the existing literature mainly attempts to match second-order moments or does simple impulse response exercises with small linear shocks that slowly decay over time, I conclude that this framework substantially improves our economic modelling.

The remainder of the chapter is organized as follows. In section 3.2, I explore the data for the six countries, paying special attention to the Argentinean data. In section 3.3 I discuss the new stochastic structure and incorporate the possibility of a financial "panic" regime into the model. In section 3.4 I briefly discuss the calibration of some parameters that were not considered in section 1.7 in chapter 1. In section 3.5, I explain how the model is simulated and discuss the main results. I pay particular attention to the ability of the model to reproduce the data of Argentina. Finally, section 3.6 briefly highlights the pitfalls of the framework and concludes the paper.

3.2 Exploring the Data

In this section I graphically present and analyse the data of nine macroeconomic variables for each country selected. The criterion by which a variable is chosen is simple: it has to be an endogenous variable of the model, so that I can evaluate the empirical performance of the model. For the sake of data homogeneity, all data was collected from the Inter-American Development Bank "Latin Macro Watch Data Tool", a free and open database.[106] For the sake of comparison across countries, I present each variable in a panel of six graphs - one per country. All individual graphs share the same structure: the horizontal axis measures time in quarters (ranging from the third quarter of 2005 until the second quarter of 2011). The left vertical axis measures the endogenous variable normalized to one in the fourth quarter of 2005 and, in case the variable is a "quantity variable", also its Hodrick-Prescott trend.[107] Alongside each variable, I plot real export prices (right-hand side axis) to visually illustrate the connection between terms of trade - realistically assuming constant import prices - and the evolution of the macro aggregates.

Before delving into the details of each individual country and variable, it is important to convey the broad message of the empirical analysis: notwithstanding the heterogeneity within the group of countries, the price cycle of the commodities induced a homogeneous macroeconomic performance in the region. The reason for this is that the economies of the region share a common structural dependency on primary commodities as the main source of exports. Hence, shocks to commodity prices have large effects on the economies of the region. This simple fact can easily be confirmed by visual inspection. Indeed, in all charts there seems to be a common pattern of three distinguishable macroeconomic sub-periods: The first one of a slow-building booming phase driven by continuously increasing commodity prices that gained momentum in 2007 and lasted until Lehman Brothers' bankruptcy in

[106] To access visit http://www.iadb.org/Research/LatinMacroWatch/lmw.cfm.

[107] The HP trends were calculated using quarterly data that goes back to 2002-Q1. Variables are detrended in levels. I also explored with logarithm detrending and then converting back to levels and found that there were no substantial differences.

September 2008. The second of a sharp contractionary phase driven by plummeting commodity prices and stressing global financial conditions during the following three to five quarters. Finally, the ongoing strong recovery phase, pulled by skyrocketing primary commodity prices and easy financial conditions. Next, I dig into the details of the data and highlight how this pattern emerges over and over again.

The top six panels in Figure 20 depict output alongside export prices.[108] A quick glimpse at each panel confirms that export prices skyrocketed in 2007 and sent output above its trend. In the last quarter of 2008, prices went down abruptly and the economies decelerated quickly with small negative growth rates. By the beginning of 2010, output had fully recovered while prices were on their way back to recover their lost ground. As expected, real output has been highly positively correlated with export prices during this period. For Argentina, this coefficient was 0.72 and the highest value was attained by Chile with a correlation coefficient of 0.80. From the trend lines (solid thin blue), it is reasonable to conclude that the 2008-2009 crisis was a short-lived negative external shock that does not seem to have caused any permanent output loss. The record regional recovery that took place in 2010 with an average growth of 7.3% guaranteed that by 2011-Q2, all countries had fully recovered their pre-crisis trend levels.[109]

Figure 20h in the middle panel confirms that aggregate consumption followed exactly the same pattern as real output. The interesting feature to highlight is that, contrary to what is a well-established stylized fact as concerns emerging economies, consumption was less volatile than output during this period in each and every country. For example, in Brazil, consumption was 23% less volatile than output; a relationship typically found for large developed countries like the U.S. and not consistent with the pre-established stylized facts of emerging markets.[110] Even though there is still not enough data to jump to new conclusions, this novel finding be might signalling the end of a generally accepted stylized fact. One possible explanation for this finding is that countries in the region have improved their external financial positions and can now avoid experiencing a full-blown balance of payments crisis as in the past, effectively behaving as would be suggested by the intertemporal approach to the current account.

An identical, but more pronounced, pattern emerges when analysing industrial production with the help of Figure 20n. In this case, the contraction during the acute phase of the global crisis is an order of magnitude larger. For example, in

[108] I plot export prices instead of commodity prices because the share of commodity exports in total exports varies across countries; hence this is better for comparison purposes. Nonetheless, the share of total exports in output also varies across countries; hence, the relative size of the shocks cannot be compared among countries.

[109] For the sake of comparison, during the 1980's, average growth was less than 1.4% and during the 1990's, this value was around 2.6%. The only notably exception during the 1990's was Chile that experienced an average growth rate of 5.8%.

[110] See Neumeyer and Perri 2005.

Argentina, from peak to trough the fall was around 8%, while in, Brazil, the most industrialized country in the region, the fall was close to 24%. By the end of 2009, industrial production in all countries was quickly recovering the lost ground. The attentive reader would have noticed that Chile (third column) seems to be the outlier in the group with a further drop in industrial production during 2010. The truth is that this was caused by a second "truly-real" shock: the earthquake in February 2010.

Even more accentuated is the boom-bust like pattern for investment and, especially, imports around Lehman's collapse as shown in Figures 21b and 21h, respectively. In every country but Colombia, in a matter of two quarters, investment and imports moved from very large above trend values to the polar situation. Surprisingly, a strong V-shaped recovery took place afterwards. If it were valid to extrapolate findings from the literature dealing with macro responses to Lehman's collapse in developed countries to less developed ones, the cause behind the simultaneous large fall in investment and imports was the unprecedented uncertainty shock that followed the downfall of the banks.[111] The so-called composition effects hypothesis conjectures that the primary effect of an uncertainty shock is a sharp drop in durable and investment goods demand, as agents delay their medium-run demand decisions. As such, this effect does not only seal the fate of investment, it also seals the fate of imports since durable and investment goods are to a large extent foreign goods.[112] In emerging markets, one could add the fall in commercial credit lines and the flight to quality as another cause that explains this abrupt fall.

The bottom Figure 21n depicts the trade balance as a fraction of output. The calculations (not shown) confirm that net exports are countercyclical in all countries, albeit very weakly in Colombia and Ecuador. This outcome should come as no surprise since the literature has consistently found that net exports are countercyclical in the developing world and a-cyclical in the developed one.[113] The other two characteristics are the hump-shaped pattern in net exports around the time of the crisis and, possibly, the secular downward trend. That is, although it is not so straightforward to establish a long-term pattern, especially when considering Colombia, a possible reading from the data of Argentina, Brazil, Chile and Peru is the following: there is a secular trend of deterioration in the trade balance that was only temporarily reversed during the acute phase of the crisis.

In the final Figure 22, I plot three key macroeconomic prices in any emerging market economy that, surprisingly, tend to be partially ignored by the literature

[111] See Nick Bloom (2009, 2011) for a model that deals with uncertainty shocks and its consequences, in particular investment.

[112] See Levchenko and Tesar (2009) and Anderton and Tewolde (2010) for papers that argue that composition effects drove the sharp fall in international trade during the recession.

[113] See Neumeyer and Perri (2005) and Aguiar and Gopinath (2007).

when constructing/testing models[114]: the total yield on sovereign bonds, the real exchange rate (vis à vis the United States) and stock market prices in real terms. In the canonical one-good model, the first price is normally an exogenous shock, there is nothing to say about the second price and the third is never modelled. My model takes on this challenge and endogenizes these prices, albeit admittedly, with mixed empirical success.

One of the difficulties in recognizing the pattern for interest rates before the crisis is that Argentina is an outlier. That is, the yields on bonds were going down in every country during 2006 and 2007, as expected given the improvement in external solvency; nonetheless, in Argentina this trend is reversed at some point. The simple reason is that the Argentinean consumer price index estimation lost credibility in 2007. After the government intervention, the institute that produces the index and markets began penalizing domestic bonds. Thus, excluding Argentina, the pattern of improvement in financial conditions was there during the pre-Lehman collapse period, as observed in all panel graphs in 22b. Nonetheless, once the crisis unfolded, a common inverted V-shape pattern emerged: the interest rates suddenly peaked and went down quickly once the panic receded. The middle panel 22h provides information on the real exchange rate. Excluding the dollarized economy of Ecuador from the analysis for obvious reasons, it seems clear that a secular trend of real exchange rate appreciation started in 2005 and continued until it was abruptly reversed in the aftermath of Lehman's bankruptcy. As with interest rates, once uncertainty subdued in mid-2009, the real exchange rate secular appreciation trend resumed with force. The strongly negative correlation between the real exchange rate and export prices should then come as no surprise, with values ranging between -0.31 for Ecuador (fixed exchange rate) and -0.83 for Brazil (a pure floating exchange rate).

The stock market indexes in panel 22n moved according to the general pattern outlined, albeit with a subtle difference: they started moving down at least two quarters before Lehman's collapse, at a time of crisis in the U.S. but when the domestic economies were still growing strongly. Clearly, this simple fact reflects the tight interconnection among equity markets across the globe and, possibly, the forward looking nature of asset markets. As expected for primary goods exporters, stock prices were highly positively correlated with export prices during this period, the minimum value being 0.29 for Argentina and the maximum 0.78 for Peru. The most outstanding characteristic of this variable is simply the order of magnitude in the fall in prices that took place between September 2008 and the first quarter of 2009. For example, in this short span of time, Argentina and Brazil's stock indexes more than halved.

[114] I have in mind the canonical one-sector small open economy model with exogenous interest rate shocks.

3.3 Incorporating Stochastic Financial Panics

For the sake of conciseness, in this section I only present and discuss the differences between the stochastic structure developed in chapter 1 and the present one. The main starting point is that I must expand the universe of potential sources of shocks to include shocks that could capture financial environments such as that following Lehman's bankruptcy.

3.3.1 Commodity Prices Regimes

In this specification of the model, it is still the case that the main driving force is the behaviour of the Argentinean commodity export basket price, denoted by p_x. Based on the estimations in chapter 1, I continue modelling this price with a two-state Markov switching AR(1) process, which reads as follows:

$$p^x_\tau = v_{s_\tau} + \rho_{p^x} p^x_{\tau-1} + \sigma\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\,\mathcal{N}(0,1) \tag{124}$$

where s_τ is the regime at time τ. This implies that the unconditional mean price in the low and high regimes are $p^x_l = \frac{v_l}{1-\rho^x_p}$ and $p^x_h = \frac{v_h}{1-\rho^x_p}$, respectively. The transition probabilities are collected in a 2×2 matrix denoted by $\mathcal{P}_{p^x}$.

A valid question at this point is whether the outcome would be materially different if I were to model terms of trade instead of the commodity price bundle? The answer is negative, since the commodity price index drives the terms of trade in Argentina (also in the region). The reason for this is that industrialized export and import prices are very stable in the medium run, explaining why the Argentinean Central Bank constructs the commodity exports price index and uses it to forecast the evolution of the terms of trade. The other benefit of modelling trade shocks from commodity prices is that I avoid all issues of endogeneity and compositional effects that would arise if dealing with terms of trade. In this sense, I consider that commodity prices provide a very transparent source of trade-related shocks for Argentina.

3.3.2 Financial Regimes

The model as it is now is unable to capture the recession that took place following Lehman's collapse, since a negative trade shock only moves the economy towards the previous steady state. Hence, I need to find a simple way of incorporating this event and its consequences. As suggested in section (3.2), a reasonable interpretation is that Lehman's collapse triggered a global uncertainty shock with knock-on effects in Argentina's financial conditions: it increases the risk premium and triggered a flight to quality; effects that contributed to the short-lived recession experienced by the country around this time. The simplest way of modelling the nature of this unusually turbulent period in my framework is to assume, following Bacchetta, Tille and van Wincoop (2010), that global financial conditions can be characterized by two regimes: "normal" and "panic" times, where the latter describes financial conditions in the months following Lehman's downfall. However, this immediately raises two questions of how to incorporate this in the framework: First, what is the stochastic process driving financial the financial regimes. Second, how can a "panic" shock be represented in the extended framework? The rest of this section is devoted to addressing these two questions.

To answer the first question, I need a generally accepted proxy variable for the perception of risk that could signal the presence of a panic in financial markets. Following many empirical papers, I employ the VIX index calculated by the Chicago Board of Options Exchange as the best proxy for global risk (panic). The index measures the expected variation in the S&P 500 within a 30-day maturity and is quoted in annual percentage terms. It is commonly referred to as the *Fear Index*, because higher values typically correspond to a more volatile market and are associated with higher levels of investor uncertainty and fear.

I use the index to estimate a two-state Markov switching AR(1) process. The logic behind the autoregressive component assumption is based on the fact that time series of stock returns have positive autocorrelations for squared returns and can be characterized with an ARCH process. Thus, it is reasonable to model implied volatility as an autoregressive process and capture jumps in uncertainty - normal and panic times - with a two-state Markov chain as Hamilton and Susmel (1994) did with returns volatility. The specification I estimate reads as follow:

$$VIX_\tau = c_{s_\tau} + \rho_{vix} VIX_{\tau-1} + \sigma_{s_\tau}\mu_\tau \quad , \quad \mu_\tau \sim i.i.d\, \mathcal{N}(0,1) \tag{125}$$

where VIX_τ is the volatility index, s_τ is the regime at time τ, c_{s_τ} is the regime conditional intercept, ρ_{vix} is the autoregressive term and σ_{s_τ} is the state conditional standard deviation.

I first estimate the model on a quarterly basis with data ranging between 1992-Q1 and 2011-Q2. The most relevant result is that I find statistical support for the claim that a "panic" shock took place around the time of Lehman's collapse as revealed by the smoothed probabilities in Figure 23a. In effect, the estimation shows that the switch took place around the time of the first signs of problems in the U.S. economy in 2008-Q1, and that the high volatility continued until the end of 2010. But a simple visual inspection shows that the weakness of this model is that it identifies periods of relatively high volatility as panic regimes, which is simply not correct. Clearly, one possible way of improving this is to expand on the number of states to, for example, disentangle high volatility periods from panic periods. To further avoid complicating the model with more stochastic states, I choose an alternative and simpler way: I narrow down the window event to see if I can isolate the subperiod that followed the bankruptcy by reestimating the model, but in this case on a monthly basis during a shorter span of time, covering January 2005 until July 2011. The monthly results are presented in Figure 23b which identifies September 2008 as the initial month of the "panic" regime and April 2009 as the final month, a result that coincides with all narrative explanations of what took place in financial markets during these months. Table 7 presents detailed estimation results for both models. There is no need to further expand on these findings, it suffices to say that in both models, I rejected the linearity hypothesis in favour of a two-regime model.

These estimations provide an answer to my first question, by providing the transition probability matrix and the timing of the "panic" regime for the simulation. Indeed, from the quarterly estimation, I borrow the 2×2 estimated transition probability matrix, denoted by $\mathcal{P}_{vix}$, to describe the Markov chain governing financial regime probabilities and from the monthly estimation, I conclude that the financial "panic" regime started in 2008-Q4 and finished in 2009-Q1.

3.3.3 Joint Regimes

By now, the reader would have noticed that my estimation strategy directly assumes independency between financial and commodity prices regimes. This seems at odds with basic economic theory and the empirical data, since nothing guarantees orthogonality between these two shocks. My excuse for this over-simplification is that a model that jointly estimates a regime switching process for commodity prices and the VIX index would be quite involved and is beyond the scope of this work.

With my assumption, the joint (global) regimes transition matrix can be trivially constructed from the two independent regime estimations. Indeed, the joint Markov chain, denoted by $\mathcal{P}_{joint}$, is given by the Kronecker product of the two specific chains:

$$\mathcal{P}_{joint} = \mathcal{P}_{p^x} \otimes \mathcal{P}_{vix} = \begin{pmatrix} 0.95 & 0.05 \\ 0.06 & 0.94 \end{pmatrix} \otimes \begin{pmatrix} 0.91 & 0.09 \\ 0.08 & 0.92 \end{pmatrix} \tag{126}$$

where the rows in $\mathcal{P}_{p^x}$ collect transition probabilities from commodity price regimes as shown in Table 2, and the rows of $\mathcal{P}_{vix}$ collect transition probabilities from VIX regimes as shown in Table 7.

The joint regimes matrix $\mathcal{P}_{joint}$ now has cardinality four and a global state is a pair indicating the price regime and the financial regime.[115] I denote the regime state space by $\mathcal{S}^4$ and, without lost of generality, I order the global stochastic states

[115] I say global state to distinguish this matrix from the one that is used to solve the model and contains all the stochastic states, that is, once the AR(1) process for commodity prices p_x has been discretized. As an example, if I discretize p_x using $n \geq 2$ points, the global regime states will always be 4 while the total number of states will be given by $n \times 4$.

conveniently as follows:

$$\mathcal{S}^4 = \begin{cases} s^1 & \text{low prices \& panic financial times} \\ s^2 & \text{low prices \& normal financial times} \\ s^3 & \text{high prices \& panic financial times} \\ s^4 & \text{high prices \& normal financial times} \end{cases} \tag{127}$$

where a simple mnemotechnic rule might help the reader keep in mind what each regime represents: the "high" commodity price regime takes place in the global states with "high" values (that is s^3 and s^4), and the "panic" financial regime takes place in the global states with "odd" values (that is s^1 and s^3).

3.3.4 Modelling a Financial "Panic"

I am now ready to address the second question: what are the effects of a panic in the model? The concise answer is that I model a panic as a simultaneous increase in the tightness of the firms' working capital constraint and in the foreign creditors' perception of "default" risk probability. Although the specification is ad-hoc, it captures in a stylized way the different channels through which a global financial meltdown negatively affects a country like Argentina. For example, the increase in the firms' intratemporal financial friction directly reduces output and intermediate production (the proxy for industrial production), hence this shock can be considered as incorporating the negative consequences of the fall in trade credit and financing lines that took place during the crisis, as described by Aubion (2009). The increase in risk perception by investors generates an instantaneous jump in domestic spreads with all its negative general equilibrium consequences. Thus, this shock simply captures the fact that global factors mainly drive the spreads of emerging markets, as estimated in Longstaff et al. (2010). Indeed, the authors find statistical support for the claim that global factors such as risk aversion, liquidity conditions and flight to quality episodes, principally explain movements in emerging market spreads.

In formal terms, these assumptions imply that κ_m in the firms' intermediate inputs constraint and ϕ_1 in the logistic function that determines the perceived probability of default, can take on two values according to the global regime. As such, the working capital constraint now reads as follows:

$$\frac{\chi_\tau}{R_\tau} \geq \kappa_m(s^i) p_{h,\tau} m_\tau \tag{128}$$

with $\kappa_m(s^1) = \kappa_m(s^3) > \kappa_m(s^2) = \kappa_m(s^4)$ indicating that in the financial "panic" regime, firms are forced to hold proportionally more non-interest rate bearing assets as collateral. For the perceived probability of default, the new condition reads as follows:

$$\pi_\tau^{def} = \frac{exp\left(\phi_0 + \phi_1(s^i)\left(\frac{d_{\tau+1}}{\mathbb{E}(p^x_{\tau+1})}\right)\right)}{1 + exp\left(\phi_0 + \phi_1(s^i)\left(\frac{d_{\tau+1}}{\mathbb{E}(p^x_{\tau+1})}\right)\right)} \tag{129}$$

with $\phi_1(s^1) = \phi_1(s^3) > \phi_1(s^2) = \phi_1(s^4)$ indicating that in the financial "panic" regime, foreign lenders increase their assessment of default probability proportionally to the leverage ratio. This concludes the modifications to the structure of the model.

3.4 Calibration and Discretization

I keep the basic calibration presented in section 1.7, but with three modifications. First, the risk-free rate (r_f) is a fixed parameter in this version of the model. I set its value at $r_f = 2.25\%$ annually, which is simply the average between the two regimes in chapter 1. The main effects of modifying this value are that it shuts down one source of boom-bust cycles and slightly alters the ergodic distribution of debt. Second, I need to calibrate the financial parameters - κ_m and ϕ_1 - that characterize the financial panic regime. Since I have no empirical support for this, I follow an ad-hoc practical approach: I simulate the model for a range of reasonable values and then select the configuration that best reproduces the data during the acute phase of the crisis. For example, a value of κ_m 1.5 higher in the panic regime generates empirically accurate falls in industrial production during the crisis which seems to be empirically plausible, since it implies that the working capital constraint as a fraction of GDP jumps from 16% to 24% in a financial panic shock. Increasing ϕ_1 by 25% during the panic guarantees that the simulated data matches the increase in total yield that took place between 2008-Q4 and 2009-Q1. Third, I set the unconditional commodity price means in each regime to $p^x_l = 1$ and $p^x_h = 1.87$. These values guarantee that the simulated commodity prices track the price data quite well. The remaining parameters governing p^x remain unchanged.

I discretize p^x with a grid of 35 equidistant nodes using the quadrature method proposed by Tauchen and Hussey (1991). The grid for each endogenous state variable, d and k, contains 30 grid points. Thus, the total grid size for this version of the model is $N = n_S \times n_{p^x} \times n_d \times n_k = 4 \times 35 \times 30 \times 30 = 126000$.

Finally, when evaluating the ability of the model to reproduce the data, the reader should bear it in mind that the size of the shock that I introduce is quite small. Indeed, the calibration assigns to a commodity price regime shift a total long-term shock of around 4.35% of total output (at initial prices and after some years). In other words, the price shock is akin to an increase in the natural resource good endowment by 4.35%: the outcome of multiplying the share of natural resource exports in output of 5% times the medium-run commodity price swing of 87%.

3.5 Evaluating the Model

The main advantage of using a stochastic model that is solved globally with numerical methods is that we can analyse the trajectory of the economy outside its steady state. This property is crucial in policy evaluation exercises, like in the one performed in chapter 1, because we can calculate consumption along the trajectory towards a new stochastic steady state. In some exercises, accounting for these transitional effects result in diametrically opposite results to the ones obtained by simply evaluating steady states.

Thus, in this section I try to validate empirically the model introduced in chapter 1 with an ad-hoc approach. My approach profits from the sequence of non-linear shocks that Argentina experienced under the period of analysis to evaluate how good is the model at reproducing the data. To do so, I first use the inference about global regimes at each point in time to establish the sequence of global regimes that best describe the external shocks. The next step is to simulate the model for a long period of time (100000 periods) to generate artificial data for all the endogenous variables. I then select all the subseries of length 24 (ranging from 2005-Q3 to 2011-Q2) for which the sequence of stochastic global shocks coincides with the estimated global regimes.[116] Finally, for each variable, I take the average value over all subseries and also calculate the area that contains 90% of the subseries. Then, I plot the artificial data alongside the actual data from the economy. Although I do not develop a metric that allows me to evaluate statistically how close are the model's simulations from the data, I consider that as a first approach a simple visual inspection provides a good guidance on the model's empirical strengths and weaknesses. In other words, I am interested in assesing whether the artificial data (9 series in total) closely follows the actual data over this six-year horizon.

The first simulation, labelled baseline case, only considers the possibily of regime switches in commodity prices. It has the following sequence as concerns the timing of the commodity price regimes: in the first three quarters, commodity prices are in the low regime (bust phase); during the following year there must be a transition to the high price regime (building-up of the boom); commodity prices must remain in the high price regime for five consecutive quarters (boom phase); during the following four quarters, prices must be in the low regime (bust phase); prices begging to recover during the next two quarters (building-up of the boom) and thereafter prices must be in the high state (boom).

The final simulation, labelled the "panic" case, has the same sequence of regimes for commodity prices but further imposes the condition that from October 2008 until March 2009, the model must be in the financial 'panic' regime as estimated in section

[116] I follow a simple rule to assign the regimes for the commodity price index and the VIX index: if any smoothed probability of a state is greater than 90% I assign the regime to that state. When both probabilities are below 90% the regime is not assigned to any state.

3.3. The following table clarifies the sequence of global regimes that corresponds to both cases:

Subperiod	*State baseline*	*State panic*	*Macro phase*
2005Q3-2006Q2	s^2	s^2	Bust
2006Q3-2007Q2	s^2 s^4	s^2 s^4	Build up boom
2007Q3-2008Q3	s^4	s^4	Boom
2008Q4-2009Q1	s^2	$(\mathbf{s^1})$	Bust (**panic**)
2009Q2-2009Q3	s^2	s^2	Bust
2009Q4	s^2 s^4	s^2 s^4	Build up boom
2010Q1-2011Q2	s^4	s^4	Boom

The simulations are presented in ten individual graphs. As explained, In each graph I plot the mean value over all series collected (solid blue line) as the model data and paint the area (gray) where 90% of these series lie. Alongside these artificial data, I plot actual data from Argentina (dashed red line) that is calculated as deviations from the Hodrick-Prescott trend in case the variable represents a quantity (output, consumption, industrial production, investment and imports) and in levels for the others. Whenever it is convenient, variables are normalized to a value of one in 2005-Q3. A vertical line in a graph indicates the quarter in which regime switches take place.

3.5.1 Baseline Simulation

Before going into the details, as a general evaluation of the model it is fair to say that although accuracy in this context can not be statiscally corroborated, the most striking feature of the framework is that it generates the correct movements in each variable, albeit for some in defect and for others in excess. Thus, the general conclusion given the complicated nature of the exercise I am performing should be that the model does a reasonably good job in reproducing the dynamic adjustment of all variables.

The first graph on top of Figure 24a plots the driving force of the model: the simulated price of the commodity bundle alongside the data price. It is clear from simple visual examination that the regime switch timing criterion is quite accurate to reproduce the data. Implicitly, this also confirms that the discretization of the two-state Markov switching AR(1) reasonably maintains the properties of the continuous process.

Moving to the analysis of the endogenous variables, in the second row, Figures 24b, 24c and 24d plot output, consumption and industrial production, respectively. As a general assessment, it can be said that the model does a good job in reproducing the shape in each case, but falls short when it comes to capturing the negative impact of the crisis between 2008-Q4 and 2009-Q4. The reason for this deficiency is the absence of a recessionary shock in the baseline case, since a switch to the low commodity prices regime simply brings back the model to the pre-boom steady state rather than sending the economy below pre-boom levels. The introduction of a financial panic regime aims at remedying this shortfall of the current configuration.

The next row shows investment, imports and the ratio of trade balance to output in Figures 24e, 24f and 24g, respectively. For this group of variables, the model still tracks the direction of change reasonably well, but with some important discrepancies in terms of quantities for the first two variables: investment in the model increases by 25% during the boom while only by 10% in the data and imports fall by 18% in the model during the crisis while in the data this figure is around 30%.

Although these discrepancies are relatively large, it is important to bear in mind that these results are quite sensitive to detrending, especially since investment and imports were growing at annual rates of 11% and 13% from 2005 until 2008-Q3, respectively. In this scenario, it is reasonable to assume that there is not any clear cut between the trend and the fluctuations around it.[117] Thus, one important reason behind this failure can be attributed to the difficulty in disentangling between the trend component and the low frequency cycles component during these unusual years.

In terms of investment, the large boom produced by the model is partially the result of model specification. It is possible to enumerate three characteristics of the model that contribute to this result: first, that only foreign goods can be used to build domestic capital. Second, that the share of foreign goods in aggregate consumption is low (20%). Third, that the elasticity of substitution in consumption between domestic and foreign goods is quite low (0.45 as estimated in Gonzalez-Rozada and Neumeyer 2005). As a result, when commodity prices rise, there are plenty of foreign goods that mainly end up building domestic capital since the price of domestic goods rises sharply.[118]

Regarding imports, the failure of the model to reproduce their drastic fall during the crisis is reasonable since the response of global trade to output during the crisis was larger than what the profession expected. Thus, one can think of the gap between the simulation and the data as an indirect measure of all effects that are not incorporated in the model but have been proposed as the reasons behind the drastic fall in global trade during the crisis: constraints in trade finance, the uncertainty shock causing composition effects in demand, the fall in intraindustry trade and

[117]As explained in Aguiar and Gopinath (2007), the usual scenario in emerging markets is a trend growth shock as the primary source of fluctuations, rather than transitory fluctuations around a stable trend as in developed countries.

[118]In a simulation with a higher elasticity of substitution (not shown), this problem was partially reduced since more resources were channelled to consumption rather than investment. Nonetheless, the cost is that in this version, the model fails to produce significant real exchange rate appreciations or depreciations as in the data.

the disruption in international production chains as firms relied more on inventories stocks.[119]

The trade balance (Figure 24g) initially goes down during the boom, then jumps from 2% to 4.5% during the crisis, and resumes its downward trend once the global context improves exactly as is the case with the data. Thus, the main weakness in this respect is that the model does not sufficiently capture the jump in net exports during the acute phase of the crisis. Obviously, the failure in the trade balance adjustment is the mirror image of the failure in imports adjustment described above.

The last row of panels plot the three endogenous prices of the model. It is clear that there are difficulties in reproducing the evolution of bond yields during the initial bust and boom phases, as seen in Figure 24h. The reason is that in contrast to what is expected, the interest rates were initially going down in Argentina, but suddenly this trend was reversed before the crisis unfolded. As explained, the reason for this weird behaviour is that at the beginning of 2007, the government intervened in the national statistics office and the markets lost confidence in the willingness of the authorities to fulfill contractual agreements. Nonetheless, the model captures the increase in spreads once the crisis unfolds, albeit not in full and with a lag. In the financial panic case, these difficulties will be overcome.

Figure 24i plots the real exchange rate vis à vis the U.S. In the simulations, like in the data, the real exchange rate begins to appreciate once the commodity prices improve and depreciates sharply after Lehman's collapse. Then, once the external conditions begin improving, the real exchange rates once more start appreciating as in the data, but faster. Overall, it could be said that the model does a pretty good job in reproducing this data. Nevertheless, it is probably fair to say that the real exchange rate would have depreciated further during the crisis if it were not for the active role of the government in avoiding further depreciations.

The final Figure 24j plots data for the stock market value in real terms alongside the asset price in the model. A casual visual inspection reveals that the model is incapable of reproducing the scale of the collapse and the subsequent recovery in asset prices that took place during the acute phase of the crisis. Moreover, I am certain that with this type of framework, it is not possible to reproduce these swings. The only consolation is that this shortfall is not peculiar to this model, but a property common to the general class of dynamic stochastic general equilibrium models: Caballero (2009) convincingly argues that the profession has been self deluding by ignoring this failure and instead focusing on the apparent "success" at matching second-order business fluctuations in quantities. A promising line of research in this direction is Adam and Marcet (2011) which slightly departs from the rational expectations paradigm by introducing learning in a model of asset pricing, albeit in a partial equilibrium framework.

[119] See Blanchard, Das and Faruquee (2010) for a description of the alternative hypothesis.

3.5.2 Panic Simulation

In Figure 25, I present the simulation results for the version of the model that I considered to more accurately represent the events that took place around the time of Lehman's collapse. In each graph, I have added a new vertical line indicating the quarter in which the financial "panic" ends (2009-Q2). As confirmed by Figures 25b, 25c and 25d, the new version of the model does an outstanding job in reproducing output, consumption and industrial production during the turbulent period of the crisis. Critical to this success is the additional role now played by the intermediate input financial constraint that automatically imposes a negative shock in the intermediate input production and explains the ability of the model to reproduce the 10% fall in industrial output as in the data. The only weakness of this version is that the recovery is faster in the model that in the data. This possibly suggests that the negative consequences of the financial panic went beyond the first quarter of 2009. In a simulation (not shown) where I assume that the financial panic lasted for a whole year (2008-Q4 until 2009-Q3), I substantially improved the performance of the model in this respect.

An inspection of the middle panels 25e and 25f shows that the financial panic reduces investment and imports during the crisis, but not to the necessary extent for replicating the data. As explained in the previous simulation, this result is expected and is partly model-specific. That is, during the financial panic, there is a tightening of the firms' financial constraint that mainly affects non-tradable production, and only mildly affects investment and imports, mainly through the increase in interest rates. Nonetheless, the fall in imports is enough to reproduce the evolution of the trade balance during the whole sample. I consider this to be an outstanding achievement of the model, especially when considering that success in this strand of research is measured as the ability of the model to reproduce some restrictive second-order properties of the data.

In the last row, we can see that after the introduction of a financial panic, the model does a great job in reproducing the large jump in bond spreads during the acute phase of the crisis (see Figure 25h). But this has to be the case because the model is calibrated to reproduce this fact. The second Figure in the bottom row, reference 25i, reveals that the cost I pay for introducing a panic is that during the crisis, the real exchange rate overshoots the data with its depreciation. Once more, one needs to consider that I am dealing with a real model; thus, the ability to match the real exchange rate in times of financial crisis can be difficult. Besides, if I were to increase the elasticity of substitution in consumption between foreign and domestic goods, this problem would vanish.

The bottom right Figure 25j confirms that the financial panic does not improve the performance of the model in terms of reproducing the drastic fall in asset prices that took place during the crisis. Once more, as I explained, it is expected that this framework is not capable of reproducing the asset price swings observed in the data. In this panic case, asset prices are, on average, only 4% less than in the baseline case, confirming how hard is for this framework to attain asset price movements of the same size as those observed in the data.

All in all, the final conclusion is that the framework developed in this work reproduces the behaviour of an economy that experiences large external shocks reasonably well. I consider that the ability of the model to reproduce the observed non-linear dynamics is a major step forward in the professions' ability to model natural resource rich emerging economies. I also consider that this empirical success validates the results of the policy experiments evaluated in section 1.9.

3.6 General Assessment and Conclusions

The simulations have shown that a model combining commodity prices and financial regime switches goes a long way towards reproducing the behaviour of the most important aggregate variables over the last few years in Argentina. This result is remarkable when considering that the simulations cover 24 quarters and that I am tracking 9 endogenous variables, including variables commonly ignored by the literature, such as industrial production, imports, the real exchange rate, total yield on debt and stock market prices. From this success, I conclude that the literature should put more effort into introducing regime switches in its models, in particular considering the highly non-linear behaviour of these economies during these years.

The other important lesson to be drawn from these exercises is that this type of framework is incapable of reproducing the large swings in asset prices observed in the data. Although this failure is inconsequential in this model, since the price of land does not have any general equilibrium effects, it is critical from a policy making perspective or even in terms of the reliability of models where assets serve as collateral or determine interest rates. The general warning is that predictions from this class of models will generally underestimate the scale of the potential asset price fluctuations; a particularly worrying aspect when acknowledging that the typical emerging market depends heavily on collateralized borrowing to access international markets and domestic lending and borrowing is also based on this type of operation. This feature reinforces the calls to increase research in this area as emphasized in chapter 2.

C Appendix

C.1 Tables

TABLE 7: MARKOV SWITCHING AR(1) MODEL ESTIMATES: VIX INDEX

Statistic	Parameter	$VIXmonthly$ Regime		VIX quarterly Regime	
		Normal	"Panic"	Normal	"Panic"
Intercept	c_s	4.688 (1.358)	12.562 (6.760)	6.279 (3.358)	11.683 (8.210)
Autoregressive	ρ_{vix}	0.716 (0.271)		0.551 (0.216)	
Standard deviation	σ_s	2.756	8.151	1.702	5.50
Transition matrix	$\mathcal{P}'_{vix}$	0.94	0.23	0.94	0.05
		0.06	0.77	0.06	0.95
Stationary probability		0.80	0.20	0.48	0.52
Expected duration		16.6	4.25	16.39	18.18
Observations		79		80	
Log likelihood		-202.89		-200.37	
Log likelihood AR1		-238.41		-234.44	
Linearity test(p-value)		0.000		0.000	

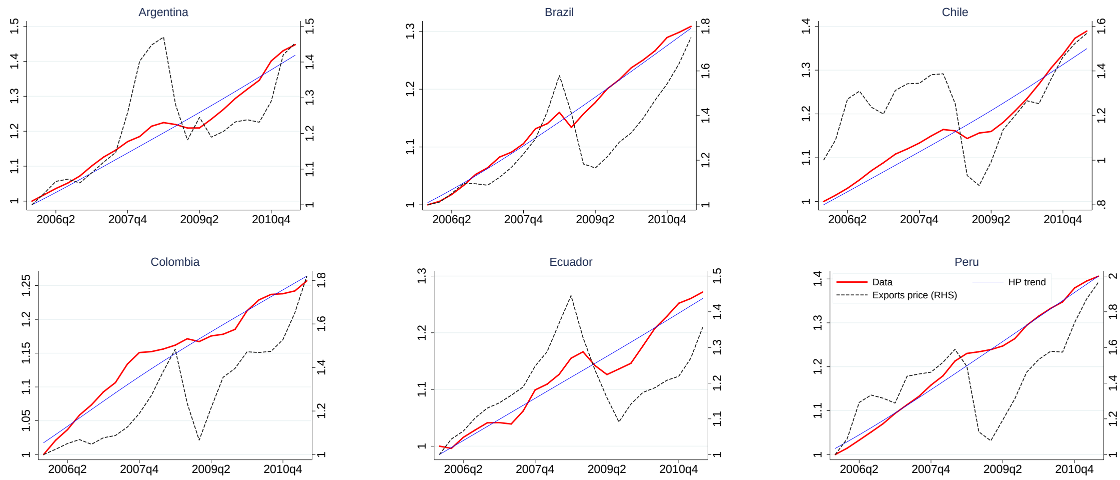
Notes: The table reports the estimation results of a Markov Switching Intercept Autoregressive process of Order 1 (MSI) for the VIX index on a quarterly basis and a monthly basis. Standard deviations are between brackets. The linearity test is conducted over 1 000 simulations. Data source: Bloomberg.

C.2 Figures

Figure 20: Output, Consumption & Industrial Production: South America 2006-11

(b) Output

(h) Consumption

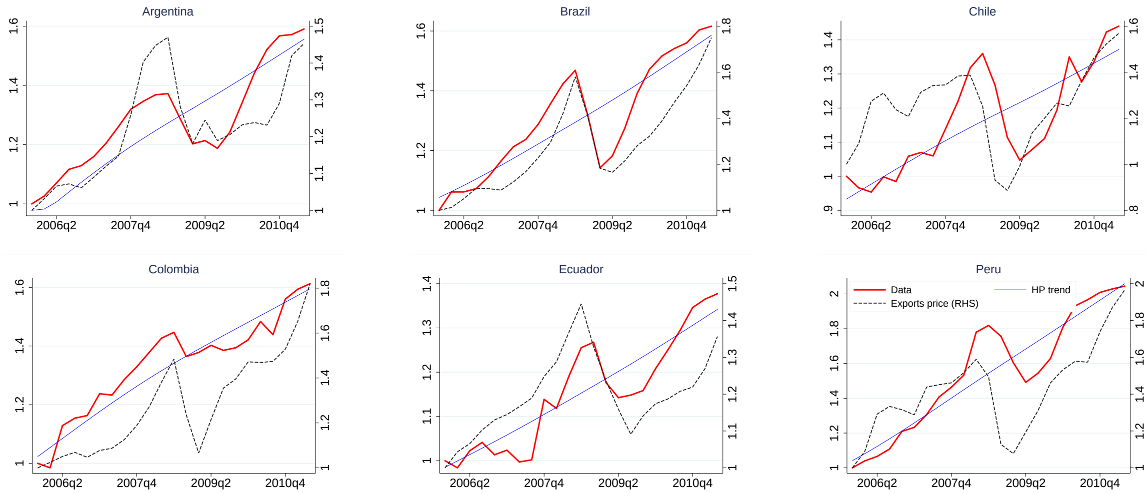


(n) Industrial Prod.

Notes: Figure 20 shows the evolution of output, consumption and industrial production (variables in levels and with their respective HP trend) for the largest countries in South America. Right axis plots the export price. Source: IDB.

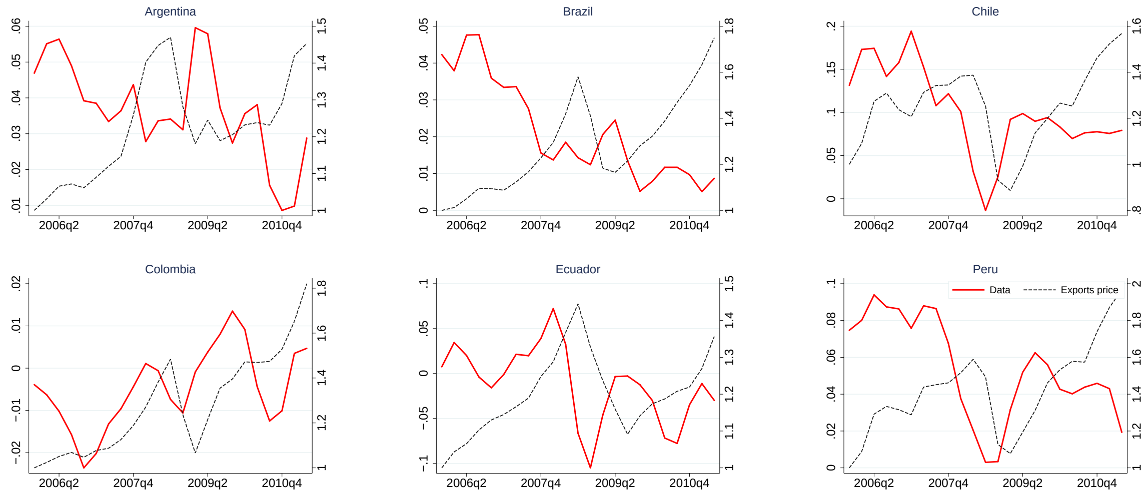
Figure 21: Investment, Imports & Trade Balance: South America 2006-11

(b) Investment



(h) Imports

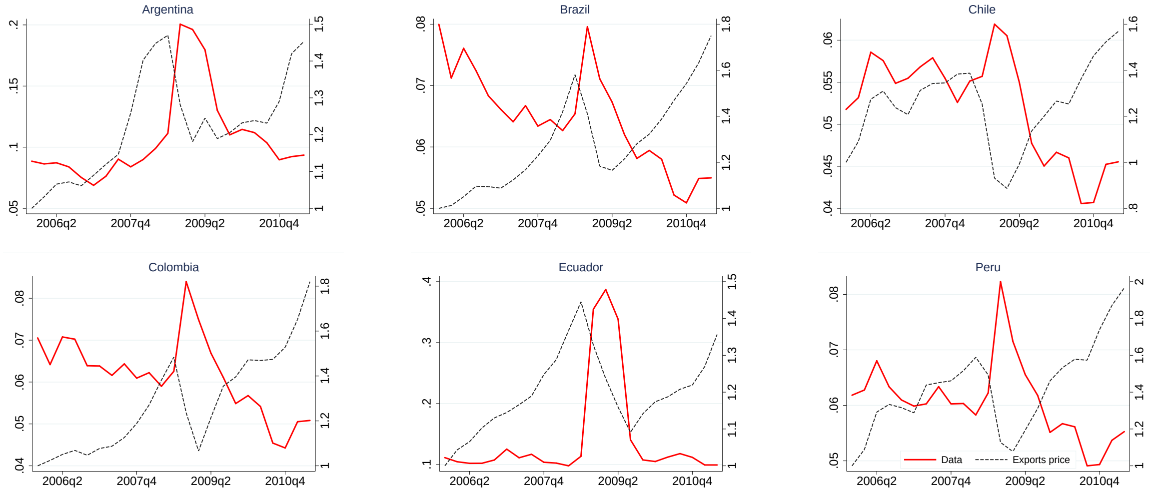
(n) Trade balance (%)



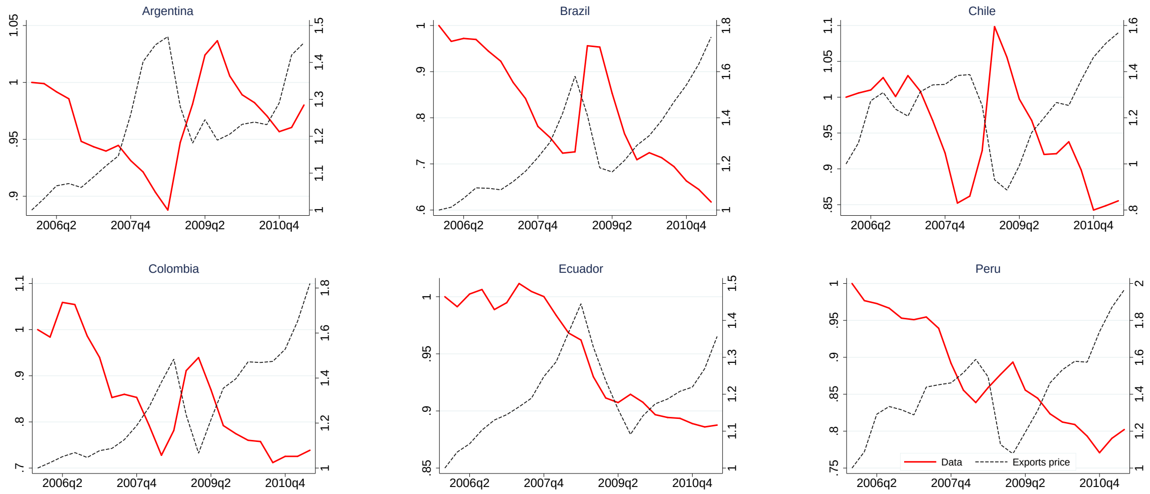
Notes: Figure 21 shows the evolution of investment, imports (in levels and with their respective HP trend) and the trade balance (share of GDP) for the largest countries in South America. Right axis plots the export price. Source: IDB.

Figure 22: Yields, Real Exchange Rate & Stock Prices: South America 2006-11

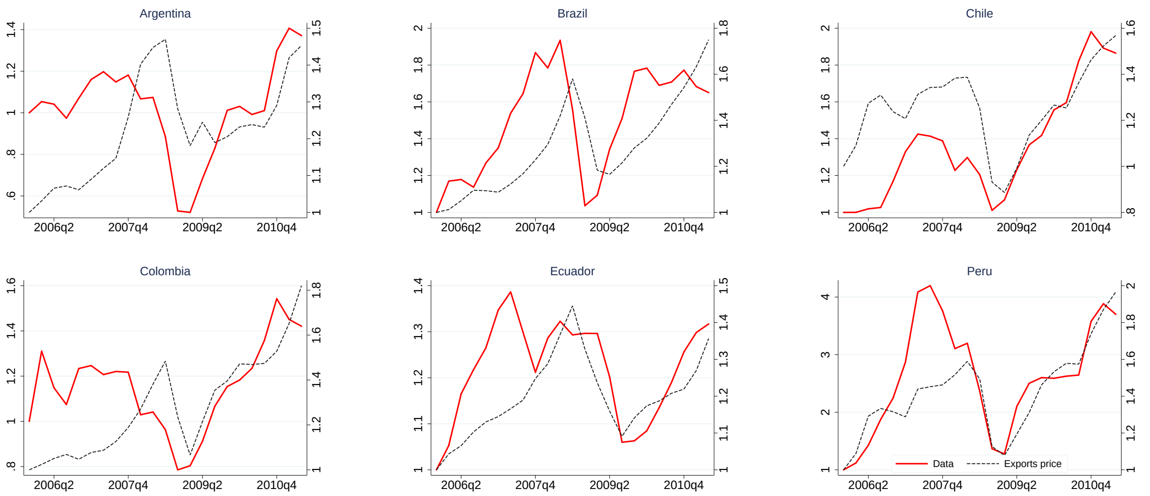
(b) Yield bonds



(h) Real Exchange Rate



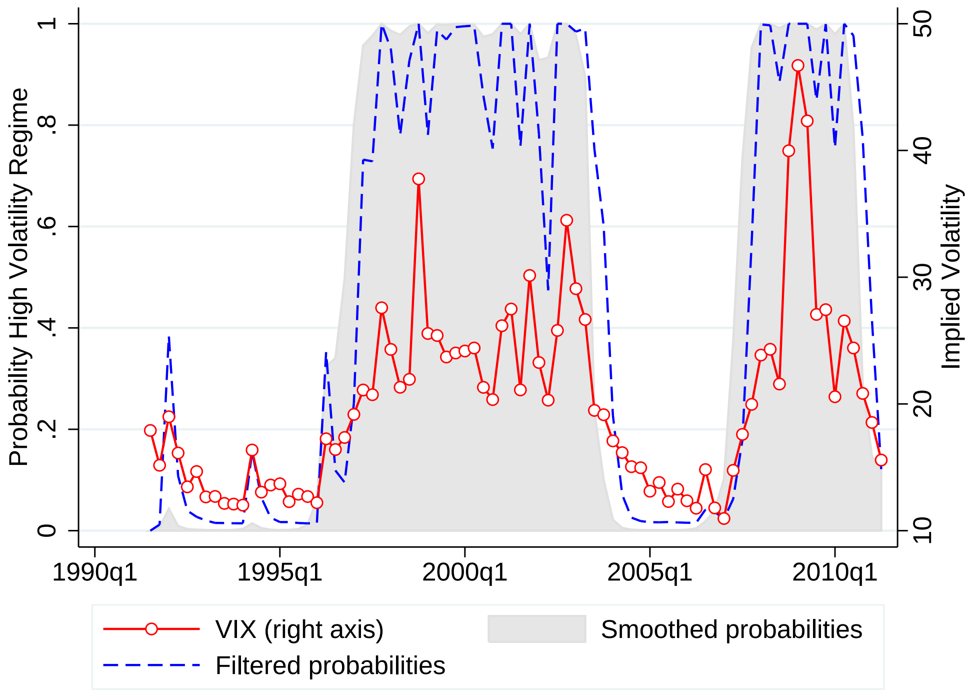
(n) Stock Market



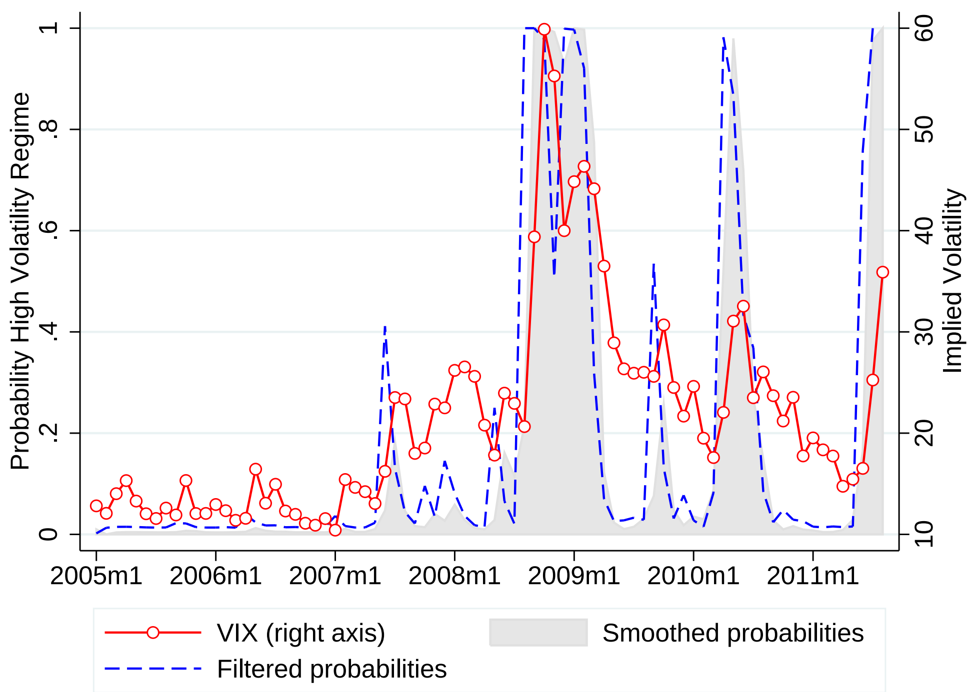
Notes: Figure 22 shows the evolution of bond yields, the real exchange rate and the stock market index for the largest countries in South America during the period of analysis. Right axis plots the export price. Source: IDB.

Figure 23: Markov Switching AR(1) Models of VIX index

(a) Quarterly estimation



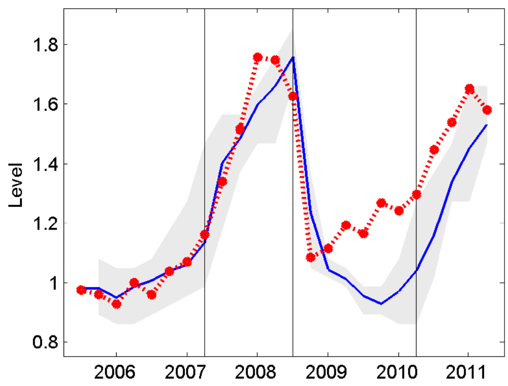
(b) Monthly estimation



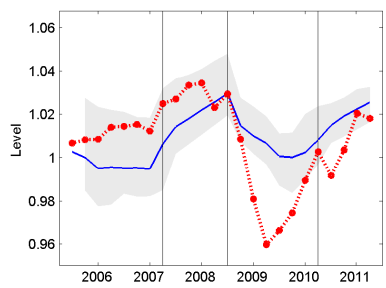
Notes: Figure 23a (23b) shows the regime inference outcome for the VIX index on a quarterly and a monthly basis, respectively. The lhs axis measures the smoothed (shaded area) and the filtered (dashed line) probabilities of being in the high volatility regime, respectively. The rhs axis measures the implied volatility of the VIX (red line). Filtered and smoothed probabilities are estimated using Hamilton's Forward algorithm and Kim's Backward algorithm, respectively.

Figure 24: Simulation Baseline Model

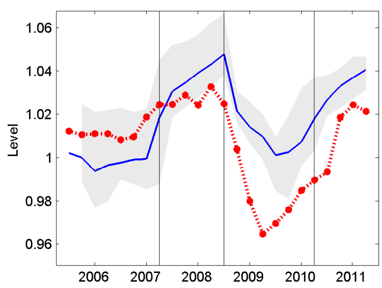
(a) Commodity bundle price



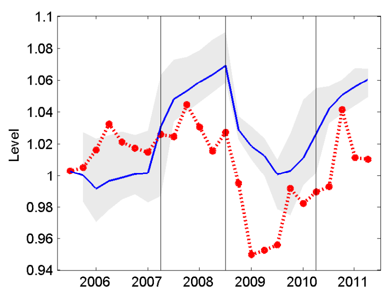
(b) Output



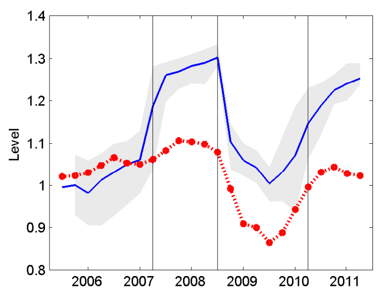
(c) Consumption



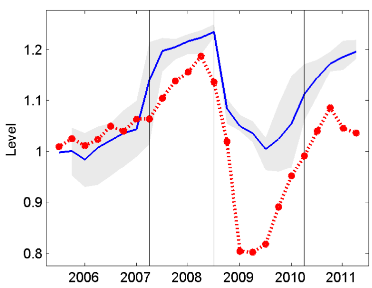
(d) Industrial production



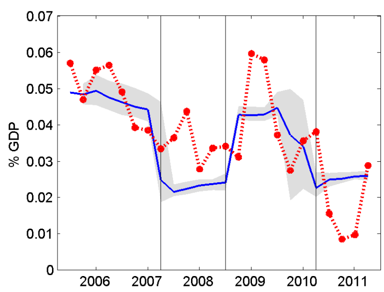
(e) Investment



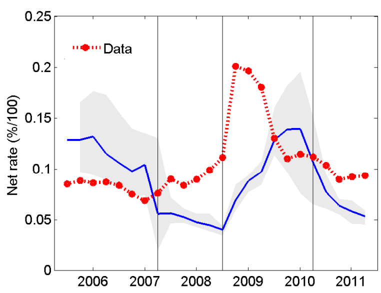
(f) Imports



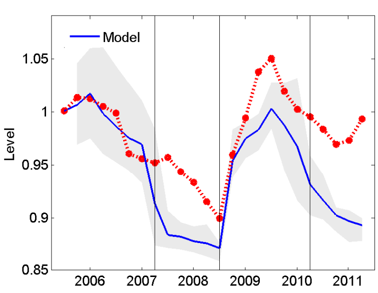
(g) Trade balance



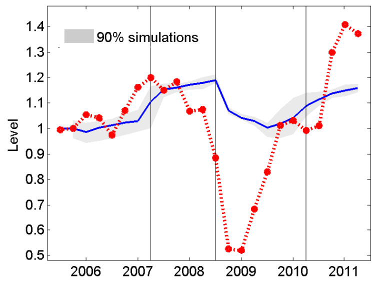
(h) Yield bonds



(i) Real exchange rate



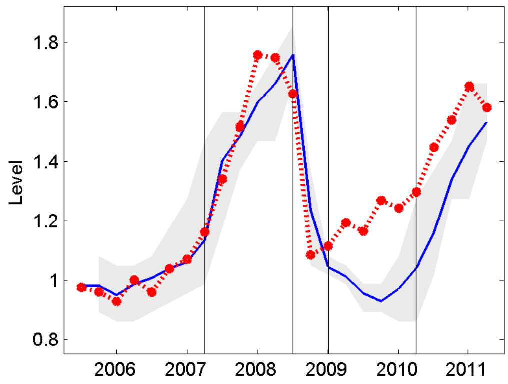
(j) Stock Market



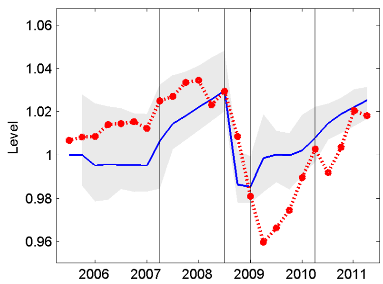
Notes: Figure 24 shows the artificial data generated in the simulations of the model without financial "panics" (solid line and gray area) alongside the actual data.

Figure 25: Simulation "Panic" Model

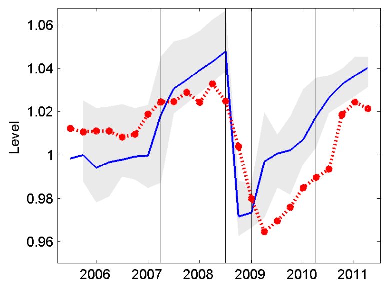
(a) Commodity bundle price



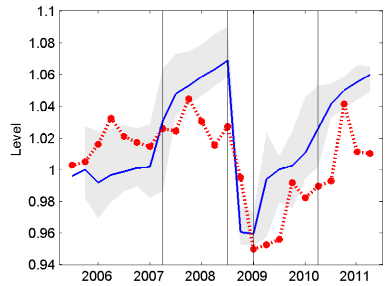
(b) Output



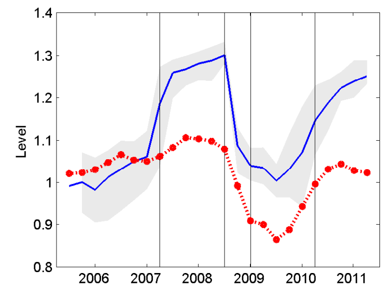
(c) Consumption



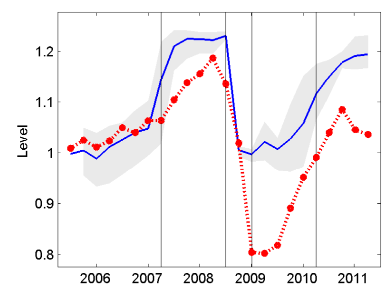
(d) Industrial production



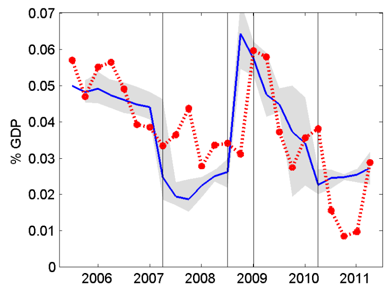
(e) Investment



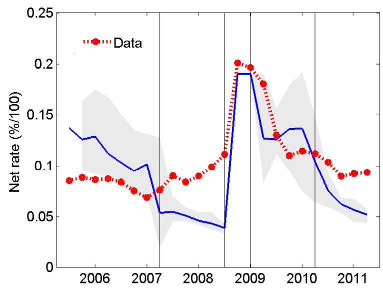
(f) Imports



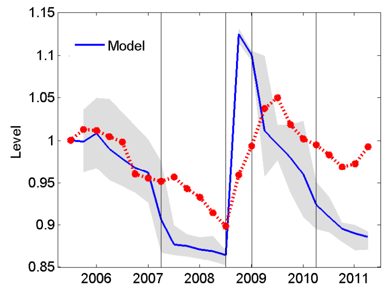
(g) Trade balance



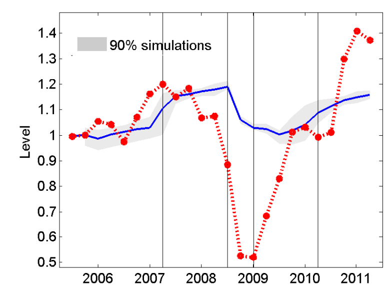
(h) Yield bonds



(i) Real exchange rate



(j) Stock Market



Notes: Figure 25 shows the artificial data generated in the simulations of the model with financial "panics" (solid line and gray area) alongside the actual data.

References

[1] Adam, K. and A. Marcet (2011): "Booms and Busts in Asset Prices," CEP Discussion Papers dp1059, Centre for Economic Performance, LSE.

[2] Agenor, P.R. and P.J. Montiel (1996): "Development Macroeconomics," Princeton: Pricenton University Press.

[3] Aghion, P., P. Bacchetta, and A. Banerjee(2004): "Financial development and the instability of open economies," *Journal of Monetary Economics*, vol. 51(6), pages 1077-1106, September.

[4] Aguiar, M., and G. Gopinath (2007): "Emerging Market Business Cycles: The Cycle Is the Trend," *Journal of Political Economy*, University of Chicago Press, vol. 115, pages 69-102.

[5] Aizenman, J. (1989): "Country Risk, Incomplete Information and Taxes on International Borrowing," *Economic Journal*, vol. 99, pp. 147-161, March.

[6] Akinci, O. (2011): "Note on the Estimation of the Atemporal Elasticity of Substitution Between Tradable and Nontradable Goods", mimeo, Columbia university, February.

[7] Anderton, R. and T. Tewolde (2010): "Financial Turmoil, the Global Trade Downturn, and Global Production Chains," Frankfurt: European Central Bank.

[8] Ang, A., and G. Bekaert (2002): "Regime Switches in Interest Rates," *Journal of Business and Economic Statistics*, vol. 20(2), pages 163-82, April.

[9] Aoki, K., G. Benigno and N. Kiyotaki (2009): "Capital Flows and Asset Prices," *NBER Chapters, in: NBER International Seminar on Macroeconomics 2007*, pages 175-216.

[10] Aoki, K., G. Benigno, and N. Kiyotaki (2010): "Adjusting to Capital Account Liberalization," *CEPR Discussion Papers 8087*.

[11] Arellano, C. (2008): "Default Risk and Income Fluctuations in Emerging Economies," *American Economic Review*, vol. 98(3), pages 690-712, June.

[12] Auboin, M. (2009): "Restoring trade finance during a period of financial crisis: Stock-Taking of recent initiatives", *Staff Working Paper ERSD-2009-16*, World Trade Organization, Geneva.

[13] Bacchetta, P., C. Tille and E. van Wincoop (2010): "Self-Fulfilling Risk Panics," *NBER Working Papers 16159*.

[14] Bacchetta, P., C. Tille and E. van Wincoop (2011): "Regulating Asset Price Risk," *American Economic Review*, vol. 101(3), pages 410-12, May.

[15] Barillas, F., and J. Fernandez-Villaverde (2007): "A generalization of the endogenous grid method," *Journal of Economic Dynamics and Control*, vol. 31(8), pages 2698-2712, August.

[16] Barone S., R. Descalzi, and A. Díaz Cafferata (2009): "Terms of Trade Shocks and Current Account Adjustment in Latin American Countries", presented in XXIV Jornadas Anuales de Economía del Banco Central del Uruguay. October 2009.

[17] Barro, R. (2006): "Rare Disasters and Asset Markets in the Twentieth Century," *Quarterly Journal of Economics*, 121:823-866.

[18] Basu, S. (1995): "Intermediate Goods and Business Cycles: Implications for Productivity and Welfare," *American Economic Review*, American Economic Association, vol. 85(3), pages 512-31, June.

[19] Becker, G. S. and C. B. Mulligan (1997): "The Endogenous Determination of Time Preference," *The Quarterly Journal of Economics*,Vol. 112, no. 3, pp. 729-58.

[20] Benigno, G., H. Chen, C. Otrok, A. Rebucci, and E.R. Young (2010): "Revisiting Overborrowing and its Policy Implications," CEPR Discussion Papers 7872.

[21] Benigno, G., H. Chen, C. Otrok, A. Rebucci, and E.R. Young (2011): "Financial Crisis and Macroeconomic Prudential Policies," CEPR Discussion Papers 8175.

[22] Bianchi, J. (2010): "Credit Externalities: Macroeconomic Effects and Policy Implications," *American Economic Review*, vol. 100(2), pages 398-402, May.

[23] Blanchard, O. J., M. Das and H. Faruqee (2010): "The Initial Impact of the Crisis on Emerging Market Countries," *Brookings Papers on Economic Activity*, vol. 41(1 (Spring), pages 263-323.

[24] Bloom, N. (2009): "The Impact of Uncertainty Shocks", *Econometrica*, May 623-685.

[25] Bloom, N. (2011): "The uncertainty shock from the debt disaster will cause a double-dip recession, VoxEU.org, 11 June.

[26] Burstein, A., M. Eichenbaum, and S. Rebelo (2005): "Large Devaluations and the Real Exchange Rate," *Journal of Political Economy*, University of Chicago Press, vol. 113(4), pages 742-784, August.

[27] Caballero, R. J. (2001): "Macroeconomic volatility in Latin America: a view and three case studies," *Estudios de Economia*, University of Chile, Department of Economics, vol. 28(1 Year 20), pages 5-52, June.

[28] Caballero, R. J. (2010): "Macroeconomics after the Crisis: Time to Deal with the Pretense-of-Knowledge Syndrome," *Journal of Economic Perspectives*, vol. 24(4), pages 85-102, Fall.

[29] Caballero, R. J., E. Farhi, and P.O. Gourinchas (2008a): "An Equilibrium Model of Global Imbalances and Low Interest Rates," *American Economic Review*, vol. 98(1), pages 358-93, March.

[30] Caballero, R. J., E. Farhi, and P.O. Gourinchas (2008b): "Financial Crash, Commodity Prices and Global Imbalances," *NBER Working Papers 14521*.

[31] Caballero, R. J., and G. Lorenzoni (2007): "Persistent Appreciations and Overshooting: A Normative Analysis," *NBER Working Papers 13077*.

[32] Caballero, R. J. and A. Krishnamurthy (1999): "Emerging Market Crises: An Asset Markets Perspective," Working papers 99-23, Massachusetts Institute of Technology.

[33] Caballero, R. J. and A. Krishnamurthy (2006): "Bubbles and capital flow volatility: Causes and risk management," *Journal of Monetary Economics*, vol. 53(1), pages 35-53, January.

[34] Calvo, G. (1998): Capital Flows and Capital-Market Crises: The Simple Economics of Sudden Stops, *Journal of Applied Economics* 1(1): 35-54.

[35] Calvo-Gonzalez, O., R. Shankar, and R. Trezzi (2010): "Are Commodity Prices More Volatile Now? A Long-Run Perspective," *World Bank Policy Research Working Paper 5460*.

[36] Calvo, G., A. Izquierdo, and L. F. Mejia (2004): "On the empirics of Sudden Stops: the relevance of balance-sheet effects," Proceedings, Federal Reserve Bank of San Francisco, issue June.

[37] Calvo, G., L. Leiderman and C. Reinhart (1993): "Capital Inflows and Real Exchange Rate Appreciation in Latin America: The Role of External Factors," IMF Staff Papers 40(1):108-151.

[38] Calvo, G., L. Leiderman and C. Reinhart (1996): "Inflows of Capital to Developing Countries in the 1990s," *Journal of Economic Perspectives*, vol. 10(2), pages 123-39, Spring.

[39] Calvo, G. and E. Talvi (2005): "Sudden Stop, Financial Factors and Economic Collpase in Latin America: Learning from Argentina and Chile", *NBER Working Papers 11153*.

[40] Calvo, G., A. Izquierdo, and E. Talvi (2006): "Phoenix Miracles in Emerging Markets: Recovering without Credit from Systemic Financial Crises," *NBER Working Papers 12101*.

[41] Canova, F (2005): "The Transmission of US Shocks to Latin America," *Journal of Applied Economics* 20: 229-251.

[42] Carroll, C. D. (2006): "The method of endogenous gridpoints for solving dynamic stochastic optimization problems," *Economics Letters*, Elsevier, vol. 91(3), pages 312-320, June.

[43] Caselli, F. and J. Feyrer (2007) "The Marginal Product of Capital," *The Quarterly Journal of Economics*, MIT Press, vol. 122(2), pages 535-568, 05.

[44] Cena, M. A. (2011): "A Quantitative Exploration into the Economics of Contingent Capital Inflows Taxation in a South America Facing Double-Tailwinds", mimeo, LSE, January 2011.

[45] Cerra, V., and S. Saxena (2008): "Growth dynamics: The myth of economic recover," *American Economic Review* vol. 98, pages 439-457, June.

[46] Chari, V., P. Kehoe, and E. McGrattan (2007): "Business Cycle Accounting,"*Econometrica*, vol. 75(3), pages 781-836.

[47] Christiano, L. and J. Fisher (2000): "Algorithms for solving dynamic models with occasionally binding constraints,"*Journal of Economic Dynamics and Control*, vol. 24(8), pages 1179-1232, July.

[48] Christiano, L. and J. Davis (2006): "Two Flaws In Business Cycle Accounting,"*NBER Working Papers 12647*.

[49] Clements, B. J., and H. Kamil (2009): "Are Capital Controls Effective in the 21st Century? The Recent Experience of Colombia," IMF Working Paper 09/30.

[50] Coleman, W. J. (1990): "Solving the Stochastic Growth Model by Policy-Function Iteration," *Journal of Business and Economic Statistics*, vol. 8(1), pages 27-29, January.

[51] COMIN, D., AND M. GERTLER (2006): "Medium-Term Business Cycles," *American Economic Review*, vol. 96(3), pages 523-551, June.

[52] CORDEN W. M. (1984): "Boom Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers* vol. 36: 362.

[53] CUADRA, G., AND H. SAPRIZA (2006): "Sovereign Default, Terms of Trade and Interest Rates in Emerging Markets," Working Papers 2006-01, Banco de Mexico.

[54] DAVIG, T., AND E. M. LEEPER (2006): "Endogenous Monetary Policy Regime Change," *NBER Working Papers 12405.*

[55] DAVIG, T., AND E. M. LEEPER (2007): "Fluctuating Macro Policies and the Fiscal Theory," *NBER Chapters, in: NBER Macroeconomics Annual 2006*, Volume 21, pages 247-316.

[56] DE GREGORIO, J., S. EDWARDS, AND R. O. VALDES (2000): "Controls on Capital Inflows: Do they Work?", *Journal of Development Economics*, 63(1):59-83, October.

[57] DEMPSTER, A.P., N.M. LAIRD, AND D.B. RUBIN (1977): "Maximum Likelihood from Incomplete Data via the EM algorithm", *Journal of the Royal Statistical Society*, Series B, vol. 39, 1:1-38.

[58] DEN HAAN, W. AND A. MARCET (1990): "Solving the Stochastic Growth Model by Parameterizing Expectations," *Journal of Business and Economic Statistics*, vol. 8(1), pages 31-34, January.

[59] DETEMPLE, J. AND S. MURTHY (19974): "Equilibrium Asset Prices and No-Arbitrage with Portfolio Constraints", *Review of Financial Studies*, 10, 1233-1174.

[60] DIAZ-ALEJANDRO, C. F. (1985): Good-bye financial repression, hello financial crash, *Journal of Development Economics 19.*

[61] DI SANZO, S. (2009): "Testing for Linearity in Markov Switching Models: A Bootstrap Approach" Statistical Methods and Applications, 18, 153-168.

[62] EDWARDS, S. (1999): "How Effective are Controls on Capital Inflows? An Evaluation of Chile´s Experience," Mimeo, University of California, Los Angeles.

[63] EICHENGREEN, B., R. HAUSMANN, AND U. PANIZZA (2003): "Currency Mismatches, Debt Intolerance and Original Sin: Why They Are Not the Same and Why it Matters?",NBER Working Papers 10036.

[64] Eyzaguirre, N., M. Kaufman, S. Phillips, and R. Valdes (2011): "Managing Abundance to Avoid a Bust in Latin America" *IMF Discussion Note*, April 7.

[65] Fernandez-Villaverde, J., P. Guerron-Quintana, P. Rubio-Ramirez, and M. Uribe (2011): "Risk Matters: The Real Effects of Volatility,", forthcoming, *American Economic Review.*

[66] Forbes, K. J. (2004): "Capital Controls: Mud in the Wheels of Market Discipline," *NBER Working Papers 10284.*

[67] Forbes, K. J. (2005): "The Microeconomic Evidence on Capital Controls: No Free Lunch,"*NBER Working Papers 11372.*

[68] Forbes, K. J. (2007): "One cost of the Chilean capital controls: Increased financial constraints for smaller traded firms," *Journal of International Economics*, Elsevier, vol. 71(2), pages 294-323, April.

[71] Frankel, J., (2008): "The Effects of Monetary Policy on Real Commodity Prices,"*in J.Y. Campbell, ed., Asset Prices and Monetary Policy, Chicago IL, The University of Chicago Press*, pp. 291-334.

[70] Frankel, J. (2007): "Getting Carried Away: How the Carry Trade and Its Potential Unwinding Can Explain Movements in International Financial Markets", mimeo Harvard.

[71] Frankel, J. (2008): Carried Away: Everything You Wanted to Know about the Carry Trade. Milken Institute Review, 1st quarter:3845.

[72] G20 (2010): The G20 Seoul Summit, Leaders Declaration, 11-12 November.

[73] G20 (2011): Coherent Conclusions for the Management of Capital Flows Drawing on Country Experiences as endorsed by G20 Finance Ministers and Central Bank Governors October 15.

[74] Gallego, F., L. Hernandez, and K. Schmidt-Hebbel (2002): "Capital Controls in Chile: Were they effective, In L. Hernandez and K. Schmidt-Hebbel (eds.), Banking, Financial Integration, and International Crises, Central Bank of Chile.

[75] Gallego, F. and L. Hernandez (2003): "Microeconomics effects of capital controls: the Chilean experience during the 1990s", Working Papers N° 203, Central Bank of Chile, February.

[76] Garcia, R. (1998): "Asymptotic Null Distribution of the Likelihood Ratio Test in Markov Switching Models", International Economic Review, 39, 763-788.

[77] Garcia, R. and P. Perron (1996): "An Analysis of the Real Interest Rate under Regime Shifts," The Review of Economics and Statistics, MIT Press, vol. 78(1), pages 111-25, February.

[78] Garcia, J. (2008): "What Drives the Roller Coaster? Sources of Fluctuations in Emerging Countries," Mimeo, Duke University.

[79] Garcia-Cicco, J., R. Pancrazi, and M. Uribe (2010): "Real Business Cycles in Emerging Countries?," *American Economic Review*, vol. 100, 25102531, December.

[80] Geneakoplos, J., and H. Polemarchakis (1986): "Existence, regularity, and constrained suboptimality of competitive portfolio allocations when asset markets are incomplete," in Equilibrium Analysis, Essays in Honor of K. Arrow, Vol. III, Chap.3, Cambridge Univ. Press.

[81] Glick, R. and K. Rogoff (1995): "Global versus country-specific productivity shocks and the current account,"*Journal of Monetary Economics*,V. 35 pp. 159-192.

[82] Gonzalez-Rozada, M. and E. Levy Yeyati (2008): "Global Factors and Emerging Market Spreads," *Economic Journal*, Royal Economic Society, vol. 118(533), pages 1917-1936, Nov.

[83] Gonzalez Rozada, M., P. Neumeyer, A. Clemente, D. Sasson, and N. Trachter (2004): "The Elasticity of Substitution in Demand for Non-Tradable Goods in Latin America: The Case of Argentina," RES Working Papers 3179, IADB.

[84] Greenwood, J., Z. Hercowitz, and G. Huffman (1988): "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 78 (3), 402-417.

[85] Gromb, D. and D. Vayanos (2002): "Equilibrium and welfare in markets with financially constrained arbitrageurs," *Journal of Financial Economics*, vol. 66(2-3), pages 361-407.

[86] Gruss, B. and K. Mertens (2009): "Regime Switching Interest Rates and Fluctuations in Emerging Markets," Economics Working Papers ECO2009/22, European University Institute.

[87] Hamilton, J. D. (1989): "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," *Econometrica*, vol. 57(2), pages 357-84, March.

[88] Hamilton, J. D. (1990): "Analysis of time series subject to changes in regime," *Journal of Econometrics*, vol. 45(1-2), pages 39-70.

[89] Hamilton, J. D. (1994):*Time Series Analysis*, Princeton, NJ: Princeton University Press.

[90] Hamilton, J. D. (2009): "Causes and Consequences of the Oil Shock of 2007-08,"*in D. Romer and J. Wolfers, eds., Brookings Papers on Economic Activity*, Spring.

[91] Hamilton, J. and R. Susmel (1994): "Autoregressive conditional heteroskedasticity and changes in regime.", *Journal of Econometrics*, 64, 307-333.

[92] Hansen, B.E. (1992): "The likelihood ratio test under nostandard conditions: Testing the Markov switching model of GNP," *Journal of Applied Econometrics* 7, 307-333.

[93] Hansen, B.E. (1996a): "Erratum.: The likelihood ratio test under nostandard conditions: Testing the Markov switching model of GNP," *Journal of Applied Econometrics* 11, 195-198.

[94] Hansen, B.E. (1996b): "Inference when the nuisance parameter is not identified under the null hypothesis," *Econometrica* 64, 413-430.

[95] Harberger, A. (1950): "Currency Depreciation, Income, and the Balance of Trade," *The Journal of Political Economy*, 58(1), pp. 47-60.

[96] Harberger, A. (1976): "On Country Risk and the Social Cost of Foreign Borrowing by Developing Countries", University of Chicago, mimeo, september.

[97] Harberger, A. (1980): "Vignettes on the World Capital Market, *American Economic Review*, may.

[98] Harberger, A. (1986): "Welfare Consequences of Capital Inflows, in A.M. Choksi and D. Papageorgiou (eds.)*Economic Liberalization in Developing Countries*, 157-78 (Oxford: Basil Blackwell).

[99] Herrera, L . and R. Valdes (2001): "The Effect of Capital Controls on Interest Rate Differentials," *Journal of International Economics* 53(2): 385-98.

[100] Hilscher, J. and Y. Nosbusch (2010): "Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt," *Review of Finance*, vol. 14(2), pages 235-262.

[101] Izquierdo, A., R. Romero, and E. Talvi (2008): "Booms and Busts in Latin America: The Role of External Factors," Inter-American Development Bank, RES Working Papers 4569.

[102] Jeanne, O. (2010): "Dealing with Volatile Capital Flows," Policy Briefs PB10-18, Peterson Institute for International Economics.

[106] Jeanne, O. and A. Korinek (2010): "Managing Credit Booms and Busts: A Pigouvian Taxation Approach,"*NBER Working Papers 16377.*

[105] Jeanne, O.(2011a): "Managing Capital Flows", Banque de France, May 31.

[105] Jeanne, O. (2011b): "Capital Account Policies and the Real Exchange Rate," Johns Hopkins University Mimeo.

[106] Jeanne, O. and A. Korinek (2010) "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach," *American Economic Review*, vol. 100(2), pages 403-07, May.

[107] Jeanne, O., A. Subramanian, and J. Williamson (2012): "Who Needs to Open the Capital Account?," Peterson Institute for International Economics.

[108] Judd, K. L. (1998): "Numerical Methods in Economics,"*MIT Press Books*, The MIT Press.

[109] Kaminsky, G. L., C. M. Reinhart, and C. A. Vegh (2005): "When It Rains, It Pours: Procyclical Capital Flows and Macroeconomic Policies," *NBER Chapters, in: NBER Macroeconomics Annual 2004, Volume 19, pages 11-82.*

[110] Kim, C. J. (1994): "Dynamic linear models with Markov-switching," *Journal of Econometrics*, 60:122.

[111] Kiyotaki, N. and J. Moore (1997): "Credit Cycles,"*Journal of Political Economy*, vol. 105(2), pages 211-48, April.

[112] Kocherlakota, N. (2009): "Bursting Bubbles: Consequences and Cures", Paper presented at the Macroeconomic and Policy Challenges Following Financial Meltdowns Conference Hosted by the International Monetary Fund Washington, DC, April 3.

[113] Kopecky, K. and R. Suen (2010): "Finite State Markov-chain Approximations to Highly Persistent Processes,"*Review of Economic Dynamics*, vol. 13(3), pages 701-714, July.

[114] Krishnamurthy, A. (2003) "Collateral Constraints and the Amplification Mechanism," *Journal of Economic Theory*, 111(2): 277-292.

[115] Krolzig, H. M. (1997): "Markov-Switching Vector Autoregressions: Modelling, Statistical Inference and Application to Business Cycle Analysis,", Springer.

[116] Krugman, P. (1987): "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher." *Journal of Development Economics* 27 1-2:50.

[117] Kumhof, M. and R. Ranciere (2011): "Inequality, Leverage and Crises," CEPR Discussion Papers 8179.

[118] Lane, P. R. and G. M. Milesi-Ferretti (2007): "The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970-2004,", *Journal of International Economics*, vol. 73(2), pages 223-250, November.

[119] Laursen, S. and L. Metzler (1950): "Flexible Exchange Rates and the Theory of Employment," *Review of Economics and Statistics*, XXXII, 28199, November.

[120] Levchenko, A. A., L. T. Lewis, and L. L. Tesar(2009): "The Collapse of International Trade during the 20082009 Crisis: In Search of the Smoking Gun."*NBER Working Paper no. 16006*.

[121] Levy Yeyati, E. (2011): "Are capital controls effective?, VoxEU.org, 20 January.

[122] Levy-Yeyati, E., S. Schmukler, and N. Van Horen (2004): "The Price of Inconvertible Deposits: The Stock Market Boom during the Argentine Crisis," *Economic Letters*, vol. 83, pp. 7-13.

[123] Levy-Yeyati, E., S. Schmukler, and N. Van Horen (2008): "Crises, capital controls, and financial integration," Policy Research Working Paper Series 4770, The World Bank.

[124] Levy-Yeyati, E., S. Schmukler, and N. Van Horen (2009): "International financial integration through the law of one price: The role of liquidity and capital controls," *Journal of Financial Intermediation*, Elsevier, vol. 18(3), pages 432-463, July.

[125] Lim, G. and P. McNeils (2008): "Computational Macroeconomics for the Open Economy", book, MIT Press, October.

[126] Lorenzoni, G. (2008): "Inefficient Credit Booms",*Review of Economic Studies 75* (3),809-833.

[127] Longstaff, F., J. Pan, L. Pedersen, and K. Singleton (2011): "How Sovereign Is Sovereign Credit Risk?,"*American Economic Journal*, vol. 3(2), pages 75-103, April.

[128] Maliar, L. and S. Maliar (2005): "Parameterized Expectations Algorithm: How to Solve for Labor Easily," *Computational Economics*, Springer, vol. 25(3), pages 269-274, June.

[129] Marcet, A. and K. Singleton (1999): "Equilibrium Asset Prices And Savings Of Heterogeneous Agents In The Presence Of Incomplete Markets And Portfolio Constraints,"*Macroeconomic Dynamics*, vol. 3(02), pages 243-277, June.

[130] Mendoza, E. G. (1995): "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations," *International Economic Review*, vol. 36(1), pages 101-37, February.

[131] Mendoza, E. G. (2010): "Sudden Stops, Financial Crises, and Leverage," *American Economic Review*, vol. 100(5), pages 1941-66, December.

[132] Mendoza, E. and K. Smith (2006): "Quantitative implications of a debt-deflation theory of Sudden Stops and asset prices," *Journal of International Economics*, vol. 70(1), pages 82-114, September.

[133] Mendoza, E. and M. Terrones (2008): 'An Anatomy Of Credit Booms: Evidence From Macro Aggregates And Micro Data", *NBER Working Papers 14049*.

[134] Mendoza, E. G. and V. Yue (2011): "A General Equilibrium Model of Sovereign Default and Business Cycles," *NBER Working Papers 17151.*

[135] Mizrach, B. and J. Watkins (1999): " Markov Switching Cookbook", in Philip Rothman (ed.), *Time Series Analysis of Economics and Financial Data*, Dordrecht: Kluwer, 33-43.

[136] Moreno, L. (2011): "The decade of Latin America and the Caribbean: a real opportunity," the Inter-American Development Bank, Washington D.C.

[137] Neumeyer, P. and F. Perri (2005): "Business Cycles in Emerging Economies: The Role of Interest Rate," *Journal of Monetary Economics*, V.52, pp.345-380.

[138] Obstfeld, M. (1982): "Aggregate Spending and the Terms of Trade: Is There a Laursen-Metzler Effect?," *The Quarterly Journal of Economics*, MIT Press, vol. 97(2), pages 251-70, May.

[139] Osterholm, P., and J. Zettelmeyer (2007): The Effect of External Conditions on Growth in Latin America. *IMF Working Paper WP/07/176.*

[140] Ostry, J. D., A. R. Ghosh, K. Habermeier, M. Chamon, M. S. Qureshi and D. B. S. Reinhardt (2010): "Capital Inflows: The Role of Controls" *in IMF Staff Position Note.*

[141] Ostry, J. D., A. R. Ghosh, K. Habermeier, M. Chamon, L. Laeven, M. S. Qureshi and A. Kokenyne (2011): "Managing Capital Inflows: What Tools to Use?, *Staff Discussion Paper, IMF.*

[142] Paasche, B. (2001): "Credit Constraints and International Financial Crises." *Journal of Monetary Economics*, Vol. 48, no. 3, pp. 623-650.

[143] Pouzo, D. and I. Presno (2010): "Sovereign Default Risk and Uncertainty Premia, mimeo, University of California, Berkeley.

[144] Reinhart, C. M. and V. R. Reinhart (2008): "Capital Flow Bonanzas: An Encompassing View of the Past and Present," *NBER Working Papers 14321.*

[145] Reinhart, C. M. and R. Todd Smith (2002): "Temporary Controls on Capital Inflows," *Journal of International Economics*, Elsevier, vol. 57(2), pages 327-351, August.

[146] Rouwenhorst, G. (1995): "Asset Pricing Implications of Equilibrium Business Cycle Models", in: Cooley, T. (Ed.), Frontiers of Business Cycle Research. Princeton University Press, Princeton, NJ, pp. 294-330.

[147] Schmitt-Grohe, S. and M. Uribe (2003): "Closing Small Open Economy Models," *Journal of International Economics*, Elsevier, vol. 61(1), pages 163-185, October.

[148] Schmitt-Grohe, S. and M. Uribe (2011): "Pegs and Pain,", manuscript, Columbia University, February.

[149] Smith, K. and D. Valderrama (2009): "The composition of capital inflows when emerging market firms face financing constraints," *Journal of Development Economics*, vol. 89(2), pages 223-234, July.

[150] Sturzenegger, F. and J. Zettelmeyer (2005): "Haircuts: Estimating Investor Losses in Sovereign Debt Restructurings, 1998-2005," IMF, Mimeo.

[151] Stiglitz, J. E. (1982): "The Inefficiency of the Stock Market Equilibrium," *The Review of Economic Studies*, pp. 241-261.

[152] Svensson, L. E. and A. Razin (1983): "The Terms of Trade and the Current Account: The Harberger-Laursen-Metzler Effect," *Journal of Political Economy*, University of Chicago Press, vol. 91(1), pages 97-125, February.

[153] Tang, K. and W. Xiong (2010): "Index Investment and Financialization of Commodities," *NBER Working Paper 16385*.

[154] Tauchen, G and R. Hussey (1991): "Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," *Econometrica*, 59(2): 317396.

[155] The Economist (2010): "Flying too high for safety," *The Economist*, 20 May.

[156] Uribe, M. (2006): "On Overborrowing," *American Economic Review Papers and Proceedings 96*, pp. 417-421, May.

[157] Uribe, M. (2011): "Lectures in Open Economy Macroeconomics", lecture notes Phd course, Columbia University, March.

[158] Uribe, M. and V. Yue (2006): "Country Spreads and Emerging Countries: Who Drives Whom?," *Journal of International Economics* 69, 6-36, June.

[159] Van Wijnbergen, S. (1984): "The Dutch Disease: A Disease After All?" *The Economic Journal* 94 373:41.

[160] Ventura, J. (2011): Bubbles and Capital Flows, *Journal of Economic Theory*, forthcoming.

[161] World Bank (2009): "Global Economic Prospects. Commodities at the Crossroads," Washington D.C., The International Bank for Reconstruction and Development.

[162] IMF (2011): "World Economic Outlook", April.

[163] Yue, V. Z. (2010): "Sovereign default and debt renegotiation," *Journal of International Economics*, vol. 80(2), pages 176-187, March.