Regime Switching Interest Rates and Fluctuations in Emerging Markets*

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First version: June 2009.
This version: December 2010.

Abstract

Many emerging economies have experienced current account reversals followed by large declines in economic activity. These sudden stops are reflected in their real interest rates, which alternate between tranquil times, when the level is relatively low and stable, and crises, during which interest rates are higher and more volatile. We embed an estimated regime switching process of interest rates into a small open economy model with financial frictions. Our model nests infrequent dramatic crises within regular business cycles, successfully matches the key second and higher order moments of the macroeconomic aggregates and produces plausible endogenous dynamics during crises. We find that the occurrence of sudden stops can account for the empirical regularities of emerging market business cycles. Financial frictions are essential for explaining emerging market fluctuations, but almost exclusively because of their effects in crises.

JEL classification: E32, F32, F41

Keywords: regime switching model, sudden stops, small open economy, business cycles

*We are grateful for comments received from Árpád Ábrahám, Javier Bianchi, Russell Cooper, Giancarlo Corsetti, Ramon Marimon, Enrique Mendoza, Eswar Prasad, Vincenzo Quadrini, Morten Ravn, Viktor Tsyrennikov and Carlos Végh and seminar participants at the XIV Workshop on Dynamic Macroeconomics, XXV Latin American Meeting of the Econometric Society, Banco Central del Uruguay, European Central Bank, Bank for International Settlements, Banca d'Italia, Stockholm Institute of Transition Economics and the European University Institute. Karel Mertens is grateful for the hospitality of the National Bank of Belgium where part of the research for this paper was conducted.

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1 Introduction

Many emerging economies' business cycle fluctuations notably differ from those of developed small open economies: they are characterized by (1) a higher volatility of macroeconomic variables, (2) a strongly countercyclical trade balance, (3) consumption volatility exceeding output volatility, and (4) a real interest rate that is much more volatile in emerging economies, strongly countercyclical and leads the cycle.[1] Another characteristic of emerging economies is the occurrence of infrequent but traumatic current account reversals, followed by unusually large declines in economic activity. Given the prevalence of these sudden stop crises in the samples typically used in studies of emerging market fluctuations, it is not clear to what extent they are related to the salient features of the traditional business cycle moments in these countries. In this paper, we present a dynamic small open economy model that integrates infrequent sudden stops and regular business fluctuations and find that the potential for those abrupt and severe disruptions in access to foreign lending can account for the empirical regularities of business cycles in emerging markets.

Our analysis emphasizes the nonlinearities implied by the large but rare macroeconomic fluctuations following financial crises, and highlights the asymmetries these imply in the unconditional probability distributions of macroeconomic aggregates. We generate these asymmetries in the model by imposing a nonlinear exogenous process for interest rates: A key feature of real interest rate series for emerging economies is that they alternate between tranquil times, when the level is relatively low and stable, and more infrequent turbulent periods, during which the interest rate jumps to much higher and volatile levels. Our specification for the interest rate process is therefore based on empirical estimates from a Markov switching model. The nonlinear nature of interest rates turns out to be important for the quantitative properties of otherwise conventional business cycle models. We focus on a version of the neoclassical small open economy model of Mendoza (1991) or Correia, Neves and Rebelo (1995) with two main extensions: first, we include an inter-

[1] For a documentation of these regularities see, for instance, Neumeyer and Perri (2005) and Aguiar and Gopinath (2007).

mediate input in the production process and assume a working capital constraint associated to the purchase of intermediate goods. Second, we allow for variable capacity utilization. We calibrate the model to Argentinean data, solve it using a global solution method and find it is successful in replicating the empirical regularities of business cycles in emerging markets. The model performs well not only in terms of matching the traditional second moments from data but also in terms of fitting the higher order moments of the main macroeconomic aggregates. In addition, the model produces plausible endogenous dynamics during crises, which are caused by a switch to a regime of high and volatile interest rates.

We use our calibrated model for Argentina to conduct a number of counterfactual experiments, which identify sudden stop episodes as the main reason for the stylized facts of business cycles in emerging economies: features such as the high relative volatility of consumption and counter-cyclicality of the trade balance largely disappear when these crises do not occur. The experiments also identify interest rate fluctuations as a major source of volatility. In our benchmark model, shutting down all interest rate shocks lowers volatility of output growth by more than half, though it is almost exclusively the crises episodes that are responsible for this large effect. Another implication regards the importance of domestic financial frictions for emerging markets: while their role for explaining business cycles is key, this is due to their interaction with crises episodes. An alternative version of our model in which credit frictions are only active during crises performs at least as well as the benchmark model, in which strong credit frictions exist in every period.

The quantitative success of the model relies importantly on three elements. The first is the non-linear specification of the interest rate process. A switch to a regime of higher and more volatile interest rates is a clear mechanism generating sudden stops occurring with empirically plausible frequency. In addition, the asymmetric distribution of interest rates, together with the presence of the working capital constraint, translate into skewed distributions for output, consumption and other macro aggregates that are very much as observed in Argentinean data. Other effects of the

nonlinearity are more subtle and operate by affecting agents' precautionary savings motive. We find that interest rates processes that display rare disaster states, as for instance discussed by Barro (2006), induce significantly less precautionary savings by optimizing agents than processes with symmetric distributions but identical first and second order unconditional moments. This implies that the specification for interest rates in small open economy models matters importantly for the vulnerability to unexpected drops in bond prices.

Whereas regime switching behavior is key in matching the second and higher order properties of the Argentinean data, we incorporate two further elements into the neoclassical model that improve its quantitative performance. Motivated by the countercyclicality of interest rates in emerging markets, Neumeyer and Perri (2005), Uribe and Yue (2006) and others have highlighted the role of domestic financial frictions for understanding their business cycles. Moreover, most of the literature on the dynamics of sudden stops has focused on credit frictions as propagation mechanisms (see for instance Calvo (1998), Christiano et al. (2004), Cook and Devereux (2006a,b), Gertler et al. (2007), Braggion et al. (2009)). Given the importance of credit from suppliers as a source of short-term finance for firms, we assume a working capital friction linked to the purchase of intermediate inputs. Thus, changes in interest rates have direct effects on factor demands and production. Finally, we allow for variable capital utilization as an additional propagation mechanism that, together with credit frictions, can account for the large drop in capacity utilization and the Solow residual during crises (see for instance Mendoza (2006) and Meza and Quintin (2007)).

The model in Mendoza (2010) shares with ours the emphasis on nesting infrequent crises within regular business cycle fluctuations and on the role of nonlinear dynamics. It incorporates many of the same elements, such as a working capital constraint, intermediate inputs and variable capacity utilization, but in addition introduces an occasionally binding collateral constraint. Sudden stops arise after a sequence of shocks lead the economy to a region in the state space where a small shock can make this constraint bind, triggering Fisherian debt deflation dynamics. In contrast

to our analysis and based on a calibration to Mexican data, Mendoza (2010) concludes that the occurrence of crises does not alter the business cycle moments significantly. The key reason for the divergent conclusions lies in the different precautionary savings behavior in both models. In Mendoza (2010), agents accumulate precautionary savings when approaching states in which the collateral constraint has a higher probability of becoming binding. This lowers the vulnerability and decreases the probability of a severe crisis significantly. In our model, sudden stops are caused by an exogenous regime shift and, although agents are always rationally aware of possible disaster outcomes, crises take them by surprise when they materialize. The frequency and severity of crises follows primarily from the empirical estimates of the regime switching model for interest rates. We acknowledge nevertheless that the small open economy assumption for interest rates neglects that the country spread comprises an endogenous default risk component. However, what the spread captures is rather foreign investors' perceived probability of default, which might not be necessarily driven by changes in domestic fundamentals.[2] To the extent that external factors play an important role in the pricing of emerging markets' debt as many empirical studies suggest, viewing financial crises as being triggered by exogenous switches in regime seems not only a reasonable first approximation, but perhaps almost inevitable in the context of modern dynamic models with optimizing forward looking agents with strong self-insurance motives: Mendoza (2010) acknowledges that, with an endogenously binding collateral constraint, a realistic sudden stop does not occur in model simulations unless a sequence of favorable interest rate movements is reversed by a large negative shock, while simultaneously a large negative productivity shock materializes.

Our work is also related to the broader literature on fluctuations in emerging economies, in particular to Neumeyer and Perri (2005), Uribe and Yue (2006) and Aguiar and Gopinath (2007). The

[2]Calvo, Izquierdo and Mejia (2004) provide evidence of periods of sudden stops occurring simultaneously in a group of countries that were quite heterogenous in terms of fundamentals, suggesting contagion effects. According to the authors, it is hard to argue that there was a common deterioration of fundamentals driving these episodes, the only common link being that they were all emerging economies. Similarly, Kaminsky and Schmukler (1999) identify several episodes of extreme movements in financial markets during the 1997 East Asian crisis that cannot be linked to any substantial news about fundamentals, but seem to be caused by herding behavior of investors. Finally, Uribe and Yue (2006), Longstaff et al. (2007) and González-Rozada et al. (2008), among others, assign a limited role to innovations to domestic fundamentals in explaining changes in country spreads.

main difference is that we emphasize nesting infrequent dramatic crisis events within regular business cycles. As crises in our model are associated with both a change in the level and the volatility of interest rates, our paper is also related to the work of Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez and Uribe (2010), who analyze the effect of volatility shocks to the interest rate in small open economy models. A key difference between our specification of the interest rate process and theirs is that the regime switching model combines both level and volatility shifts and captures the asymmetric alternation between tranquil and turbulent times, while the stochastic volatility model implies a symmetric distribution (i.e. extreme negative deviations are equally probable than positive ones). Finally, this paper is related to the literature that explores the transmission of sudden stops, such as Cook and Devereux (2006a,b), Gertler et al. (2007) and Braggion et al. (2009). While sudden stops are also driven by exogenous movements in real interest rates in these papers, the approximation method they use implies that the crisis shock does not affect agents' ex ante behavior. Instead, the solution method we adopt ensures that the probability distribution of sudden stop events is reflected in agents' decision rules.

The rest of the paper is structured as follows. In Section 2 we document the evidence for regime switching interest rates in a sample of emerging market economies and provide a numerical example that illustrates the effects of regime switching interest rates in dynamic stochastic general equilibrium models of small open economies. Section 3 describes the model we use for our empirical analysis and discusses its calibration to Argentinean data. In Section 4 we evaluate the model quantitatively and conduct a number of counterfactual experiments. Section 5 presents additional discussion of our modeling assumptions and draws some comparisons with related models in the literature. Finally, Section 6 summarizes our conclusions.

2 Regime Switching in Emerging Market Interest Rates

2 .1 Empirical Evidence of Regime Switching

We begin by documenting the evidence for the regime switching behavior of interest rates for a sample of emerging economies and, in particular, for Argentina. For our purposes, the most relevant interest rate is the expected real borrowing rate faced by the domestic private sector, for which we need data on both private sector borrowing rates and expected domestic inflation. As Neumeyer and Perri (2005) argue, the high variability of inflation in emerging economies makes it extremely difficult to construct a reliable measure of expected inflation. In addition, private sector interest rates are not readily available for samples of sufficient size. We therefore follow Neumeyer and Perri (2005), Uribe and Yue (2006), Fernández-Villaverde et al. (2010) and others by constructing a domestic rate from a measure of the international risk free rate and data on sovereign bond spreads. Arellano and Kocherlakota (2008) and Mendoza and Yue (2008) report that sovereign interest rates and rates faced by firms in emerging economies are closely related; for Argentina, in particular, these studies report correlations above 0.8. We compute sovereign bond monthly average spreads using the EMBI daily data reported by J.P.Morgan since December 1993. For Argentina we also extend the series backward relying on quarterly bond return data used by Neumeyer and Perri (2005). The international risk free real rate is obtained by subtracting the average year-on-year gross inflation of the U.S. GDP Implicit Deflator over the previous year from the annual yield on 3-month U.S. Treasury bills. Section A of the Appendix contains further details.

Figure 1 displays the extended quarterly real interest rate for Argentina and Figure 2 depicts the monthly data for a sample of emerging economies. Summary statistics and sample coverage are reported in Tables 1 and 2 respectively. For most of the countries in our sample, one or more episodes stand out in which the interest rate jumps to a much higher and more volatile level. Distinctive examples include the periods following the 1994 crisis in Venezuela, the Mexican Tequila crisis of 1994, the Russian default of 1998, the 1998 financial crisis in Ecuador, the repercussions

of the 1997-1998 Asian crisis, the 1999 and 2002 crises in Brazil and the 2001 Argentinean crisis. Several of these episodes, e.g. the Tequila crisis or the Russian default, have clearly spread beyond domestic borders. These crisis episodes are also reflected in the sample statistics: not only are the sample standard deviations generally high, the sample averages are also considerably higher than the medians (the average ratio of the mean over the median across countries is 1.6 in our sample). Based on this informal evidence, simple linear models seem unlikely to be the best approximation of the interest rate dynamics faced by these economies. Our alternative is the following Markov switching autoregressive model,

$$r_t = \nu(s_t) + \rho_r r_{t-1} + \sigma(s_t)\varepsilon_t \ \ , \ \ \varepsilon_t \sim \text{i.i.d}\, N(0,1) \tag{1}$$

where r_t is the real interest rate and ε_t is white noise. The state s_t is assumed to follow an irreducible ergodic two-state Markov process with transition matrix Π. This specification allows the intercept, $\nu(s_t)$, and the standard deviations of the statistical innovation, $\sigma(s_t)$, to be regime dependent, but assumes that the persistence parameter $0 \leq \rho_r < 1$ is the same across regimes.[3] More precisely, $\nu(s_t)$ and $\sigma(s_t)$ are parameter shift functions stating the dependence of the parameters on the realization of one of two regimes, which we denote by C (crisis) and T (tranquil). There are therefore seven parameters to be estimated: ν_T, ν_C, ρ_r, σ_T, σ_C and two out of the four elements in the transition matrix Π.[4] We refer to Hamilton (1994) and Krolzig (1997) for details on the estimation of Markov switching models.

Table 1 shows the maximum likelihood estimates of the Markov switching model for the quarterly real interest rate in Argentina between 1983Q1 and 2008Q4. In the tranquil regime, the real interest rate averages 10.6% with a 1.7% standard deviation for the shocks, while in the crisis

[3]We also allowed for the persistence parameter to be regime dependent. However, based on results from a formal hypothesis test using Argentinean quarterly data, we could not reject the null hypothesis that the persistence parameter is the same across regimes. More precisely, we constructed a likelihood ratio test statistic and, since it has a nonstandard distribution due to a nuisance parameter problem, computed critical values by performing Monte Carlo simulations (2,000 repetitions). The p-value for the test statistic is 0.34.

[4]To be more precise, there is an additional parameter to estimate: the starting period state probability, which we estimate with the smooth probability for period one; see Hamilton (1990).

regime the average is 47.3% and the standard deviation for the shocks is 12%. The tranquil regime is estimated to occur on average 77% of the time. Each quarter there is a 9% probability for Argentina of moving to the crisis regime. Once it enters the crisis regime, on average it stays there three to four quarters. The estimated smooth probabilities of the crisis regime are shown as grey areas in Figure 1. The empirical model assigns significant crisis probabilities in all of the known turbulent periods in the sample: the end of the exchange rate stabilization plan in the first half of 1980s, the crisis-hyperinflation in the late 1980s and early 1990s, the aftermath of the 1994 Tequila crisis and the end of the convertibility plan (currency board), sovereign default and subsequent crisis in the last quarter of 2001. Also, the recent global financial crisis is reflected in the last two observations, 2008Q3 and 2008Q4. At the bottom of Table 1 we include the results from testing the hypothesis of a linear AR(1) against the alternative of the Markov switching model using a likelihood ratio test statistic. The value of the likelihood ratio for our sample is 61.35 while the 1% critical value is 22.35, so we can strongly reject the null hypothesis of linearity.[5]

In Table 2 we report the results for the sample of emerging economies. As for Argentina's extended sample, the estimation identifies a crisis regime characterized by a higher average interest rate (from 3 to 20 times higher than in the tranquil regime) and higher standard deviation of the shocks (ranging from 2 to 17 times higher). Except for Brazil, the tranquil regime occurs more frequently than the crisis regime. For Peru the crisis regime is almost as frequent as the tranquil regime. For the remaining countries the estimated ergodic probability for the tranquil regime ranges from 68% to 84%. For all countries the linearity test rejects the null hypothesis of linearity at the 1% confidence level. Although the estimates based on monthly data are relatively imprecise because the small sample size, we find evidence that the results for Argentinean quarterly sample extend to other emerging markets. Our conclusion is that the real interest rate faced by Argentina and many other developing countries can be characterized as alternating between a more frequent low level/low volatility regime and an infrequent high level/high volatility regime.

[5] As pointed out by Hansen (1992) the test statistic has a nonstandard distribution in this context due to a nuisance parameters problem, so we computed critical values by performing 10,000 Monte Carlo simulations.

2 .2 The Role of Regime Switching Interest Rates in Dynamic Models

Several papers, such as Neumeyer and Perri (2005) and Uribe and Yue (2006), have focused on interest rate shocks as a source of fluctuations in emerging markets. By emphasizing domestic financial frictions as a propagation mechanism, these studies have shown how volatile interest rates can reconcile small open economy models with the main stylized facts of emerging market fluctuations. Before turning to our full-blown model, it is useful to consider an example that illustrates the importance of the specification of the interest rate process in dynamic models of small open economies. The model used in the example is a simpler version of those in Neumeyer and Perri (2005) and Uribe and Yue (2006): a neoclassical small open economy with a working capital constraint linked to the wage bill. For clarity, we assume that the only exogenous shocks are to the interest rate on an internationally traded bond. We conduct two different simulations for a given set of parameters based on a global approximation of the equilibrium dynamics. For model details and parameter values, we refer to Appendix E.

In a first set of simulations, interest rates follow a Markov switching autoregressive process. The parameters are such that the mean under the crisis regime is approximately 3 times larger than under the tranquil regime. The same ratio for the standard deviations is approximately 1.5. The degree of asymmetry implied by those ratios is in the lower end of the estimation results reported in the previous section. The transition matrix is such that the crisis regime is relatively infrequent: it occurs 29% of the time. At this stage, the parameter values are not intended to be realistic, but they do imply interest rate fluctuations that are qualitatively consistent with our empirical findings of the previous section: interest rates switch between a more frequent low level/low volatility regime and an infrequent high level/high volatility regime. In a second set of simulations, interest rates are realizations of a linear AR(1) process parametrized to imply the same unconditional mean and variance as the regime switching process. Evidently, the AR(1) has a perfectly symmetric probability distribution. The densities of the interest rate process from the regime switching process and the linear process are shown in the left panel of Figure 4.

Table 3 displays summary statistics of the probability distributions of some key variables around the balanced growth path for interest rate realizations drawn from both stochastic processes. A first observation is that, even though both processes have identical first and second order moments, the same moments of the endogenous variables can be substantially different. For example, the relative standard deviation of consumption and the countercyclicality of the trade balance, two statistics that typically receive much attention in emerging market business cycle studies, are both significantly greater under the nonlinear specification. A second result that stands out is the large difference in the average external debt to GDP ratio: it is substantially higher under the nonlinear specification than under the linear specification. This illustrates how the nature of the uncertainty faced by optimizing agents determines precautionary savings behavior. Agents self insure in different ways against interest rates that are volatile all the time, or interest rates that switch between tranquil and rare crisis regimes. Finally, both specifications have different implications for the skewness of the variables. Whereas the model with symmetrically distributed shocks implies fairly symmetric distributions for the equilibrium values, the simulations with asymmetrically distributed interest rates produces asymmetries in the distributions of the endogenous variables. The properties of higher order moments are particularly relevant when analyzing fluctuations in emerging markets. The bottom of Table 3 reports the average skewness in the sample of 13 emerging and 13 developed economies included in the database of Aguiar and Gopinath (2007). The comparison suggests that, at least for consumption and the trade balance, there are clear differences between these groups of countries. Consumption displays negative skewness on average for emerging economies while it is moderately positive for developed ones. The trade balance, instead, displays a clear positive skewness on average for emerging markets, reflecting the occasional reversals in their current accounts, while it shows no asymmetry on average for the sample of developed economies. This skewness pattern seems to be a general characteristic for emerging economies and also appears in Argentinean data, as evidenced by Table 6.

The precise quantitative and qualitative effects of nonlinearities in interest rates will obviously depend on parameter values and model details, but the example suggests they will often be non-trivial and can help to reconcile theoretical models with empirical facts. Moreover, extending the empirical evaluation of models by looking at the higher order properties of the data can be very informative for discriminating between models. In this sense, a model predicting symmetric distributions of its endogenous variables would be missing a very defining characteristic of fluctuations in emerging economies. In what follows, we conduct a rigorous quantitative analysis of the role of regime switching interest rates based on the Argentinean experience.

3 Model and Calibration

In this section, we present our benchmark model and discuss its calibration to Argentinean data. We also present some evidence to support our modeling assumptions of a credit friction associated with purchases of intermediate inputs and of variable capacity utilization.

3 .1 The Model Environment

The model is that of a small open economy that faces stochastic shocks to productivity and the real interest rate, similar to Mendoza (1991), Correia, Neves and Rebelo (1995) or Schmitt-Grohé and Uribe (2003). Both households and domestic firms trade a noncontingent real discount bond. As in Neumeyer and Perri (2005), Mendoza (2006) and Uribe and Yue (2006), the latter trade in the asset because of the presence of a working capital constraint: firms need to hold an amount of non-interest-bearing liquid assets equivalent to a fraction of their intermediate inputs purchases.

Households and Preferences. The economy is populated by identical, infinitely-lived households with preferences described by

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t/\Gamma_t - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{1-\gamma} - 1}{1-\gamma} \ , \ 0 < \beta < 1, \gamma \geq 1, \psi \geq 0, \zeta > 0 \tag{2}$$

where $c_t \geq 0$ denotes consumption and $h_t \geq 0$ is time spent in the workplace. The momentary utility function is of the form proposed by Greenwood, Hercowitz and Huffman (1988). With this specification, labor supply depends only on the contemporaneous real wage. These preferences are popular in small open economy models because they generate more realistic business cycles moments (Correia et al., 1995). They also facilitate our numerical solution procedure by eliminating a root finding operation. Households supply labor and capital services, receive factor payments and make consumption, saving and investment decisions. $\Gamma_t = g\Gamma_{t-1}$ measures the level of labor augmenting technology and enters utility to ensure balanced growth; $g \geq 1$ is the economy's average productivity growth factor. Households own a stock of capital $k_t \geq 0$, and provide capital services $k_t^s \geq 0$ equal to the product of the capital stock and the rate of capacity utilization $u_t \geq 0$. The households' budget constraint in period t is

$$c_t + x_t + d_t \leq R_t^{-1} d_{t+1} + w_t h_t + r_t^k u_t k_t \quad , \tag{3}$$

where x_t are resources for investment and d_{t+1} is the households' foreign debt position in a one period noncontingent discount bond which is traded at price $1/R_t < 1$, r_t^k is the rental rate of capital services and w_t is the real wage. Long run solvency is enforced by imposing an upper bound on foreign debt, $d_{t+1} < \Gamma_t D$, precluding households from running Ponzi schemes. In practice, we set the value of D high enough such that this constraint never binds. We assume that $R_t = 1 + r_t$ when $d_{t+1} \geq 0$ where the interest rate r_t is given by (1). We also assume that if $d_{t+1} < 0$, i.e. if domestic households become creditors in international markets, the interest rate faced by the households is $R_t = \min\{1 + r_t, \bar{R}\}$ where $\bar{R} > 1$. Without this assumption, households have strong incentives to save and accumulate unrealistic amounts of bonds when the real interest rate jumps to crisis levels. In contrast, Argentina has always been a net debtor in our sample period: according to the data of Lane and Milesi-Ferretti (2007), the net foreign asset to GDP ratio from 1980 to 2004 has fluctuated between -9% to -72%. Although during the Argentinean crises domestic agents do increase saving, in practice they do so by investing in very safe foreign assets, which pay a much lower

interest rate than the borrowing rate faced by domestic households and firms. The upper bound on the return to international lending is intended to capture this feature.

The law of motion for capital is

$$k_{t+1} = x_t + \left(1-\delta-\eta\frac{u_t^{1+\omega}}{1+\omega}\right)k_t - \frac{\phi_k}{2}\left(\frac{k_{t+1}}{gk_t}-1\right)^2 k_t \;,\; \eta>0 \;,\; \omega>0 \tag{4}$$

There is a quadratic capital adjustment cost and, as in Baxter and Farr (2001), the rate of capital depreciation depends positively on capital utilization.

The households' problem is to choose state contingent sequences of c_t, h_t, x_t, u_t, k_{t+1} and d_{t+1} to maximize expected utility (2), subject to the nonnegativity constraints, the budget constraints (3), the borrowing constraints and the law of motion for capital (4), for given prices w_t, r_t^k and R_t and initial values k_0 and d_0. The representative household's optimality conditions include:

$$\lambda_t = \frac{1}{\Gamma_t}\left(\frac{c_t}{\Gamma_t}-\zeta\frac{h_t^{1+\psi}}{1+\psi}\right)^{-\gamma} \tag{5}$$

$$\Gamma_t\zeta h_t^{\psi} = w_t \tag{6}$$

$$\eta u_t^{\omega} = r_t^k \tag{7}$$

$$\lambda_t = \beta E_t\left[\lambda_{t+1}\right]R_t \tag{8}$$

$$\lambda_t\left(1+\frac{\phi_k}{g}\left(\frac{k_{t+1}}{gk_t}-1\right)\right) = \beta E_t\left[\lambda_{t+1}\left(r_{t+1}^k u_{t+1}+1-\delta-\eta\frac{u_{t+1}^{1+\omega}}{1+\omega}+\frac{\phi_k}{2}\left(\left(\frac{k_{t+2}}{gk_{t+1}}\right)^2-1\right)\right)\right] \tag{9}$$

Equation (5) defines the marginal utility of consumption. Equation (6) determines optimal labor supply, requiring that the marginal rate of substitution between leisure and consumption equals the real wage. Equation (7) determines the optimal capital utilization rate by equating the marginal cost of increased utilization due to higher depreciation to the rental rate of capital services. Equations (8) and (9) are the intertemporal Euler conditions determining the optimal portfolio allocation between bonds and capital.

Firms and Technology. At time t a representative firm rents capital services k_t^s and, in combination with labor input h_t and an intermediate input m_t, produces z_t of a final good according to the production function

$$z_t = A_t \left[\mu^{1-\rho} m_t^{\rho} + (1-\mu)^{1-\rho} \left(\upsilon (k_t^s)^{\alpha} (\Gamma_t h_t)^{1-\alpha} \right)^{\rho} \right]^{\frac{1}{\rho}} \tag{10}$$

$$\Gamma_t = g\Gamma_{t-1} \ , \ 0 < \alpha < 1 \ , \ 0 \leq \mu < 1 \ , \ \rho < 1, \upsilon > 0 \ . \tag{11}$$

where A_t is the stochastic level of productivity. The firm is entirely owned by domestic households and all factor markets are perfectly competitive. Both intermediate and final goods are traded internationally. As long as the intermediate good is tradable, whether it is produced domestically or is imported from abroad is irrelevant.[6] Also, and for simplicity, we assume that the relative price of the intermediate input in terms of the final good is unity.[7] As in Uribe and Yue (2006), production is subject to a financing constraint requiring final goods producing firms to hold an amount κ_t of a non-interest bearing asset as collateral. We assume that κ_t must be a proportion $\varphi \geq 0$ of the cost of the intermediate good inputs:

$$\kappa_t \geq \varphi m_t \tag{12}$$

The representative firm's distribution of profits at period t is $\pi_t = z_t - w_t h_t - r_t^k k_t^s - m_t - \kappa_t + \kappa_{t-1}$. The firm's problem is to choose state contingent sequences for k_t^s, h_t, m_t and κ_t in order to maximize the present discounted value of expected profits distributed to the households:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \pi_t \ , \tag{13}$$

subject to the financing constraints in (12) and taking as given all prices w_t, r_t^k and the representative household's marginal utility of consumption, λ_t in (5). The representative firm's optimality

[6] In a model with nominal exchange rate, this distinction would have more consequences.

[7] An alternative assumption is that the relative price is an exogenous random variable. In that case, fluctuations in this price are isomorphic to fluctuations in A_t.

conditions include (8) and:

$$A_t^{\rho}(1-\mu)^{1-\rho}\left(\frac{z_t}{f_t}\right)^{1-\rho}\alpha\frac{f_t}{k_t^s}=r_t^k \tag{14}$$

$$A_t^{\rho}(1-\mu)^{1-\rho}\left(\frac{z_t}{f_t}\right)^{1-\rho}(1-\alpha)\frac{f_t}{h_t}=w_t \tag{15}$$

$$A_t^{\rho}(\mu)^{1-\rho}\left(\frac{z_t}{m_t}\right)^{1-\rho}=1+\varphi\left[\frac{R_t-1}{R_t}\right] \tag{16}$$

where $f_t=\upsilon(k_t^s)^{\alpha}(\Gamma_t h_t)^{1-\alpha}$. Equations (14) to (16) determine the firms' factor demands. It is clear from equation (16) that the working capital constraint introduces a wedge between the marginal product of intermediate inputs and its relative price (which is constant and equal to one). This distortion increases in the opportunity cost of working capital for firms, $(R_t-1)/R_t$, and in the strength of the financial friction, φ.

Equilibrium An equilibrium is a set of infinite sequences for prices r_t^k, w_t and allocations c_t, h_t, x_t, u_t, m_t, κ_t, k_{t+1}, d_{t+1} such that households and firms solve their respective problems given initial conditions k_0 and d_0 for given sequences of A_t and R_t, and labor, asset and goods markets clear. A balanced growth equilibrium is an equilibrium where c_t/Γ_t, h_t, x_t/Γ_t, u_t, m_t/Γ_t, k_{t+1}/Γ_t, d_{t+1}/Γ_t are stationary variables. Henceforth, we denote the detrended variables by a hat (optimality conditions expressed in terms of the detrended variables are shown in Appendix C). Using equations (14) to (16), Appendix B shows how detrended GDP ($\hat{y}_t=r_t^k u_t\hat{k}_t+\hat{w}_t h_t$) in equilibrium can be expressed as:

$$\hat{y}_t = \mathcal{A}_t(A_t,q_t)\left(u_t\frac{\hat{k}_t}{g}\right)^{\alpha}h_t^{1-\alpha} \tag{17}$$

$$\mathcal{A}_t(A_t,q_t) = \upsilon\left(\frac{A_t^{\frac{\rho}{\rho-1}}-\mu(1+\varphi q_t)^{\frac{\rho}{\rho-1}}}{1-\mu}\right)^{\frac{\rho-1}{\rho}} \tag{18}$$

where $q_t=(R_t-1)/R_t>0$. We denote the term $\mathcal{A}_t(A_t,q_t)$ as "measured" TFP , which corrects for capital utilization but is still affected by the distortion introduced by the working capital constraint. An increase in R_t raises q_t, the opportunity cost of funds for the firm, and lowers $\mathcal{A}_t(A_t,q_t)$. A

smaller elasticity of substitution $1/(1-\rho)$ between intermediate inputs and value added and a higher value of φ both magnify the negative effect of interest rates on total factor productivity. The market clearing conditions are

$$\hat{z}_t - \hat{m}_t\left(1+\varphi q_t\right) = \hat{y}_t \tag{19}$$

$$\hat{c}_t + \hat{x}_t + \hat{nx}_t = \hat{y}_t \tag{20}$$

where $\hat{nx}_t$ are (detrended) net exports, given by $\hat{nx}_t = \hat{d}_t/g - R_t^{-1}\hat{d}_{t+1}$. The household's debt position $\hat{d}_t$ is the economy's net foreign debt position in period t, and the trade balance, or net exports, are all resources not used for consumption and investment.

3 .2 Evidence on Modeling Assumptions

This section discusses the empirical motivation for two features of the model: the credit friction associated with intermediate inputs and variable capacity utilization. We assume that firms need intermediate inputs for production and that a fraction of its payment entails a financial cost.[8] There is broad evidence indicating that the trade of intermediate inputs between firms often involves some sort of financial arrangement, both when it refers to domestic or to foreign suppliers. Petersen and Rajan (1997), for example, signal trade credit as the single most important source of short-term funding for firms in the US, and that its importance is greater for firms that have less access to financial institutions. Reliance on credit from suppliers might be even more important in developing economies, given the lower development of the financial sector.[9] Regarding the relationship with providers across borders, the existence of financial costs linked to the purchase of inputs is even more common: Auboin (2009) signals that 80% to 90% of world trade relies on trade finance (trade credit and insurance/guarantees), mostly of a short-term nature. Evidence from periods of financial

[8]Other examples in the literature of this assumption include Christiano et al. (2004), Mendoza and Yue (2008), Braggion et al. (2009) and Mendoza (2010).

[9]In Mexico, for example, more than 65% of firms have stated credit from suppliers as the main source of credit on average from 1998 to 2009 (survey results, "Encuesta de Evaluación Coyuntural del Mercado Crediticio", Central Bank of Mexico).

instability in emerging markets suggests that reductions in trade credit are an important transmission mechanism through which financial shocks affect the real economy.[10] Figure 3 shows a very close correlation between the drop in total loans to the private sector, imported intermediate inputs and GDP during the 2001 crisis in Argentina. Energy consumption, an indirect measure of materials use, shows a sharp drop around the crisis. According to the IMF (2003), trade credit declined 30%-50% in Brazil and Argentina during the 2001-2002 crisis and 50% in Korea in 1997-1998, maturities were drastically reduced and the financial cost of these credits increased significantly. Auboin and Meier-Ewert (2003) argue that the credit crunch in trade finance also affected "domestic" trade credit in general in Argentina and other countries. Finally, some evidence suggests that there is a shift from open account arrangements between trade partners to cash-in-advance or to bank intermediated transactions during financial crises and that there is an increase in the fraction of trade credit backed up by collateral; see ICC (2008) and Braggion et al. (2009). This motivates a later extension of the model in Section 5 .1. As in Meza and Quintin (2007), we allow for variable capital utilization in our model. The utilization rate in Argentina shows important variations over time and seems to have played a relevant role in the adjustment of the Argentinean economy during the major crises. Figure 3 shows that the utilization rate fell significantly during the 2001 crisis. Available data starts only on 1990Q1, but the low utilization rate at the beginning of the sample suggests that it also played a relevant role during the 1989 crisis.

3 .3 Calibration and Solution Method

We calibrate the model to Argentinean quarterly data from 1980Q1-2008Q2. Appendix A provides more detail on data sources and transformations. Besides the parameters of the interest rate shock process, there are 17 parameters in the model. For 11 of those parameters (α, β, δ, η, ζ, υ, μ, ϕ_k, $\bar{R}$, g, σ_a), we calibrate the values to match data on the basis of moments of the ergodic distribution implied by the nonlinear solution of the model. In the case of trending variables, the moments used for calibration are from year on year growth rates. For 5 parameters ($\gamma, \psi, \omega, \rho_A, \rho$), the values are

[10] See Auboin and Meier-Ewert (2003), ICC (2008), Braggion, Christiano and Roldos (2009) and IMF (2003, 2009a,b) for further reference.

harder to pin down directly from the data, and we chose values we believe are most common in the literature. The remaining parameter, φ, which determines the strength of the financial friction, is very important for the empirical success of the model as pointed out by Neumeyer and Perri (2005). For now we set $\varphi = 1$, such that the required working capital equals the total cost of intermediate good purchases, and we will devote Section 5.1 to a discussion of this assumption.

Preference parameters The moment utility and labor curvature parameters are fixed to $\gamma = 2$ and $\psi = 0.6$, which are the values in Mendoza (1991), Aguiar and Gopinath (2007) and others. The discount factor β is set to match the average trade balance to GDP ratio in Argentina of 1.1% during 1981Q1 to 2008Q2. The implied average debt to GDP ratio is about 50%.[11] The labor weight ζ matters only for scaling and normalizes the average labor input to approximately one.

Technology parameters. The quarterly growth rate $g-1$ is 0.83%, the average quarterly growth rate of output in Argentina in the sample, excluding the crises after 1989Q1 and 2001Q2 (see Appendix A). The parameter α is set to obtain a labor income share of 0.62 as in Mendoza (1991), Aguiar and Gopinath (2007) or Neumeyer and Perri (2005). The value of μ matches the 44.2% share of intermediate goods consumption in gross output in Argentina's 1997 input-output matrix. We assume very little possibility to substitute away from material inputs and set the elasticity of substitution $1/(1-\rho)$ to a very low number, as in Rotemberg and Woodford (1996). There is no evidence on this elasticity for Argentina. Estimates for the US surveyed in Bruno (1984) suggest a range between 0.3 and 0.4, but Basu (1996) considers this an upper bound. In Section 4.2 we do a sensitivity check that suggests the low elasticity we assume is not too essential for our results.

The depreciation parameters δ and η are set to normalize the rate of capital utilization and to match the average investment-output ratio in Argentina of 18.2%. The resulting quarterly depre-

[11] Expressed in terms of annual GDP, the average debt to GDP ratio in the model is 12.5%. The average net foreign asset to GDP ratio between 1980 and 2004 in the data of Lane and Milesi-Ferretti (2007) is -36.5%. In the model the only asset is a one-period bond and there is no default, which makes it impossible to match both the average trade balance to GDP and debt to GDP ratios in the data at the same time.

ciation rate is about 3.7% on average. The parameter ω, which determines the elasticity of the depreciation rate with respect to variations in capital utilization, is set to 0.44, the value in Meza and Quintin (2007).[12] For this value of ω, the volatility of the utilization rate happens to coincide with the volatility of the quarterly series of capacity utilization rate in Argentina (available only from 1990 onwards). The capital adjustment cost parameter ϕ_k matches the volatility of investment in the data. We posit an autoregressive process for technology:

$$\ln(A_t) = \rho_A \ln(A_{t-1}) + \sigma_A \varepsilon_{A,t} \ , \ \varepsilon_{A,t} \sim \text{i.i.d } N(0,1) \tag{21}$$

with $\rho_A = 0.95$, as in Neumeyer and Perri (2005), and σ_A matching the volatility of output.[13]

Real Interest Rates The interest rate process is the estimated regime switching model for Argentina, with parameters given in Table 1 and $\bar{R}$ set to $1.02^{0.25}$, the average real rate on a US 3-month Treasury-bill.

Numerical Solution We compute discrete approximations to the stochastic processes for technology and the interest rate. The technology process in (21) is approximated using the quadrature-based method of Tauchen and Hussey (1991) on a grid of 11 nodes. We approximate the Markov switching process for the interest rate in (1) on a grid of 51 equidistant nodes. To facilitate the numerical solution procedure, our approximation of the interest rate process imposes that innovations are drawn from normal distributions that are truncated to ensure that the annualized net interest rate has a support bounded between 0% and 100%. To guarantee a satisfactory approximation to the Markov switching model estimated from the data, we follow a simulated method of moments procedure: For given parameters $\Theta = [\nu(s_t), \sigma(s_t), vec(\Pi), \rho_r]$, we obtain the discrete approximation, simulate 52,000 observations and construct $\tilde{\Psi}(\Theta) = [\tilde{\nu}(s_t), \tilde{\sigma}(s_t), vec(\tilde{\Pi}), \tilde{\rho}_r, \tilde{\mu}_r,$

[12]The value is not entirely comparable to Meza and Quintin (2007) because of slightly different parametrization of the depreciation function. Our specification allows us to match the investment-output ratio, but the depreciation elasticity is not constant and depends on u_t.

[13]This is also the procedure adopted in Neumeyer and Perri (2005), among others, since labor statistics in Argentina do not allow to estimate a reliable series for Argentina's Solow residuals with quarterly frequency.

$\tilde{\sigma}_r]'$ where $\tilde{\nu}(s_t)$, $\tilde{\sigma}(s_t)$, $vec(\tilde{\Pi})$ and $\tilde{\rho}_r$ are the Markov switching model estimates and $\tilde{\mu}_r$ and $\tilde{\sigma}_r$ are the average unconditional sample mean and standard deviation over samples of the same length as the data. Finally, we find Θ that minimizes the loss function $\left[\tilde{\Psi}(\Theta) - \hat{\Psi}\right]' W \left[\tilde{\Psi}(\Theta) - \hat{\Psi}\right]$ where $\hat{\Psi}$ is a vector stacking the parameters estimated from the data and W is a diagonal weighting matrix containing the inverses of the variances of the parameter estimates. Figure 5 depicts the density of the Argentinean interest rate and the density implied by our discrete approximation to the process.

We approximate the policy functions for the state variables $\hat{d}_{t+1}$ and $\hat{k}_{t+1}$ by piecewise linear functions over a grid and compute the approximate solution by iterating over the intertemporal Euler conditions, as suggested by Coleman (1990). The standard iteration procedure is generally slow and therefore we combine it with the method of endogenous gridpoints, proposed by Carroll (2006). The lack of any wealth effects on labor supply implies that there are no numerical rootfinding operations required in the algorithm. The details are presented in Appendix C and Matlab programs are available on the authors' websites.

4 Quantitative Model Analysis

Before turning to the numerical results, it is instructive to give some intuition behind the model response to the exogenous disturbances driving aggregate fluctuations: technology shocks, interest rate shocks and shifts in the volatility of interest rates.

The effects of technology and interest rate shocks in the standard small open economy model are relatively well understood. A positive and transitory shock to technology increases labor demand which, depending on the elasticity of labor supply, induces an increase in employment and production; see for instance Mendoza (1991) or Correia et al. (1995). The increase in current and future expected real income raises consumption, but as the productivity boom is transitory, households also respond by saving more. The increase in saving boosts investment in domestic capital and lowers debt to foreigners. On the other hand, households take advantage of higher productivity

in domestic production and shift resources towards domestic investment, increasing foreign borrowing. The net effect on the trade balance depends on the model specifics and calibration. In our case with variable capital utilization and persistent technology shocks, the net effect is a positive comovement between output and the trade balance.

The main effect of an interest rate increase in the standard model is a shift away from domestic investment and a reduction of foreign debt. A reduction in wealth induces a drop of consumption, but there is generally little contemporaneous effect on output or labor supply. Because of the financial constraint in our model, however, there are additional effects through an increase in the financing distortion. Higher interest rates cause a rise in the relative cost of intermediate inputs which in turn lowers the marginal product of both labor and capital services. From equation (18), it is clear that this additional effect is isomorphic to a negative technology shock. The regime switching nature of the interest rate, however, implies very persistent drops in the marginal product of labor and capital when the economy moves to the crisis regime. Given the variable rate of capacity utilization, capital services respond immediately to the drop in marginal productivity, which, together with a reduction in labor input, contributes to an immediate drop in production. As a result, interest rate shocks yield comovement between output, investment and consumption, but unlike technology shocks, they also yield consumption responses that exceed those of output and a negative comovement between output and the trade balance.

The dynamics in the model are governed not only by shocks to the levels of technology and interest rates, but also by shifts across tranquil and crisis regimes. A transition to a crisis is characterized by increases in the level as well as the volatility of interest rates. As shown by Fernández-Villaverde et al. (2010), these volatility shifts have important distinct effects. An increase in the relative risk of foreign bonds induces households to reduce foreign indebtness, which requires a reduction in consumption. During crises, the returns on capital investment and bonds are more highly correlated as interest rate fluctuations become more dominant in determining factor productivities. The

increased risk discourages investment and a lower capital stock in turn decreases labor input and production. Shifts in interest rate volatility contribute to a negative comovement between output and the trade balance.

4 .1 Business Cycle Statistics

All three sources of fluctuations generate comovement between output, consumption, investment and hours worked, and are therefore candidates for explaining a substantial fraction of aggregate fluctuations. However, the relative importance of technology shocks, interest rate shocks as well as the frequency of crises determines the relative volatility of consumption, the correlation of the trade balance with output as well as the unconditional correlations of interest rates with output.

Table 5 contains simulated moments based on the benchmark calibration of the model. The first column contains the key business cycle statistics in the 1980Q1-2008Q2 sample of Argentinean quarterly data. The second column contains the corresponding moments in model simulated data, obtained by generating 1000 samples of the same size as the actual data, each with a burn-in of 1000 quarters. The table also reports the 10% and 90% quantiles of the simulated sample moments. The moments are for the year on year growth rates of output, consumption and investment as well as the trade balance to GDP ratio. As a reference, a table in the appendix reports the moments when either a linear trend or the HP filter is used.[14]

Consumption Volatility Recalling that the volatility of the growth rates of output and investment are matched by construction in the calibration, we first highlight the fact that the model is successful in producing a relative volatility of consumption that is in line with the data. The model moment averages 1.10, very close to value in data, which lies comfortably within the 10% and 90% quantiles of simulated moments. As suggested before, the nonlinearity in interest rates tends to magnify consumption volatility: On the one hand, the self-insurance motive is less strong

[14]The data moments targeted in the calibration are always in terms of annual growth rates of the variables. Some moments in the data are sensitive to the detrending method.

compared to models where interest rates are relatively volatile all the time. On the other hand, unexpected movements in wealth induced by changes in interest rate are more infrequent, but at the same time much larger and therefore generate stronger consumption responses. In addition, changes in the volatility of interest rates also translate into higher consumption volatility.

Countercyclical Trade Balance The model does very well in reproducing a strongly countercyclical trade balance: the correlation between output growth and the trade balance to GDP ratio is -0.53 in the model, whereas in the data it is -0.30 which is slightly above the 90% quantile of simulated moments. Even though the precise number in the data is somewhat sensitive to the detrending method, the negative correlation produced by our model is nevertheless high. For comparison, the correlation is much more pronounced than in the model specification of Neumeyer and Perri (2005) that, as in our model, assumes independent interest rate and productivity shocks.[15] Again, the difference depends importantly on the regime switching behavior of interest rates, as suggested by our earlier example and as evidenced further below.

Cyclicality of Interest Rates The correlations between output and consumption on the one hand, and real interest rates on the other hand are all negative in the data. The correlation between investment and interest rates is close to zero when we use growth rates. The model is successful in reproducing the countercyclical properties of real interest rates: the average sample correlation is -0.45. It somewhat overstates the negative contemporaneous correlation between the real interest rate and output: the moment in the data lies above the 90% quantile. Neumeyer and Perri (2005) show not only that interest rates are countercyclical in emerging markets, but also that interest rates lead the cycle. Figure 6 plots the cross-correlations between interest rates and output growth at different leads and lags for Argentinean data: The model accurately matches the inverse S-shape of

[15]The model specification in Neumeyer and Perri (2005) with independent processes for interest rates and productivity shocks is the closest to our model. Their preferred specification, instead, assumes that interest rates (or their spread component) is a function of expected productivity. We have no evidence to assume such a structural dependence. Moreover, some empirical estimations suggest that the role of innovations to domestic fundamentals in explaining fluctuations in spreads is limited (see, for example, Uribe and Yue (2006), Longstaff et al. (2007) and González-Rozada et al. (2008)). Accordingly, we assume both processes to be independent.

the cross correlations between output growth and real interest rates. The average sample correlation between consumption and interest rates is -0.40. The moment in the data is somewhat higher but lies within the 10% and 90% quantiles of simulated sample moments. In the case of investment the average sample correlation with the interest rate is somewhat below the data counterpart (the moment in the data is, however, strongly negative when using alternative detrending methods). The model performs well in matching the correlation of the trade balance with interest rates. The sample average of the correlation is 0.68, very close to the 0.71 correlation in the data.

The Persistence of the Trade Balance Figure 7 depicts the autocorrelation function of the trade balance to GDP ratio, both in Argentinean data and the model generated samples. Garcia-Cicco et al. (2010) show how the standard small open economy RBC model with only temporary and permanent technology shocks predicts a nearly flat autocorrelation function for the trade balance. From the empirical evidence in their paper, as well as from Figure 7, it is clear that this prediction is strongly counterfactual for Argentina: the autocorrelations are all significantly below one and converge to zero relatively quickly as the number of lags increases. Figure 7 shows that the model with interest rate shocks is successful in replicating the autocorrelation function.

4 .2 Crisis Dynamics

In terms of the second order moments the model is relatively successful in matching the Argentinean experience. We now explore the ability of the model to account for the behavior of macroeconomic aggregates in Argentina during times of financial crisis. First, we present the responses of macro-aggregates in the model around sudden stop episodes and compare them with two actual episodes. Second, we investigate the predictions of the model conditional on the observed series for the real interest rate. Finally, we look at the higher order moments.

Sudden Stops Figure 8 plots the model response of output, consumption, investment and the trade balance during a sudden stop. The graph also depicts the path of the variables during two

crises in the sample, which we date using the estimated crisis probabilities from the regime switching model. The first crisis has a zero date of 1989Q1 after which, as is clear from Figure 1, the estimated crisis probabilities is elevated for around 6 quarters. The second crisis has a zero date of 2001Q2 after which the estimated crisis probabilities remain very high for almost four years. In the graph, the economy enters the crisis regime in period 1 and the responses are the averages over the simulated samples for crises that last between 6 and 16 quarters.[16] The grey area shows where 80% of the simulated paths are situated, all of which have been normalized by their period 0 value.

On average, output falls 10% below its pre-crisis level in the model, consumption drops more than output and investment contracts by more than one fourth a few periods after the transition. The average response of the trade balance shows every characteristic of a sudden stop, with the trade surplus quickly rising to 7% of GDP on average. One important feature of the responses is the persistence of the crisis induced dynamics: it takes very long for output, consumption and investment to return to their trend values. We believe this result can be reconciled with the findings of Aguiar and Gopinath (2007) who, in the context of a standard frictionless model, assign a predominant role to permanent shocks to account for fluctuations in emerging economies. Using a longer sample for Argentina and Mexico, however, Garcia-Cicco et al. (2010) argue that there is not much support in data for the predominance of permanent shocks. In our model technology shocks are stationary, but the specification of the financial friction and the regime switching nature of the financial shock imply on average persistent deviations in measured TFP. The average response of the trade balance is much less persistent, which is in line with the arguments made by Garcia-Cicco et al. (2010). Judging by Argentina's experience in the 1989 and 2001 crises, the model produces crisis dynamics that are overall empirically plausible. One potential discrepancy is the speed of the recovery of investment: in both instances it has posted a higher growth rate onwards from 2 or 3 years after the start of the crisis than the rate predicted on average by the model. This could be a failure of the model, but it could also be due to positive realizations of shocks.

[16] See Appendix D for more details.

In Sections 5 .2 and 5 .3 we repeat this exercise for alternative specifications of the model and show that both intermediate inputs and variable capacity utilization matter for the quantitative success of the model in terms of crisis dynamics. Here we provide evidence that these modeling assumptions are, overall, empirically plausible by comparing the model response to a crisis of the utilization rate and intermediate inputs with some data counterparts.[17] Figure 9 shows that capacity utilization decreased substantially during the 2001 crisis, and Figure 3 suggests this was also the case in the 1989 crisis. The model captures this fact; if anything, it somewhat understates the decrease in utilization in the data. Although there is no aggregate series on the use of intermediate inputs in Argentina, there are three series that we can use as indirect evidence for samples that include the 2001 crisis: (1) imports of intermediate inputs (which account for around 40% of total imports); (2) demand of electricity; and (3) a synthetic energy production index. Figure 9 compares the average evolution of intermediate inputs in the model during crises and the path of those three series around the 2001 crisis. All variables show a significant decrease. The magnitude of the average drop of material inputs in the model is consistent with the paths of the energy index and electricity demand in data. The fall in imported intermediate inputs during the 2001 crisis is larger than what the model predicts. However, in reality the imported inputs are only a fraction of the total. It is likely that during crises firms substitute imported inputs for domestic inputs, such that the actual decrease is smaller. Also, the data is on flows of imports and does not consider changes in inventories that might have taken place at the onset of the crisis.

The role played by the credit friction in producing the abrupt drop in output during crises depends on the assumed elasticity of substitution between material inputs and value added. Unfortunately, there is no data from Argentina to estimate this elasticity. Equation (17) implies that the output response to a shift to the crisis regime is determined by the induced change in measured TFP. We can assess the sensitivity of our results to different elasticities by looking at how measured TFP

[17]The limited sample for the series on capacity utilization and intermediate inputs precludes us from including them among the series for which we compare second moments from simulations (see Appendix A).

responds for alternative values of the elasticity $1/(1-\rho)$. Figure 10 plots the average response of $\mathcal{A}_t(A_t, q_t)$ to a crisis under different elasticity values: 0.0001 (our benchmark calibration value), 1, and 100 (infinite elasticity). According to Bruno (1984) and Basu (1996), a unitary elasticity is most likely an upper bound for the US. Fortunately, the difference in the reaction of measured TFP between a very low elasticity and a unitary elasticity is very small. With infinite elasticity of substitution the drop in measured TFP is obviously much smaller, and in that case the model would fail to match the drop in output in the data. However, a low elasticity seems more realistic.

Dynamics in Response to the Actual Interest Rate Series Figure 11 plots detrended output, consumption, investment and the trade balance to GDP ratio predicted by the model when we embed the observed series for the interest rate in Argentina depicted in Figure 1. For this exercise we keep the level of technology equal to its long run average. The figure also depicts the corresponding variables for Argentinean data. The model series generated only by interest rate movements track the observed series remarkably well. The fit for the trade balance to GDP ratio is particulary good. The main discrepancy is that the model overstates the downward reaction of investment in the 2001 crisis. Again, it might be that the simple structure of the model misses some dimensions of the adjustment in the data, or it might be simply due to positive realizations of shocks in data after the crisis (e.g. the boom in commodity prices).

Higher Order Properties. The nonlinear nature of interest rates is reflected in the unconditional probability distributions of the variables. Model evaluation in terms of higher order properties complements the evidence on plausible dynamics during crises: if the model response to a crisis were in line with data but crises were too frequent or too rare, the model would fail in terms of its predicted unconditional probability distributions. Figure 12 reports fitted densities for both model and Argentinean data series. The distributions of output, consumption and investment in data show a clear tail to the left, reflecting the large declines that follow current account reversals. The latter are reflected in the right tail for the trade balance. Figure 12 shows that the model variables display the same pattern of asymmetry. The sample skewness of data and model series is reported in

Table 6: Although there are some differences in values, the direction of the asymmetry is always correct. Another check of model performance is a comparison of outcomes in crises and booms. We compute the average of each detrended series in the lower tail of the distribution (5% quantile) and their average in the upper (95% quantile) tail of the distribution. We then construct the ratio of the distance to trend of crises outcomes over the distance to trend of booms outcomes. These crisis-to-booms ratios both for data and the model series are reported in Table 6. The asymmetry between good and bad times in the model is in line with the data, notwithstanding a significant discrepancy for the investment series. The relative success in fitting the higher order moments of the macro variables is in the first place due to the asymmetric distribution of interest rates. However, how these translate quantitatively into asymmetries in the distribution of output and other variables depends on sufficiently strong propagation caused by model features such as credit frictions and variable capacity utilization.

Overall, the evidence provided in this section shows that the model succeeds in producing plausible sudden stop dynamics and in generating asymmetries in the probability distributions of macro variables that are similar to Argentinean data.

4 .3 The Relative Importance of Shocks and the Role of Crises

We now turn to the quantitative importance of interest rate shocks and crises for understanding the properties of the Argentinean business cycle. The last two columns in Table 5 contain the results of two simulation experiments aimed at quantifying the role of interest rate shocks. In the first experiment, we isolate the role of crises by computing the moments for 1000 samples in which the crisis regime does not occur. When simulating the data, we use the same policy functions as before but force the realized interest rate process to be generated by an AR(1) process, the parameters of which are those of the estimated tranquil regime. In the second experiment, we compute the moments when interest rate shocks are absent and there are only technology shocks. In both experiments, we do not change any of the parameter values of the model.

The first observation is that the presence of crises is the main reason why interest rate shocks are important in accounting for business cycle volatility in Argentina. The standard deviation of output growth is 6.5% in the data. Without crises occurring, the standard deviation drops to 3.2%, or 51% lower than the value in the data. Removing the interest rate shocks altogether further reduces the standard deviation, but only by 0.4% or another 6%. Therefore, it is almost exclusively the crisis episodes that comprise the contribution of interest rate shocks to business cycle volatility.

The second observation and main result from our experiments is that the ability of the model to match the data along several important dimensions depends to a large extent on the presence of crises. Without crises, the relative volatility of consumption drops from 1.10 to 0.83, which is much lower than in the data and closer to values from developed small open economies. The correlation of the trade balance with output growth drops from -0.52 to -0.12, such that the trade balance is much less strongly countercyclical. When interest rate shocks are removed altogether, the relative volatility of consumption drops further to 0.75, and the trade balance becomes strongly procyclical with a correlation of 0.70. These findings are of course reminiscent of Neumeyer and Perri (2005), Garcia-Cicco et al. (2010) and others, who show that the standard RBC model with only technology shocks fails along these important dimensions. Our results suggest though that while we need financial frictions to bring the model closer to the data, quantitatively it is the combination with the occurrence of sudden stop crises that matters most for the improved performance.

These results contrast with those of Mendoza (2010), who finds in model simulations based on a calibration to Mexican data that the occurrence of crises does not influence the properties of regular business cycle fluctuations very much. The key difference with our analysis is that the model in Mendoza (2010) has the appealing property that sudden stop events are triggered endogenously. Crises dynamics are explained by a suddenly binding collateral constraint producing debt deflation dynamics. We believe the main reason for the discrepancy is that self insurance tends to make

severe crises more unlikely in models of optimizing agents with rational expectations. In Mendoza (2010), only when a particular history of favorable shocks leading to increased borrowing is followed by a sudden reversal of fortune including an adverse interest rate shock as well as a negative technology shock, does the model produces dynamics that are quantitatively as observed during emerging market crises. In our approach, sudden stops are exogenously generated by regime shifts at a frequency that is determined by the empirical estimates of the regime switching model of interest rates. If we define a sudden stop as Mendoza (2010) as a situation in which the economy is in the crisis regime and the trade balance to GDP ratio is at least one standard deviation above the sample mean, the ergodic probability of sudden stops in the model is 12%.[18] In the Argentinean sample this probability is about 9%. An advantage of our approach is that it generates empirically more plausible probabilities of tail events, which is one of the reasons we emphasize model evaluation on the basis of the higher order properties of the macroeconomic variables.

5 Exploring Alternative Modeling Assumptions

In this section we present some alternative models in order to gain further insight into the quantitative contribution of the main features of our benchmark model. In the first exercise, we allow for the domestic credit friction to be regime dependent. A second experiment evaluates the role of variable rate of capacity utilization. Finally, we compare our model with a basic small open economy model with a financial friction linked to the wage bill instead of intermediate inputs. This last exercise employs a framework that is very similar to Neumeyer and Perri (2005) or Uribe and Yue (2006) but with nonlinear shocks to the interest rate.

5 .1 A Model with Regime Dependent Financial Frictions

Before, we demonstrated that it is the combination of financial frictions and crises that accounts for virtually all of the contribution of interest shocks to business cycle volatility. This suggests that

[18] Mendoza (2010) defines sudden stop states as those in which the collateral constraint binds and the trade balance to GDP ratio is at least one standard deviation above the mean. The frequency of sudden stops in his calibrated model is 3.3%.

what matters most quantitatively is the tightness of the financing constraint around crisis episodes, but not necessarily during tranquil times. To capture this idea, we modify the model by allowing the parameter φ to take on different values across the different regimes. Our motivation is twofold. First, although there are no direct aggregate empirical measures of φ or the value of working capital, a criticism of models with working capital frictions has been that, to be successful, an implausible large stock of working capital or collateral needs to be assumed. However, the model in this section implies a much smaller average value for the working capital parameter while leaving the results unchanged or even improved. Second, there is wide consensus that during times of financial stress, access to interfirm credit or trade finance is reduced and firms are forced to adopt cash-in-advance or bank-intermediated financial arrangements. This has important consequences on trade of intermediate inputs and production.[19]

We capture the time varying nature of credit frictions by assuming $\varphi = 0$ in the tranquil regime and $\varphi = 0.80$ during the crisis regime.[20] Given our estimated regime switching process for Argentina, where the ergodic probability of the tranquil regime is 77%, the average value of φ is around 0.22, almost 80% lower than the value under the benchmark model. This implies that the average stock of working capital is 6.3% of GDP in this model, while this ratio is 27% in the benchmark model. In order to be consistent with the same target statistics as the benchmark calibration, only very minor changes in the other parameter values were required (see the footnote in Table 7).

The third column in Table 7 displays the relevant business cycle moments of the model with a regime dependent financing friction. The results are remarkably similar to the benchmark model and, in some aspects, even more in line with the Argentinean data. The relative standard deviation of consumption is almost identical to the benchmark model value. The trade balance remains

[19] See Auboin and Meier-Ewert (2003), ICC (2008) and IMF (2003).

[20] We assume $\varphi = 0.8$ in the crisis regime since we found that, when setting $\varphi = 1$, the combined effect of movements in φ and the interest rate shocks yielded excessive output volatility: the standard deviation of output growth in the simulations exceeded the value in the data, even when setting the standard deviation of the technology shock to zero. To make the results more comparable, we therefore chose to keep the volatility of technology shocks the same as in the benchmark calibration, and instead adjust the value of φ to match the observed standard deviation of output growth.

strongly countercyclical, but the value of -0.45 is closer to the observed value of -0.30, which is now also within 10%-90% quantiles of the simulated moments. Since now interest rate shocks directly affect labor and capital productivity only in the crisis state, the cross correlations of output, consumption and investment with the interest rate are considerably lower. This brings these numbers closer to the values in the data, which, except for investment, are now within the 10%-90% quantiles of the simulated moments. Removing the crises lowers the volatility of output by 59%, as opposed to 51% in the benchmark. Removing all interest rate shocks (as well as keeping $\varphi = 0$) does not further reduce output volatility significantly. This confirms the result of the benchmark model that it is crises episodes that are key for the empirical success of the model. Outside of crises episodes, the financing friction is by and large inconsequential as movements in interest rates are far too small. Figure 13 compares the paths of the main macro-aggregates during sudden stops in the modified model. Because of the simultaneous tightening of credit conditions, the average drops in output, consumption and investment are more pronounced than in the benchmark model.

All of this suggests, first, that a lack of evidence of sizeable financial constraints in a sample dominated by tranquil episodes does not automatically imply that these frictions are irrelevant for understanding emerging market fluctuations. This has important implications in terms of validating models with working capital frictions empirically. It also suggests that the assumption of tightening domestic credit conditions occurring in conjunction with rises in interest rates and interest rate volatility is empirically plausible. This extension is particularly appealing in the light of evidence that trade credit is an important channel through which financial shocks affected real outcomes during recent financial turmoils.

5 .2 A Model with Fixed Capacity Utilization

Before, we pointed to the role of variable capital utilization as an amplification mechanism of interest rate shocks in the benchmark model, and we showed that the model predictions for the utilization rate during crises is not contradicted by available data. To further assess the relative

contribution of this feature, in this section we solve a different version of the model in which utilization is kept constant. The parameters are recalibrated to remain consistent with the moments of the ergodic distribution. The fourth column of Table 7 presents business cycle moments for this alternative model. In terms of second moments, the model still performs relatively well. Smaller amplification of interest rate shocks means technology shocks must account for a larger share of output volatility than in the benchmark model. As a result, the model with fixed utilization yields lower consumption volatility: the relative standard deviation of consumption is now 1.03, but the moment in data still lies within the 10%-90% quantiles of simulated moments. The smaller propagation of interest rate shocks weakens the countercyclical nature of interest rates and lowers the negative correlation of the trade balance with output relative to the benchmark model: both moments in the data now lie within the 10%-90% quantiles of the simulated moments. Overall, the correlations of consumption, investment and the trade balance with output growth, as well as the correlations of all variables with interest rates are consistent with the data.

However, Figure 13 shows that the specification with fixed capacity utilization is unable to explain the response of output and consumption to crises and consequently fails to match the higher properties of the data. This finding is consistent with the arguments in Meza and Quintin (2007). The main discrepancy with the Argentinean crises is in the size of the drop in economic activity and in the speed of the adjustment. When a rise in the interest rate reduces measured TFP, this affects directly the marginal productivity of capital. In the benchmark model, variable capacity utilization allows households to adjust the amount of capital services supplied, leading to an immediate reduction in output. The volatility of output growth is reduced by 18% when we remove the crises, as opposed to 51% in the benchmark model. Eliminating interest rate shocks altogether, the additional drop in output volatility is quantitatively very small. Therefore, the volatility contribution of interest rate shocks depends on the feature of varying capacity utilization, but it is still almost exclusively the presence of crises that comprises the effect of interest rate fluctuations.

5 .3 A Model With a Working Capital Constraint Linked to the Wage Bill

In this section we wish to clarify further the quantitative contribution of linking the working capital friction to intermediate inputs rather than the wage bill, and its interaction with the nonlinearity of interest rates. The model we use for comparison has fixed utilization, only capital and labor are used in production and the working capital friction is linked to the wage bill (the details are given in Appendix E). The model is thus very similar to Neumeyer and Perri (2005) or in Uribe and Yue (2006). The key difference is that we embed into the model the same nonlinear process for the interest rate as in our benchmark model and employ a nonlinear global solution method. Business cycle moments for the wage bill model are reported in the fifth column of Table 7. Overall it is relatively consistent with the data in terms of the second order properties of simulated series. One shortcoming of the wage bill model is that the trade balance to GDP ratio becomes acyclical: the average correlation with output growth is only -0.03, while in the data is -0.30 which is outside the 10% and 90% quantiles of the simulated sample moments. The absence of a countercyclical trade balance is very similar to the simulation results in Neumeyer and Perri (2005) for the model with independent interest rate and technology processes.

More relevant implications of linking the friction to material inputs and its interaction with nonlinear interest rates become clear when we analyze higher order moments and dynamics around crises episodes. Figure 12 compares the probability distribution of endogenous variables from the wage bill and the benchmark model and Table 6 reports sample skewness and the crises-to-booms statistic. The degree of asymmetry of consumption, investment and the trade balance to GDP ratio in both the benchmark and the wage bill model is very much in line with data. As argued before, this success is due to the regime switching nature of the interest rate we estimate from data. However, the distribution of output implied by the wage bill model is almost symmetric: the skewness of detrended GDP is only -0.03 while in data it is -0.50. This lack of asymmetry suggests an important failure in the propagation mechanism of financial shocks to output when the friction is linked to the wage bill. This specification implies that an interest rate shock affects directly only

the marginal productivity of labor (see equation (A-20) in the Appendix E), while when the friction is linked to material inputs the shock affects directly the marginal productivity of both labor and capital. The comparison between the wage bill model and the fixed utilization model shown in the upper left panel of Figure 13 is particularly illustrative: Although the only specification difference is linking the friction to the wage bill rather than to intermediate inputs, the response of output to a crisis in the wage bill model is much milder and further away from the reaction in data. These results are consistent with the fact that our benchmark model assigns a larger role for interest rate shocks in accounting for output volatility in Argentina in comparison with Neumeyer and Perri (2005): Our counterfactual experiments suggested a reduction of output volatility of more than half once interest shocks are eliminated, while in their paper the reduction is around 30%.

6 Conclusion

The occurrence of dramatic crises in many emerging markets raises the question of their role in determining the distinctive features of emerging market fluctuations such as the high volatility of consumption and the strong countercyclicality of the trade balance. Our analysis suggests that these may be driven to a large extent by the occasional disruptions in access to foreign lending that is typical of emerging markets. We exploit the nonlinear behavior of interest rates to capture the probability distribution of these sudden stop episodes: Interest rates in emerging economies are well characterized by a regime switching process alternating between a low level/low volatility regime and an infrequent high level/high volatility regime. We embed a nonlinear process estimated for Argentina into a neoclassical small open economy model with financial frictions and variable capacity utilization and emphasize its empirical evaluation in terms of higher order moments of endogenous variables and their dynamics during crises episodes. Our counterfactual experiments indicate that interest rate fluctuations associated with sudden stops can explain a large part of the output volatility observed in Argentina and are the main reason for its high relative volatility of consumption and countercyclicality of the trade balance.

Financial frictions are essential for explaining emerging market fluctuations in our model, but almost exclusively because of their effects in crisis episodes. This outcome supports the modeling approach of Mendoza (2010), who shares with us the emphasis on nesting infrequent dramatic crises with regular fluctuations and views crises as times when financing constraints become particularly stringent. An important challenge for future research employing dynamic models with rational forward looking agents is to reconcile the occurrence of severe crises with the incentive for households to engage in precautionary savings behavior in anticipation of the possibility of future crises. Modeling crises as rare exogenous shifts to a regime of high and volatile interest rates greatly reduces the agents' ability and incentives to self insure relative to models where crises arise endogenously, such as in Mendoza (2010). This difference in modeling approach has important consequences for the incidence of crises and consequently for their impact on the properties of business cycles in emerging economies. We acknowledge nevertheless that the small open economy assumption for interest rates neglects that the country spread comprises an endogenous default risk component. But to the extent that external factors play an important role in the pricing of emerging markets' debt as many empirical studies suggest, viewing financial crises as being triggered by exogenous switches in regime seems a reasonable first approximation.

Although we targeted the calibration and empirical evaluation of the model to Argentina, we believe the main results in this paper extend broadly to other emerging economies. The regime switching estimation for our sample of emerging markets revealed that the asymmetric distribution of interest rates is similar in other countries. Moreover, the skewed distributions of some macroeconomic aggregates, reflecting the occasional occurrence of severe crises, is a common feature for these economies. It is these asymmetries, rather than just higher volatility, that seem to constitute a key difference with most developed small open economies.

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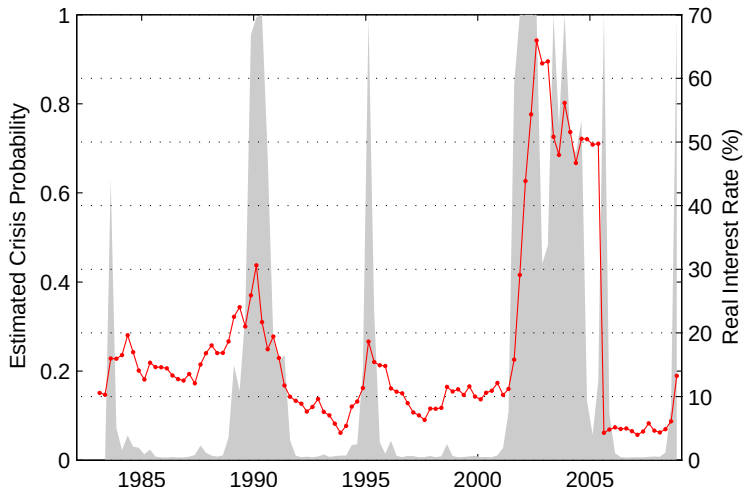

Figure 1: Real interest rate in Argentina (quarterly data). Grey areas denote estimated probability of the crisis state.

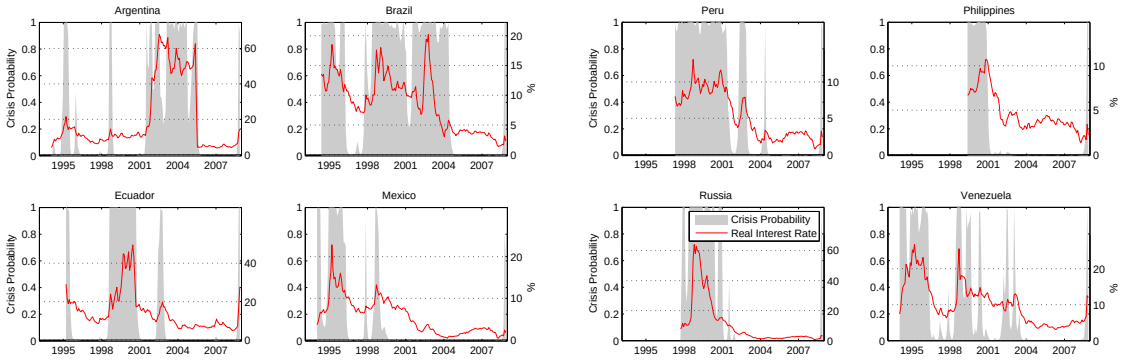

Figure 2: Real interest rates in selected emerging markets (monthly data). Grey areas denote estimated probability of the crisis state.

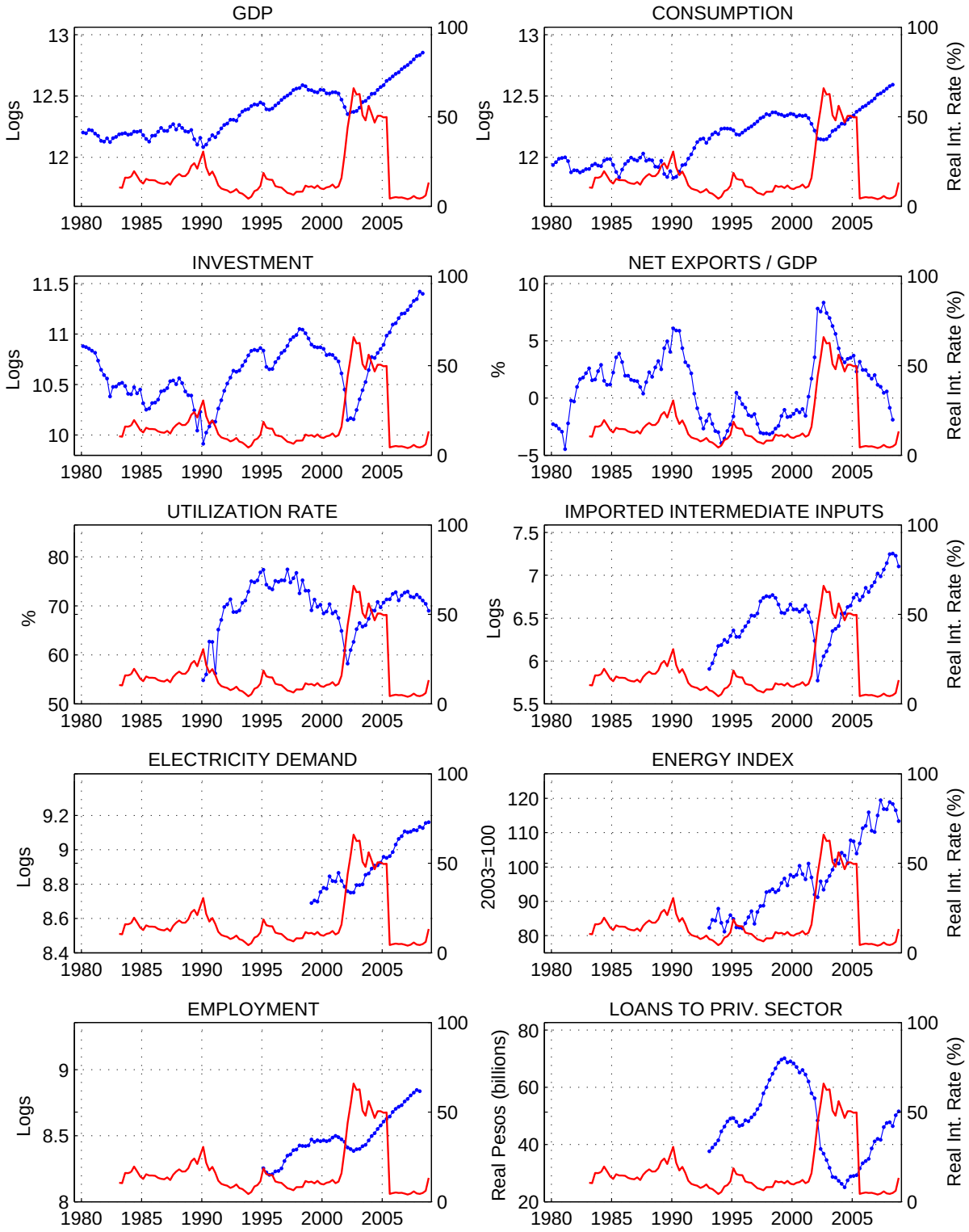

Figure 3: Main macroeconomic variables for Argentina.

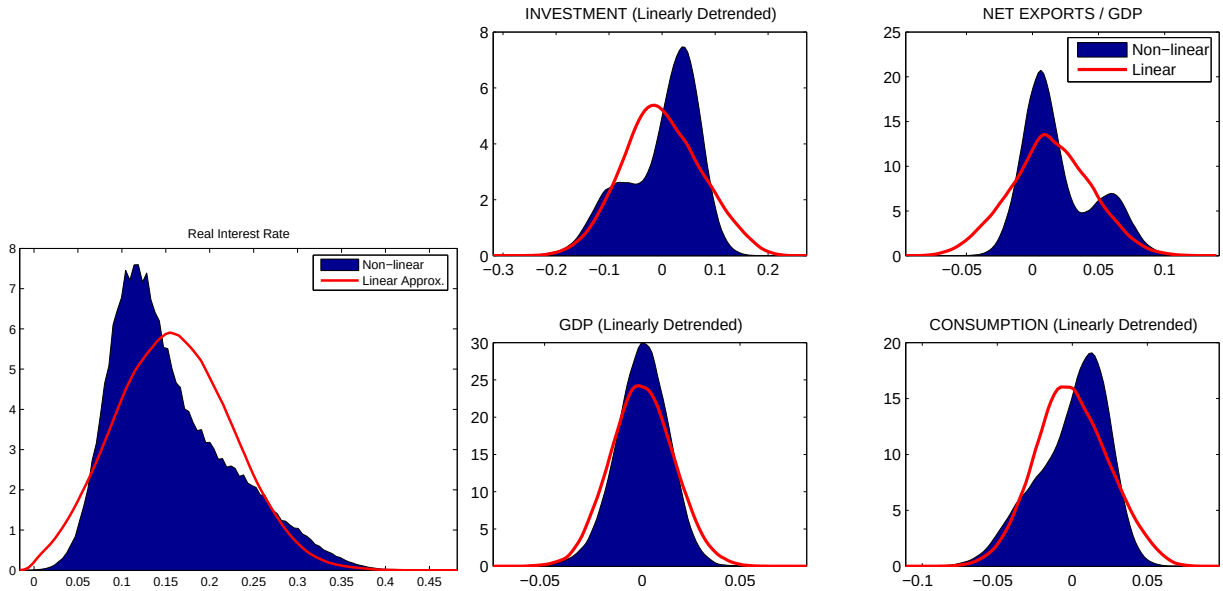

Figure 4: *Left Figure*: Distribution of the nonlinear DGP for the interest rate and of an equivalent AR(1) approximation. *Right Four Figures*: Distribution of model simulated series under the different processes for the interest rates. In both cases the model is solved using a global nonlinear solution method.

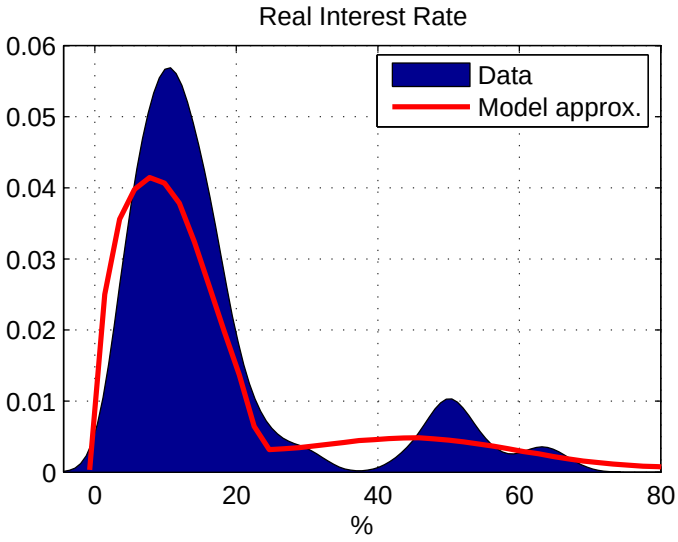

Figure 5: Distribution of the real interest rate in data and implied by the discrete approximation used in the model.

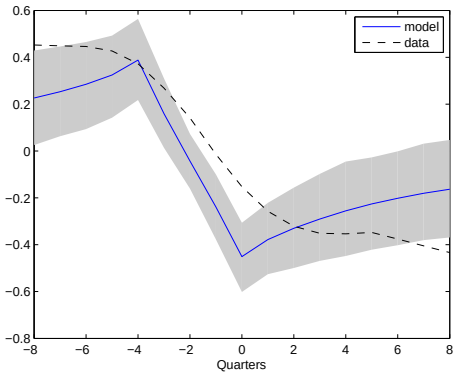

Figure 6: Cross-correlations between GDP growth at various leads and lags, and interest rates. The grey area indicates the region in which 80% of the simulated sample moments lie.

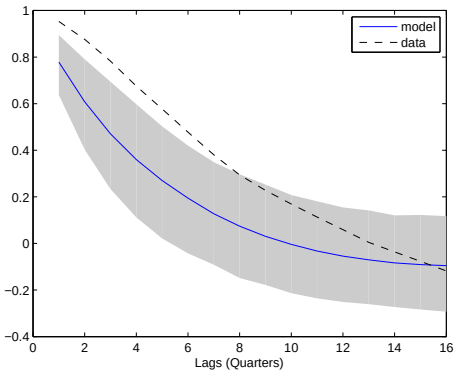

Figure 7: Autocorrelation function of the trade balance to GDP ratio. The grey area indicates the region in which 80% of the simulated sample moments lie.

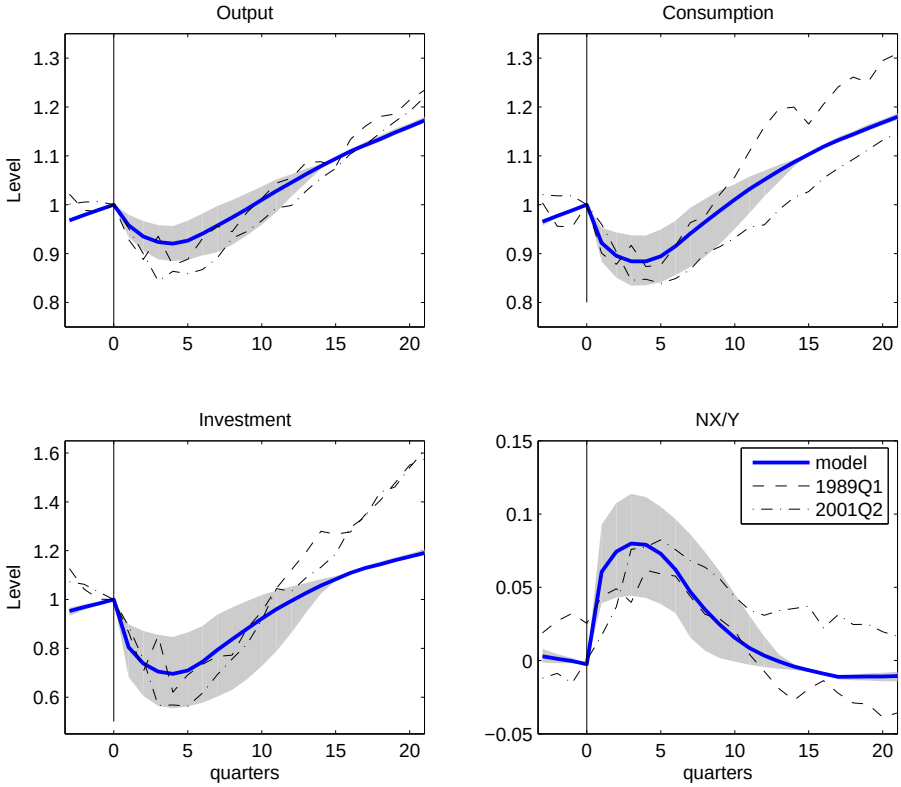

Figure 8: Response to a Crisis. Variables are in levels. For output, consumption and investment the period 0 value is normalized to one. The grey area indicates the region in which 80% of the simulated sample moments lie. Broken lines are Argentinean data with period 0 equal to 1989Q1 and 2001Q2 respectively. See Appendix D for more details.

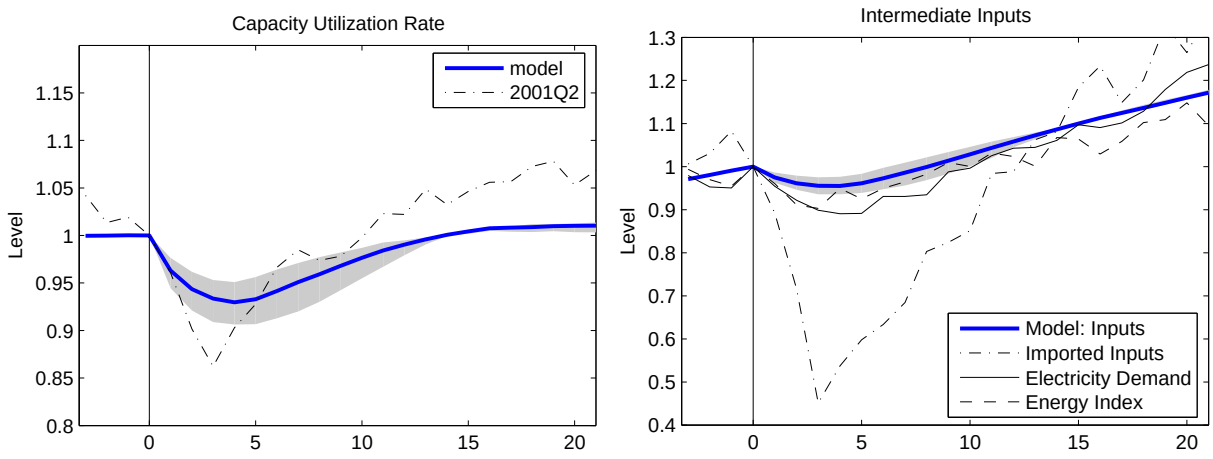

Figure 9: Response to a Crisis. *Left Panel:* The solid line is the response of capacity utilization rate in the model. The broken line corresponds to Argentinean data on industrial capacity utilization rate with period 0 equal to 2001Q2. *Right Panel:* The solid line is the response of intermediate inputs in the model. The other series correspond to Argentinean data on imported intermediate inputs, on electricity demand and on the synthetic energy index, with period 0 equal to 2001Q2. For all series in both panels the period 0 value is normalized to one. See Appendix D for more details.

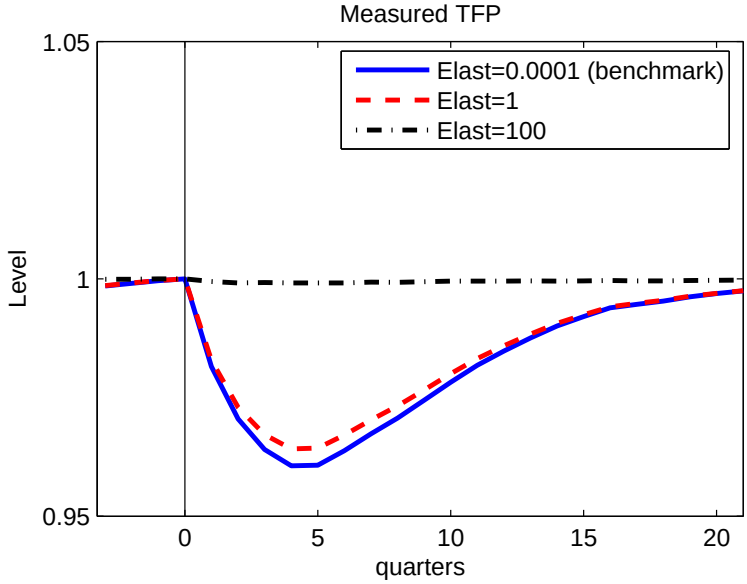

Figure 10: Response to a Crisis of measured TFP in the benchmark model, equation (18), for different values for the production elasticity of substitution $1/(1-\rho)$. See Appendix D for more details.

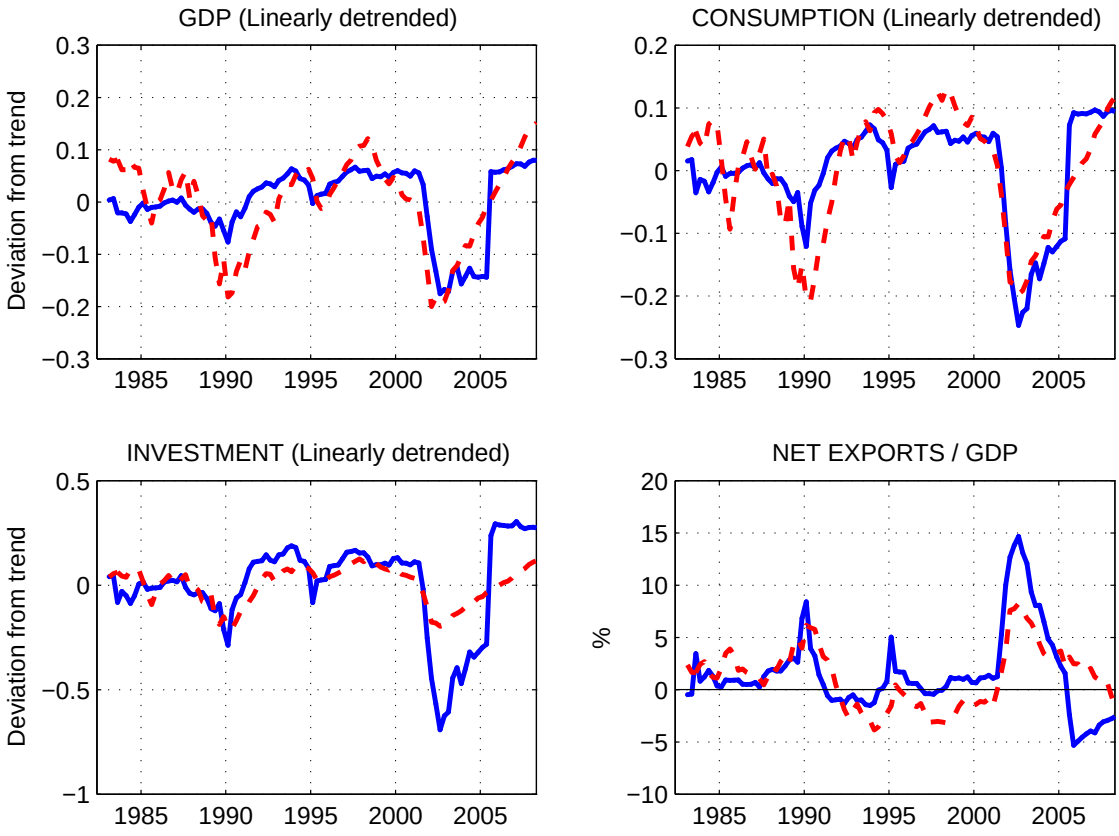

Figure 11: Simulated (solid lines) and actual (broken lines) macroeconomic aggregates when the actual series for the real interest rete is fed into the benchmark model. Output, consumption and investment variables are linearly detrended.

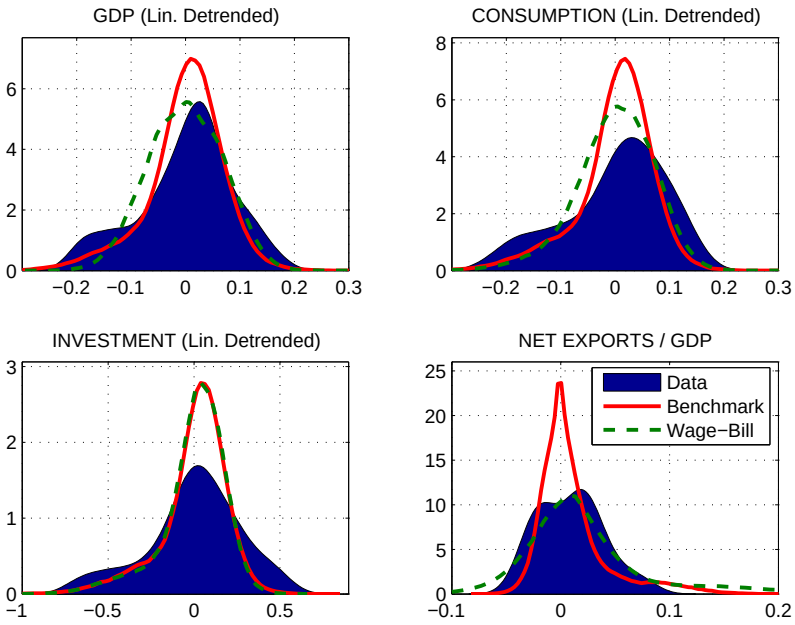

Figure 12: Fitted kernel densities to data (areas), benchmark model (solid lines) and wage-bill model macroeconomic aggregates (broken lines). Output, consumption and investment correspond to linear detrended series.

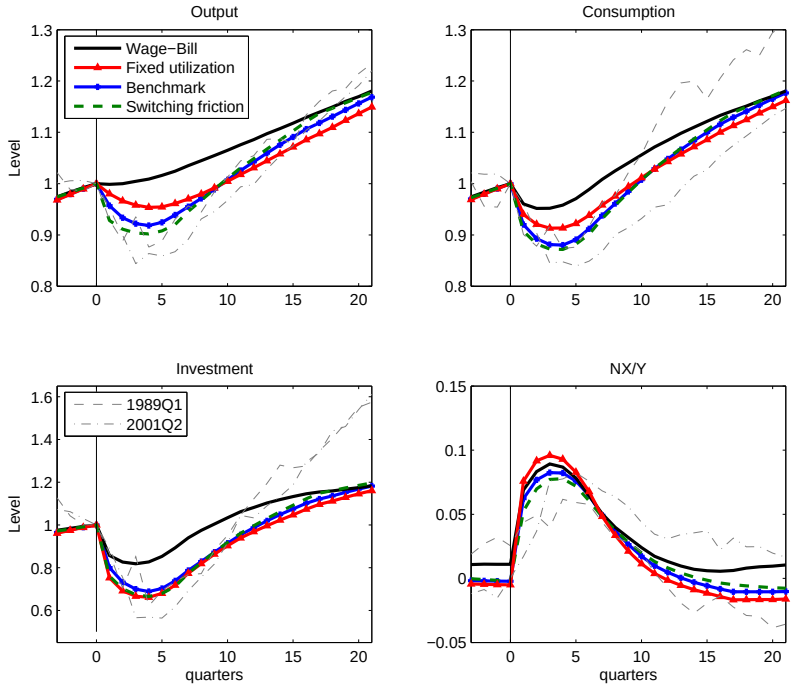

Figure 13: Comparison of alternative models in terms of the response to a crisis of the main macro-aggregates. Switching friction denotes the model with regime dependent financial frictions in Section 5.1, Fixed utilization refers to the model in Section 5.2, and Wage-Bill corresponds to the model in Section 5.3. Thin broken lines are Argentinean data with period 0 equal to 1989Q1 and 2001Q2 respectively. See Appendix D for more details.

Table 1: Argentina Real Interest Rate: Summary Statistics and Markov-Switching Model Estimates (Quarterly Data).

Summary Statistics:			
Sample		Q1/1983	Q4/2008
Observations		104	
Min.		3.94%	
Max.		65.95%	
Mean		17.55%	
Median		12.13%	
Standard Deviation:		15.21%	
Markov Switching AR Estimation:			
Parameters:		$s_t = T$	$s_t = C$
Intercept	$\widehat{\nu}(s_t)$	0.39	1.73
		[0.4061]	[3.2577]
Autoregressive	$\widehat{\rho}_r$	0.9634	
		[0.0356]	
Unconditional Mean	$\widehat{\nu}(s_t)/(1-\widehat{\rho}_r)$	10.59	47.30
Standard Deviation	$\widehat{\sigma}(s_t)$	1.66	12.07
		[0.4647]	[5.9722]
Transition matrix	$\widehat{Pr}\{s_{t+1} = T \mid s_t\}$	0.91	0.32
		[0.046]	
	$\widehat{Pr}\{s_{t+1} = C \mid s_t\}$	0.09	0.68
			[0.3077]
Ergodic Probabilities		77%	23%
Linearity Test:			
	LR	61.81	
	p-value	0.0001	

Numbers in brackets are standard errors of estimates, computed with the Newey-West estimator. The p-value of the likelihood ratio statistic is obtained by Monte Carlo simulations (10,000 repetitions)

Table 2: Real Interest Rate for a Sample of Emerging Economies, Data Statistics and Markov-Switching Model Estimates (Monthly Data).

		Argentina		Brazil		Ecuador		Mexico	
Summary Statistics:									
Sample		12/1993-11/2008		04/1994-11/2008		02/1995-11/2008		12/1993-11/2008	
Range (%)		3.8	67.9	1.4	20.2	4.9	49.6	0.4	22.8
Mean (%)		19.7		8.6		14.4		5.6	
Median (%)		10.7		8.9		11.0		4.3	
Std. dev. (%)		19.4		4.6		9.5		4.3	
Markov Switching AR Estimation:									
Parameters:		$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$
Intercept	$\widehat{\nu}(s_t)$	0.26	1.25	0.08	0.46	0.57	2.69	0.04	0.68
Autoregressive	$\widehat{\rho}$	0.97		0.96		0.93		0.97	
Unconditional Mean	$\widehat{\nu}(s_t)/(1-\widehat{\rho})$	10.18	49.66	1.99	11.36	7.79	36.50	1.35	24.32
Standard Deviation	$\widehat{\sigma}(s_t)$	0.75	7.28	0.28	1.46	0.83	5.47	0.36	2.20
Transition Matrix	$\widehat{\pi}$	0.94	0.06	0.94	0.06	0.97	0.03	0.97	0.03
		0.13	0.87	0.05	0.95	0.08	0.92	0.15	0.85
Ergodic Probabilities		68%	32%	45%	55%	77%	23%	84%	16%
Linearity Test (p-value LR test)		0.0000		0.0002		0.0000		0.0000	

		Peru		Philippines		Russia		Venezuela	
Summary Statistics:									
Sample		03/1997-11/2008		04/1999-11/2008		08/1997-11/2008		12/1993-11/2008	
Range (%)		0.8	13.1	1.3	10.7	0.7	63.9	3.1	26.7
Mean (%)		5.3		4.7		10.8		10.2	
Median (%)		4.0		3.8		3.1		9.5	
Std. dev. (%)		3.2		2.2		15.4		5.7	
Markov Switching AR Estimation:									
Parameters:		$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$	$s_t = T$	$s_t = C$
Intercept	$\widehat{\nu}(s_t)$	0.22	1.07	0.26	0.84	0.12	2.50	0.31	1.51
Autoregressive	$\widehat{\rho}$	0.88		0.91		0.93		0.94	
Unconditional Mean	$\widehat{\nu}(s_t)/(1-\widehat{\rho})$	1.89	9.06	3.00	9.65	1.62	33.72	5.02	24.32
Standard Deviation	$\widehat{\sigma}(s_t)$	0.29	0.80	0.31	0.64	0.33	5.87	0.52	2.58
Transition Matrix	$\widehat{\pi}$	0.96	0.04	0.99	0.01	0.96	0.04	0.93	0.07
		0.06	0.94	0.05	0.95	0.11	0.89	0.17	0.83
Ergodic Probabilities		57%	43%	81%	19%	70%	30%	72%	28%
Linearity Test (p-value LR test)		0.0022		0.0062		0.0000		0.0000	

The p-values of the likelihood ratio statistics are obtained by Monte Carlo simulations (5,000 repetitions).

Table 3: Simulation Results of Section 2 .2

		Nonlinear Shock	AR(1) Approx
a) Unconditional Means			
Debt to GDP	d/y	0.80	0.57
b) Standard Deviations			
Output	$std(\hat{y})$	0.015	0.017
Consumption	$std(\hat{c})/std(\hat{y})$	1.89	1.68
Investment	$std(\hat{x})/std(\hat{y})$	4.96	4.65
Trade balance to GDP	$std(nx/y)$	0.028	0.030
c) Skewness			
Output		-0.15	0.04
Consumption		-0.58	0.12
Investment		-0.70	0.13
Trade balance to GDP		0.76	-0.04
d) Cross-Correlations with Output			
Consumption	$corr(\hat{c},\hat{y})$	0.75	0.68
Investment	$corr(\hat{x},\hat{y})$	0.65	0.62
Trade balance to GDP	$corr(nx/y,\hat{y})$	-0.39	-0.26
e) Cross-Correlations with Real Interest Rate			
Output	$corr(\hat{y},R)$	-0.66	-0.58
Consumption	$corr(\hat{c},R)$	-0.94	-0.93
Investment	$corr(\hat{x},R)$	-0.92	-0.93
Trade balance to GDP	$corr(nx/y,R)$	0.89	0.86

Skewness of Macroeconomic Aggregates in the Data

	GDP	Investment	Consumption	Trade Balance
Average Emerging	+0.03	-0.08	-0.24	+0.35
Average Developed	+0.01	-0.04	+0.16	-0.07

The data is from Aguiar and Gopinath (2007) and it includes 13 emerging and 13 developed small open economies. GDP, consumption and investment series have been linearly detrended. The trade balance corresponds to the trade balance to GDP ratio.

Table 4: Calibration, Benchmark Model

a) Preferences	Symbol	Value	Target
Discount factor	β/g	0.9598	Trade balance to GDP ratio
Utility curvature	γ	2	Mendoza (1991), ...
Labor disutility weight	ζ	0.62	Normalized labor input
Inverse wage elasticity of labor supply	ψ	0.6	Mendoza (1991), ...
b) Technology			
Capital income share	α	0.38	Labor income share
Scaling parameter	υ	0.57	normalized GDP
Intermediate inputs weight	μ	0.44	IO table
Growth factor	g	1.0083	Average output growth
Production substitution elasticity	$1/(1-\rho)$	0.0001	Rotemberg and Woodford (1996)
Working capital requirement	φ	1	See Section 5.1
Capital depreciation parameter 1	δ	-0.017	I-Y ratio, normalized utilization rate
Capital depreciation parameter 2	η	0.081	I-Y ratio, normalized utilization rate
Capital depreciation parameter 3	ω	0.44	Meza and Quintin (2007), utilization rate
Capital adjustment cost	$\phi_k/2$	19.3	Relative investment volatility
Saving interest rate ceiling	$\bar{R}$	$1.02^{0.25}$	International riskless rate
c) Technology Shock Process			
Persistence of TFP shock	ρ_A	0.95	Neumeyer and Perri (2005)
Standard deviation of TFP shock	σ_A	0.0027	Output volatility
d) Interest Rate Shock Process			
See Table 1.			

Table 5: Simulation Results: Year on Year Growth Rates

		Data	Benchmark	No Crises	Tech Shocks Only
a) Standard Deviations					
Output (T)	$std(g_y)$	0.065	0.065 *(0.044,0.086)*	0.032	0.028
Consumption	$std(g_c)/std(g_y)$	1.14	1.10 *(0.94,1.25)*	0.83	0.75
Investment (T)	$std(g_x)/std(g_y)$	3.14	3.14 *(2.68,3.62)*	2.59	1.75
Trade balance to GDP	$std(nx/y)$	0.029	0.032 *(0.021,0.042)*	0.010	0.003
b) Cross-Correlations with g_y					
Consumption	$corr(g_c, g_y)$	0.94	0.95 *(0.92,0.97)*	0.96	0.99
Investment	$corr(g_x, g_y)$	0.92	0.94 *(0.91,0.96)*	0.94	0.99
Trade balance to GDP	$corr(nx/y, g_y)$	-0.30	-0.52^* *(-0.66,-0.36)*	-0.12	0.70
c) Cross-Correlations with R					
Output	$corr(g_y, R)$	-0.21	-0.45^* *(-0.59,-0.31)*	-0.28	0
Consumption	$corr(g_c, R)$	-0.26	-0.40 *(-0.56,-0.25)*	-0.36	0
Investment	$corr(g_x, R)$	-0.07	-0.32^* *(-0.47,-0.17)*	-0.32	0
Trade balance to GDP	$corr(nx/y, R)$	0.71	0.68 *(0.37,0.88)*	0.91	0

(T) denotes that the statistic was targeted in the calibration. Numbers in parenthesis are 10% and 90% quantiles. An asterisk in the second column denotes that the corresponding data moment does not lie within these quantiles.

Table 6: Asymmetry in Macro-Aggregates: Data, Benchmark and Wage-Bill Model.

	Skewness			Crises-to-Booms ratio		
	Data	Benchmark	Wage-Bill	Data	Benchmark	Wage-Bill
Output	-0.5	-0.62	-0.03	1.3	1.4	1.0
Consumption	-0.68	-0.92	-0.42	1.5	1.6	1.2
Investment	-0.53	-1.02	-1.03	1.3	1.7	1.4
Trade Balance to GDP	$+0.37$	$+1.56$	$+1.13$	0.7	0.4	0.5

Output, consumption and investment series for Argentina have been linearly detrended. The crises-to-booms ratio for each macro-aggregate is computed as the distance from outcomes during crises to trend over the distance from outcomes during booms to trend. Outcomes during crises (booms) for each variable correspond to the average of the realizations smaller (bigger) than the 5% (95%) quantile of the distribution.

Table 7: Simulation Results for Alternative Models (Year on Year Growth Rates)

		Data	Benchmark	Switching φ_t	Fixed u_t	Wage-Bill
a) Standard Deviations						
Consumption	$std(g_c)/std(g_y)$	1.14	1.10	1.09	1.03	1.04
			(0.94,1.25)	*(0.96,1.23)*	*(0.90,1.19)*	*(0.88,1.21)*
Trade balance to GDP	$std(nx/y)$	0.029	0.032	0.032	0.039	0.036
			(0.021,0.042)	*(0.021,0.043)*	*(0.026,0.055)*	*(0.021,0.049)*
b) Cross-Correlations with g_y						
Consumption	$corr(g_c, g_y)$	0.94	0.95	0.95	0.92	0.88
			(0.92,0.97)	*(0.92,0.97)*	*(0.88,0.96)*	*(0.81,0.94)*
Investment	$corr(g_x, g_y)$	0.92	0.94	0.93	0.69^*	0.69^*
			(0.91,0.96)	*(0.90,0.96)*	*(0.57,0.79)*	*(0.57,0.82)*
Trade balance to GDP	$corr(nx/y, g_y)$	-0.30	-0.52^*	-0.45	-0.31	-0.03^*
			(−0.66,−0.36)	*(-0.62,-0.23)*	*(-0.54,-0.07)*	*(-0.25,-0.19)*
c) Cross-Correlations with R						
Output	$corr(g_y, R)$	-0.21	-0.45^*	-0.35	-0.38	-0.13
			(-0.59,-0.31)	*(-0.50,-0.17)*	*(-0.56,-0.20)*	*(-0.32,0.07)*
Consumption	$corr(g_c, R)$	-0.26	-0.40	-0.35	-0.37	-0.24
			(-0.56,-0.25)	*(-0.50,-0.21)*	*(-0.54,-0.20)*	*(-0.42,-0.07)*
Investment	$corr(g_x, R)$	-0.07	-0.32^*	-0.26^*	-0.30^*	-0.23^*
			(-0.47,-0.17)	*(-0.41,-0.12)*	*(-0.46,-0.15)*	*(-0.39,-0.06)*
Trade balance to GDP	$corr(nx/y, R)$	0.71	0.68	0.73	0.61	0.86^*
			(0.37,0.88)	*(0.43,0.92)*	*(0.29,0.85)*	*(0.81,0.91)*

Numbers in parenthesis are 10% and 90% quantiles. An asterisk denotes that the corresponding data moment does not lie within these quantiles. For the model with fixed utilization, the only parameters that are different from the benchmark calibration in Table 4 are $\eta = 0.074$, $\sigma_A = 0.00915$, $\phi_k/2 = 9.05$ and $\beta = 0.96235$. For the model with a regime dependent financial friction, the only parameter that is different from the benchmark is $\beta = 0.95984$. For the wage-bill model the parameters are presented in appendix.

Appendix

A Data Sources and Transformations

We use data for Argentina from 1980Q1 to 2008Q2 for GDP, consumption, investment, exports and imports, and from 1983Q1 to 2008Q4 for the real interest rate. The data used are plotted in Figures 1 and 3. The series from the National Accounts are in constant prices (millions of pesos, prices of 1993). GDP is obtained from the Instituto Nacional de Estadisticas y Censos (INDEC) for the whole period. Consumption corresponds to private plus public consumption. Series on consumption, investment, imports and exports are obtained from INDEC for the period 1993Q1 to 2008Q2 and extended backwards until 1980Q1 by splicing with the data in Neumeyer and Perri (2005). To compute the average quarterly growth rate of GDP we excluded the rates corresponding to quarters 1989Q2 to 1990Q2 and 2001Q3 to 2004Q1, corresponding to crises periods. The beginning of the crises were dated using the estimated crisis probabilities from the regime switching model. The end of each crisis was dated at the period at which output reached its pre-crisis level.

The data on capacity utilization rate, imported intermediate inputs, energy index, electricity demand, employment and total loans to the private sector shown in Figure 3 was obtained from CEIC database (http://www.ceicdata.com/). The utilization rate corresponds to the quarterly average of the industrial capacity utilization rate series constructed by the Fundación de Investigaciones Económicas Latinoamericanas (FIEL) since 1990M01. The electricity demand series is in physical units (GWh), available since 1999M01, and is constructed by the Wholesale Electricity Market Regulatory Company; we report the quarterly average. The synthetic energy index (2003=100) is reported by the INDEC from 1993M01 onwards. The imported intermediate inputs series is constructed by the INDEC, corresponds to millions of US dollars and is available since 1992M01. We take the quarterly average and convert it to millions of pesos, prices of 1993, using the GDP implicit price deflator for imports (INDEC, available from 1993Q1). The total loans to the private sector series (1993Q1-2008Q4) corresponds to the sum of loans to the non-financial private sector

in foreign and in domestic currency, constructed by the Central Bank, expressed both in real pesos (millions of pesos, 1993 prices). The employment series correspond to the quarterly average of employed workers (thousands of people) reported by the INDEC as registered in the social security system (SIJP), available since 1995M01.

The real interest rates are constructed as in Neumeyer and Perri (2005). The nominal interest rates in US dollars correspond, each period (quarter or month), to the average daily yield for the 90-day U.S. T-bill in the secondary market plus the average J.P. Morgan EMBI+ Stripped Spread for each country. The real rates are obtained by deflating the nominal rate by the U.S. GDP Deflator expected inflation. Quarterly expected inflation is computed as the average of the actual GDP Deflator inflation in that quarter and in the three preceding ones. Monthly expected inflation is obtained by linearly interpolating the quarterly rate. From December 1993 onwards we use the country spreads calculated by J.P. Morgan. We extend the series for Argentina backwards at quarterly frequency until 1983Q1 by splicing with the data in Neumeyer and Perri (2005). For the last observation in our sample, 2008Q4, we used preliminary values. For the country spreads we used values available until November 11th, 2008, while for the U.S. T-bill yield we used values until November 13th, 2008. Regarding the U.S. GDP deflator inflation, we fitted an AR(1) model to its growth rate with data from 1980Q1 to 2008Q3 and projected the value for the last quarter: 2008Q4.

B Measured TFP

Substituting m_t from equation (16) in equation (10) and rearranging we can obtain:

$$\left(\frac{z_t}{f_t}\right)^{1-\rho} = \left[1-\mu A_t^{\frac{\rho}{1-\rho}}\left(1+\varphi q_t\right)^{-\frac{\rho}{1-\rho}}\right]^{-\frac{1-\rho}{\rho}} A_t^{1-\rho}(1-\mu)^{\frac{(1-\rho)^2}{\rho}} \tag{A-1}$$

Then, (A-1) is plugged in equations (14) and (15), giving:

$$r_t^k = \alpha \left(\frac{A_t^{\frac{\rho}{\rho-1}} - \mu(1+\varphi q_t)^{\frac{\rho}{\rho-1}}}{1-\mu} \right)^{\frac{\rho-1}{\rho}} \frac{f_t}{k_t^s} \tag{A-2}$$

$$w_t = (1-\alpha) \left(\frac{A_t^{\frac{\rho}{\rho-1}} - \mu(1+\varphi q_t)^{\frac{\rho}{\rho-1}}}{1-\mu} \right)^{\frac{\rho-1}{\rho}} \frac{f_t}{h_t} \tag{A-3}$$

Finally, the resulting expressions for r_t^k and w_t are used in the definition of GDP, $y_t = r_t^k u_t k_t + w_t h_t$, to obtain:

$$y_t = \mathcal{A}_t(A_t, q_t)(u_t k_t)^{\alpha}(\Gamma_t h_t)^{1-\alpha} \tag{A-4}$$

$$\mathcal{A}_t(A_t, q_t) = \upsilon \left(\frac{A_t^{\frac{\rho}{\rho-1}} - \mu(1+\varphi q_t)^{\frac{\rho}{\rho-1}}}{1-\mu} \right)^{\frac{\rho-1}{\rho}} \tag{A-5}$$

C Numerical Algorithm

The algorithm seeks an approximate solution to the following system of stochastic difference equations

$$\hat{y}_t = \hat{c}_t + \hat{x}_t + \frac{\hat{d}_t}{g} - R_t^{-1}\hat{d}_{t+1} \tag{A-6}$$

$$\widetilde{\lambda}_t = \left(\hat{c}_t - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{-\gamma} \tag{A-7}$$

$$\zeta h_t^{\psi} = (1-\alpha)\frac{\hat{y}_t}{h_t} \tag{A-8}$$

$$\eta u_t^{\omega} = \alpha \frac{g\hat{y}_t}{u_t \hat{k}_t} \tag{A-9}$$

$$\widetilde{\lambda}_t = \frac{\beta}{g} \mathrm{E}_t \left[\widetilde{\lambda}_{t+1} \right] R_t \tag{A-10}$$

$$\widetilde{\lambda}_t \left(1 + \frac{\phi_k}{g} \left(\frac{\hat{k}_{t+1}}{\hat{k}_t} - 1 \right) \right) = \frac{\beta}{g} \mathrm{E}_t \left[\widetilde{\lambda}_{t+1} \left(\alpha \frac{g\hat{y}_{t+1}}{\hat{k}_{t+1}} + 1 - \delta - \eta \frac{u_{t+1}^{1+\omega}}{1+\omega} + \frac{\phi_k}{2} \left(\left(\frac{\hat{k}_{t+2}}{\hat{k}_{t+1}} \right)^2 - 1 \right) \right) \right] \tag{A-11}$$

where $\hat{y}_t$ is given in (17). Denoting the vector of state variables by $S_t = \left[\hat{k}_t, \hat{d}_t, R_t, s_t, A_t \right]$, we approximate the policy functions for the state variables $\hat{d}_{t+1} = d(S_t)$ and $\hat{k}_{t+1} = k(S_t)$ by piecewise linear functions over a grid, denoted by S, of $21 \times 21 \times 51 \times 2 \times 11 = 494,802$ nodes each and

compute the approximate solution by iterating over the the policy functions (Coleman (1990)). We combine the procedure with the method of endogenous gridpoints in Carroll (2006) to speed up the algorithm. More specifically, the algorithm is:

Step 1 Obtain an initial guess $k_0(S)$ and $d_0(S)$ from a loglinear approximation around the deterministic steady state.

Step 2 Given the last guess $k_{j-1}(S)$ and $d_{j-1}(S)$, calculate $k'' = k_{j-1}(S)$, $d'' = d_{j-1}(S)$ and find c', y', h', u', λ' using the budget constraint and equations (17) and (A-6)-(A-9).

Step 3 Compute

$$e_1 = \frac{\beta}{g}\mathrm{E}\left[\lambda' | R, s, A\right]$$
$$e_2 = \frac{\beta}{g}\mathrm{E}\left[\lambda'\left(\alpha\frac{gy'}{k'} + 1 - \delta - \eta\frac{u'^{1+\omega}}{1+\omega} + \frac{\phi_k}{2}\left(\left(\frac{k''}{k'}\right)^2 - 1\right)\right)|R, s, A\right]$$

and solve for d and k, using

$$e_1 = \lambda R^{-1}$$
$$e_2 = \lambda\left(1 + \frac{\phi_k}{g}\left(\frac{k'}{k} - 1\right)\right)$$

as well equations (17) and (A-6)-(A-9).

Step 4 Using k', d' and k, d, R, s and A, interpolate to obtain $k'' = k_j(S)$ and $d'' = d_j(S)$.

Step 5 Repeat step 2 to 4 until convergence.

D Response to a Crisis in Simulations

Model simulated data is obtained by generating 1000 samples of the same size as the actual data, each with a burn-in of 1000 quarters. The response to a crisis of the different macro aggregates in the model, reported in Figures 8 to 10 and Figure 13, is computed in the following way: First,

we identify all the subperiods among the simulated series in which the economy was in the crisis regime for at least 6 quarters and not more than 16 quarters. Second, we construct a crisis sample for each of these subperiods including from 5 quarters before to 25 quarters after entering the crisis. We denote the period in which the economy enters the crisis regime as period 1. Third, for each sample we re-scale all the series to the value of the series in period 0 (i.e. the period before entering the crisis regime). Fourth, for each series, we compute the average and the 10% and 90% quantiles across samples.

E Model In Section 2 .2 and Section 5 .3

The models we use in sections 2.2 and 5.3 are versions of the model proposed in Neumeyer and Perri (2005) and Uribe and Yue (2006). The main difference with Neumeyer and Perri (2005) is the timing we assume for the opportunity cost of funds for firms. They assume that at the beginning of each period firms issue a within-period bond but at the interest rate of the previous period (even if at the beginning of periods all shocks are known). In our model, as in Uribe and Yue (2006), the opportunity cost of funds for the firm at t is related to the interest rate of that same period. Finally, Uribe and Yue (2006) assume three additional features that we do not include here: they assume that real decisions are made prior to the realization of that period financial shocks, they include habits in consumption and gestation lags in capital accumulation.

The representative household's problem is:

$$\max_{\{c_t,h_t,k_{t+1},d_{t+1}\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(\frac{c_t}{\Gamma_t} - \zeta \frac{h_t^{1+\psi}}{1+\psi}\right)^{1-\gamma} - 1}{1-\gamma} \quad , \tag{A-12}$$

$$\text{s.t.} \quad c_t + x_t + d_t + \Phi(d_{t+1}) \leq R_t^{-1} d_{t+1} + w_t h_t + r_t^k k_t \quad , \tag{A-13}$$

$$k_{t+1} = x_t + (1-\delta) k_t - \frac{\phi_k}{2}\left(\frac{k_{t+1}}{g k_t} - 1\right)^2 k_t \tag{A-14}$$

$$\Phi(d_{t+1}) = \Gamma_t \frac{\phi_d}{2}\left(\frac{d_{t+1}}{\Gamma_t} - \bar{d}\right)^2 \, , \, \phi_d > 0 \tag{A-15}$$

where all parameters and variables correspond to the benchmark model description in the main text. As in Neumeyer and Perri (2005), a portfolio adjustment cost function was introduced in (A-13) and for the exercise in section 5.3 it was calibrated so that the volatility of the trade balance to GDP ratio remained close to the data counterpart (in the benchmark model $\phi_d = 0$). The parameter $\bar{d}$ is the average debt level from the ergodic distribution.

The only factors of production are capital and labor, and a working capital constraint linked to the wage bill is assumed. The representative firm's problem is:

$$\max_{\{k_t, h_t, \kappa_t\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \left[y_t - w_t h_t - r_t^k k_t - \kappa_t + \kappa_{t-1} \right], \tag{A-16}$$

$$\text{s.t.} \quad \kappa_t \geq \varphi w_t h_t \tag{A-17}$$

$$y_t = A_t (k_t)^{\alpha} (\Gamma_t h_t)^{1-\alpha} \tag{A-18}$$

Equilibrium conditions implied by the households' and firms' optimality conditions include:

$$\lambda_t = \frac{1}{\Gamma_t} \left(\frac{c_t}{\Gamma_t} - \zeta \frac{h_t^{1+\psi}}{1+\psi} \right)^{-\gamma} \tag{A-19}$$

$$\Gamma_t \zeta h_t^{\psi} = \left(1 + \varphi \left(\frac{R_t - 1}{R_t} \right) \right)^{-1} (1-\alpha) \frac{y_t}{h_t} \tag{A-20}$$

$$\lambda_t = \beta \mathrm{E}_t \left[\lambda_{t+1} \right] R_t \tag{A-21}$$

$$\lambda_t \left(1 + \frac{\phi_k}{g} \left(\frac{k_{t+1}}{g k_t} - 1 \right) \right) = \beta \mathrm{E}_t \left[\lambda_{t+1} \left(\alpha \frac{y_t}{k_t} + 1 - \delta + \frac{\phi_k}{2} \left(\left(\frac{k_{t+2}}{g k_{t+1}} \right)^2 - 1 \right) \right) \right] \tag{A-22}$$

For the example in Section 2.2 the level of productivity A_t is assumed to be deterministic. The interest rates are realizations of either the Markov switching autoregressive process in (1) or a linear autoregressive process of order one, with parameters given in Table A-2. The rest of the parameter value assumed for the exercise in section 2.2 are shown in Table A-1.

For the exercise in Section 5.3 (wage-bill model) productivity A_t is stochastic and is given by

equation (21) in the main text. The interest rates are realizations of the Markov switching autoregressive process used for the benchmark model and consistent with estimations for Argentina. The other parameter values are set to remain consistent with the moments of the ergodic distribution and are reported in Table A-3.

Table A-1: Calibration, Nonlinear vs. Linear Shock Example of Section 2 .2

a) Preferences	Symbol	Value
Discount factor	β/g	0.9643
Utility curvature	γ	2
Labor disutility weight	ζ	0.62
Inverse wage elasticity of labor supply	ψ	0.6
b) Technology		
Capital income share	α	0.38
Growth factor	g	1.0083
Working capital requirement	φ	1
Capital depreciation parameter 1	δ	0.033
Capital adjustment cost	$\phi_k/2$	10
Portfolio adjustment cost	$\phi_d/2$	0
d) Interest Rate Shock Process		
See Table A-2.		

Table A-2: Parameters of nonlinear DGP and linear AR(1) in Section 2 .2.

	Unconditional Mean		Autoregressive	Standard Deviation	
	Tranquil	Crisis		Tranquil	Crisis
Nonlinear DGP	10%	30%	0.70	2%	3%
AR(1) approximation	15.7%		0.87	3.3%	

Table A-3: Calibration, Wage-Bill Model in Section 5 .3.

a) Preferences	Symbol	Value	Target
Discount factor	β/g	0.9608	Trade balance to GDP ratio
Utility curvature	γ	2	Mendoza (1991), ...
Labor disutility weight	ζ	0.62	Normalized labor input
Inverse wage elasticity of labor supply	ψ	0.6	Mendoza (1991), ...
b) Technology			
Capital income share	α	0.38	Labor income share
Growth factor	g	1.0083	Average output growth
Working capital requirement	φ	1	Neumeyer and Perri (2005)
Capital depreciation parameter 1	δ	0.022	I-Y ratio
Capital adjustment cost	$\phi_k/2$	10	Relative investment volatility
Portfolio adjustment cost	$\phi_d/2$	0.09	Trade balance volatility
Saving interest rate ceiling	$\bar{R}$	$1.02^{0.25}$	International riskless rate
c) Technology Shock Process			
Persistence of TFP shock	ρ_A	0.95	Neumeyer and Perri (2005)
Standard deviation of TFP shock	σ_A	0.022	Output volatility
d) Interest Rate Shock Process			
See Table 1 of the main text.			

Table A-4: Simulation Results in Benchmark Model: Alternative Detrending Methods

		Linear Trend		HP-Filter	
		Data	Model	Data	Model
a) Standard Deviations					
Output	$std(\hat{y})$	0.086	0.068 *(0.040,0.100)*	0.042	0.041 *(0.027,0.055)*
Consumption	$std(\hat{c})/std(\hat{y})$	1.07	1.03 *(0.87,1.18)*	1.17	1.11 *(0.96,1.26)*
Investment	$std(\hat{x})/std(\hat{y})$	3.15	2.85 *(2.44,3.29)*	3.26	3.08 *(2.68,3.50)*
b) Cross-Correlations with $\hat{y}$					
Consumption	$corr(\hat{c},\hat{y})$	0.94	0.95 *(0.92,0.97)*	0.94	0.95 *(0.92,0.97)*
Investment	$corr(\hat{x},\hat{y})$	0.96	0.93 *(0.90,0.97)*	0.94	0.95 *(0.92,0.97)*
Trade balance to GDP	$corr(nx/y,\hat{y})$	-0.76	-0.50^{*} *(-0.73,-0.24)*	-0.67	-0.51 *(-0.70,0.15)*
c) Cross-Correlations with R					
Output	$corr(\hat{y},R)$	-0.65	-0.79 *(-0.93,-0.62)*	-0.55	-0.65 *(-0.80,-0.47)*
Consumption	$corr(\hat{c},R)$	-0.68	-0.84 *(-0.95,-0.68)*	-0.54	-0.67 *(-0.84,-0.48)*
Investment	$corr(\hat{x},R)$	-0.63	-0.85^{*} *(-0.95,-0.71)*	-0.50	-0.68 *(-0.84,-0.48)*

For the HP filter, a smoothing parameter of 1600 was used. Numbers in parenthesis are 10% and 90% quantiles. An asterisk denotes that the corresponding data moment does not lie within these quantiles.