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Monetary Policy under Sudden Stops

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Monetary Policy under Sudden Stops*

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Abstract

Emerging markets are often exposed to sudden stops of capital inflows. What are the effects of monetary policy in such an environment? To answer this question, the paper proposes a model with the typical elements of an emerging market economy. Credit frictions generate balance sheet effects, debt is denominated in foreign currency, production requires an imported input, and households have access to the international capital market only indirectly, through their ownership of leveraged firms. In the model, a sudden stop is generated by a change in the perceptions of foreign lenders, which leads to an increase in the cost of borrowing. The paper then compares the response of the economy to a sudden stop under alternative monetary policy rules. A first result is that the recession is most acute in a fixed exchange rate regime. Taylor rules reacting to inflation and output are more stabilizing. The comparison of policies also suggests that, rather than focus on whether to increase or decrease interest rates, it is more important to influence agents' expectations about future monetary policy. Furthermore, the flexible price equilibrium is attained if the monetary policy is set to completely stabilize the domestic price index.

Keywords: sudden stops, monetary policy, emerging markets, financial crises

JEL: E5, F3, F4

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1 Introduction

Emerging market countries are characterized by weak access to the international capital market, featuring recurrent credit crunches and financial underdevelopment. As a consequence, these countries are especially vulnerable to foreign investors' perceptions about the underlying economic and institutional conditions. Changes in these perceptions can swiftly cause capital inflows to come to a halt, leading to what Calvo (1998) labeled a "sudden stop." The Mexican crisis of 1994-95 was the first big episode of this type. The late 1990s and beginning of the 21st century, with the Asian, Russian and Brazilian crises, showed that this was not a unique event. Instead, sudden stops are now considered a "fact of life" for emerging markets.

Given their recurrent nature, sudden stops add to the volatility of the economy and complicate the trade-offs faced by policy makers, as pointed out by Fraga, Goldfajn, and Minella (2003). It is then of the utmost importance to develop structural models in which monetary policy can be evaluated in the event of sudden stops or under the threat of their possible future occurrence. This paper proposes one such model, with foundations pertinent enough to allow for extended investigation.

The model is a modified version of the financial accelerator model proposed by Bernanke, Gertler, and Gilchrist (1999), based in the model of asymmetric information and costly state verification of Townsend (1979). Therefore, it captures one of the main features of sudden stops, which is the presence of balance sheet effects, as pointed out by Krugman (1999) and Dornbusch (2001) among many others. In the model, these effects are present because the risk premium paid by firms will depend on their leverage level. Another common feature of sudden stops is the existence of substandard balance sheet effects of exchange rate changes, due to the mismatch of the currency denomination between assets and liabilities. In particular, a significant fraction of the external debt is denominated in foreign currency, while assets are valued in domestic currency. The so called "original sin" may lead to a magnification of the crisis in the event of a devaluation because it will further weaken the balance sheets.[1] In the model, for simplification, all foreign debt is denominated in foreign currency.[2]

The financial accelerator model is not the only type of model used in the analysis of sudden stops and the economies in which they occur. Another important branch of the literature makes explicit use of collateral constraints, in some variant of the pioneer work of Kiyotaki and Moore (1997). The literature on this is well reviewed in Arellano and Mendoza (2002). We can include in this second branch the models presented by Izquierdo (2000), Mendoza (2001, 2004), Mendoza and Smith (2003) and Christiano, Gust, and Roldos (2004). In these models, the crisis is triggered by a tightening of the collateral constraint, which then leaves firms and/or households in the economy with less available credit. Instead of quantity restrictions, the financial accelerator model operates through the cost of credit. It is, however, possible to rearrange the resulting equilibrium conditions to express them in the form of a collateral constraint, where the risk premium is linked to the fraction of collateral that is required. The financial accelerator is, thus, not the only framework capable of generating a wedge between internal and external funds. However, it provides a tractable and realistic model of financial frictions, in which it is natural to think about the foreign lenders and their perceptions about the economy, which is at the core of a sudden stop.

In most versions of the financial accelerator model there are agents, labeled the "entrepreneurs," who are subject to financial frictions when borrowing. Ordinary households are then either completely restricted from accessing the international capital market or, alter-

[1] This is why authorities in these countries developed a growing rigidity in their exchange rate regimes, labeled in Calvo and Reinhart (2002), as "fear of floating." This was noticeable in the response to the crises, when the authorities defended their fixed exchange rate regimes until they had no reserves left, or it was too costly to raise the interest rates.

[2] Other features of sudden stops are contagion and financial fragility in the financial sector (banks), but those will not be the focus of this paper.

natively, have full access without restrictions or frictions. The former assumption seems too restrictive as it allows for absolutely no smoothing of households' consumption. But the latter assumption is rather unrealistic for the context of an emerging market, and implies that uncovered interest parity (UIP) should hold without any risk premium for the country (there is instead only a risk premium for the "entrepreneurs"). The model developed here, considers households without any direct access to the international capital market. However, instead of "entrepreneurs," there are firms owned by the households, which can use their net worth to obtain credit in the international capital market. This provides many advantages over the more traditional framework. First, households can now indirectly access foreign capital by holding shares of the leveraged firms and therefore some amount of consumption smoothing is possible. Second, this leads to an endogenous country risk premium (different from, but linked to, the firms' risk premium) and a modified UIP relation. Third, it provides a simpler way to evaluate optimal monetary policy by making the households' utility the logical welfare measure, while in the other framework, either the capitalists' welfare would have to be disregarded, or it would have to be added to the households' utility in some fashion, as done in Devereux, Lane, and Xu (2006).

The sudden stop shock is defined as a period in which foreigners become skeptical about firms' productivity, which leads them to enforce tighter credit conditions on the firms that borrow. These will weaken the latter ones, forcing them to accumulate more net worth and less debt (the financial account reversal). Equilibrium changes in the economy end up reducing the productivity of firms, which validates foreigners' initial skepticism. Therefore, the shock is one of self-fulfilling pessimism about the emerging market economy.

This is a significant departure from previous applications of the financial accelerator model to financial crises, in which the shock is typically defined as an exogenous increase in the foreign interest rate. Good examples of that approach are Céspedes, Chang, and Velasco (2004), Devereux et al. (2006) and Gertler, Gilchrist, and Natalucci (2003). By linking the shock to the foreign interest rate, these authors implicitly assume that the shock influences all emerging markets at the same time, and rule out country-specific sudden stops (e.g. Mexico 1994-95 and Brazil 2002). Neither of these features are very realistic.[3] Indeed, Neumeyer and Perri (2005) show that variations in country risk play an important role in business fluctuations of output. The shock that I propose, instead, is not intrinsically tied to a contagion story, but can be imbed to one if so desired – therefore it may provide a better empirical framework. Furthermore, its structural insertion in the model allows for easy and intuitive future extensions incorporating some feedback into the probability of occurrence of a sudden stop.

A last modification of the framework used here is the introduction of imported inputs (assumed to be purchased one period in advance), which replace the role of capital in the production function of Bernanke et al. (1999). This has not been addressed in the financial accelerator literature, but is an important change because it adds an extra channel to the exchange rate transmission.[4] This is all the more important when most imports of emerging markets are directed to intermediate and capital goods.[5]

The main goal of the paper is a comparison of the responses of the economy to a sudden stop event under alternative monetary regimes. The regimes considered are first a fixed exchange rate, and secondly, a variety of Taylor rules, in which interest rates react to inflation and output to different degrees. Taylor rules that respond to different measures of inflation (consumer price index vs. a domestic price index) and output deviations from steady state are also compared.

[3]While sudden stops in one emerging market often appear to affect other markets as well, one does not observe the exact coordination of the sudden stops in time that would be predicted by the model where the sudden stop is identified with a jump in the foreign interest rate. For example, in the Asian crises, in which several countries were affected, there were non-negligible time lags and the contagion did not occur solely through an effect on interest rates.

[4]For example, Agénor and Montiel (1999) mention the possible impact of imported inputs in the responses to a real devaluation.

[5]This claim has been already raised in the literature by Fraga et al. (2003) and Braggion, Christiano, and Roldos (2005). Further empirical evidence in support of it is discussed in section 3.2.

One first conclusion is that the recession is most acute under a fixed exchange rate regime. Taylor rules are more stabilizing, with some of these rules able to turn the effects from output contraction into expansion. This result is consistent with the findings of Gertler et al. (2003), Céspedes et al. (2004) and Devereux et al. (2006), all of which analyze which exchange rate regime performs better in response to a shock to the cost of borrowing. Only Cook (2004) finds the opposite result, claiming that the reason for the difference in results is the fact that, in the others, price stickiness does not affect the firms producing the goods directly, while in his model that is the case.[6]

The comparison of policies also suggests that, rather than focus on whether to increase or decrease interest rates, it is more important to influence agents expectations about future monetary policy. This emphasizes the role of announcement of the intended monetary policy and the importance of policy credibility. (Here I assume full credibility, though in emerging markets that is not necessarily the case.) This result brings some new light into the debate on whether to raise or decrease the interest rate in such episodes. Previously, Aghion, Bacchetta, and Banerjee (2000) and Christiano et al. (2004), concluded that it is ambiguous. Braggion et al. (2005) argue that optimal policy can be very similar to the one actually followed by some Asian countries that first increased the interest rate and then lowered it. In spite of this possible optimality, there are several signs that policy was not wholly consistent and that agents were unsure about the future policy. My results show that changes in domestic interest rates matter, but that the agents' expectations about future monetary policy matter even more.

Furthermore, in the model presented, the flexible price equilibrium is attained if monetary policy is set to fully stabilize the domestic price index (the equivalent to the GDP deflator). This shows that it is possible to simultaneously eliminate the output gap and attain price stability (at least for some price index).

[6] But he also mentions that his results could be reversed if there is wage rigidity.

The remainder of the paper is organized as follows. Section 2 presents some facts about sudden stop episodes that serve as motivation for the model. Section 3 presents the model in detail. Section 4 presents the responses of key variables to a sudden stop under alternative policies and section 5 concludes.

2 Some facts about sudden stops

This section presents some empirical evidence about the sudden stops, with focus on those episodes that are the most typical (those starting in the mid 1990s). More precisely, the events of Mexico in 1994-95, Asia in 1996-97 and Turkey in 1993-94 and 2000-01 will be considered,[7] as it was possible to obtain quarterly data on key macroeconomic variables, which is the same frequency assumed in the calibration of the model.

The sudden stop is, in its essence, a reversal in the capital inflows to the country. Therefore, sudden stops are best measured by the reversal in net private financial flows (NPF) to a given country. For this measure, data was not available for all episodes and countries, but Calvo and Reinhart (1999) (henceforth CR99) present some evidence, even though it is not clear what is the frequency of their data. In order to build a series in quarterly frequency, the IMF's International Financial Statistics (IMF/IFS) database was used to collect the financial account (FA). The entire FA series (in US dollars) was normalized by the average quarterly level of GDP (in US dollars) in the year before the crisis, for each country and episode. It was then possible to calculate the financial account reversal in a common measure (percentage of initial GDP). Table 1 compares these calculations with those of CR99.[8] The financial

[7] The countries included are Mexico, South Korea, Thailand, Philippines and Turkey. Others, like Indonesia and Malaysia, would constitute obvious additions but lack of comparable data restricted their usage.

[8] It is noticeable the discrepancy in the measure for the episodes of Philippines and South Korea. On this matter, the numbers are somewhat sensitive to the exact timing of the crisis and to what is considered to be the pre-crisis level. Another possible reason for the differences may be simply the revision of the data. The fact that a different variable is used is not the main reason, since the NPF is also available in the database for the specific case of South Korea, and the number is very similar to that using the FA, presented in the

account reversals can be significant, with the median values representing 10% of the GDP for CR99 and 20% in this paper's calculations, and means of 12% and 18%, respectively.

The path of the financial account is presented in Figure 1 in order to show that the full extent of the capital account reversal is not attained in the impact period but, instead, one quarter afterwards. Actually, the maximum capital reversal occurs with a median delay of 1.5 periods. It is possible to conclude, from the figure, that the financial account reversal is quite persistent, lasting for several quarters below the pre-crisis levels.

A typical measure of the severity of the crisis is the impact on output and other real variables. The responses of output, consumption, exports and imports are presented in Figure 2. These responses correspond to the growth rates from four quarters before, following CR99 methodology (there applied in months), with the peculiarity that growth rates are computed here in log differences (in order to use a measure consistent with the results from the theoretical model). The figures are all in percentage points and in deviations from the average in the year preceding the crisis.

Two main characteristics can be identified in the typical response of output, as depicted in panel A of Figure 2: the fall in output growth is very severe (median fall of 14.6 percentage points in the growth rates, relative to pre-crisis year) and it is relatively short-lived (growth rates seem to recover between five and six quarters after the crisis starts). A very similar path was typically followed by consumption (panel B of Figure 2), with the difference that the fall in the growth rate is usually stronger, with a median fall of 22 percentage points in the growth rate relative to the pre-crisis year. The financial account reversal implies an increase in net exports, but, more important than just acknowledging that, is to understand how it is attained. Panels C and D of Figure 2 show a temporary increase in the growth rate of exports and a significant reduction in the growth rates of imports.

It is also important to understand what is the typical response of the monetary authori-

table.

ties. As CR99 mention, these crises "took place against a background of soft-pegged exchange rates." These soft-pegs, however, did not last for too long in the recent crisis episodes, due to the strong currency market speculation. Figure 3 presents the paths of the exchange rate, nominal interest rate and inflation rate. The exchange rate is in logs and refers to the bilateral parity vis-à-vis the US dollar. The figures are all in percentage points and in deviations from the average in the year preceding the crisis. The path of the exchange rate (in panel A) shows a significant devaluation of the currency, if not in the quarter of impact, then immediately after. Irrespective of the exact timing of the initial devaluation, one period after the crisis started the currency the median cumulative depreciation is 60%.[9]

It is also possible to identify a steep increase in the short term interest rates (panel B of Figure 3), which is a natural consequence of the initial defence of the peg. Caution should be exerted here though, given that in the Asian crises, aware of financial fragility in their economies, authorities avoided tightening too much monetary policy. Instead, the Asian authorities preferred to use sterilized intervention and even some capital controls, to try to enforce the pegs. Interest rate hikes were, thus, smaller and with a delay, after it was impossible to keep the sterilized interventions' policy and capital controls proved ineffective. The exact timings are not visible on a quarterly frequency though. The figure also suggests that interest rates quickly return to lower levels, after the initial hike. In the Asian crises the interest rates actually got below the pre-crisis levels. This was the result of the big desire of authorities to stimulate the economies, which is normally not a possibility on the fiscal side due to IMF program restrictions. Another interpretation of this may be that authorities wanted to take pressure away from the deteriorated balance sheets of firms.

One further relevant empirical feature is that the path of the inflation changes (panel C of Figure 3) can vary across different episodes. For example, in the Asian crises the inflation

[9] Calculated in logs, so talking about the appreciation of foreign currency or the depreciation of the domestic currency is exactly the same.

rate increased only a few percentage points from pre-crises levels, in the Mexican crisis it increased by as much as 30% and in the latter crisis of Turkey the inflation rate actually decreased quite significantly. The different outcomes can actually be attained in light of the model proposed here, depending on the monetary policy being followed, as shall be discussed later.

3 The model

The domestic economy is populated by a representative household, firms and the monetary authority. The households consume, provide labor for the production of the domestic good and are the shareholders of the firms of the economy. The domestic good is produced in a perfectly competitive wholesale market. Retail firms then purchase the domestic good from the wholesale firms, convert it into their own varieties, and operate in a monopolistic competition environment setting prices, which are sticky a la Calvo. The retail firms sell their varieties of the domestic good to the domestic household and foreigners. The remainder of this section describes in detail the model.[10]

3.1 Households

The representative household receives utility from consumption and disutility from labor, according to

$$\sum_{t=0}^{\infty} \beta^t U\left(C_t, L_t\right), \tag{3.1}$$

where C_t refers to the consumption and L_t to labor, with the within-period utility represented by

$$U\left(C_t, L_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\psi}}{1+\psi}.$$

[10] For easier reading of the paper I insert in appendix B tables listing all the variables (Table 7) and parameters (Table 8) of the model.

The budget is spent in consumption (with P_t denoting the consumption price index, CPI) and investment in domestic assets, D_t, which pay a return rate of i_t. The domestic assets exist in zero net supply so that, in equilibrium, $D_t = 0$ at all times. The sources of income are the wage collected, W_t, profits, Π_t (with $\Pi_{w,t}$ denoting the profits from wholesalers and $\Pi_{r,t}$ denoting the profits from the retailers)[11] and returns on domestic asset holdings:

$$P_t C_t + D_t \leq (1 + i_{t-1}) D_{t-1} + W_t L_t + \Pi_t. \tag{3.2}$$

There is a no-Ponzi games condition, so that the problem is well defined,

$$\lim_{T \to \infty} \prod_{s=0}^{T-1} (1 + i_{t+s})^{-1} D_{t+T} \geq 0.$$

The households are restricted from accessing the international capital markets and, therefore, cannot borrow or lend to foreigners. This is an assumption that matches reality, as Table 2 shows. Households are clearly a residual borrower from the international capital market. In this model economy the only way households achieve some consumption smoothing is through their holdings of firms. These can use their net worth to borrow in the international capital market and give higher or lower dividends to their shareholders, the households. In spite of no direct access to foreign credit, there is still some indirect access, through firms' leverage.

The representative household maximizes (3.1) subject to (3.2). The resulting Euler equation for consumption is

$$\frac{1}{1 + i_t} = \beta E_t \left[\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} \right], \tag{3.3}$$

[11] Profits are defined more formally as $\Pi_t \equiv \Pi_{w,t} + \Pi_{r,t}$ with $\Pi_{w,t} \equiv \int_0^1 \Pi_{w,t}(j)\, dj$ and $\Pi_{r,t} \equiv \int_0^1 \Pi_{r,t}(j)\, dj$.

and the labor supply is described as

$$\frac{W_t}{P_t} = L_t^{\psi} C_t^{\sigma}. \tag{3.4}$$

The households consumption bundle is composed by domestic and foreign goods denoted by $C_{H,t}$ and $C_{F,t}$, respectively. Preferences over the two goods have constant elasticity of substitution (CES) and are represented by:

$$C_t = \left[\gamma^{1/\nu} \left(C_{H,t}\right)^{\frac{\nu-1}{\nu}} + (1-\gamma)^{1/\nu} \left(C_{F,t}\right)^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}}. \tag{3.5}$$

where $\nu \geq 0$ is the elasticity of substitution. The law of one price is assumed for the imported final good. Cost minimization implies the following consumption schedules

$$C_{H,t} = \gamma \left(\frac{P_{H,t}}{P_t}\right)^{-\nu} C_t, \tag{3.6}$$

$$C_{F,t} = (1-\gamma) \left(\frac{S_t P_{F,t}^*}{P_t}\right)^{-\nu} C_t, \tag{3.7}$$

and the CPI,

$$P_t = \left[\gamma P_{H,t}^{1-\nu} + (1-\gamma)\left(S_t P_{F,t}^*\right)^{1-\nu}\right]^{\frac{1}{1-\nu}}, \tag{3.8}$$

where $P_{H,t}$ is the retail price index of the domestic good, $P_{F,t}^*$ is the price of imported final goods, in foreign currency, and S_t is the nominal exchange rate, defined as the value of one unit of foreign currency in units of national currency.

3.2 Wholesale firms

Wholesale firms operate as price takers in a competitive market. They hire labor, L_t, and purchase an imported input, Z_t, that is required for production but takes one period to process and be used.[12] The technology used by firm j is given by:

$$Y_t(j) = A_t \left\{ \alpha^{\frac{1}{\phi}} L_t(j)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left[\omega_t(j) Z_{t-1}(j)\right]^{\frac{\phi-1}{\phi}} \right\}^{\frac{\phi}{\phi-1}}, \tag{3.9}$$

where $\phi \in (0, \infty)$ is the elasticity of substitution between domestic and foreign inputs in the production of the domestic goods, A_t is a shock to total factor productivity and $\omega_t(j)$ is an idiosyncratic shock to the productivity of the imported input that is i.i.d. across firms and time, with $E[\omega_t(j)] = 1$, and is assumed to have a log-normal distribution, $\log(\omega_{t+1}(j)) \sim N\left(-\frac{1}{2}\sigma_\omega^2, \sigma_\omega^2\right)$.

The inclusion of imported inputs is already present in Christiano et al. (2004), but not in the financial accelerator literature. The fact that capital is excluded from the model is just for simplification purposes and could yield an interesting extension of this framework. By considering imported inputs, the model allows for the potential cost effects of real devaluations, through this extra channel, and that is rather important given the empirical evidence. Table 3 extends the information already provided in Fraga et al. (2003) and Braggion et al. (2005). The conclusion is that consumption goods represent less than 17% of total imports. The remaining is split among capital and intermediate goods. Therefore any model for these countries should have imported inputs. Given that capital imports are also a significant share of total imports, the data also validates the interpretation in this paper, that imported inputs may not be immediately available for use. So one should think of the imported inputs as including both intermediate and capital goods. Imported inputs were considered in McCallum and Nelson (1999) but there they excluded entirely the consumption component. In the framework considered here, both types of imports are taken into account, allowing for the CPI to be different from the domestic price inflation (DPI), which can play a role when it comes to choosing the price index targeted by monetary policy.

[12] I follow the convention of using time subscript t to denote variables known at t. Hence, Z_t is the amount of imported input that is bought in period t, but available for use in period $t+1$.

Given the available imported inputs, purchased in the previous period, the labor demand can be expressed as

$$L_t(j) = \alpha A_t^{\phi-1} Y_t(j) \left(\frac{W_t}{P_{w,t}}\right)^{-\phi}, \tag{3.10}$$

where $P_{w,t}$ is the wholesale price of the domestic good. The aggregate labor demand is the same, once the j index is suppressed.

At the end of the period each firm has available net worth in domestic currency, $N_t(j)$. In order to finance the imports of inputs for the next period it borrows from foreigners the difference between the value of its net worth and the expenditures in the imports. The debt to foreigners, B_t, is denominated in foreign currency, so it is possible to represent the balance sheet of the firm as

$$S_t B_t(j) = S_t P_{Z,t}^* Z_t(j) - N_t(j), \tag{3.11}$$

where $P_{Z,t}^*$ is the price in foreign currency of the imported inputs. The assumption that liabilities are in foreign currency is typical in the emerging market literature and reflects the "original sin". It does not imply that firms necessarily prefer to borrow in foreign currency. Instead, it usually is the case that the available credit is denominated in foreign currency as a way for creditors to partly insure themselves against currency movements. Table 4 shows that this is not an unrealistic assumption.

The risk free opportunity cost for the foreigners is the international interest rate, i_t^*. That, however, is not the interest rate charged to the firms on their debt. This is because of the uncertain productivity of the firms, implying risk for the creditors. I follow Bernanke and Gertler (1989), setting the problem as one of "costly state verification." However, I depart from their framework in that foreign lenders are risk neutral. Before describing the exact participation constraint of these lenders we first need to present some more of the structure of the problem.

Define $R_{Z,t+1}(j)$ as the gross returns from investing one domestic currency unit in the imported input:

$$R_{Z,t+1}(j) \equiv \frac{P_{w,t+1} Y_Z(L_{t+1}(j), Z_t(j))}{S_t P^*_{Z,t}}, \tag{3.12}$$

where $Y_Z(L_{t+1}(j), Z_t(j))$ is the marginal product of imported input. Given the current assumptions for the production function, it is possible to show that we can write

$$R_{Z,t+1}(j) = \omega_{t+1}(j) R_{Z,t+1}. \tag{3.13}$$

Foreigners, though, do not necessarily have a good knowledge of this structure and that is where the sudden stop is originated, in this model. The shock is assumed to come from misperceptions on the side of foreign investors. Under normal circumstances they have an accurate idea of the true distribution of $\omega_{t+1}(j)$. However, in some periods, which I will label sudden stop periods, they become very uncertain about what is the correct distribution. The uncertainty about the underlying probability model of the economy is usually described as Knightian uncertainty. Several authors considered already how to incorporate formally this type of uncertainty into economic models, like the contributions of Gilboa and Schmeidler (1989) and Backus, Routledge, and Zin (2004). More recently, Caballero and Krishnamurthy (2005b) also use Knightian uncertainty to analyze financial system risk.

The formal representation of foreigners perceptions about $\omega_{t+1}(j)$ is given by

$$\omega^*_{t+1}(j) = \omega_{t+1}(j) \kappa_t, \tag{3.14}$$

where $\omega^*_{t+1}(j)$ refers to foreigners perceptions about $\omega_{t+1}(j)$ and κ_t is the misperception factor. If it is one, then there is no misperception (the normal case); and if it is different from one and the perceived distribution is different from the true one. During sudden stop periods, ambiguity about the distribution for the next period can be described by allowing κ_t to have support over a given interval of values, $[\kappa_{ss}, \kappa^{ss}]$. In this paper, foreign lenders deal with the Knightian uncertainty through a max-min criterion, as in Gilboa and Schmeidler (1989), or, in other words, that in the face of uncertainty about the underlying distribution they will pick the worst case scenario. In the words of Backus et al. (2004), this can be described as foreign lenders facing "ambiguity aversion." As a consequence, in a sudden stop period, they will take the worst case scenario, κ_{ss}, as the mean of the distribution of $\omega_{t+1}(j)$, instead of one.

The max-min assumption can be understood as an acceptable description of decision making procedures in practice, as referred in Caballero and Krishnamurthy (2005b). Namely, they mention that financial firms' stress test their working models for different scenarios and that the widespread use of "Value-at-Risk" is an example of robust decision making. They further refer to corporate liquidity management decisions as being made with a worst case scenario in the background. These are precisely examples of what foreign lending firms' decision processes might look like, here simplified to the worst case scenario assumption.

The sudden stop is then defined as the state in which foreign lenders face the Knightian uncertainty, a state denoted by $\mathcal{S}_t = \mathcal{U}$. The normal state, is denoted by $\mathcal{S}_t = \mathcal{N}$. The misperceptions factor, κ_t, follows a Markov switching process, with probability of occurring a sudden stop given by $\Pr[\mathcal{S}_{t+1} = \mathcal{U} | \mathcal{S}_t = \mathcal{N}] = \delta_{ss}$, and the probability of exiting a sudden stop given by $\Pr[\mathcal{S}_{t+1} = \mathcal{N} | \mathcal{S}_t = \mathcal{U}] = \delta_n$. Given the transition probabilities, it is possible to refer to this exogenous shock in terms of a hidden Markov chain, as suggested in Ljungqvist and Sargent (2000) and Hamilton (1994),[13]

$$\hat{\kappa}_t = \delta_{ss}\hat{\kappa}_{ss} + (1 - \delta_n - \delta_{ss})\,\hat{\kappa}_{t-1} + \varepsilon_{\kappa,t}, \tag{3.15}$$

with $\hat{\kappa}_t \equiv \ln \kappa_t$, $\hat{\kappa}_{ss} \equiv \ln \kappa_{ss}$ and $\varepsilon_{\kappa,t}$ the structural shock of the chain.[14]

[13] A description of transformation from the transition probabilities into the hidden Markov chain is provided in the appendix, in section C.1.

[14] This structural shock is not identically distributed across time, due to the markov structure. Its support is made of four values partitioned in two subsets, one for the normal periods' case and one for the sudden

The "costly state verification" assumption implies that, in order to verify the realized idiosyncratic return, the lender has to pay a cost, consisting of a fraction of those returns, so that the total cost of verification, in foreign currency, is $\mu\omega_{t+1}(j) R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j)$. The debt contract is, then, characterized by a default threshold and a contractual interest rate. I assume a standard debt contract, in which the interest rate is not state contingent and only the default threshold will be state contingent (only when firms cannot fulfill their obligations will they default). This is, however, not the optimal contract, which would allow for both of these to be state contingent, but it should be understood as a close approximation to it. The standard debt contract assumption follows from the fact that most observed financing contracts are shaped in this fashion.[15]

The default threshold, $\bar{\omega}_{t+1}(j)$, is set to the level of returns that is just enough to fulfill the debt contract obligations,

$$\bar{\omega}_{t+1}(j) R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j) = R_{B,t}(j) B_t(j), \tag{3.16}$$

where $R_{B,t}(j)$ is the contractual rate of the loan, set in the contract written in period t. If the idiosyncratic shock is greater than or equal to $\bar{\omega}_{t+1}(j)$, then the firm repays the loan and collects the remainder of the profits, equal to $\omega_{t+1}(j) R_{Z,t+1}S_tP^*_{Z,t}Z_t(j) - S_{t+1}R_{B,t}(j) B_t(j)$. Otherwise, it declares default, foreign lenders pay the auditing cost and collect everything there is to collect, and the firm receives nothing. Because foreign lenders are risk neutral, their participation constraint takes the form of

$$\begin{aligned}(1+i^*_t) B_t(j) \quad = \quad & E_t\left[(1-F^*(\bar{\omega}_{t+1}(j))) R_{B,t}(j) B_t(j)\right] \\ & + (1-\mu) E_t\left[\int_0^{\bar{\omega}_{t+1}(j)} \omega^* R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j)\, dF^*(\omega^*)\right],\end{aligned}$$

stops' case. Nonetheless, it is true that the shock is independent from period to period.

[15] Experiments with an optimal contract yield similar qualitative results, even though the added degree of flexibility allows firms to get returns that imply better consumption smoothing of the households.

where $F^*(\cdot)$ denotes the distribution of $\omega_{t+1}(j)$, as perceived by foreigners. Using a change of variables, according to the definition of ω^*, in (3.14), the previous expression can be rewritten as[16]

$$E_t\left[\Omega\left(\bar{\omega}_{t+1}(j);\kappa_t\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j)\right]=\left(1+i^*_t\right)\left(P^*_{Z,t}Z_t(j)-\frac{N_t(j)}{S_t}\right), \tag{3.17}$$

with

$$\Omega(\bar{\omega};\kappa) \equiv \kappa\left[\Gamma\left(\frac{\bar{\omega}}{\kappa}\right)-\mu G\left(\frac{\bar{\omega}}{\kappa}\right)\right], \tag{3.18}$$

$$\Gamma(\bar{\omega}) \equiv \left[1-F(\bar{\omega})\right]\bar{\omega}+\int_0^{\bar{\omega}}\omega dF(\omega), \tag{3.19}$$

$$G(\bar{\omega}) \equiv \int_0^{\bar{\omega}}\omega dF(\omega), \tag{3.20}$$

and $F(\cdot)$ denotes the correct distribution of ω_{t+1} (as opposed to the distribution perceived by foreigners).

Firms' cash flows, distributed as dividends to the households, are defined as

$$\Pi_{w,t}(j)\equiv P_{w,t}Y\left(L_t(j),Z_{t-1}(j)\right)-W_tL_t(j)-S_tR_{B,t}(j)B_{t-1}(j)-N_t(j).$$

Using the balance sheet equation, (3.11), and the assumption of constant returns to scale,[17] the above equation can be expressed as

$$\Pi_{w,t}(j)=\omega_t(j)R_{Z,t}S_{t-1}P^*_{Z,t-1}Z_{t-1}(j)-S_tR_{B,t}(j)\left(P^*_{Z,t-1}Z_{t-1}(j)-\frac{N_{t-1}(j)}{S_{t-1}}\right)-N_t(j).$$

[16] For details on this simplification, please consult the appendix, in section C.2.

[17] With constant returns to scale we can write

$$P_{w,t}Y\left(L_t(j),Z_{t-1}(j)\right)=W_tL_t(j)+\omega_t(j)R_{Z,t}S_{t-1}P_{Z,t-1}Z_{t-1}(j).$$

Note that the dividends to the households are not restricted to be zero. Actually, if $\omega_t(j) \leq \bar{\omega}(j)$ the firm defaults on the debt and, without any equity left, files for bankruptcy, ceasing to exist. I assume that a new firm is immediately created in its place. The dividend should then be interpreted as the injection of money households are using to start up the new firm, so that $\Pi_{w,t}(j) = -N_t(j)$. Given the state contingent nature of the optimal contract, the expected cash flow of the firm is

$$E_{t-1}\Pi_{w,t}(j) = E_{t-1}\left\{[1-\Gamma(\bar{\omega}_t(j))]\,R_{Z,t}S_{t-1}P^*_{Z,t-1}Z_{t-1}(j) - N_t(j)\right\}. \tag{3.21}$$

Firms maximize the discounted sum of cash flows,

$$E_0\sum_{t=1}^{\infty}\beta^t\Lambda_t\Pi_{w,t}(j),$$

subject to the participation constraint, (3.17), and the default threshold definition, (3.16), with respect to $Z_t(j)$, $\bar{\omega}_t(j)$, $R_{B,t-1}(j)$ and $N_t(j)$. The appropriate discount factor is given by $\beta^t\Lambda_t$, from the households problem, where $\Lambda_t = C_t^{-\sigma}/P_t$ is the Lagrangian multiplier of the budget constraint. The exact maximization problem that firms face and all the first order conditions are presented in the appendix, in section C.3. Here I present only the simplified results.

Combining the Euler equation for the net worth $N_t(j)$ with the households' Euler equation for consumption, we get an expression that is very similar to the UIP (with a risk premium term), except that this is not yet an aggregate level relation,

$$(1+i_t)\,E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] = (1+i_t^*)\,E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}(j)\right], \tag{3.22}$$

with the risk premium term defined by

$$\lambda_{t+1}(j) = \frac{\Gamma'(\bar{\omega}_{t+1}(j))}{E_t[\Omega'(\bar{\omega}_{t+1}(j);\kappa_t)]}. \tag{3.23}$$

The optimal decision on the imported input yields the risk premium relation for the firm,

$$E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\Upsilon_{t+1}(j) R_{Z,t+1}\right] = (1+i_t^*) E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}(j)\right], \tag{3.24}$$

with

$$\Upsilon_{t+1}(j) \equiv 1 - \Gamma(\bar{\omega}_{t+1}(j)) + \frac{E_t\left[\lambda_{t+1}(j) C_{t+1}^{-\sigma} S_{t+1}/P_{t+1}\right]}{C_{t+1}^{-\sigma} S_{t+1}/P_{t+1}} \Omega(\bar{\omega}_{t+1}(j);\kappa_t). \tag{3.25}$$

In order to proceed with the analysis it is more convenient to define $b_t(j) \equiv B_t(j)/P_{Z,t}^* Z_t(j)$, a measure of the firm's leverage, present the participation constraint as

$$E_t\left[\Omega(\bar{\omega}_{t+1}(j);\kappa_t) R_{Z,t+1}\frac{S_t}{S_{t+1}}\right] = (1+i_t^*) b_t(j), \tag{3.26}$$

and the default threshold as

$$\bar{\omega}_{t+1}(j) = \frac{R_{B,t}(j)}{R_{Z,t+1}}\frac{S_{t+1}}{S_t} b_t(j). \tag{3.27}$$

If there was no aggregate risk in the economy we could combine (3.24) and (3.27) to substitute out $\bar{\omega}_{t+1}(j)$ and obtain the exact relation of the risk premium in terms of

$$\frac{R_{Z,t+1}}{1+i_t^*}\frac{S_t}{S_{t+1}} = \chi(b_t(j);\kappa_t),$$

with $\chi(\cdot)$ some function such that $\partial\chi(b_t(j);\kappa_t)/\partial b > 0$, in the same way as in Bernanke et al. (1999). With aggregate risk, though, it is impossible to get an explicit function $\chi(\cdot)$

and only an approximation would be available.[18]

Independently of getting that exact relation or not, the two equations, (3.26) and (3.27), define implicitly $R_{B,t}(j)$ and $\bar{\omega}_{t+1}(j)$ as functions of several aggregate variables and $b_t(j)$. Because the idiosyncratic shock is independent from all other shocks and across time, and identical across firms, then all firms will take the same decisions in face of the expectations about the future. That is so because, ex-ante, all firms are identical. The only variable that will differ across firms is the amount of dividends actually distributed to the shareholders, which will absorb all of the idiosyncratic shock. This implies the above relationships can all be expressed in aggregate terms. Something that is worth some more careful analysis.

The term $R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t$ can be labeled as the operational profit of the firms, after paying the wages, and denominated in foreign currency units. The term $\Gamma(\bar{\omega}_t)$ is the fraction of this operational profit that is used to repay the foreign lenders (including the contractual rate of interest for those firms which do not default and all the operational profit of those firms which defaulted). The term $\mu G(\bar{\omega})$ is the fraction of the operational profits that is then used by the foreigners to pay for the auditing costs. Therefore $\Omega(\bar{\omega}_{t+1};\kappa_t)$ is the fraction of the operational profit that foreign lenders perceive that they will keep for themselves after paying the auditing costs, and taking into account that their perceptions about the underlying distribution might be different, through the misperceptions factor κ_t.

The aggregate level of dividends is given by

$$\Pi_{w,t} = [1-\Gamma(\bar{\omega}_t)]\, R_{Z,t}S_{t-1}P^*_{Z,t-1}Z_{t-1} - N_t, \tag{3.28}$$

which is readily understood as the fraction of the operational profits that is not paid to the foreign lenders, converted into domestic currency and subtracted from the net worth that is needed for financing the imported input.

[18] In order to use as few approximations as possible, none is used at this stage, allowing the log-linearization to be performed around the true functional forms.

The aggregate UIP relationship is given by

$$(1+i_t)\, E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] = (1+i_t^*)\, E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}\right], \tag{3.29}$$

which takes the form of an usual UIP relationship linking domestic and foreign interest rates, added by a risk premium term, λ_{t+1}, due to the fact that households have access to the international capital market only through leveraged firms, which might default on their debt. That risk premium term is given, in equilibrium, by

$$\lambda_{t+1} = \frac{\Gamma'\left(\bar{\omega}_{t+1}\right)}{E_t\left[\Omega'\left(\bar{\omega}_{t+1};\kappa_t\right)\right]}, \tag{3.30}$$

which can be read as the ratio of the marginal share of the operational profits actually paid to the foreign lenders over the expected marginal share the latter ones expected to receive for themselves, ex-ante.

Firms operational profit will, in equilibrium, be enough to pay a premium on the foreign risk free interest rate,

$$E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\Upsilon_{t+1}R_{Z,t+1}\right] = (1+i_t^*)\, E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}\right], \tag{3.31}$$

with

$$\Upsilon_{t+1} = 1-\Gamma\left(\bar{\omega}_{t+1}\right) + \frac{E_t\left[\lambda_{t+1}C_{t+1}^{-\sigma}S_{t+1}/P_{t+1}\right]}{C_{t+1}^{-\sigma}S_{t+1}/P_{t+1}}\Omega\left(\bar{\omega}_{t+1};\kappa_t\right). \tag{3.32}$$

In (3.31) it is possible to note that the risk premium of the firms return on investment, $R_{Z,t+1}$, is different from the risk premium for the households, λ_{t+1}. The reason for this is that households are residual claimers to those profits/returns. Therefore their returns are leveraged and Υ_{t+1} measures the wedge between the two rates of return.

3.3 Retail firms

There is a continuum, of size one, of retail firms operating in a monopolistic competition environment. Each retail firm purchases the domestic good from the wholesale firms, at the price $P_{w,t}$, converts it at no additional cost into its own variety and then sells it to both the domestic and foreign markets, charging a price of $P_{H,t}(j)$ in both markets. These firms face price stickiness a la Calvo, i.e. with probability $(1-\alpha_p)$ each firm is able to set prices in a given period and with probability α_p it is not able to do so.

The preferences of the consumers for the different varieties of the domestic good belong to the CES class,

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}},$$

with the elasticity of substitution given by $\eta > 1$. The demand for each variety is given by

$$Y_t(j) = Y_t \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\eta}. \tag{3.33}$$

In equilibrium, the market must clear,

$$Y_t = C_{H,t} + C^*_{H,t}, \tag{3.34}$$

where $C^*_{H,t}$ is the foreign demand for the domestic good, assumed to have a functional form equivalent to that of the domestic demand,

$$C^*_{H,t} = \gamma^* \left(\frac{P_{H,t}}{S_t P^*_t} \right)^{-\nu^*} C^*_t, \tag{3.35}$$

where P^*_t is the exogenous foreign price level, C^*_t is the exogenous foreign aggregate consumption level and ν^* the elasticity of foreign consumption over domestic and foreign goods.

When firm j is able to set a new price, $P_{H,t}^{s}(j)$, it solves the following problem

$$\max_{P_{H,t}^{s}(j)} E_t \sum_{\tau=0}^{\infty} \alpha_p^{\tau} \beta^{\tau} \Lambda_{t+\tau} Y_{t+\tau} \left(\frac{P_{H,t}^{s}(j)}{P_{H,t+\tau}} \right)^{-\eta} \left(P_{H,t}^{s}(j) - P_{w,t+\tau} \right).$$

Taking into account that all firms that are able to set prices face the same problem we can use the aggregate expression for all prices set at t,

$$P_{H,t}^{s} = \frac{\eta}{\eta-1} \frac{E_t \sum_{\tau=0}^{\infty} \alpha_p^{\tau} \beta^{\tau} \frac{C_{t+\tau}^{-\sigma}}{P_{t+\tau}} Y_{t+\tau} P_{H,t+\tau}^{\eta} P_{w,t+\tau}}{E_t \sum_{\tau=0}^{\infty} \alpha_p^{\tau} \beta^{\tau} \frac{C_{t+\tau}^{-\sigma}}{P_{t+\tau}} Y_{t+\tau} P_{H,t+\tau}^{\eta}}, \tag{3.36}$$

and the aggregate domestic price index is given by

$$P_{H,t} = \left[(1-\alpha_p) \left(P_{H,t}^{s} \right)^{1-\eta} + \alpha_p \left(P_{H,t-1} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}}. \tag{3.37}$$

3.4 Balance of payments

The resources of this economy are determined by the budget constraint of the representative household (3.2). If we substitute out the profits from firms, using (3.28), the fact that in the aggregate $\Pi_{r,t} = P_{H,t} Y_t - P_{w,t} Y_t$, and making a few other manipulations we convert the budget constraint into the balance of payments (BP) of this economy:

$$0 = P_{H,t} C_{H,t}^{*} - \left(S_t P_{F,t}^{*} C_{F,t} + S_t P_{Z,t}^{*} Z_t \right) - \Gamma(\bar{\omega}_t) R_{Z,t} S_{t-1} P_{Z,t-1}^{*} Z_{t-1} + S_t B_t, \tag{3.38}$$

where the first term, $P_{H,t} C_{H,t}^{*}$, refers to the exports, the next, $\left(S_t P_{F,t}^{*} C_{F,t} + S_t P_{Z,t}^{*} Z_t \right)$, to the imports of both final goods and inputs, the following one, $\Gamma(\bar{\omega}_t) R_{Z,t} S_{t-1} P_{Z,t-1}^{*} Z_{t-1}$, to the repayment of the debt and its service, and the last one, $S_t B_t$, to the level of new debt.

Note that the financial account is the change in foreigners holdings of domestic assets and the current account is defined as exports subtracted by imports and added by the service of the debt,

$$
\begin{aligned}
CA_t &\equiv P_{H,t}C^*_{H,t} - \left(S_t P^*_{F,t} C_{F,t} + S_t P^*_{Z,t} Z_t\right) - \left(\Gamma\left(\bar{\omega}_t\right) R_{Z,t} S_{t-1} P^*_{Z,t-1} Z_{t-1} - S_t B_{t-1}\right), \\
FA_t &\equiv S_t \left(B_t - B_{t-1}\right).
\end{aligned}
$$

As presented above, the service of the debt is not just the simple $i^*_{t-1} S_t B_{t-1}$ as is usual. This is due to the presence of monitoring costs and the misperceptions.

3.5 Monetary authority

In this economy the role of the monetary authority is to control the interest rate. Something that is reasonable in light of the evidence presented in Table 1 of Hawkins (2005), according to which most emerging markets monetary authorities set as an operating target or instrument some short term interest rate. In the absence of explicit monetary aggregates, it is possible to think of this economy as in the cashless-limiting case of Woodford (2003).

This paper considers a variety of alternative policy rules, all of which can be presented in terms of the following interest rate rule:

$$
1 + i_t = (1+i)\left(P_t/P_{t-1}\right)^{\phi_{CPI}} \left(P_{H,t}/P_{H,t-1}\right)^{\phi_{DPI}} \left(Y_t/Y\right)^{\frac{\phi_Y}{4}} \left(S_t/S_{t-1}\right)^{\phi_S}, \tag{3.39}
$$

where variables without time subscript stand for the steady state values and the coefficient on output is divided by four so that the coefficients retain their usual annual interpretation.

The first rule considered is a fixed exchange rate regime, in which the nominal exchange rate is kept fixed at the steady state level at all times and the interest rate is determined according to the UIP, as necessary to insure the regime. This is equivalent to setting $\phi_S \to \infty$. An alternative policy considered will be a simple Taylor rule reacting to CPI inflation and output, with coefficients $\phi_{CPI} = 3$ and $\phi_Y = 0.75$. The coefficient on inflation is just an example, calibrated to prevent inflation from being too high in comparison to the observed rates in the typical episodes. The coefficient on output follows Gertler et al. (2003). I also consider domestic price index (DPI), instead of the CPI, hence $\phi_{CPI} = 0$ and $\phi_{DPI} = 3$, while keeping $\phi_Y = 0.75$. Finally, I consider the two cases in which the monetary authority enforces complete stabilization of inflation, based on CPI ($\phi_{CPI} \to \infty$) and DPI ($\phi_{DPI} \to \infty$) as well as the case in which the stabilization of inflation is rather small with $\phi_{CPI} = 1.5$. Table 9 summarizes the coefficients for all the rules.

3.6 Solution and calibration

In general equilibrium models, only relative prices and real variables are well defined. It is, then, convenient to normalize some variables, so that they reflect the relative prices. Define the inflation rate, $\pi_t \equiv \frac{P_t}{P_{t-1}}$, and normalize all domestic prices, as well as the net worth, by the domestic CPI: $p_{H,t} \equiv \frac{P_{H,t}}{P_t}$, $p_{w,t} \equiv \frac{P_{w,t}}{P_t}$, $w_t \equiv \frac{W_t}{P_t}$ and $n_t \equiv \frac{N_t}{P_t}$. Further define the real exchange rate, $s_t \equiv \frac{S_t P_t^*}{P_t}$, and the real return on imported inputs, $(1 + r_{Z,t}) \equiv R_{Z,t}/(1 + \pi_t)$. It is also a relevant variable for analysis the real interest rate, which I define as $(1 + r_t) \equiv (1 + i_t)/E_t[1 + \pi_{t+1}]$. Foreign prices are assumed to be stationary and therefore do not need to be normalized.

In the steady state, inflation is assumed to be zero and all shocks are at their neutral positions, including no misperceptions of the foreigners. The model is then solved in log-linearized form, with variables without time subscript referring to steady state values and those denoted with "^" referring to log-percentage deviations from steady state values.[19] For a complete list of all the log-linearized equations please refer to Appendix D.

Regarding the steady state, it is worth mentioning that the UIP and Euler equations lead

[19] For most variables, this implies $\hat{x}_t \equiv \log(x_t/x)$ but for the interest rates, returns on imported input and inflation rate the relevant variable is always the gross rate, so that for example, $\hat{\imath}_t \equiv \log\left(\frac{1+i_t}{1+i}\right)$.

to the condition that

$$1 = \beta (1 + i^*) \lambda,$$

and it is true that $\lambda > 1$, unless $\mu = 0$ (ruled out by assumption). So this implies $\beta (1 + i^*) < 1$. This is different from the usual assumption for small open economies, that $\beta (1 + i^*) = 1$. Christiano et al. (2004) takes that assumption in order to make the collateral constraint marginally not binding in steady state, with the consequence that the financial frictions disappear marginally. In their model this assumption is reasonable because they define normal times as having a loose collateral constraint and therefore this assumption implies, to some extent, a return to normal times in the long run (at least in the margin), after agents adjusted their behavior. The data however contradicts this, with emerging markets persistently facing country risk premia and hitting the collateral constraints, not just during financial crises. Notice also that this relation is a direct consequence from the fact that households cannot borrow directly from foreigners and, instead, resort to investing in leveraged companies, which face financial frictions due to asymmetric information. In a developed market, households would be able to access directly the foreign capital market and, therefore, it would follow that $i = i^*$ and $\beta (1 + i^*) = 1$, even if the firms themselves faced financial frictions, as in Bernanke et al. (1999).

The frequency assumed in this paper is quarterly and, therefore, the foreign interest rate, i^*, is set to 1%. For the risk premium, I used information presented in Eichengreen and Mody (2000) to determine average historical spreads paid on sovereign bonds and by the private sector, as shown in Table 5. The average spread on public sector debt is about 2.6% (annual) and the private sector pays an average spread of 3.78%, but this is much higher in Latin America than in Asia. In the model presented here it is not well established what is the nature of the domestic assets being traded. But, for simplicity, I consider them to have a spread like that of the public sector. Indeed, a simple way to introduce a microfoundation for those assets would be to assume some simple form of public sector, collecting taxes and consuming goods. Therefore, I assume that the country risk premium in steady state, λ, is 2.5% annual (0.62% quarterly). The assumptions on the foreign interest rate and risk premium imply that the value of β is about 0.984.

In order to calibrate the financial frictions of the economy, I assumed a steady state leverage ratio of the firms, b, of 50%. Glen and Singh (2003) use data on emerging markets and find a median debt-to-assets ratio of 49%. Pomerleano and Zhang (1999) provide firm-level data, from which I construct debt-to-assets ratios, presented in Table 6. The values of the frictions coefficients for μ and σ_ω are obtained in the process of calibrating the leverage ratio, the country spread and a firm-level debt annual spread of 4% (slightly higher than the average for emerging markets but in the range). The implied values are 0.0191 for μ and 0.3922 for σ_ω, which are values lower than the ones used in other works.[20]

For the sudden stop shock, I set the probability of arrival, δ_{ss}, to 2.5% which implies an expected arrival every 10 years. The probability of exiting the sudden stop, δ_n, is set to 5%, implying an average duration of a single sudden stop of 5 years. The size of the misperceptions shock was set together with the remaining parameter configuration in order to imply a fall in the debt level of the firms,[21] equivalent to about 15% of initial GDP.[22] In the baseline configuration of parameters, this implies that κ_{ss} is set to 0.75.

In the calibration of the more standard parameters, I followed the remainder of the literature on open economies and emerging market crises. Like Devereux et al. (2006), I set the intertemporal elasticity of substitution, $1/\sigma$, to 0.5 and the labor supply elasticity, $1/\psi$, to 1. The elasticity of substitution of consumption between domestic and foreign goods, ν, is assumed, in the baseline case, to be unity. I set the fraction of domestic goods in the consumption basket of the households, γ, to be 90%. This is consistent with the results

[20] For example Bernanke et al. (1999) use 0.12 for μ and 0.529 for σ_ω.
[21] This is evaluated at the trough of the crisis.
[22] In the model the ratio is computed as $SB/P_H Y$.

presented in Table 3 showing that imports of consumption goods are a very small fraction of total imports and taking into account the results of Elekdag, Justiniano, and Tchakarov (2005).

For the production side, I consider, in the baseline scenario, that firms have technology with unit elasticity of substitution between inputs, so that ϕ is set to one, and the share of labor used in production, α, is 55%, something comparable to Devereux et al. (2006) and others. The retailers face the impossibility to set prices with a probability, α_p, of 75%. Their demand elasticity of substitution, η, is set to 11, so that the monopolistic markup is 10%. The elasticity of substitution of foreign consumption between domestic and foreign goods, ν^*, is set to 0.6, a number mentioned by Cook (2004) to be appropriate for emerging markets. The share of domestic good in the foreign consumption basket, γ^*, is calibrated together with the value of foreign aggregate consumption so that $\gamma^* C^*$ is unity so I set γ^* to 10% and C^* to 10. The total factor productivity in steady state, A, is set to one, just like all the foreign price levels. The parameter values of the baseline calibration are presented in Table 10.

4 Responses to a sudden stop

In this section, I present the responses of the economy to a sudden stop shock under alternative monetary policies.[23] The shock is set in order to generate a reversal in the capital account equivalent to 14-15% of the GDP in steady state. A first check on the performance of the model is to compare the theoretical responses to the actual typical paths of the most important variables. However, this task is made difficult by the fact that policy changed throughout the crises, as they took place. Therefore, it is hard to exactly replicate

[23] The IRFs can be interpreted as percentage points, even though it should be noted that we are talking about log deviations, not exactly percentage deviations from steady state. For small deviations this distinction is not relevant but given that in this case significant deviations occur it is important to notice this. Furthermore the interest and inflation rates are annualized.

what policy really looked like in those times. As already suggested in section 2, all the crises started with regimes of soft pegs, but these quickly gave way. Hence looking at the responses under a peg is only indicative for the very first periods of the crisis, but not from then onwards. Once the peg was abandoned monetary policy was not clear either. One important concern of authorities was to control for output and to avoid the loss of control of inflation and the depreciation of the currency. Therefore an approximation is to assume a Taylor rule that reacts to inflation and output. This approach is not perfect either, because it assumes that, from the very beginning, defending the currency is not the main concern and that was not the case whatsoever. The perspective I follow is that these two policies are probably the bounds within which we can frame the actual policy being followed in those events.

Gertler et al. (2003) go one step further and consider a regime in which a peg is the starting policy but there is a probability of floating (and reverting to a Taylor rule like the one considered here) and, in face of a shock, the peg is actually abandoned after two periods. They get that the responses are identical to the ones in the peg for the first couple of periods and then, once the float takes place, quickly revert to levels similar to those in the simple Taylor rule. Therefore my interpretation appears to be reasonable, the reason why I start with a comparison of the responses under these two regimes in subsection 4.1. I then consider alternative monetary policy regimes, in 4.2. Finally, alternative calibrations are considered, in subsection 4.3.

4.1 Comparing a peg with a simple Taylor rule

Here I consider the response of the economy under a fixed exchange rate regime, in comparison to the response under a floating exchange rate regime, in which the interest rate reacts to CPI inflation and to output deviations from the steady state. The impulse response functions (IRFs) are presented in Figure 4.

What is the mechanism driving the shock? As the misperceptions take place, foreigners begin to demand much more for lending money to the firms. The immediate response of firms is to reduce future invoices of the imported input because their financing just got more expensive. This, however, will affect production only in the next period. On impact, firms reduce the amount of debt significantly and increase the amount of net worth, in order to reduce the risk premium they face. The consequence is the distribution of fewer dividends to the households. This implies an income shock to these agents, which then reduce their consumption. Note that at this stage, the shock is no longer just a supply side shock, it now implies a shock to the demand side. In particular this leads to lower domestic demand for the domestic good. Therefore I have the same result as Martin and Rey (2005), that the crisis leads to a contraction in the demand for goods.

As a consequence of lower demand for the domestic goods' firms lower their demand for labor (the only variable input within period) and this leads to lower real wages, which then reinforces the income shock to the households. With lower output levels and the same amount of imported input used, the return rate on imported input falls on impact, with subsequent increase in the number of defaults on the debt. The result is the validation, in that same period, of the worries of foreigners about the returns on imported inputs. In this sense it is a self-fulfilling type of story, as Calvo (1998) and Krugman (1999) proposed.

An additional effect also takes place. As the financial account falls the pressure on the exchange rate is for a real depreciation, which will increase foreign demand for the domestic good. This minimizes the negative impact of the initial shock. It also implies a further contraction in domestic demand for foreign goods. This effect is always present in all policies, but its magnitude greatly depends on the policy followed, as the Figures show very clearly. There are, thus, two opposing forces driving aggregate demand: there is a contraction in domestic demand and, at the same time, an increase in the foreign demand. Which one prevails depends on the price elasticity of foreign demand and the share of imported goods in the consumption basket of domestic households, as well as on monetary policy.

With respect to labor market, it is possible to identify a path that is common as well. There is an initial contraction in the demand from firms, which leads to a reduction in the real wage. However, in the period immediately after the impact, labor increases in order to compensate for the fall in available imported input. This effect is even more significant under floating exchange rates, with employment levels above the steady state. This is not so consistent with the evidence from past episodes but it is due to lack of enough complementarity in the factors of production and to lack of rigidity in the labor market. Further below I show that with higher complementarity the path is more realistic. The same would probably be true if we introduced sticky wages.

The mechanism just described is the structural underlying story. Now I shall identify the impact of different policies. First of all, it is noticeable that the two policies have very different implications in terms of output stabilization. While enforcing the peg leads to significant contraction of the output, the Taylor rule implies a smaller contraction in output. This is the consequence of a lower real interest rate in the case of the Taylor rule, together with a sharp devaluation of the currency on impact (and real devaluation as well), which leads to a significant increase in the foreign demand for the domestic goods. The consequences of such are clearly visible, with a more significant expansion of exports under the floating exchange rate.

One feature of the response of output is comparable with the facts presented earlier: there is a sharp contraction (if we assume an initial peg) but, by the 6th quarter after impact, it is back in pre-crisis levels. The u-shape pattern, however, was not replicated and the magnitude of the contraction is not exactly the same. The fast recovery of the output is what Calvo (2005) labeled as the "Phoenix miracle." As Calvo describes it, the recovery takes place before credit lines are restored, which implies that firms had to reorganize and use more internal financing. The Calvo's description is consistent with the results from the model presented here, with the increase in the net worth, while the debt level recovers only gradually.

Both the real interest rate and the real wage have smaller responses under the Taylor rule than under the peg. This leads to a smaller contraction of the consumption of the domestic good. However, the significant real devaluation taking place leads to an even sharper contraction in the consumption of the imported goods. With the current calibration, it is the contractionary effect that is more influent but, under alternative calibrations, it could turn out otherwise. Because the demand for the domestic good is higher under the Taylor rule, firms can afford to pay a higher cost for debt financing and therefore the reduction in debt and increase in net worth are somewhat smaller.

The devaluation that takes place under the Taylor rule leads to significant inflation. This contrasts with the peg, in which the real devaluation is attained through deflation or, at least, a fall in the inflation rate relative to the steady state. This is also consistent with empirical evidence, given that in the cases in which the exchange rate was kept fixed for longer the countries experienced falls in the inflation rate and increases immediately after devaluation. What is not so consistent with empirical evidence is the size of the fall in the inflation rate, which in the current calibration is as big as 15% in annual terms.

Given the Gertler et al. (2003) experiment, with an hybrid system of peg abandonment followed by Taylor rule, we would get the initial impact as described here for the peg and, then, convergence to the Taylor rule case responses. This would imply a faster recovery from the output contraction and hump-shaped real exchange rate and exports. The interest rate would initially increase as much as in the peg and then be reduced much like in the data, even if the model would not forecast a complete reduction to steady state levels or even to levels lower than in steady state, as in the Asian crises. Overall, I consider that the model performs rather well in mimicking the empirical evidence for such disrupting events as sudden stops.

The flexible exchange rate regime seems to stabilize output, consumption (recall that consumption of domestic goods constitutes 90% of the total consumption basket) and real wages. Therefore it appears to be a policy more effective from this perspective, but only a welfare evaluation would yield a definitive answer. Indeed, only Cook (2004) presents a model in which fixed exchange rates lead to greater stability than flexible exchange rates, unlike Céspedes et al. (2004), Devereux et al. (2006) and Gertler et al. (2003). All of these three papers conclude that flexible exchange rates lead to higher stability. The reason for Cook's different result, as he argues, is that in his model there are sticky prices at the level of the borrowers, not just at the level of the retailers. Therefore if the producers cannot adjust their prices, but face big cost changes due to the flexible exchange rates, this becomes very destabilizing. In this model like in the other ones the sticky prices do not act at that level but, instead only at a retail level, hence not interacting with the borrowing constraint so much. Introducing sticky wages could revert his results though.

It is important to note that all the above papers, which analyzed the impact of the exchange rate regime on the evolution of the economy after an increase in the risk premium, use some version of the financial accelerator model, but none of them considers the impact of imported inputs. With imported inputs a devaluation will make it more costly to produce, adding one more channel to the destabilizing effects of flexible exchange rate regimes. However, the results above suggest that this effect is subdued by the benefits of an increased foreign demand and, therefore, the flexible exchange rate regime still stabilizes more the economy.

Another novel feature of the model presented here is the importance of the demand shock. This demand effect leads consumption to fall more than output, as suggested by the empirical evidence. This is a result not present in Gertler et al. (2003) but present in Cook (2004). However in both of them the shock arrives at the households only because foreign interest rates are increasing (households in their models can borrow freely in the international capital market). The way it is modeled in my framework is more interesting because it links explicitly the impact to the households with the financial fragility of the firms which are the ones that actually face the first shock, much like what happened in past sudden stop episodes, especially evident in the Asian crises.

4.2 Comparing the effects of alternative policies

In the previous subsection the analysis of monetary policy was limited to two rules. A broader set of policies is now considered. Namely, I investigate the impact of different levels of the reaction of the interest rate to CPI inflation. Then I consider the case in which authorities respond to the domestic price index, rather than the consumer price index.

In the Taylor rule considered so far the coefficient on inflation is set to 3. Now I look at the consequences of more hawkish and dovish stances. I compare the benchmark case of $\phi_{CPI} = 3$ with the alternative $\phi_{CPI} = 1.5$ and $\phi_{CPI} \rightarrow \infty$. The latter is the most strict inflation control that there can be, implying full CPI inflation stabilization at all times, while the former is a more dovish approach, in which the leash on inflation is not so tight (but is not the minimal coefficient that still enforces determinacy of the system, lower values could be considered). The results are presented in Figure 5.

The first result from this experiment is the expected one: the most hawkish policy leads to a stronger contraction of the output with the more dovish policy actually leading to an expansion. This is attained through, correspondingly, lower and higher real devaluations that lead to lower and higher increases in the foreign demand for the domestic goods. The different policy stances also have the obvious impact on equilibrium inflation rates, with the more dovish policy implying higher inflation.

The comparison of the nominal interest rates yields the interesting fact that these are actually higher in the scenario that leads to the output expansion and lowest in the scenario with stronger contraction. Even after considering the real interest rate instead of the nominal one it is striking that, on impact, it is higher under the dovish case as compared to the hawkish one. The explanation for this is inflation and currency depreciation expectations. The shock itself generates inflationary pressures and the more expansionary is the policy the higher is inflation and its expectations. More dovish policy stances imply higher inflation and, automatically, an interest rate rule reacting to inflation will imply higher interest rate.

This analysis shows, to some extent, the importance of expectations about the monetary stance when confronting such a big shock as a sudden stop. Perceptions that policy will be more or less strict on inflation lead to significant changes in inflation expectations, and ensuing devaluation. Even with higher interest rates the devaluation is higher, just because of those expectations. Therefore, changes to the interest rate matter, but announcing the monetary policy matters even more. Namely how inflation, output and exchange rate are taken into account, which would allow the control of expectations. This result seems to confirm that communicating with the public the intended policy is of very important, especially when facing such big shocks, something that Fraga et al. (2003) already advocated.

The previous discussion also raises the issue of credibility of monetary policy. If the control of inflation is credible, it is much easier for the authorities to shift the interest rate around, without worrying so much about the expectations of inflation. If, instead, credibility is very low, the authorities will be very restricted in their options and, probably, have to try to implement a harder policy than they could otherwise. These are relatively usual remarks but here they take a new importance due to the magnitude of the shock hitting the economy.

An alternative policy is that the authorities respond to domestic prices, instead of the consumer price index. Therefore, we can compare a Taylor rule with DPI inflation, as opposed to CPI inflation. This is presented in Figure 6. One result is that the path of output is significantly different on impact and short run. While responding to CPI leads to some contraction in output, responding to DPI implies an impact slight expansion in output, followed by a stronger contraction in the following periods. This is the result of a policy that, by responding to domestic prices, does not take into account the direct effects of the devaluation on imported final goods prices. Therefore, there is a much smaller increase in the interest rate on impact, accompanied by lower real interest rate as well, which leads to higher inflation and stronger nominal and real devaluations. Lower real interest rates and stronger real devaluation lead to increased domestic and foreign demand on impact, which explains the temporary hike in output. The reason why the subsequent contraction is stronger has to do with more substantial real devaluation that makes the imported input more costly. Hence, the cost-push shock is stronger, something not yet present in the impact period, because in that period previously purchased inputs are used (before they become more costly).

One last policy can be considered: the case in which authorities react to domestic prices and take it to the extreme of full stabilization. This would not add too much to the previous analysis, except that when doing so the authorities actually enforce the flexible price equilibrium, which is always a case to consider. Figure 7 shows this equivalence by reporting the IRFs under sticky and flexible prices. The reason for this exact matching between the two IRFs is simple to explain. If firms expect the monetary authorities to take enough actions so as to completely stabilize the aggregate price of the domestic good, then each individual firm has no incentive to change their price in the first place. Therefore, sticky and flexible price equilibria are exactly the same.

In the flexible price equilibrium, the main effects can be described as follows. The natural interest rate undertakes a steep fall on impact and subsequent increase above the steady state. This contributes to curtail initially the contraction in consumption that typically occurred in all the other policies considered. However, as the natural interest rate switches to the high levels, then, consumption takes the full blow, much like in other policies under sticky prices. At the same time, under flexible prices, there is a significant real devaluation on impact, immediately reduced afterwards. This leads to an immediate big increase in exports that, then, slows down. The paths of exports and consumption of domestic good explain the behavior of potential output. Initially it increases sharply, just to suffer a contraction immediately after. The reason why the natural interest rate and the real devaluation take place in the first place is due to the initial availability of imported inputs, purchased in the previous period, which, given the lower domestic demand, lead to a fall in the domestic prices relative to foreign ones. This reduces, on impact, the return on the imported input and the natural interest rate.

4.3 Alternative calibrations

In the previous subsections, I considered alternative parameter configurations but only for the monetary policies. However, it is important to understand to what extent are these results related to the specific calibration used here. I consider, in all cases, the pair of policies of peg and CPI Taylor rule (with $\phi_{CPI} = 3$), which are the benchmark policies, plus the flexible price case.[24]

This analysis will address, to some extent, the debate initiated by Chari, Kehoe, and McGrattan (2005) regarding the effects of a sudden stop on output. In that paper the authors assert that the sudden stop can be interpreted as a positive net exports shock and, therefore, it should be expansionary, not contractionary. They claim that previous papers can generate the contraction only through extra assumptions of financial frictions. My perspective on this debate is that their results are in part due to their framework. More precisely, one reason why they get their results is that all goods in the economy are tradable goods and their international demand and supply are infinitely elastic. Hence, there is no

[24] In the subsequent figures the path of nominal variables (π, i and S) is not shown for the flexible price case. These variables are policy dependent and discharged of much content in the flexible price case.

distinction in the way the transmission of the shock, from the sudden contraction in debt, to the net exports increase. However, if the elasticity of foreign demand is low and the increase in the net exports is attained mainly due to a contraction in consumption and imports, then the shock can induce a fall in the output.

Within the model presented here, in the flexible price case, output immediately jumps up but that is a transitory state due to the existence of accumulated inputs bought previously so the relevant effect should be considered in the periods afterwards. And in both the sticky price and flexible price cases there is a contraction of the output due to a receding domestic demand, even though the real devaluation pushes exports up, and leads to expansionary pressures. This is the main mechanism underlying the shock and why the model in Chari et al. (2005) does not explain the whole story. More than considering a simple increase in net exports, it is important to understand how it is attained. In their model it does not matter, but in general in models with tradables and non-tradables or with domestic and foreign goods, in which foreign demand is not infinitely elastic, this is a relevant issue.

The parameter that is of crucial importance for this is the elasticity of foreign demand, ν^*. The benchmark scenario set this parameter to 0.6, as suggested in Cook (2004), based on empirical evidence. But if we allow for the elasticity to be higher then we expect the exports to react much more to the real devaluation and this might twist those two forces against a contraction of output. Figure 8 presents responses with $\nu^* = 1$. The results are the expected ones, with less contractionary outcomes. Indeed, the higher elasticity of foreign demand leads to a bigger increase in exports, and the aggregate demand ends up having a positive shift. Under the CPI Taylor rule there is essentially no contraction any more. There is neither a significant expansion but, if foreign demand is allowed to become even more elastic, an expansion will take place.

Overall it appears that the increase in the elasticity of foreign demand increases output for all policies, but less so under the fixed exchange rate scenario. Therefore, besides the elasticity of foreign demand, monetary policy also matters. The above results also implies that, unlike the claim in Caballero and Krishnamurthy (2005a), monetary authorities are able to reduce the impact of the sudden stop in output, the more so if foreign demand is sufficiently price sensitive. Whether this is the optimal policy from the perspective of households is another question.

The source of the shock is in the financing costs of firms, namely in their capacity to finance the imported input required for production. Therefore, it is worth considering changes to the degree of inputs complementarity. I consider, thus, the case in which inputs are much more complementary ($\phi = 0.25$) than in the baseline scenario. The results are presented in Figure 9. In this scenario the model implies that the same size of foreigners misperceptions leads to a much smaller reversal in the capital account. The reason is that, in this scenario, the steady state equilibrium implies a much smaller debt-to-DGP ratio, of only 4.4%, compared to 20.2%, in the baseline case. Therefore, it is just a difference of initial level. But this also implies big differences in how the crisis propagates, as I shall discuss now.

The output contraction, under the peg, is now even stronger, because employment levels are low as well. This reflects the strong complementarities with the imported input, now a scarce and expensive resource. It is worth noting that in this alternative scenario the behavior of labor is much more in line with what one would expect, accompanying the evolution of output, always on the negative side.

The Taylor rule leads to negligible impact on output, unlike in the baseline scenario. This occurs due to a smaller contraction in consumption of domestic goods (the real wage falls by much less than in the baseline scenario) and a higher real devaluation that expands foreign demand more. It seems obvious, in this configuration, that a peg is not the best policy, given the implied contractions in output consumption and employment relative to the Taylor rule.

It is also interesting to compare the flexible price case under this alternative scenario because it implies a significant change in the path, compared to the baseline case: potential output is always above the steady state level. This owes to three reasons: a smaller adjustment in the real wages; a natural interest rate that falls on impact and then increases much less than in the baseline case; and a significant real devaluation.

Under this scenario, the model results support the view of Chari et al. (2005) in which the shock tends to be expansionary in the flexible price case. However, it is important to realize that this is so only because under this calibration the domestic demand contraction is rather mild, which is normally not the case in crises. One possibility is that in a crisis when there is default by some firms (recall that on impact of a sudden stop the model predicts a higher rate of default due to lower returns on imported input), these are not immediately replaced by others, as the model assumes. This would allow for a persistent contraction in income levels, hence on demand and supply. To incorporate that into the model, though, would imply some non-trivial changes.

Another calibration, worth testing, involves changing the degree of openness of the economy, in the sense that households consumption baskets contains a big fraction of foreign consumption goods. This is relevant because some authors have found evidence linking this to the probability of the sudden stop and the severity of its repercussions. Namely, Calvo, Izquierdo, and Mejía (2004) find that the more open is the economy, the lower is the probability of such a shock. In another empirical paper, Edwards (2004) mentions that the more open is the economy the less dire are the consequences of a sudden stop as measured in growth rates. Therefore, I consider the scenario in which foreign consumption goods represent 30% of the overall consumption basket, instead of the mere 10% of the baseline case, hence a much more open economy in this view. The responses are presented in Figure 10.

The results of the model are consistent with the empirical studies. As the fraction of imported final goods increases in the consumption basket the responses of the economy in all monetary policy scenarios considered are less contractionary. The reason for this is that as imported consumption goods are now more significant a smaller real devaluation is needed in equilibrium to generate the required adjustment in the economy. Because more of the adjustment is transferred to the consumption of final goods, the domestic demand does not contract as much and, therefore, in equilibrium output is higher than in the benchmark case, just like the empirical evidence suggests.

Finally, one last alternative calibration worth looking into is the reduction of the financial frictions in the economy. I consider now that the leverage ratio is 30% and that firms debt spread is 3% (annual), which implies that μ is now set to 0.045628 and σ_ω set to 0.566724. As would be expected, Figure 11 confirms that the sudden stop is much smaller (now representing only about 7% of the steady state GDP) and all responses have similar shapes but smaller magnitudes.

5 Conclusion

The main question analyzed in this paper refers to the impact of monetary policy in an environment prone to sudden stops of capital flows. In order to answer this question, the paper proposes a theoretical model that suits the purpose. The root of the model can be traced back to the financial accelerator model of Bernanke et al. (1999). However, the model presented has substantial differences from that one. First, I consider households that cannot access the international capital market directly, but that hold shares of firms, which can use their net worth to obtain credit in the international capital market. Second, I introduce imported inputs, with a significant role in the entire mechanism, something not considered in other versions of the financial accelerator model. Third, instead of performing an exogenous shock in the foreign interest rate, I assume a more structural source of the sudden stop consisting of misperceptions on the side of foreign lenders.

The first change provides many advantages over the more typical financial accelerator framework. First, households can now indirectly access foreign capital by holding shares of the leveraged firms and, therefore, some amount of consumption smoothing is possible. Second, this leads to a link between domestic and foreign interest rates with an endogenous country risk premium, yielding a modified UIP relation. Third, it provides a simpler way to evaluate optimal monetary policy by making the households utility the logical welfare measure, while, in the original financial accelerator framework, either the capitalists welfare would have to be disregarded or be added to the households utility somehow.

The assumption of imported inputs leads to additional effects when considering the effects of real devaluations as they will make the cost of imported inputs higher and therefore increases the strain on firms. The change in the underlying shock is also an important one because it exploits the advantages of the financial accelerator model in its most structural form to introduce the idea of risk on the side of foreigners. Moreover, the shock can be interpreted as self-fulfilling pessimism of foreigners, a rather common interpretation of what happened in several of these crises.

The comparison of the responses of the economy under several alternative monetary policies yields the conclusion that the recession is the worst under a peg. The Taylor rules considered appear to stabilize the economy much more in the event of a sudden stop, with some rules able to revert the effects from output contraction into expansion, at the cost of higher inflation. Whether that would be optimal goes beyond the scope of this paper but is being pursued in follow up research. Another conclusion is that, more than deciding whether to increase or decrease interest rates, it is important to control the expectations of agents about monetary policy. This emphasizes the role of announcing the intended monetary policy and ensuring its credibility. Furthermore, in this model, if the monetary policy is set to impose full DPI stabilization, the flexible price equilibrium is attained, implying no trade off between these two objectives.

I also showed that considerations about the elasticity of foreign demand play a significant role on the impact of the shock on output, precisely because there are two mechanisms at work: the increase in exports and the contraction in domestic demand. In the benchmark case, the contraction in the domestic demand is the dominant effect. But I also showed some alternative calibrations in which the second effect is less important and therefore an expansionary outcome is possible, even if that is not considered to be the scenario that best reflects reality.

In order to fully capture the value of the framework proposed here one needs to think beyond this paper though. A more interesting approach is to consider the doors that it opens, doors that could be harder to open in alternative frameworks. To start with, the issue of welfare evaluation. In this model, the obvious measure is the welfare of households, something not so obvious in other financial accelerator models, as the analysis in Devereux et al. (2006) makes evident. This allows for the analysis of optimal policy using this framework and even considerations about commitment and discretion, much more in line with the research of Caballero and Krishnamurthy (2005c). This is actually on the basis of follow up work under progress. Another important extension, from the beginning in the basis of the shock proposed here, is the consideration of the endogeneity of the shock, or at least the interactions between it and policy. Given the nature of the shock proposed here, it is only natural to consider that the misperceptions can be due to the observation of some state variables. These considerations would affect not only the optimal policy in response to a sudden stop but also the optimal policy to other shocks in the economy, and provide an *ex-ante* perspective to the issue of monetary policy in emerging markets, something not yet thoroughly explored in the current literature.

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A Empirical evidence

% of GDP	CR99 (NPF)[1]	Own Calculations (FA)[2]
Ecuador (1995-96)	19	19
Mexico (1994-95)	6	4
Indonesia (1996-97)	5	- - -
Philippines (1996-97)	7	27
S. Korea (1996-97)	11	20
Thailand (1996-97)	26	26
Turkey (1993-94)	10	10
Turkey (2000-01)	- - -	20

(1) Source: Calvo and Reinhart (1999)

(2) Source: Own calculations based on data from IMF/IFS database

Table 1: Capital account reversal during sudden stops

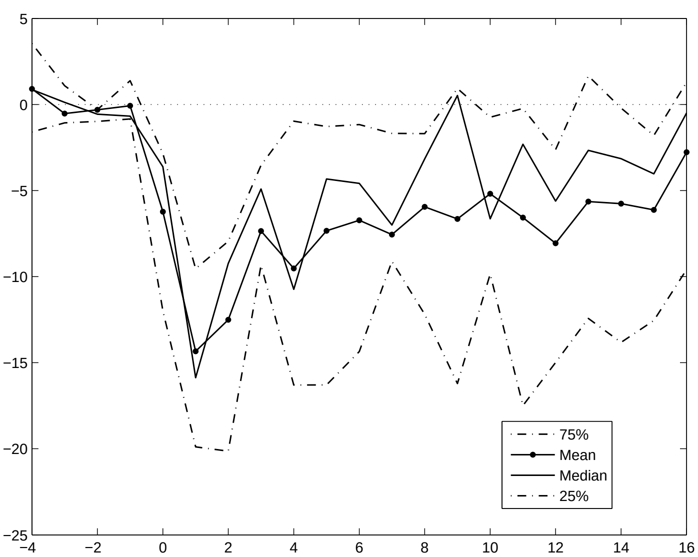

Figure 1: Path of the financial account (deviations from average in pre-crisis year, in percentage points of initial GDP)

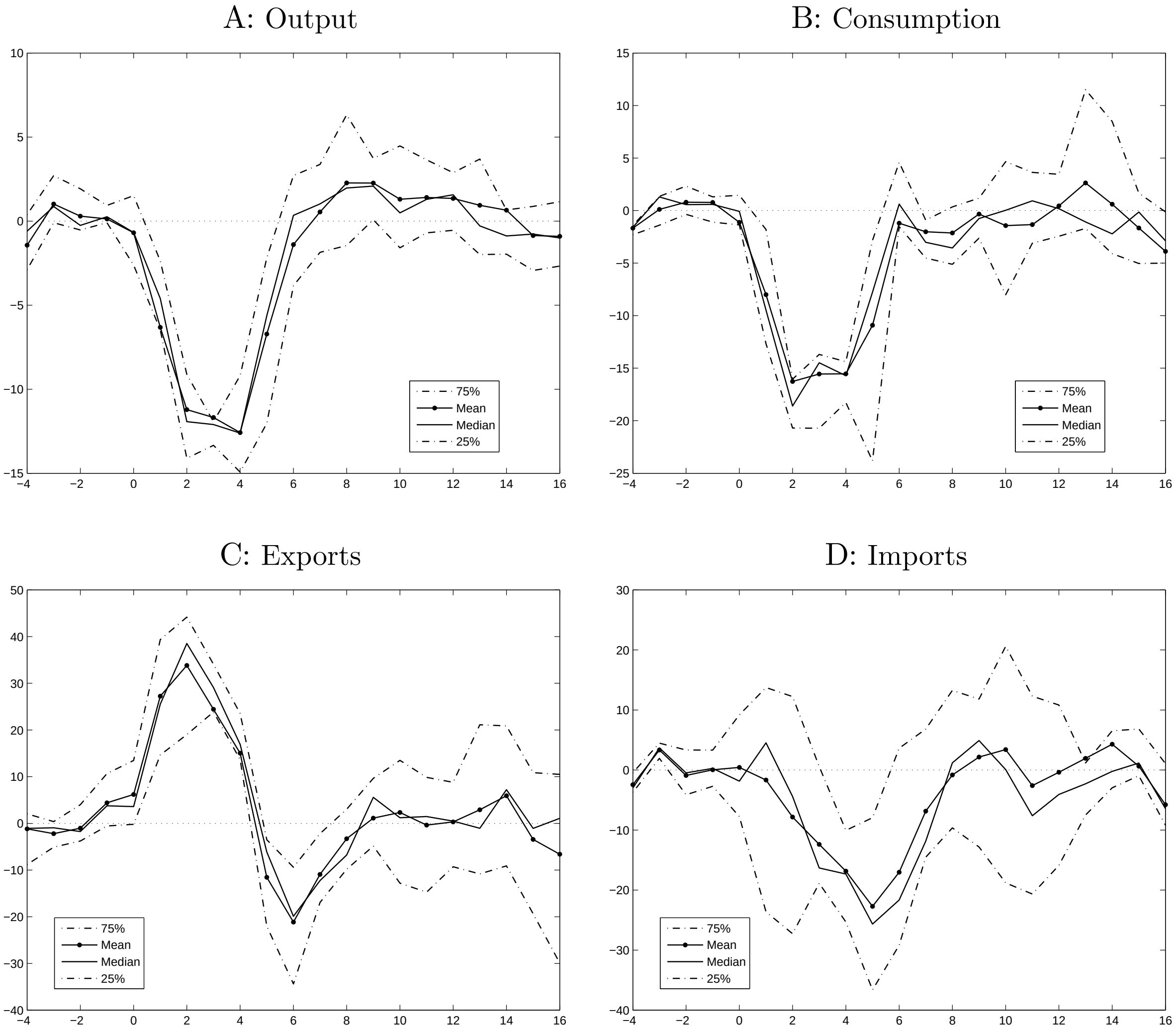

Figure 2: Responses to sudden stop shocks in the sample (change in the four-quarters growth rate)

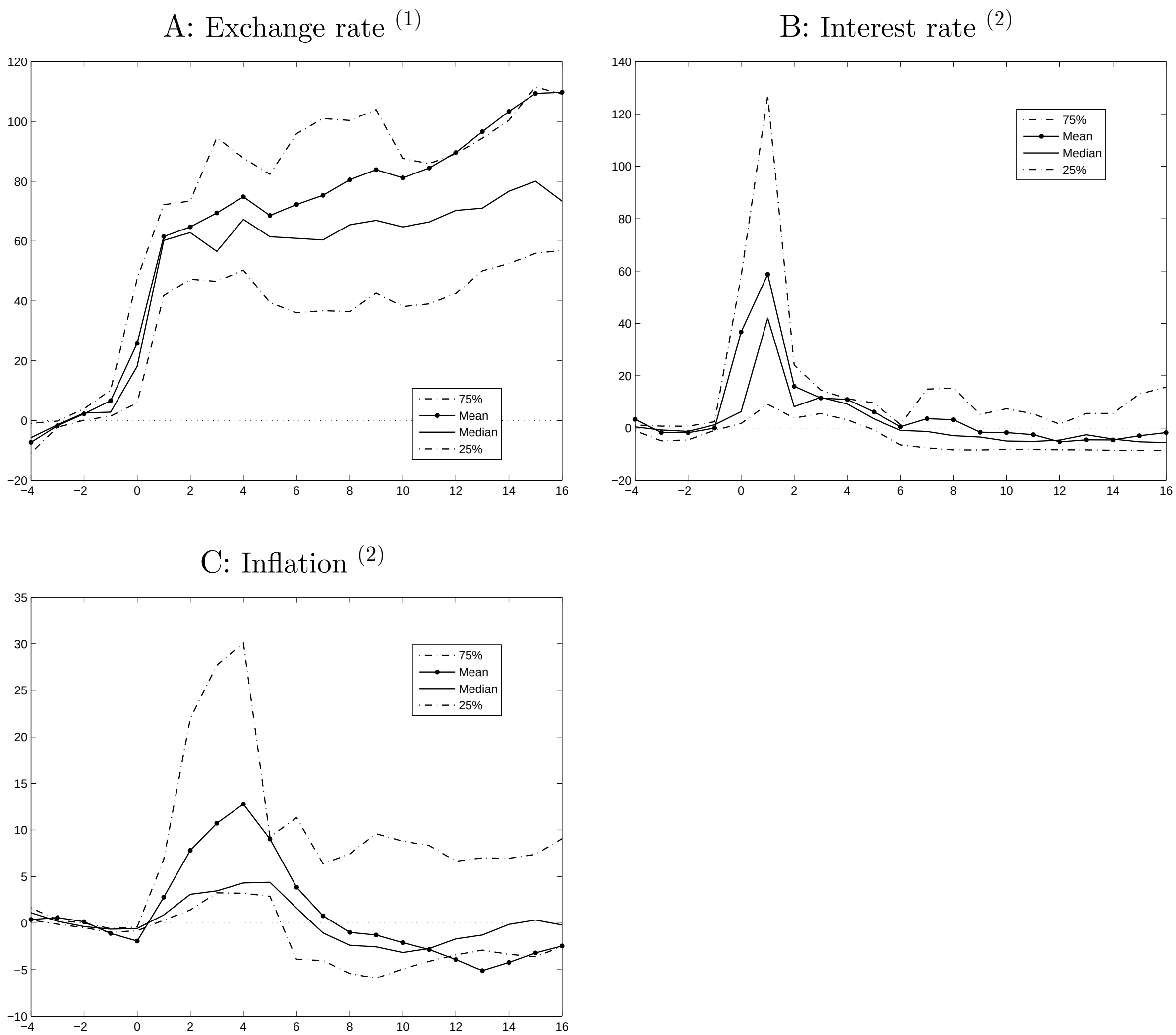

Figure 3: Responses to sudden stop shocks in the sample. (1) Log deviation from pre-crisis average; (2) change from pre-crisis average in percentage points

%	Government	Monetary Authorities	Banks	Corporations(1)	Households(2)	Intercompanies(3)
Brazil	37.36	11.53	17.89	24.54	0.07	8.54
Chile	10.79	0.04	14.36	63.99	0.12	10.49
Colombia	56.47	0.02	5.54	35.2	0.02	0.18
Ecuador	62.96	0.25	0.45	33.62	0	2.73
S. Korea	5.84	3.36	44.1	37.58	0	2.15
Mexico	38.7	0.09	7.17	54.04	0	0
Peru	77.21	0.06	3.1	17.7	0	0
Uruguay	86.03	10.13	0	3.84	0	0

(1) Excluding banks; (2) Including nonprofit institutions serving households; (3) Related to FDI

Source: World Bank Quarterly External Debt Statistics, 2004q4

Table 2: Decomposition of gross external debt by sectors

%	Intermediate(1)	Capital	Consumption
Argentina	55.0	30.7	14.3
Brazil	69.8	19.3	10.9
Chile	62.5	20.3	17.2
Indonesia	78.6	13.2	8.2
Malaysia	78.5	15.2	6.3
Mexico	75.7	11.5	12.9
S. Korea	49.1	37.8	13.1
Thailand	42.5	47.2	10.3

(1) Including fuel and energy

Source: Economist Intelligence Unit, 2004

Table 3: Decomposition of imports for some emerging market economies

%	Foreign currency	Domestic currency
Argentina	98.72	1.28
Chile	99.87	0.13
Colombia	98.99	1.01
S. Korea	94.08	5.92
Peru	99.97	0.03
Thailand	87.63	12.37
Turkey	99.76	0.24
Uruguay	95.64	4.36

Source: World Bank Quarterly External Debt Statistics, 2004q4

Table 4: Currency denomination of gross external debt

annual basis points	Sovereign	Private	Total(2)
Latin America	302	416	384
East Asia	94	226	151
Average(1)	260	378	319

(1) Weighted average based on the number of bonds with spreads

(2) Including bonds issued by other public entities

Source: Own calculations, based on data for 1991-97 in Eichengreen and Mody (2000)

Table 5: Bond spreads in Latin America and East Asia

%	Debt-to-assets ratio
Indonesia	55.157
S. Korea	82.111
Malaysia	55.357
Philippines	52.381
Thailand	65.278
Argentina	44.444
Brazil	40.828
Chile	41.860
Mexico	47.090

Source: Own calculations, based on data for 1992-96 in Pomerleano and Zhang (1999)

Table 6: Debt-to-assets ratio for some emerging market countries

B Variables and parameters

P_t	consumption price index (CPI)	π_t	CPI inflation rate
$P_{H,t}$	dom. goods retail price (DPI)	$p_{H,t}$	relative dom. goods retail price
$P_{w,t}$	dom. goods wholesale price	$p_{w,t}$	relative dom. goods wholesale price
W_t	nominal wage rate	w_t	real wage rate
i_t	domestic interest rate	r_t	real interest rate
i_t^*	foreign risk free interest rate	$P_{F,t}^*$	foreign goods price$^{(1)}$
P_t^*	foreign CPI$^{(1)}$	$P_{Z,t}^*$	price of imported inputs$^{(1)}$
S_t	nominal exchange rate	s_t	real exchange rate
C_t	consumption bundle	$C_t^{*\text{‘}}$	foreign aggregate consumption
$C_{H,t}$	consumption of domestic goods	$C_{H,t}^*$	foreign consumption of dom. goods
$C_{F,t}$	consumption of foreign goods	D_t	domestic assets
Π_t	total profits	Y_t	domestic goods production
$\Pi_{w,t}$	profits of wholesale firms	L_t	labor
$\Pi_{r,t}$	profits of retail firms	Z_t	imported inputs
N_t	nominal net worth	n_t	real net worth
B_t	debt$^{(1)}$	b_t	leverage ratio
$R_{Z,t}$	gross returns on imported inputs	$r_{Z,t}$	net real returns on imported inputs
A_t	total factor productivity	κ_t	misperception factor
$\omega_t\left(j\right)$	imported input productivity shock	$\omega_t^*\left(j\right)$	foreigners perceptions about $\omega_t\left(j\right)$
$\bar{\omega}_t\left(j\right)$	default threshold	$R_{B,t}\left(j\right)$	gross interest rate in debt contract

(1) defined in foreign currency

Table 7: Variables present in the model

β	discount factor
σ	inverse of the intertemporal elasticity of substitution
ψ	inverse of the labor supply elasticity
ν	elasticity of substitution of consumption between domestic and foreign goods
γ	share of the domestic good in the consumption under unit elasticity of substitution
ϕ	elasticity of substitution between domestic and foreign inputs in the production of domestic goods
α	share of labor in the production of the domestic goods if there was unit elasticity of substitution
σ_ω^2	variance of the log-normal distribution of ω
μ	monitoring costs
δ_{ss}	probability of arrival of sudden stop while in a normal period
δ_n	probability of exit of sudden stop
κ_{ss}	misperception factor during sudden stop
η	elasticity of substitution among the different varieties of the domestic goods
ν^*	elasticity of substitution of foreign consumption between domestic and foreign goods
γ^*	share of the domestic good in the foreign consumption under unit elasticity of substitution
α_p	probability that a firm is not able to set prices in a given period

Table 8: Parameters present in the model

	ϕ_{CPI}	ϕ_{DPI}	ϕ_Y	ϕ_S
Peg	0	0	0	∞
Taylor rule (CPI)	3	0	0.75	0
Taylor rule (DPI)	0	3	0.75	0
Inflation stabilization (CPI)	∞	0	0	0
Inflation stabilization (DPI)	0	∞	0	0
Alternative CPI Taylor rule	1.5	0	0.75	0

Table 9: Policy rule coefficients

β	0.98401	ϕ	1	α_p	0.75	A	1
σ	2	α	0.55	η	11	C^*	10
ψ	1	μ	0.019065	ν^*	0.6	P^*	1
ν	1	σ_ω	0.392202	γ^*	0.1	P_Z^*	1
γ	0.9	δ_{ss}	0.025			P_F^*	1
		δ_n	0.05			i^*	0.01
		κ_{ss}	0.75				

Table 10: Calibrated parameters

C Derivation of some results

C.1 Hidden Markov chain

The Markov chain can be described by the following matrix of transition probabilities:

$$\mathcal{P} = \begin{bmatrix} 1-\delta_{ss} & \delta_n \\ \delta_{ss} & 1-\delta_n \end{bmatrix}$$

with $\mathcal{P}_{ij} = \Pr\left(\mathcal{S}_{t+1} = \mathcal{S}_i | \mathcal{S}_t = \mathcal{S}_j\right)$ and $\mathcal{S} \equiv \{\mathcal{N}, \mathcal{U}\}$.

In Ljungqvist and Sargent (2000) the authors show how a Markov process can be described through a linear filter in what is usually called a hidden Markov chain. Hamilton (1994) goes further in claiming that for a 2-state Markov chain, the linear filter can be presented in the usual form of an AR(1) process. The following steps show that applies to the current case.

Define an indicator variable, $\varkappa$, which is one if $\mathcal{S} = \mathcal{U}$ and zero otherwise. Taking into account the worst case scenario, foreign lenders will use $\kappa_{\mathcal{S}_t=\mathcal{U}} = \kappa_{ss}$. Furthermore define $\hat{\kappa}_t \equiv \ln(\kappa_t)$ and $\hat{\kappa}_{ss} \equiv \ln(\kappa_{ss})$. Then it is possible a state space form with the following observation equation

$$\hat{\kappa}_t = \hat{\kappa}_{ss} \varkappa_t, \tag{C.1}$$

and the VAR component is

$$\begin{bmatrix} 1-\varkappa_t \\ \varkappa_t \end{bmatrix} = \begin{bmatrix} 1-\delta_{ss} & \delta_n \\ \delta_{ss} & 1-\delta_n \end{bmatrix} \begin{bmatrix} 1-\varkappa_{t-1} \\ \varkappa_{t-1} \end{bmatrix} + \begin{bmatrix} v_t \\ \varepsilon_{\varkappa,t} \end{bmatrix}.$$

In order to understand that the VAR component is in fact just an AR(1) all that one needs to do is to realize that the two rows are one and the same with $v_t = -\varepsilon_{\varkappa,t}$. Therefore one can use the second one to replace the VAR,

$$\varkappa_t = \delta_{ss} + (1 - \delta_n - \delta_{ss}) \varkappa_{t-1} + \varepsilon_{\varkappa,t}. \tag{C.2}$$

Combining (C.1) and (C.2) one the hidden Markov chain representation,

$$\hat{\kappa}_t = \delta_{ss}\hat{\kappa}_{ss} + (1 - \delta_n - \delta_{ss}) \hat{\kappa}_{t-1} + \varepsilon_{\kappa,t}, \tag{C.3}$$

with $\varepsilon_{\kappa,t} \equiv \hat{\kappa}_{ss}\varepsilon_{\varkappa,t}$.

C.2 Simplification of the participation constraint

The participation constraint of the foreign lenders is given by

$$\begin{aligned}(1+i_t^*)\,B_t(j) &= E_t\left[\left(1-F^*\left(\bar{\omega}_{t+1}(j)\right)\right)R_{B,t}(j)\,B_t(j)\right]\\ &\quad+(1-\mu)\,E_t\left[\int_0^{\bar{\omega}_{t+1}(j)}\omega^* dF^*(\omega^*)\,R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}^*Z_t(j)\right].\end{aligned}$$

Recall that

$$F^*(\bar{\omega}) \equiv \Pr\left(\omega^* \leq \bar{\omega}\right),$$

and using the definition of ω^*, as in (3.14),

$$F^*(\bar{\omega}) = \Pr\left(\omega\kappa \leq \bar{\omega}\right) = \Pr\left(\omega \leq \frac{\bar{\omega}}{\kappa}\right) = F\left(\frac{\bar{\omega}}{\kappa}\right). \tag{C.4}$$

Define now

$$G(\bar{\omega}) \equiv \int_0^{\bar{\omega}} \omega dF(\omega), \tag{C.5}$$

and note that the above expression is equivalent to

$$G(\bar{\omega}) = F(\bar{\omega})\,E\left[\omega|\omega < \bar{\omega}\right].$$

It then follows that

$$\begin{aligned}G^*(\bar{\omega}) &= F^*(\bar{\omega})\,E\left[\omega^*|\omega^* < \bar{\omega}\right]\\ &= F\left(\frac{\bar{\omega}}{\kappa}\right)E\left[\omega|\omega \leq \frac{\bar{\omega}}{\kappa}\right]\\ &= \kappa G\left(\frac{\bar{\omega}}{\kappa}\right).\end{aligned} \tag{C.6}$$

Combining the participation constraint with these two results, (C.4) and (C.6), it is possible to write

$$\begin{aligned}(1+i_t^*)\,B_t(j) &= E_t\left[\left(1-F\left(\frac{\bar{\omega}_{t+1}(j)}{\kappa_t}\right)\right)R_{B,t}(j)\,B_t(j)\right]\\ &\quad+(1-\mu)\,E_t\left[\kappa_t G\left(\frac{\bar{\omega}_{t+1}(j)}{\kappa_t}\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}^*Z_t(j)\right].\end{aligned}$$

Using the equation for the default threshold, (3.16) to substitute out $R_{B,t}(j)\,B_t(j)$, and the balance sheet equation, (3.11), to replace $B_t(j)$ by the net worth and purchases of imported input, the participation constraint becomes

$$\begin{aligned}\left(1+i_t^*\right)\left(P_{Z,t}^* Z_t\left(j\right)-\frac{N_t\left(j\right)}{S_t}\right) &= E_t\left[\left(1-F\left(\frac{\bar{\omega}_{t+1}\left(j\right)}{\kappa_t}\right)\right)\bar{\omega}_{t+1}\left(j\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}^* Z_t\left(j\right)\right] \\ &\quad +\left(1-\mu\right)E_t\left[\kappa_t G\left(\frac{\bar{\omega}_{t+1}\left(j\right)}{\kappa_t}\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}^* Z_t\left(j\right)\right],\end{aligned}$$

and reorganize into

$$E_t\left[\Omega\left(\bar{\omega}_{t+1}\left(j\right);\kappa_t\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}^* Z_t\left(j\right)\right]=\left(1+i_t^*\right)\left(P_{Z,t}^* Z_t\left(j\right)-\frac{N_t\left(j\right)}{S_t}\right), \tag{C.7}$$

with

$$\Omega\left(\bar{\omega};\kappa\right) \equiv \kappa\left[\Gamma\left(\frac{\bar{\omega}}{\kappa}\right)-\mu G\left(\frac{\bar{\omega}}{\kappa}\right)\right], \tag{C.8}$$

$$\Gamma\left(\bar{\omega}\right) \equiv \left[1-F\left(\bar{\omega}\right)\right]\bar{\omega}+\int_0^{\bar{\omega}}\omega dF\left(\omega\right). \tag{C.9}$$

C.3 Solving the wholesale firms problem

Firms maximize the discounted sum of cash flows, subject to the participation constraint, (3.17), and the default threshold definition, (3.16), with respect to $Z_t\left(j\right)$, $\bar{\omega}_t\left(j\right)$, $R_{B,t-1}\left(j\right)$ and $N_t\left(j\right)$. But one can solve (3.16) for $\bar{\omega}_t\left(j\right)$

$$\bar{\omega}_t\left(j\right)=\frac{S_t R_{B,t-1}\left(j\right)}{R_{Z,t}S_{t-1}P_{Z,t-1}Z_{t-1}\left(j\right)}\left(P_{Z,t-1}Z_{t-1}\left(j\right)-\frac{N_{t-1}\left(j\right)}{S_{t-1}}\right) \tag{C.10}$$

and eliminate that variable out of the problem. Set $\tilde{\lambda}_t\left(j\right)$ the Lagragian multiplier of the participation constraint of the foreign lenders. The Lagrangian is then

$$\mathcal{L}=E_0\sum_{t=0}^{\infty}\beta^t\Lambda_t\left\{\begin{array}{c}\left[1-\Gamma\left(\bar{\omega}_t\left(j\right)\right)\right]R_{Z,t}S_{t-1}P_{Z,t-1}Z_{t-1}\left(j\right)-N_t\left(j\right)\\ +\tilde{\lambda}_t\left(j\right)E_{t-1}\left[\Omega\left(\bar{\omega}_t\left(j\right);\kappa_{t-1}\right)R_{Z,t}\frac{S_{t-1}}{S_t}P_{Z,t-1}Z_{t-1}\left(j\right)\right]\\ -\tilde{\lambda}_t\left(j\right)\left(1+i_{t-1}^*\right)\left(P_{Z,t-1}Z_{t-1}\left(j\right)-\frac{N_{t-1}\left(j\right)}{S_{t-1}}\right)\end{array}\right\}$$

where $\bar{\omega}_t\left(j\right)$ should be read as $\frac{S_t R_{B,t-1}(j)}{R_{Z,t}S_{t-1}P_{Z,t-1}Z_{t-1}(j)}\left(P_{Z,t-1}Z_{t-1}\left(j\right)-\frac{N_{t-1}(j)}{S_{t-1}}\right)$ instead (I kept $\bar{\omega}_t\left(j\right)$ just for ease of representation).

The FOC with respect to $Z_t(j)$ yields

$$
\begin{aligned}
0 &= \beta E_t\left[\Lambda_{t+1}\left[1-\Gamma\left(\bar{\omega}_{t+1}(j)\right)\right]R_{Z,t+1}S_tP_{Z,t}\right] \\
&\quad +\tilde{\lambda}_t(j)\,E_t\left[\Omega\left(\bar{\omega}_{t+1}(j);\kappa_t\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P_{Z,t}-\left(1+i_t^*\right)P_{Z,t}\right] \\
&\quad -\beta E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)\frac{S_{t+1}R_{B,t}(j)}{Z_t(j)}\frac{N_t(j)}{S_t}\right]+\tilde{\lambda}_t(j)\,E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\frac{R_{B,t}(j)}{Z_t(j)}\frac{N_t(j)}{S_t}\right].
\end{aligned}
$$

The FOC with respect to $R_{B,t}(j)$ is

$$
\begin{aligned}
0 &= -\beta E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)S_{t+1}\left(P_{Z,t}Z_t(j)-\frac{N_t(j)}{S_t}\right)\right] \\
&\quad +\tilde{\lambda}_t(j)\,E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\left(P_{Z,t}Z_t(j)-\frac{N_t(j)}{S_t}\right)\right],
\end{aligned}
$$

and the FOC with respect to $N_t(j)$

$$
\begin{aligned}
0 &= -\Lambda_t+\tilde{\lambda}_t(j)\frac{\left(1+i_t^*\right)}{S_t} \\
&\quad +\beta E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)S_{t+1}R_{B,t}(j)\frac{N_t(j)}{S_t}\right]-\tilde{\lambda}_t(j)\,E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)R_{B,t}(j)\frac{N_t(j)}{S_t}\right].
\end{aligned}
$$

The first thing to note is that the second FOC can be simplified into

$$
\tilde{\lambda}_t(j)=\frac{\beta E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)S_{t+1}\right]}{E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\right]}
$$

which is an expression that can be used to simplify the other two. The first FOC becomes then

$$
\begin{aligned}
0 &= E_t\left[\Lambda_{t+1}\left[1-\Gamma\left(\bar{\omega}_{t+1}(j)\right)\right]R_{Z,t+1}\right] \\
&\quad +\frac{E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)\frac{S_{t+1}}{S_t}\right]}{E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\right]}E_t\left[\Omega\left(\bar{\omega}_{t+1}(j);\kappa_t\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}-\left(1+i_t^*\right)\right],
\end{aligned}
$$

and

$$
\Lambda_t=\frac{\beta E_t\left[\Lambda_{t+1}\Gamma'\left(\bar{\omega}_{t+1}(j)\right)\frac{S_{t+1}}{S_t}\right]}{E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\right]}\left(1+i_t^*\right).
$$

Define now

$$
\lambda_{t+1}(j)=\frac{\Gamma'\left(\bar{\omega}_{t+1}(j)\right)}{E_t\left[\Omega'\left(\bar{\omega}_{t+1}(j);\kappa_t\right)\right]}, \tag{C.11}
$$

and use the Euler equation for consumption, from the households problem to rewrite the last FOC as

$$\left(1+i_t\right) E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right]=\left(1+i_t^*\right) E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \frac{S_{t+1}}{S_t} \lambda_{t+1}(j)\right] . \tag{C.12}$$

which is the equivalent to a UIP relation, with the difference that the risk premium term depends on each firm j.

The remainder FOC can now be simplified into risk premium relationship for the firms,

$$E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \Upsilon_{t+1}(j) R_{Z, t+1}\right]=\left(1+i_t^*\right) E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \frac{S_{t+1}}{S_t} \lambda_{t+1}(j)\right], \tag{C.13}$$

with

$$\Upsilon_{t+1}(j) \equiv\left[1-\Gamma\left(\bar{\omega}_{t+1}(j)\right)\right]+\frac{E_t\left[\lambda_{t+1}(j) C_{t+1}^{-\sigma} S_{t+1} / P_{t+1}\right]}{C_{t+1}^{-\sigma} S_{t+1} / P_{t+1}} \Omega\left(\bar{\omega}_{t+1}(j) ; \kappa_t\right) . \tag{C.14}$$

D Log-linearized equations

We can summarize the log-linearized equations as:[25]

$$\hat{r}_t = \sigma\left(E_t\hat{C}_{t+1} - \hat{C}_t\right) \tag{D.1}$$

$$\hat{r}_t = \hat{\imath}_t - E_t\hat{\pi}_{t+1} \tag{D.2}$$

$$\hat{w}_t = \psi\hat{L}_t + \sigma\hat{C}_t \tag{D.3}$$

$$\hat{C}_{H,t} = \hat{C}_t - \nu\hat{p}_{H,t} \tag{D.4}$$

$$\hat{C}_{F,t} = \hat{C}_t - \nu\left(\hat{s}_t + \hat{P}^*_{F,t} - \hat{P}^*_t\right) \tag{D.5}$$

$$\hat{C}^*_{H,t} = \hat{C}^*_t - \nu^*\left(\hat{p}_{H,t} - \hat{s}_t\right) \tag{D.6}$$

$$\hat{Y}_t = \zeta_{Y,C_H}\hat{C}_{H,t} + \left(1 - \zeta_{Y,C_H}\right)\hat{C}^*_{H,t} \tag{D.7}$$

$$\hat{p}_{H,t} = -\bar{\gamma}\left(\hat{s}_t + \hat{P}^*_{F,t} - \hat{P}^*_t\right) \tag{D.8}$$

$$\hat{Y}_t = \hat{A}_t + \zeta_{Y,L}\hat{L}_t + \left(1 - \zeta_{Y,L}\right)\hat{Z}_{t-1} \tag{D.9}$$

$$\hat{L}_t = (\phi - 1)\hat{A}_t + \hat{Y}_t - \phi\left(\hat{w}_t - \hat{p}_{w,t}\right) \tag{D.10}$$

$$b\hat{B}_t + (1-b)\left(\hat{n}_t - \hat{s}_t + \hat{P}^*_t\right) = \hat{P}^*_{Z,t} + \hat{Z}_t \tag{D.11}$$

$$\hat{b}_t = \hat{B}_t - \hat{P}^*_{Z,t} - \hat{Z}_t \tag{D.12}$$

$$\hat{r}_{Z,t+1} = \frac{\phi - 1}{\phi}\hat{A}_{t+1} - \frac{1}{\phi}\left(\hat{Z}_t - \hat{Y}_{t+1}\right) + \hat{p}_{w,t+1} - \hat{s}_t - \hat{P}^*_{Z,t} + \hat{P}^*_t \tag{D.13}$$

$$\zeta_{\Omega,\bar{\omega}}\hat{\omega}_{t+1} + \left(1 - \zeta_{\Omega,\bar{\omega}}\right)\hat{\kappa}_t = \hat{\imath}^*_t - \hat{r}_{Z,t+1} + \hat{s}_{t+1} - \hat{s}_t - \left(\hat{P}^*_{t+1} - \hat{P}^*_t\right) + b_t \tag{D.14}$$

$$E_t\hat{r}_{Z,t+1} - \left(\hat{\imath}^*_t + E_t\hat{s}_{t+1} - \hat{s}_t - E_t\hat{P}^*_{t+1} + \hat{P}^*_t\right) = \left(\zeta_{\lambda,\bar{\omega}} - \zeta_{\Upsilon,\bar{\omega}}\right)E_t\hat{\omega}_{t+1} + \left(\zeta_{\lambda,\kappa} - \zeta_{\Upsilon,\kappa}\right)\hat{\kappa}_t \tag{D.15}$$

$$\hat{\imath}_t - E_t\pi_{t+1} = \hat{\imath}^*_t + E_t\hat{s}_{t+1} - \hat{s}_t - \left(E_t\hat{P}^*_{t+1} - \hat{P}^*_t\right) + \left(\zeta_{\lambda,\bar{\omega}}E_t\hat{\omega}_{t+1} + \zeta_{\lambda,\kappa}\hat{\kappa}_t\right) \tag{D.16}$$

$$\hat{R}_{B,t+1} = \hat{\omega}_{t+1} + \hat{r}_{Z,t+1} + \hat{s}_t - \hat{s}_{t+1} + \hat{P}^*_{t+1} - \hat{P}^*_t - \hat{b}_t \tag{D.17}$$

$$\pi_t = \beta E_t\pi_{t+1} + \beta E_t\hat{p}_{H,t+1} - \frac{1 + \alpha_p^2\beta}{\alpha_p}\hat{p}_{H,t} + \hat{p}_{H,t-1} + \frac{(1-\alpha_p)(1-\alpha_p\beta)}{\alpha_p}\hat{p}_{w,t} \tag{D.18}$$

[25]Notice that $\zeta_{f,x}$ is notation for the elasticity of function f with respect to x in steady state.

$$
\begin{aligned}
0 \quad = \quad & p_H C_H^* \left(\hat{p}_{H,t} + \hat{C}_{H,t}^*\right) - s\frac{P_F^*}{P^*} C_F \left(\hat{s}_t + \hat{P}_{F,t}^* - \hat{P}_t^* + \hat{C}_{F,t}\right) - s\frac{P_Z^*}{P^*} Z \left(\hat{s}_t + \hat{P}_{Z,t}^* - \hat{P}_t^* + \hat{Z}_t\right) \\
& -\Gamma\left(1 + r_Z\right) s\frac{P_Z^*}{P^*} Z \left(\zeta_{\Gamma,\bar{\omega}} \hat{\omega}_t + \hat{r}_{Z,t} + \hat{s}_{t-1} + \hat{P}_{Z,t-1}^* - \hat{P}_{t-1}^* + \hat{Z}_{t-1}\right) \\
& +s\frac{B}{P^*}\left(\hat{s}_t - \hat{P}_t^* + \hat{B}_t\right) \qquad \text{(D.19)}
\end{aligned}
$$

$$
\hat{\imath}_t = \phi_{CPI}\hat{\pi}_t + \phi_{DPI}\left(\hat{p}_{H,t} - \hat{p}_{H,t-1} + \hat{\pi}_t\right) + \frac{\phi_Y}{4}\hat{Y}_t + \phi_S\left(\hat{S}_t - \hat{S}_{t-1}\right) \qquad \text{(D.20)}
$$

where $\hat{S}_t \equiv \log S_t$.

E Impulse response functions

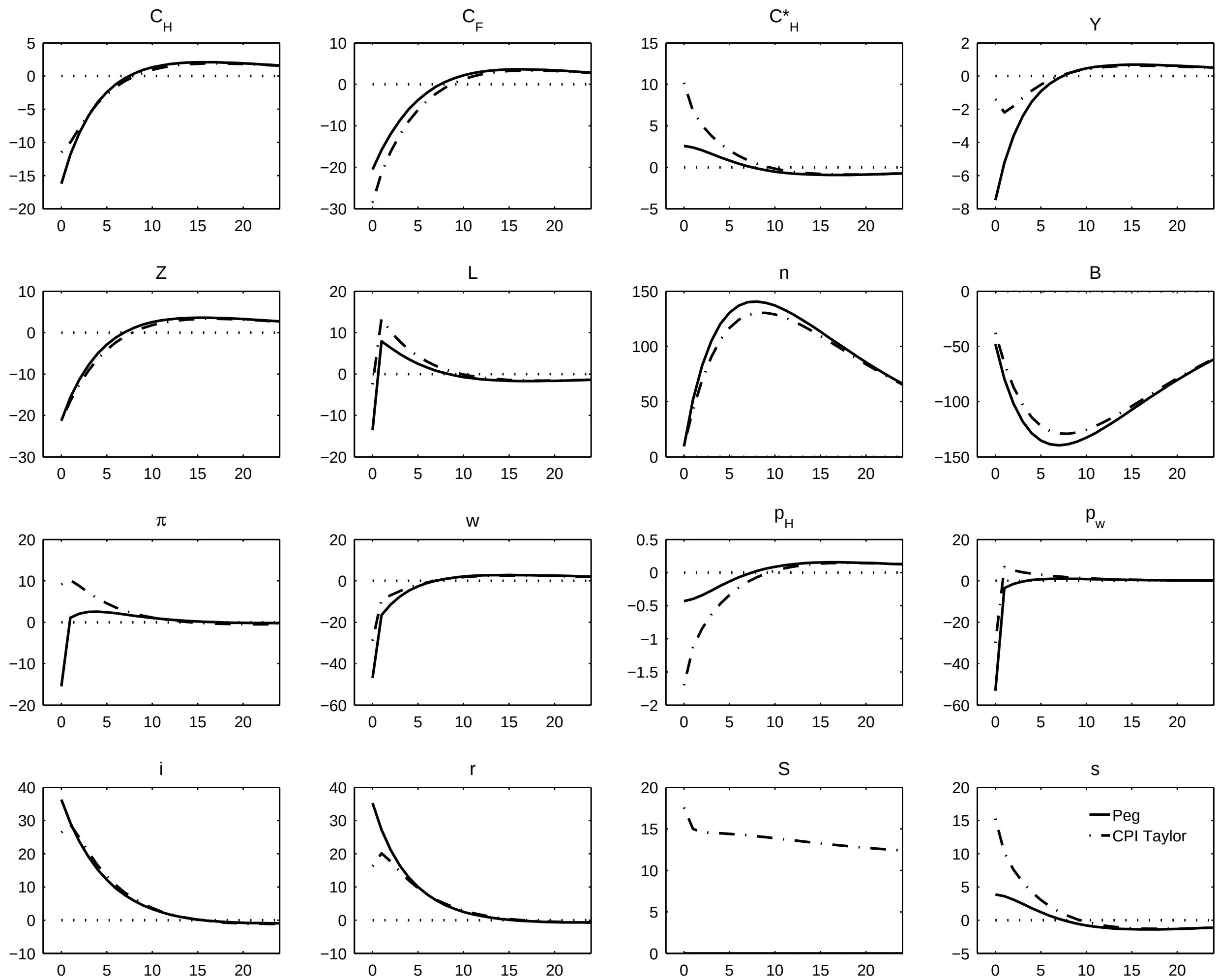

Figure 4: Responses to a sudden stop shock under a peg and a CPI Taylor rule

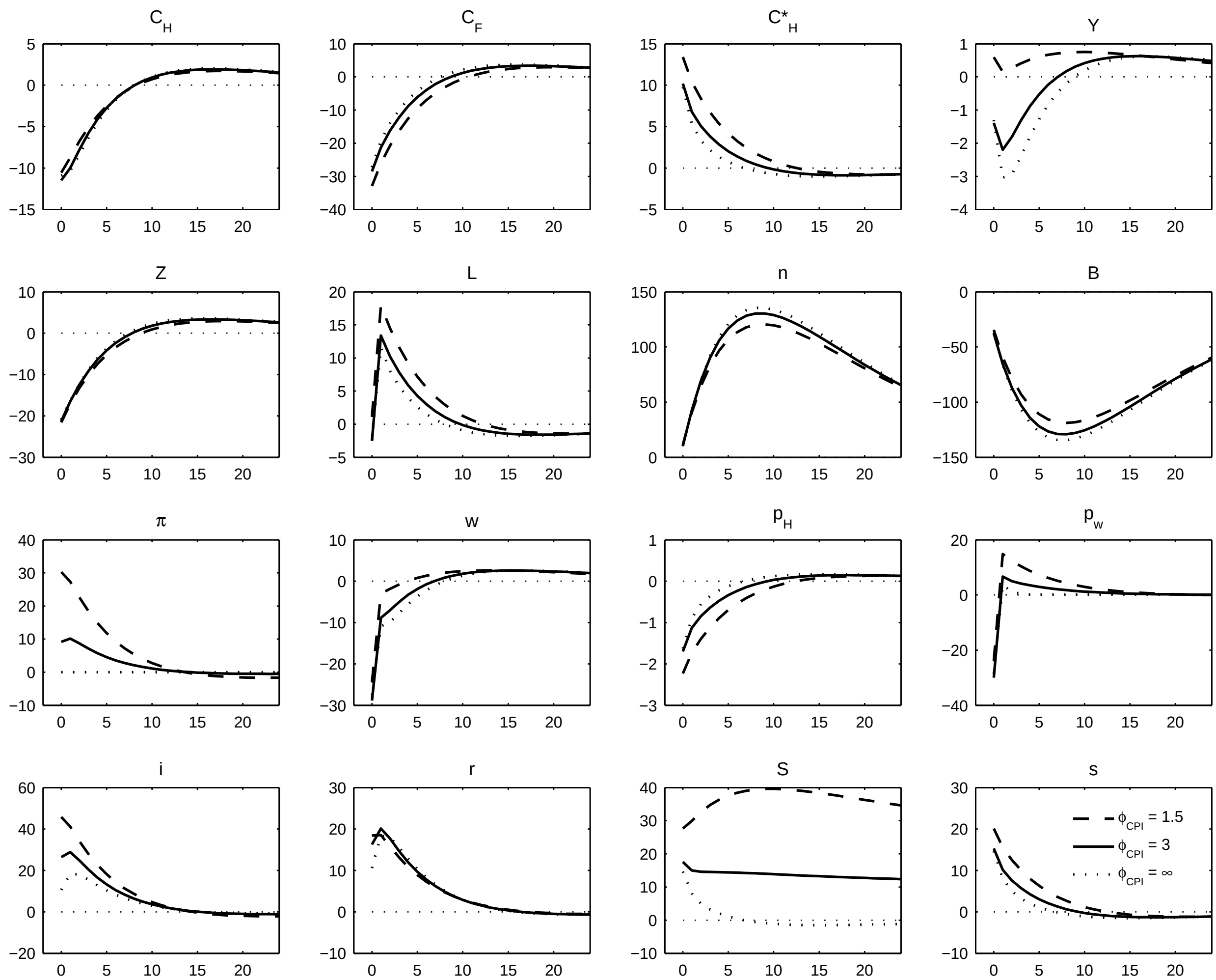

Figure 5: Responses to a sudden stop under alternative levels of interest rate reaction to CPI inflation

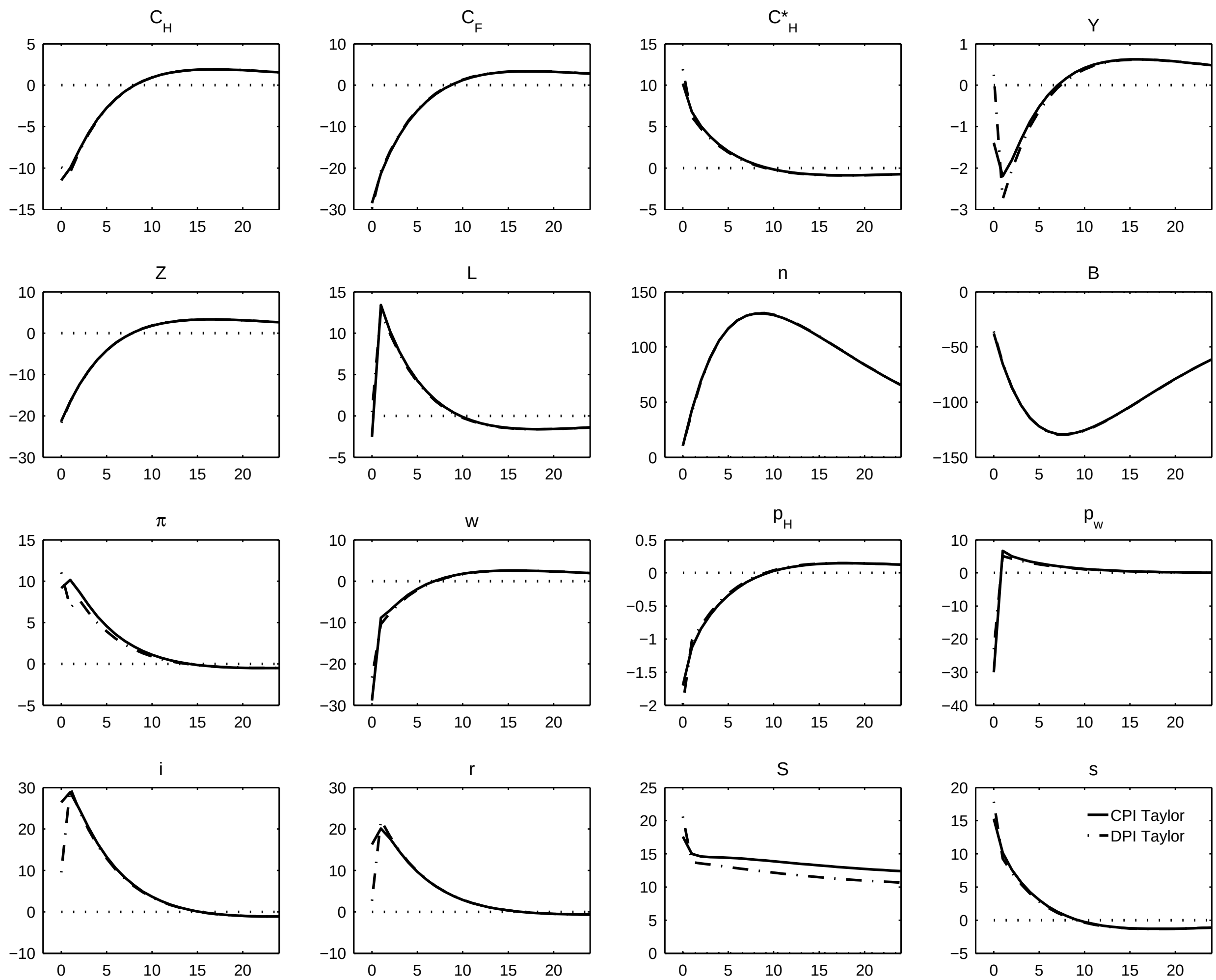

Figure 6: Responses to a sudden stop under CPI and DPI Taylor rules

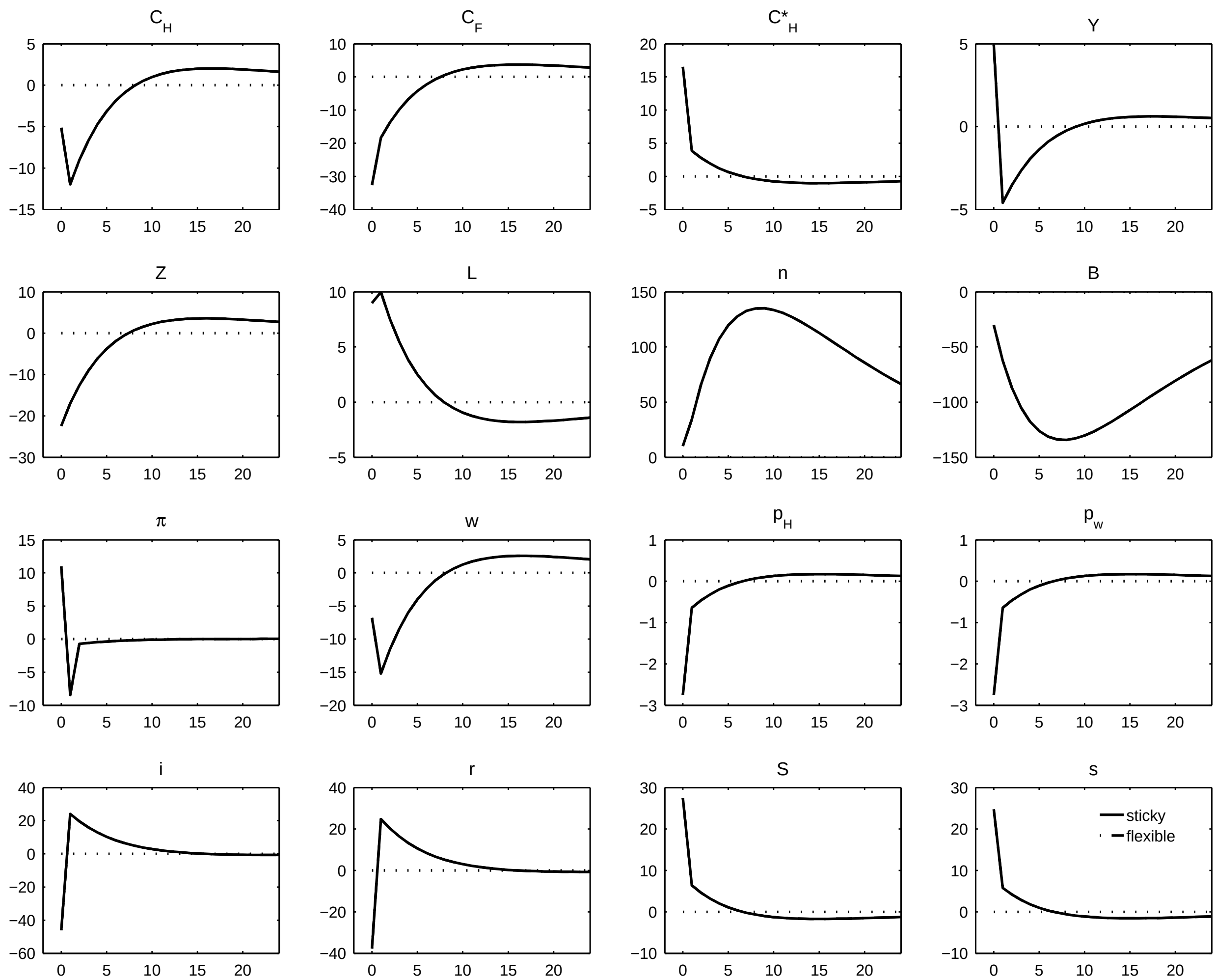

Figure 7: Responses to a sudden stop under DPI stabilization, with sticky and flexible prices

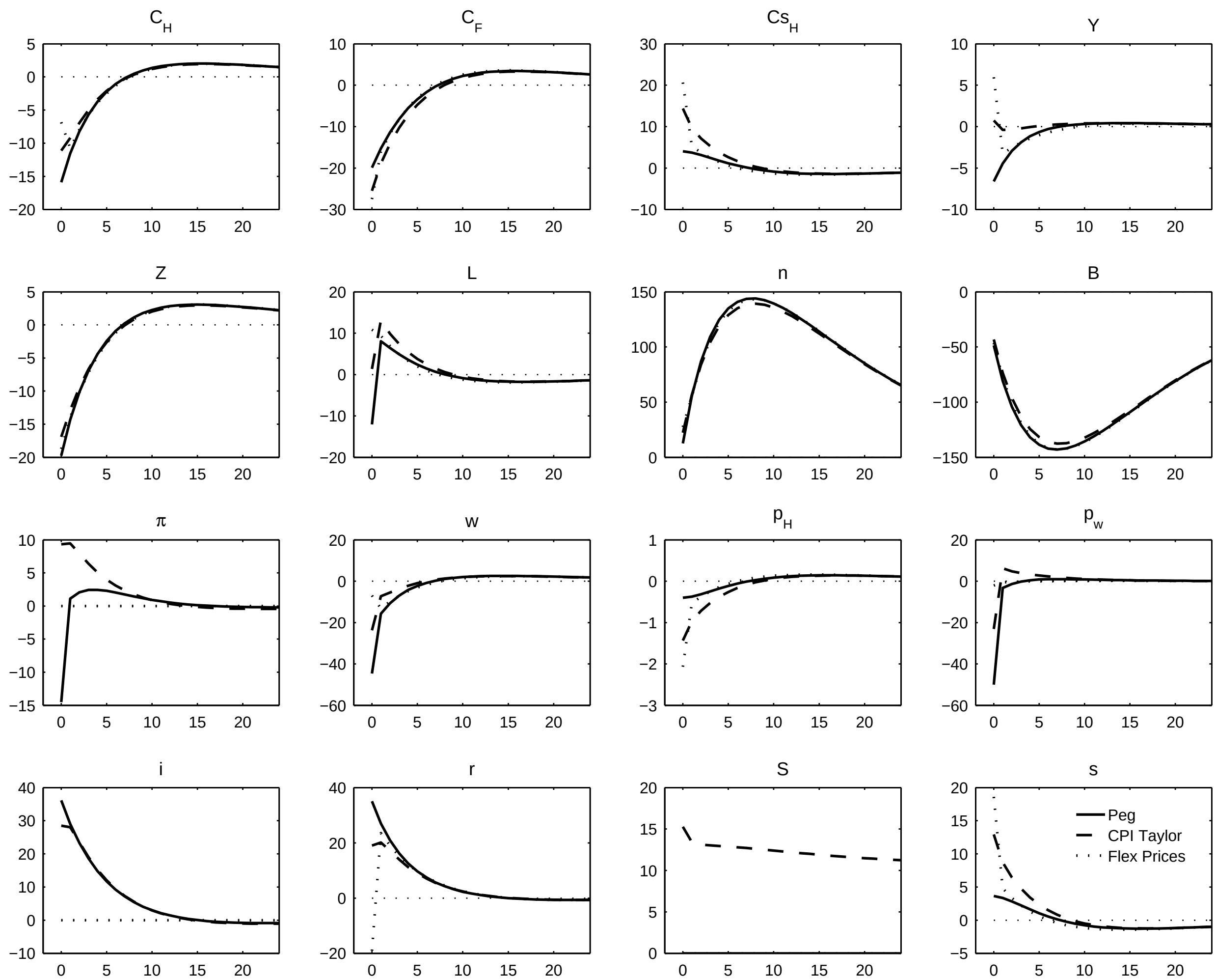

Figure 8: Responses to a sudden stop with more elastic foreign demand ($\nu^* = 1$)

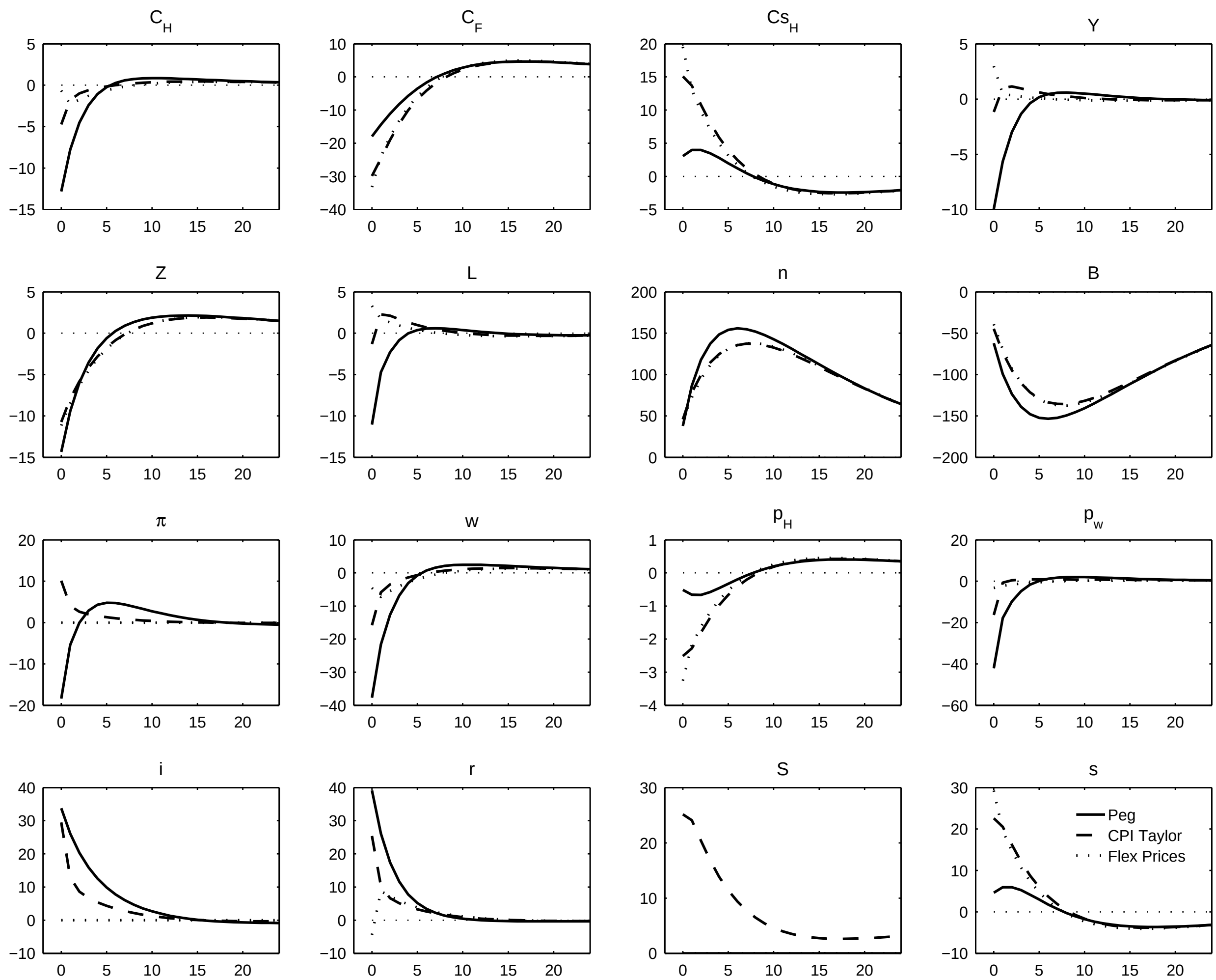

Figure 9: Responses to a sudden stop with high complementarity of production factors ($\phi = 0.25$)

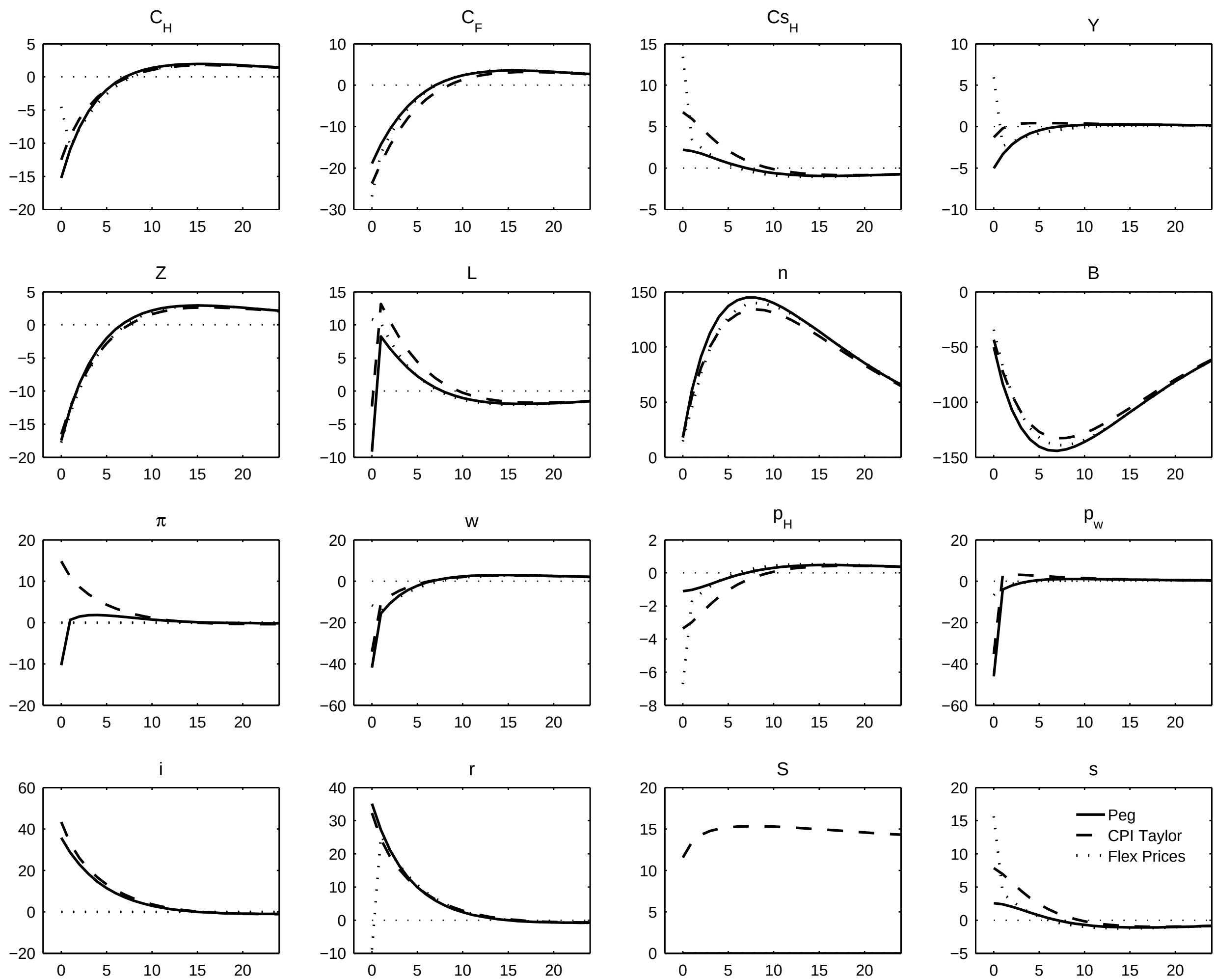

Figure 10: Responses to a sudden stop in a more open economy ($\gamma = 0.7$)

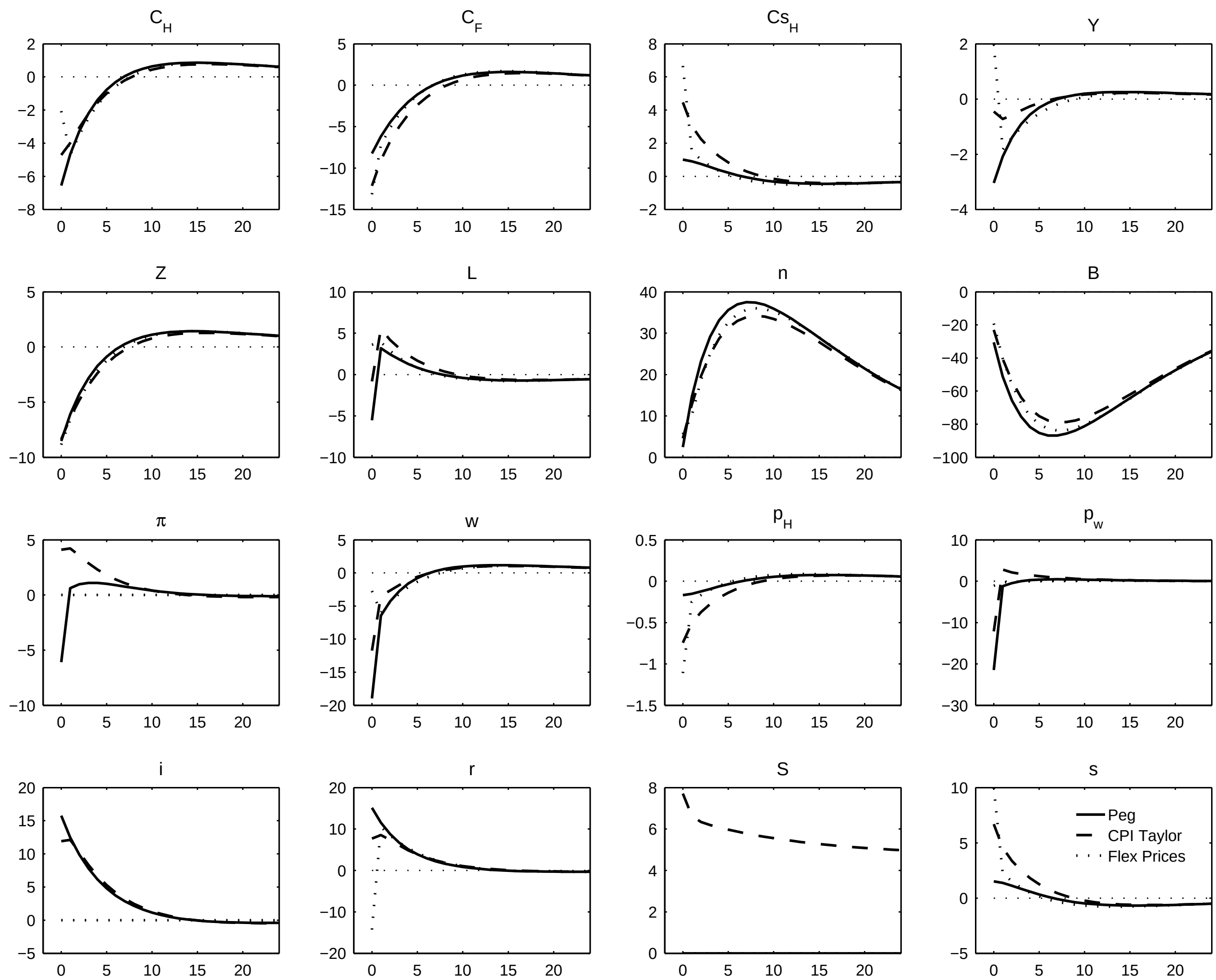

Figure 11: Responses to a sudden stop under milder financial frictions ($b = 0.3$ and spread of firms debt at 3%)