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Abstract

This paper proposes a model to investigate the effects of monetary policy in an emerging market economy that experiences a sudden stop of capital inflows. The model features credit frictions, debt denominated in foreign currency, imported inputs, and households that have access to the international capital market only indirectly, through their ownership of leveraged firms. The sudden stop is modeled as a change in the perceptions of foreign lenders that brings about an increase in the cost of borrowing. I show that the higher the elasticity of foreign demand, the lower the contraction in output—leading, at the extreme, to the possibility of an expansion, depending on policy. A second result is that the recession is most severe in a fixed exchange rate regime. Taylor rules that react to inflation and output are more stabilizing. A comparison of alternative rules shows that low commitment to inflation stabilization allows for less contraction in output and even expansion but at the cost of much stronger contraction in capital inflows and higher interest rates. Credibility is also shown to have an important role, with low credibility and the risk of loose policy implying increased trade-offs, stronger contraction of the economy, and higher interest rates.

Key words: sudden stops, monetary policy, emerging markets, financial crises

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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. And they have significant implications for the conduct of policy, as Fraga, Goldfajn, and Minella (2003) point out: "these shocks significantly affect the exchange rate, and consequently the inflation rate, leading to higher interest rates to curb the inflationary pressures."

In order to understand the nature of these pressures and how they interplay with monetary policy, this paper proposes a framework for emerging markets and that allows for an extensive evaluation of monetary policies. The model is a modified version of the financial accelerator model proposed by Bernanke, Gertler, and Gilchrist (1999). Therefore, it captures one of the main features of sudden stops, which is the presence of balance sheet effects (see for example Krugman (1999) and Dornbusch (2001)). 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.

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

[1] This helps in explaining why authorities in such countries tend to develop 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.

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, 2006), Mendoza and Smith (2003) and Christiano, Gust, and Roldos (2004). These describe the events as quantity restrictions. Instead, the financial accelerator model operates through the cost of credit. It is possible to reconcile the two approaches because they are the two sides of the same problem. 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 emerging markets, when the access to the international capital market (ICM) is curtailed in some way there is usually some cascading effect, as described in Caballero (2001). First, the biggest companies face higher cost of borrowing. Smaller ones with prior access to the ICM are cut out and need to borrow more in the domestic capital market. These will then increase the demand for funds in the latter, driving up the cost of borrowing in the economy. This then leads to a shock to the households and increased costs to other even smaller firms (without prior access to the ICM) which might get into bankruptcy. The exact elements of this cascading effect are not in the model presented but it's key mechanism. That happens because, unlike in most versions of the financial accelerator, this paper considers households restricted from the ICM but holding producing firms which themselves obtain some financing in the ICM. When firms access to the ICM is under pressure this will translate into a change in their dividend policy, affecting the households. This is then a simple and effective way of describing indirect cascading effects without the need to model a domestic capital market with all the added complexity. The country's uncovered interest parity is then the result of this indirect access to the ICM, featuring an endogenous risk premium.

In assuming that there are firms, not capitalists, as producers and borrowers, there is an additional advantage for monetary policy analysis. It provides a simpler way to evaluate optimal monetary policy. In fact the households' utility becomes the logical welfare measure, while in alternative frameworks, 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). This is just a reduced form increase in the risk premium of the country. The shock that I propose, instead, is intended to be more primitive, embedded in the asymmetric information problem between borrowers and lenders as is more natural and can lead to significant extensions.

After describing the setup, the paper makes an explicit description of the transmission mechanism of the shock, noting that there are three main effects. First, a cost push shock, through both the cost of financing and purchasing the imported input. Second, a contraction in domestic demand, through the indirect channel, lower real wages and real depreciation. Third, an expansion of the foreign demand for the domestic goods. The first is the effect usually highlighted in the literature, and what triggers all the events. But the latter two cannot be ignored. Indeed, the demand side of the economy plays a relevant role in determining output in this economy. Indeed this leads to one first important result of the paper, that the lower the foreign demand price elasticity for the domestic good the stronger the contraction in output and if high enough an elasticity is considered the outcome can be an increase in output. This reconciles the model with Chari, Kehoe, and McGrattan (2005), who considers infinite elasticity.

Moreover, the foreign demand effect, also helps in explaining why in this model the currency mismatch does not lead to a worse outcome in the event of significant depreciation of the currency. On the one hand the burden of the debt increases, but on the other the revenues of the firms are fueled by the foreign demand. Therefore the currency mismatch is not too big. If non-tradables were considered then the firms in that sector would be much more hard hit than those in the tradables sector.

The paper then looks into the interplay between the transmission mechanism and monetary policy. One first conclusion is that the recession is most acute under a fixed exchange rate regime. Taylor rules, in which the interest rate reacts to inflation and output, 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). 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.[2]

Another policy experiment is to consider different degrees of control of inflation in the Taylor rules, with the result that the tighter the control in inflation the more significant is the contraction in output, much as expected. More interestingly, if the grip on inflation is loose enough it is possible to obtain an output expansion. This same experiment also shows that, the interest rate, including the real interest rate, is lower the tighter the control of inflation, which highlights the role of commitment of policy to stabilize the economy and its strong impact on expectations, precisely as suggested by Fraga et al. (2003). In this case if slack is detected the real exchange rate will react and eventually the increased cost of borrowing and purchasing imported goods feeds back into higher prices and interest rates. Thus it might be better to debate the tightness of monetary policy, instead of whether interest rates should increase or decrease, as some previous studies have analyzed (e.g. Aghion, Bacchetta, and Banerjee (2000), Christiano et al. (2004) and Braggion, Christiano, and Roldos (2005)).

Following on this lead on the importance of commitment, the credibility of the announced policy is studied as well as its impact in the economy. The scenario considered is that of a peg in which agents foresee a probability of abandonment in favor of a Taylor rule. The results show that if there is abandonment after one period the economy moves from a response similar to that under a credible peg to quickly converge to a response under a Taylor rule as soon as it is abandoned, much like in Gertler et al. (2003). It is however noticeable that in that first period, the interest rates are higher and output and debt lower than in any of the other two regimes. This implies that lack of credibility does take its toll in the economy. Moreover, the real exchange rate and foreign demand never converge in full to the responses under a Taylor rule, implying that the fact that the economy started under a peg did have some persistent effects that are not really eliminated by simply switching to the Taylor rule.

In a scenario in which the peg is never abandoned (at least in the near future after a sudden stop) and still assuming that it is not fully credible like in the previous experiment then we can focus on the effects of credibility alone. If the alternative rule (expected to be followed if the peg is abandoned) is a reasonable one, like in the benchmark Taylor rule, then the impact in the real side of the economy is not significant even though it implies higher interest rates and slightly stronger contraction of domestic demand and output. If however the alternative policy is a slack one then the effects are much more noticeable, with

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

stronger contraction of output and domestic demand (besides increased interest rates). Lack of credibility does in any case increase the trade-offs that the monetary authorities face, much like in Céspedes and Soto (2005) describe.

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,[3] as it was possible to obtain quarterly data on key macroeconomic variables (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 is 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). 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.[4] The financial 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, showing that the full extent of the capital account reversal is not attained in the impact period but, instead, one quarter

[3]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.

[4]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 table.

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. 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 and 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 even stronger than that of output. 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. The increase in exports and contraction in domestic consumption and imports seem to explain the difference in the behavior of output and consumption: investment and domestic demand contract while foreign demand expand expands, something that the model here presented will explain in detail.

It is also important to understand what is the typical response of the monetary authorities. 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%.[5]

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

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

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 rate increased only a few percentage points from pre-crises levels, while 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.[6]

[6] 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.

3.1 Households

The representative household derives 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 consumption and L_t to labor, and

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

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 R_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 from wholesalers, $\Pi_{w,t}$, profits from the retailers, $\Pi_{r,t}$,[7] and returns on domestic asset holdings:

$$P_t C_t + D_t \leq R_{t-1} D_{t-1} + W_t L_t + \Pi_{w,t} + \Pi_{r,t}. \tag{3.2}$$

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

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

The households are restricted from accessing the international capital markets and, therefore, cannot borrow or lend to foreigners. This assumption is backed by Table 2, which shows that in typical emerging markets households are 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. This is one form of the cascading effects from the international capital markets into the domestic economy, as described in Caballero (2001).

The representative household maximizes (3.1) subject to (3.2). The resulting Euler equa-

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

tion for consumption is

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

with $\Pi_t \equiv P_t / P_{t-1}$ denoting gross inflation. Labor supply is described as

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

with W_t the nominal wage.

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:

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

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, S_t is the nominal exchange rate and P_t^* is the foreign CPI.

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.[8] 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, $\log(\omega_{t+1}(j)) \sim N\left(-\frac{1}{2}\sigma_\omega^2, \sigma_\omega^2\right)$.

In 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. The inclusion of imported inputs is considered to be very important for emerging markets, as noted by Fraga et al. (2003) and Braggion et al. (2005). Table 3 extends the information presented by those authors. 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. McCallum and Nelson (1999) already emphasized the role of imported inputs 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.

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.

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

$$R_{Z,t+1}(j) \equiv \frac{P_{w,t+1} Y_Z\left(L_{t+1}(j), Z_t(j)\right)}{S_t P_{Z,t}^*}, \tag{3.11}$$

where $Y_Z\left(L_{t+1}(j), Z_t(j)\right)$ is the marginal product of imported input. Given the current

[8] The convention is that time subscript t denotes 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 $t+1$.

assumptions for the production function, it is possible to show that we can write

$$R_{Z,t+1}(j) = \omega_{t+1}(j) R_{Z,t+1}, \tag{3.12}$$

where $R_{Z,t+1}$ is the aggregate component, common to all firms.

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

$$S_t B_t(j) = S_t P^*_{Z,t} Z_t(j) - N_t(j), \tag{3.13}$$

where $P^*_{Z,t}$ is the price in foreign currency of the imported inputs. The assumption that liabilities are denominated in foreign currency is typical in the emerging market literature and reflects the "original sin". Table 4 shows that this is not an unrealistic assumption.[9]

Foreigners, though, do not necessarily have a good knowledge of the distribution of $\omega_{t+1}(j)$ and that is where the sudden stop is originated, in this model. The shock is assumed to arise from misperceptions on the side of foreign investors. Under normal circumstances they have an accurate idea of the true distribution. However, in some periods, which are labelled 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 (2005a) 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

[9] Whether the currency composition of the debt is optimal is beyond the scope of this paper.

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 (2005a). 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 $\mathcal{S}_t = \mathcal{N}$. It shall be assumed that $\mathcal{S}_t = \mathcal{N}$ is the state of the world before any shock occurs. A change to $\mathcal{S}_t = \mathcal{U}$ is unexpected by the agents. Once the sudden stop settles in the economy there is a probability of exiting a sudden stop given by $\Pr\left[\mathcal{S}_{t+1} = \mathcal{N} | \mathcal{S}_t = \mathcal{U}\right] = \delta_n$. Once the economy returns to its normal state it is assumed that a shift back to $\mathcal{S}_t = \mathcal{U}$ cannot occur and therefore this is a one time sudden stop.[10]

The risk free opportunity cost for the foreigners is the international interest rate, R_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. The foreign lenders are risk neutral (after the knightian uncertainty is sorted out). Following Bernanke and Gertler (1989), the problem is set as one of "costly state verification." This 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. A standard debt contract is assumed, implying that the interest rate is not state contingent but the default threshold is (only when firms cannot fulfill their obligations will they default). This, however, is not the optimal contract, which would allow for both of these to be state contingent. The standard debt contract assumption

[10] This structure is assumed purposefully to simplify the analysis at this stage, leaving extensions of the arrival and exit of the sudden stop for later research.

follows from the fact that most observed financing contracts are shaped in this fashion.[11]

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,

$$\bar{\omega}_{t+1}(j)\, R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j) = R_{B,t}(j)\, B_t(j)\,, \tag{3.15}$$

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

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

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[12]

$$E_t\left[\Omega\left(\bar{\omega}_{t+1}(j)\,;\kappa_t\right)R_{Z,t+1}\frac{S_t}{S_{t+1}}P^*_{Z,t}Z_t(j)\right] = R^*_tB_t(j)\,, \tag{3.16}$$

with

$$\Omega(\bar{\omega};\kappa) \quad \equiv \quad \kappa\left[\Gamma\left(\frac{\bar{\omega}}{\kappa}\right) - \mu G\left(\frac{\bar{\omega}}{\kappa}\right)\right], \tag{3.17}$$

$$\Gamma(\bar{\omega}) \quad \equiv \quad \left[1-F(\bar{\omega})\right]\bar{\omega} + \int_0^{\bar{\omega}} \omega dF(\omega)\,, \tag{3.18}$$

$$G(\bar{\omega}) \quad \equiv \quad \int_0^{\bar{\omega}} \omega dF(\omega)\,, \tag{3.19}$$

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

[11] 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.

[12] For details on this simplification, please consult the appendix C.

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

$$\Pi_{w,t}(j) \equiv P_{w,t} Y(L_t(j), Z_{t-1}(j)) - W_t L_t(j) - S_t R_{B,t}(j) B_{t-1}(j) - N_t(j).$$

Using the balance sheet equation, (3.13), and the assumption of constant returns to scale,[13] the above equation can be expressed as

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

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. It is assumed 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

$$E_{t-1}\Pi_{w,t}(j) = E_{t-1}\left\{ \left[1 - \Gamma(\bar{\omega}_t(j))\right] R_{Z,t} S_{t-1} P^*_{Z,t-1} Z_{t-1}(j) - N_t(j) \right\}. \tag{3.20}$$

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, (3.16), and the default threshold definition, (3.15), 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 D. Here I present only the simplified results.

Define now a measure of the firm's leverage, $b_t(j) \equiv B_t(j)/P^*_{Z,t} Z_t(j)$. The participation constraint and the default threshold together 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 inde-

[13] With constant returns to scale we can write

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

pendent 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 that 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 $\Gamma\left(\bar{\omega}_t\right)$ 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 $\mu G\left(\bar{\omega}\right)$ is the fraction of the operational profits that is then used by the foreigners to pay for the auditing costs. Therefore $\Omega\left(\bar{\omega}_{t+1};\kappa_t\right)$ 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

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

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.

The aggregate UIP relationship is given by

$$R_t E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] = R^*_t E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}\right], \tag{3.22}$$

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. The risk premium term is given, in equilibrium, by

$$\lambda_t = \frac{\Gamma'\left(\bar{\omega}_t\right)}{E_{t-1}\left[\Omega'\left(\bar{\omega}_t;\kappa_{t-1}\right)\right]}, \tag{3.23}$$

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,

$$E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\left[1-\Gamma\left(\bar{\omega}_{t+1}\right)\right]R_{Z,t+1}\right]=\left(1-b_t\right)R_t^{*}E_t\left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\frac{S_{t+1}}{S_t}\lambda_{t+1}\right]. \tag{3.24}$$

The risk premium of the firms return on investment is different from the risk premium for the households, with the wedge being composed of two parts: only part of the investment is financed with domestic resources, $1-b_t$; and only part of those returns will be returned to the households, $1-\Gamma\left(\bar{\omega}_{t+1}\right)$.

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 $P_{H,t}\left(j\right)$ in both markets. These firms face price stickiness a la Calvo, i.e. with probability $\left(1-\alpha_p\right)$ 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,

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

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

$$Y_t\left(j\right)=Y_t\left(\frac{P_{H,t}\left(j\right)}{P_{H,t}}\right)^{-\eta}. \tag{3.25}$$

In equilibrium, the market must clear,

$$Y_t=C_{H,t}+C_{H,t}^{*}, \tag{3.26}$$

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,

$$C^*_{H,t} = \gamma^* \left(\frac{P_{H,t}}{S_t P^*_t}\right)^{-\nu^*} C^*_t, \tag{3.27}$$

where P^*_t is the exogenous foreign price level, C^*_t is the exogenous foreign aggregate consumption level and ν^* the foreign demand price elasticity (this parameter turns out to be crucial for the dynamics of the economy in response to a sudden stop, as discussed later).

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

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

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,

$$P^s_{H,t} = \frac{\eta}{\eta - 1} \frac{E_t \sum_{\tau=0}^{\infty} (\alpha_p \beta)^\tau \frac{C^{-\sigma}_{t+\tau}}{P_{t+\tau}} Y_{t+\tau} P^\eta_{H,t+\tau} P_{w,t+\tau}}{E_t \sum_{\tau=0}^{\infty} (\alpha_p \beta)^\tau \frac{C^{-\sigma}_{t+\tau}}{P_{t+\tau}} Y_{t+\tau} P^\eta_{H,t+\tau}}, \tag{3.28}$$

and the aggregate domestic price index is given by

$$P_{H,t} = \left[(1-\alpha_p)\left(P^s_{H,t}\right)^{1-\eta} + \alpha_p \left(P_{H,t-1}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}. \tag{3.29}$$

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 (3.21), 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:

$$0 = P_{H,t} C^*_{H,t} - \left(S_t P^*_{F,t} C_{F,t} + S_t P^*_{Z,t} Z_t\right) - \Gamma(\bar{\omega}_t) R_{Z,t} S_{t-1} P^*_{Z,t-1} Z_{t-1} + S_t B_t, \tag{3.30}$$

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. As presented above, the service of the debt is not just the simple $\left(R^*_{t-1}-1\right)S_tB_{t-1}$ 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 (Taylor) rules, all of which can be presented in terms of the following interest rate rule:

$$\frac{R_t}{R} = \left(\Pi_t\right)^{\phi_\pi}\left(\frac{Y_t}{Y}\right)^{\frac{\phi_y}{4}}\left(\frac{P_{H,t}}{P_{H,t-1}}\right)^{\phi_{DPI}}\left(\frac{S_t}{S_{t-1}}\right)^{\phi_s}, \tag{3.31}$$

where the 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 $\phi_\pi = 2$ and $\phi_y = 0.75$ (here considered the benchmark Taylor rule). These are relatively reasonable parameter values and serve here the purpose of illustrating the behavior of the economy. Alternative degrees of inflation reaction are also tested, namely $\phi_\pi = 1.1$ (to illustrate a very slack control of inflation) and $\phi_\pi \to \infty$ (for full inflation stabilization).

Two alternative rules are also considered. First, consider DPI inflation instead of CPI inflation ($\phi_\pi = 0$ and $\phi_{DPI} = 2$). Second, the rule is augmented with reaction to the nominal exchange rate depreciation, which will make it an intermediate case between the peg and the original rule ($\phi_s = 0.5$ and $\phi_s = 2$).

Finally, two additional cases are considered regarding the peg. The first one is a situation in which the authorities start by imposing a peg but there is a perceived probability of abandonment (δ_a) and indeed after one period the policy is switched to the benchmark Taylor rule. The second setting is that in which the peg is not credible, like in the previous, but it is actually never abandoned. This allows one to discuss the impact of policy credibility in the responses of the economy. Table 10 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. Normalize all domestic prices, as well as the net worth, by the domestic CPI: $p_{H,t} \equiv P_{H,t}/P_t$, $p_{w,t} \equiv P_{w,t}/P_t$, $w_t \equiv W_t/P_t$ and $n_t \equiv N_t/P_t$. Further define the real exchange rate, $s_t \equiv S_t P_t^*/P_t$, and the real return on imported inputs, $R_{Z,t}^r \equiv R_{Z,t}/\Pi_t$. It is also a relevant variable for analysis the real interest rate, R_t^r. Foreign prices are also normalized relative to foreign CPI. Therefore we get foreign inflation, $\Pi_t^* \equiv P_t^*/P_{t-1}^*$, relative price of foreign goods, $p_{F,t}^* \equiv P_{F,t}^*/P_t^*$, and relative price of imported inputs, $p_{Z,t}^* \equiv P_{Z,t}^*/P_t^*$. The exogenous variables, A_t, C_t^*, Π_t^*, $p_{F,t}^*$, $p_{Z,t}^*$ and R_t^*, are assumed to be autocorrelated processes. For the experiments considered here the autocorrelation parameter is not relevant. A full list of all the normalized equations is presented in Appendix E.

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. It is worth mentioning that the UIP and Euler equations lead to the condition that, in steady state, $1 = \beta R^* \lambda$, and it is true that $\lambda > 1$, unless $\mu = 0$ (ruled out by assumption). So this implies $\beta R^* < 1$. This is different from the usual assumption for small open economies, that $\beta R^* = 1$. Christiano et al. (2004) embraces 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 $R = R^*$ and $\beta R^* = 1$, 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 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, the steady state leverage ratio of the firms, b, is set to 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 research.[14]

For the sudden stop shock, the probability of exit, δ_n, is set to 12.5%, implying an average duration of a sudden stop of 2 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,[15] in the range of 10% to 15% of initial GDP, depending on the policy being considered. This implies that κ_{ss} is set to 0.75.

The calibration of the more standard parameters follows the literature on open economies and emerging market crises and, in particular, Elekdag, Justiniano, and Tchakarov (2006). The intertemporal elasticity of substitution, $1/\sigma$, is set to 1 and the labor supply elasticity, $1/\psi$, to 0.5. The elasticity of substitution of consumption between domestic and foreign goods, ν, is 1. The fraction of domestic goods in the consumption basket of the households,

[14] For example, Bernanke et al. (1999) use 0.12 for μ and 0.529 for σ_ω.

[15] This is evaluated at the trough of the crisis.

γ, is 75%.

For the production side, the baseline scenario considers 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 6, so that the monopolistic markup is 20%. The foreign demand price elasticity, ν^*, is set to 0.6, as suggested in Cook (2004). 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 9.

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.[16] The shock is set in order to generate a reversal in the capital account equivalent to 10-15% of the GDP in steady state, depending on which policy is considered. The first aim of this section will be to describe carefully the transmission mechanism of the shock. It should be noted though that it is hard to replicate what exactly happened in such episodes because policy changed throughout the crises, as they took place. 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 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 interpretation should be that these two policies are probably the bounds within which we can frame the actual policy being followed in those events. It is then possible to give a reasonable approximation to the dynamics emerging from the shock, leaving the debate on policy issues for a second

[16] The IRFs are presented as log-deviations from steady state, multiplied by 100. For the interest and inflation rates the IRFs are presented as log-deviations from steady state multiplied by 400 to have an interpretation in annual terms.

stage of analysis.

On that second stage a more thorough comparison is performed between those two policy alternatives, and further ones, including different degrees of reaction to the inflation rate, consideration of the DPI instead of the CPI as the focus of policy and finally the augmentation of the interest rate rule with reaction to the nominal exchange rate depreciation rate.

A third component of the analysis is then pursued bringing somewhat more reality to the policy discussion. A first experiment is identical to that of Gertler et al. (2003) in setting a framework in which authorities announce a peg, but agents assign some probability to its abandonment in favor of a Taylor rule, something that actually takes place one quarter after the sudden stop shock hits the economy. A second experiment is designed to focus on the credibility issue, instead of so much the "reality check." In that second experiment it is again assumed that a peg is announced with agents assigning some probability to its abandonment, just like in the previous case, but now the peg is never abandoned, at least not in the near future that is relevant for analysis.

4.1 The transmission mechanism of the sudden stop

Here the focus is in the key dynamics triggered by the sudden stop. Two alternative policies are considered: a peg and the benchmark Taylor rule in which the interest rate is reacting to inflation and output deviations from steady state.[17] As suggested before these are intended to set reasonable bounds within which we can consider the transmission mechanism of the shock. The responses are presented in Figures 4 and 5.

It is noticeable that, much like in the data, the impact of the shock on the real variables almost fades away after five to six quarters, much like the data presented earlier suggests. Moreover those effects are short-lived relative to the gradual recovery of the debt level and leverage ratio, again much like in the data. The fast recovery of the output and investment is what Calvo (2005) labeled as the "Phoenix miracle." As described there, the recovery takes place before credit lines are restored, which implies that firms had to reorganize and use more internal financing (precisely the reason why the leverage ratio is much lower).

The mechanism, as shown by those figures, can be broadly described as follows. The change in foreigners perceptions about the distribution of firms' productivity leads them to

[17] Experiments were performed with output deviations from the flex-price equilibrium but the differences were not significant. Moreover reacting to output deviations to steady state might be a more realistic description of what policy makers in emerging markets try to stabilize, even if that is not necessarily optimal.

expect higher rates of default in the future, which leads them to require higher contractual rates in advance, to insure against that risk. This move means that foreign lenders are requiring a higher risk premium on loans starting in this period.

Upon the higher cost of borrowing firms will immediately reduce the amount of debt they are obtaining starting in this period. This is performed due to its higher cost of financing but it also has the added value that by lowering the leverage ratio the endogenous component of the risk premium is lowered, dampening the initial impact of the foreigner misperceptions. Additionally firms will also reduce the amount of imported inputs purchased because they are now more expensive to finance. The contraction in debt implies reduced capital inflows, hence the sudden stop in capital flows.

In order to reduce their leverage firms have to reduce the dividend distributed to the households. At this stage the increased risk premium becomes a problem for these agents too because now their budget constraint just got tightened. This leads them to reduce consumption (both of domestic and foreign goods) and increase labor supply. This is precisely the indirect channel taking its toll in the consumers: even though they are not direct borrowers from foreigners they are still hit by it through the fact that they are the shareholders of the firms. In a more realistic setting we could see a cascading effect, with the firms that have access to the international capital markets losing their access, and thus switching to domestic sources, increasing the cost of financing at home, and thus burdening lower profile firms and households (without access to the international capital markets in the first place). Here that is simplified but the principle is there, without all the complexities of considering a full fledged domestic credit market too.

The households' lower consumption implies lower demand for the domestic goods. This leads firms to reduce their demand for labor (even more so on impact, at a point when they still have a good stock of previously purchased imported inputs). The labor market is then confronted with stronger supply and weaker demand, which leads to lower real wages, further tightening the budget constraint of the households. The fact that output contracts after the shock seems to validate to some extent the initial worries of the foreigners about the economy, even if it was them who triggered the events. In this sense it is a self-fulfilling type of story, as Calvo (1998) and Krugman (1999) proposed.

Simultaneously, the contraction in the supply of debt by foreigners implies a reduced demand for the domestic currency, putting pressure for it to depreciate. Under flexible exchange rate that is what happens, leading to inflation in the economy due to higher relative price of imported goods and inputs. Under a peg instead there is deflation that will lead to the real depreciation of the domestic currency and thus take the role of the nominal exchange rate. The only difference is that due to sticky prices the real depreciation is much smaller under the peg. In any case the real depreciation of the currency leads to three further developments in the economy. First it implies a contraction in the domestic demand for foreign final goods. Second, it increases the real cost of purchasing the imported inputs, leading to further reasons to contract theses imports too. Finally, it reduces the relative cost of domestic goods for foreign consumers, leading to an increased foreign demand for the domestic goods. This is crucial in dampening the impact in the total demand for the domestic good.

Overall the impact of the misperceptions shock can be summarized in three main effects. First, a cost push shock, through both the cost of financing and (subsequently) purchasing the imported input. Second, a contraction in domestic demand, through the indirect channel, lower real wages and real depreciation, something also described in Martin and Rey (2005). Third, an expansion of the foreign demand for the domestic goods. The first is the effect usually highlighted in the literature, and what triggers all the events. But the latter two cannot be ignored. Indeed, the demand side of the economy plays a relevant role in determining output in this economy.

The domestic demand implies a contraction in output, while the foreign demand implies an expansion. The empirical evidence suggests that the latter is not enough to dominate the former. The same happens in the model under the benchmark calibration and the policy alternatives presented. However, depending on parameter configuration and other policies, it is possible to attain an output expansion instead, much like what is suggested in Chari et al. (2005). These authors present a theoretical model to conclude that a sudden stop in capital inflows is equivalent to an increase in net exports. They then proceed to conclude that, as is well known, an increase in net exports leads to an expansion in output. Joining the two steps we should conclude that a sudden stop is expansionary. Given the data and the results presented here what can account for the differences to their conclusions? In their paper they claim that the wedge is the existence of financial frictions that drive the results in the sudden stops literature. Instead, here the claim is that the financial frictions do have a role but do not explain everything.

The view of net exports as a whole increasing hides information about its composition. That composition matters because it might impact the other side of the economy. In the model presented here it was already described that there are these two opposing forces: the expansionary foreign demand and the contractionary domestic demand. The view of increased net exports hides the latter and that is crucial. One important parameter that is key to determine the relative force of each of those effects is the elasticity of the foreign demand, ν^*. Figure 6 shows the difference in the responses when considering the benchmark calibration of $\nu^* = 0.6$ and a more elastic foreign demand, using $\nu^* = 2$.

In this figure it is noticeable that a peg will in both cases imply a significant contraction of the output, precisely because regardless of the price elasticity of the foreign demand the real depreciation taking place is very small and not enough to generate an increased foreign demand that would overcome the contraction in domestic demand. Instead if we focus on the Taylor rule then the elasticity of foreign demand becomes very important. for the low elasticity the contraction in output is a fact but as the elasticity increases the foreign demand increases so significantly that it overcomes the contraction in domestic demand and lead to an increase in output. Therefore not only does policy matter but the calibration does too, namely that of the foreign demand price elasticity.

This explains the key difference between data and the benchmark calibration and Chari et al. (2005). In their case flexible prices are considered, therefore policy would not matter as the real exchange rate will move freely. The explanation lies in the fact that in their simple model foreign demand is assumed to be infinitely elastic. According to the results just presented that will lead to an expansion in output indeed. This shows how relevant the demand side can actually be.

Moreover, the foreign demand effect, also helps explaining why, in this model, the currency mismatch does not lead to a worse outcome in the event of significant depreciation of the currency. On the one hand the burden of the debt increases, but on the other the revenues of the firms are fueled by the foreign demand. Therefore the currency mismatch is not too big. If non-tradables were considered then the firms in that sector would be hit much harder than those in the tradables sector, as the mismatch would be more significant.

4.2 Monetary policy and sudden stops

The focus of the comparison of the monetary policy alternatives done here takes a purely positive view of it. No judgement is done in terms of optimality of one over another, just the positive description of the dynamics under alternative policies.

The first two policies under analysis are the peg and the Taylor rule here considered as boundaries of likely action of authorities when facing a sudden stop for the reasons already mentioned. Those responses are presented in Figures 4 and 4. The obvious difference between the two is that under the peg, by not allowing the real exchange rate to do so much of the adjustment, the foreign demand is prevented from dampenning the impact of the shock and thus a much stronger contraction in output, imported inputs and capital inflows/debt takes place. In that sense these results confirm the previous findings of Céspedes et al. (2004), Devereux et al. (2006) and Gertler et al. (2003), all of which concluded that a simple interest rate rule is more stabilizing than a peg. The only exception is Cook (2004), whose findings are the exact opposite in this respect. 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.

A monetary policy experiment worth doing is to see the impact of different degrees of commitment to price stability in the transmission of the shock. For that a Taylor rule is considered, like in the benchmark, but allowing the coefficient on inflation to change. Namely three levels are considered: the benchmark, $\phi_\pi = 2$; a very loose policy, near indeterminacy, $\phi_\pi = 1.1$; and a very tight policy on inflation, with $\phi_\pi \to \infty$. The responses are presented in Figure 7.

The results show that the tighter the control of inflation the stronger the contraction in output and faster recovery of domestic demand. If policy is dovish enough it is possible to generate an expansion of output instead. The reason is that by loosening the grip on inflation the real exchange rate will depreciate further stimulating foreign demand. This implies that even in the benchmark foreign demand elasticity it is possible to attain this result, depending on policy. This should be expected. It is also interesting to notice that the interest rates are actually higher the more expansionary the policy. One could expect that nominal interest rates would be higher, due to the higher inflation, but the real interest rate is more surprising perhaps. The reason for this seems to be the fact that with loose policy the foreign demand is stimulated enough to compensate for the domestic demand that firms are willing to pay higher interest rates and therefore debt levels do not contract by as much, leading the equilibrium domestic interest rate to follow suit and be also higher.

This should be a reason to avoid focusing the policy debate on the interest rates themselves but more on the commitment of the authorities to stabilize the economy and the inflation in particular. It also highlights the impact that expectations of agents about that commitment will translate quickly into inflation, real exchange rate and interest rates. This suggests that credibility of policy might be very important. So far full credibility is assumed but below some more is said about this issue.

The degree to which interest rates react to inflation matters as shown before, but what about which price index to focus on? In the analysis so far the CPI index has been assumed but in this economy another natural candidate would be the DPI index, that of the retail price level of the domestic goods. The key difference is that the CPI is a weighted average between the latter and the price of imported goods, denominated in domestic currency. Given that foreign prices are being kept fixed in the experiments this translates into a weighted average between DPI and the exchange rate. If focus on DPI then only that is stabilized and the exchange rate will only indirectly be stabilized, while CPI in the rule implies that the exchange rate gets some direct impact on the interest rate. The responses are shown in Figure 8.

For most variables the impact of considering a Taylor rule with CPI or DPI inflation is only felt in the first period. The reason is that on impact the marginal cost of producing the domestic good actually falls (lower demand and still using the imported inputs purchased earlier) while the real exchange rate depreciates significantly. Therefore the price of domestic goods increases much less than the real exchange rate, leading to smaller urge to increase the interest rate if the DPI is the index in the reaction function. After that first period, the marginal cost increases due to the increased cost of financing the new imported inputs and the behavior of the domestic prices and real exchange rate is more aligned, leading to identical responses of the interest rate and the overall economy from this point onwards.

Another alternative policy much debated in the literature of dirty pegs and managed floats is whether the policy authorities set a rule reacting to the exchange rate depreciation, even if not in a peg. According to most estimates in small open economies that is not the case – e.g. Clarida, Galí, and Gertler (2001), Justiniano and Preston (2006) and Elekdag et al. (2006). However when it comes to financial crises that is not so obvious given the initial behavior of trying to defend their currencies. Here we simulate the economy by augmenting the benchmark Taylor rule with some reaction to the nominal exchange rate depreciation rate, in particular two levels are considered: $\phi_s = 0.5$ and $\phi_s = 2$. The responses are presented in Figure 9.

The impact is the opposite of that of the previous experiment. Now more weight is given to the exchange rate stabilization and therefore as the coefficient on this additional term increases the responses of the different variables get more similar to the responses under a peg. Interesting how close is $\phi_s = 2$ to the responses under a peg (which would imply $\phi_s \to \infty$). This implies however that positive reaction of the interest rate to the exchange rate is destabilizing to the economy.

The above results imply that for some simple Taylor rule it is possible to stabilize the output. However the same cannot be said of the consumption of domestic agents which, under all policies considered falls sharply, as attested for example in Figure 4.

4.3 Credibility of the monetary policy

In the previous analysis, monetary policy rules were considered to be fully credible by the agents. That is a rather strong assumption, especially so in emerging markets, with their history of sudden shifts in policy and lack of independence of the monetary authorities. Fraga et al. (2003) point out that lack of credibility reduces the ability of authorities to deal with these problems. The starting point of this part of the analysis is the fact already mentioned that most economies facing a sudden stop did so with a peg or a soft peg in place but that in most of the cases it was abandoned soon after. It is assumed then that agents foresee with some probability that event. It is always a questionable issue what the policy is after the abandonment of the peg, but at least for illustrative purposes it is reasonable to start by assuming that it is abandoned in favor of the benchmark Taylor rule considered so far. This is an exercise very similar to that in Gertler et al. (2003).[18]

As a simple illustration consider that the probability of abandoning the peg is 20%, so implying that the expected duration of the peg is five quarters. the responses are presented in Figure 10. The immediate observation is that, overall, the dynamics in such scenario are similar to those under a peg in that first period and then quickly converge to the responses under a Taylor rule, after the peg is abandoned. This is the same picture that one gets from the experiment in Gertler et al. (2003). On a closer look it becomes important to make three qualifications to this broad pattern. First, the real exchange rate, exports and debt level do not really converge but, instead stay at an intermediate level between the peg and Taylor respective responses, implying that starting with a peg does have persistent implications, even if it is quickly abandoned. The pattern of exports in this scenario is actually much more in line with the observed in the data, with an initial modest increase followed by a stronger expansion after the abandonment of the peg.

A second qualification, less perceptible is that even in the initial period, with the peg

[18] It should be noted that they assume abandonment after two periods while here it occurs after only one period, more in line with the empirical evidence.

still in place the contraction in output, domestic demand and debt are slightly stronger than in the credible peg. Not by a big difference but this suggests that lack of credibility does make things worse both in terms of output stabilization and in terms of capital flows. A final qualification is that the real interest rate is actually higher in the initial two periods than in any of the peg or pure Taylor rule scenarios, meaning that indeed there is a cost to the lack of credibility of the peg in terms of higher real interest rates. This is precisely what explains the stronger contraction of domestic demand, output and debt.

Given that lack of credibility seems to take its toll even in the period with the peg still in place, this calls for a clear comparison between credible and non-credible policy. The experiment is now similar to the previous one, except that there is no abandonment of the peg, at least not in the foreseeable future after the sudden stop, even though agents assign some probability to that happening. The actual probabilities considered here are 15%, 20% and 25%.[19] The responses are presented in Figure 11.

The impact of the lack of credibility is not too significant in the real variables' responses to the sudden stop. It should be noted however that lack of credibility in these calculations can still account for additional 0.8 percentage points in lost output on impact, even if it is not visible in the figures. The lack of credibility is neither noticeable in the path of inflation. Where it is noticeable is in the increased interest rates required to keep the peg without full credibility. In the case of lowest credibility considered here it can imply additional four annual percentage points in the real interest rate. This is precisely the result that with lower credibility capital inflows contract more, not necessarily on impact but over time. Indeed the trough of the crisis is more pronounced and delayed the lower the credibility of the peg.

In this experiment, the policy followed after abandonment of the peg is a very reasonable policy from the perspective of agents. However if the alternative policy considered were to be a more reckless policy then the impact on real variables is more pronounced, as well as the impact on the interest rates. This is shown in Figure 12, in which the alternative policy has a coefficient on inflation of $\phi_\pi = 1.1$. We are then left with the conclusion that if lack of credibility just means that current policy might be abandoned in favor of another reasonable policy then the impact in the real side of the economy exists but is not too significant. If however the lack of credibility means that current policy might be abandoned in favor of more slack and less committed policies then the impact in the real side of the economy might turn out to be significant. Lack of credibility does in any case increase the trade-offs that the monetary authorities face, much like Céspedes and Soto (2005) describe. In order to deal

[19] It should be noted that for high enough probability there is no rational expectations equilibrium.

with these additional problems the authorities are forced to increase the interest rates more than otherwise needed in response to a sudden stop, much like stated in Fraga et al. (2003).

5 Conclusion

The main question analyzed in this paper is the impact of monetary policy in an environment prone to sudden stops of capital flows. The paper proposes a theoretical model that emphasizes some key elements that are important in emerging markets and sudden stops. Namely the existence of foreign denominated debt; imported inputs; indirect sensitivity to the international capital markets by the households, not because they borrow from foreigners but because they are shareholders of firms which borrow in the international capital market; financial frictions in a similar fashion to the financial accelerator model of Bernanke et al. (1999); and a shock that is more primitive than a simple increase in the risk premium of the country.

The paper first describes in detail the transmission mechanism of the sudden stop in these economies and what factors have important influence on the dynamics. This analysis shows that the magnitude of the output contraction depends crucially on the elasticity of the foreign demand for the domestic goods. This highlights precisely the role of the demand side in the dynamics following a sudden stop. But not only are those dynamics dependent on the calibration but also on policy, which is the second main focus of the paper. It was detailed the extent to which several alternative monetary policies can influence, or not, the response of the economy to these shocks. Finally it was debated the impact of credibility in the ability of monetary policy to cope with the shock, concluding that its impact is not so negative, as long as the lack of credibility is not due to the fact that authorities will simply follow very bad policies. In that case the credibility becomes more important.

This framework is able to yield much more than what is presented here. This paper gives an insight into the positive analysis of the effects of a sudden stop when it hits an emerging market, taking into account the monetary policy. This setting can be very easily extended to perform welfare evaluation. In this model, the obvious measure is the welfare of households, something not so obvious in other financial accelerator models, as exposed by the analysis in Devereux et al. (2006). This allows for the analysis of optimal policy, normative policy comparison and even considerations about commitment and discretion, much more in line with the research of Caballero and Krishnamurthy (2005b). Another important extension 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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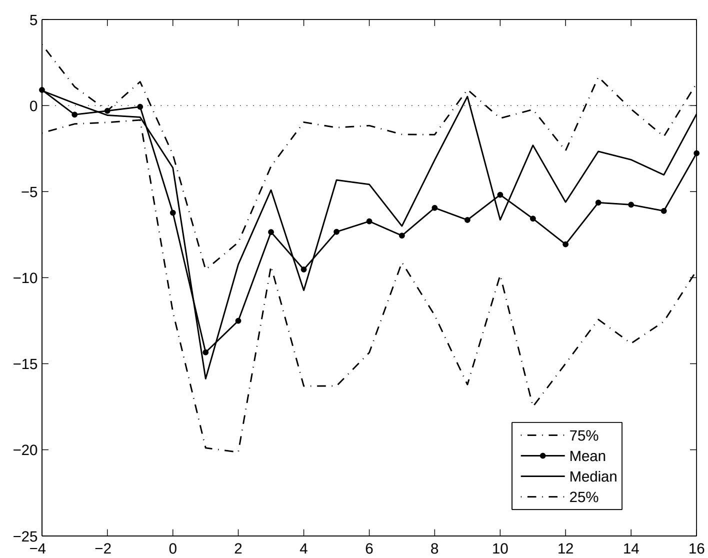
A Empirical evidence

Table 1: Capital account reversal during sudden stops

% 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

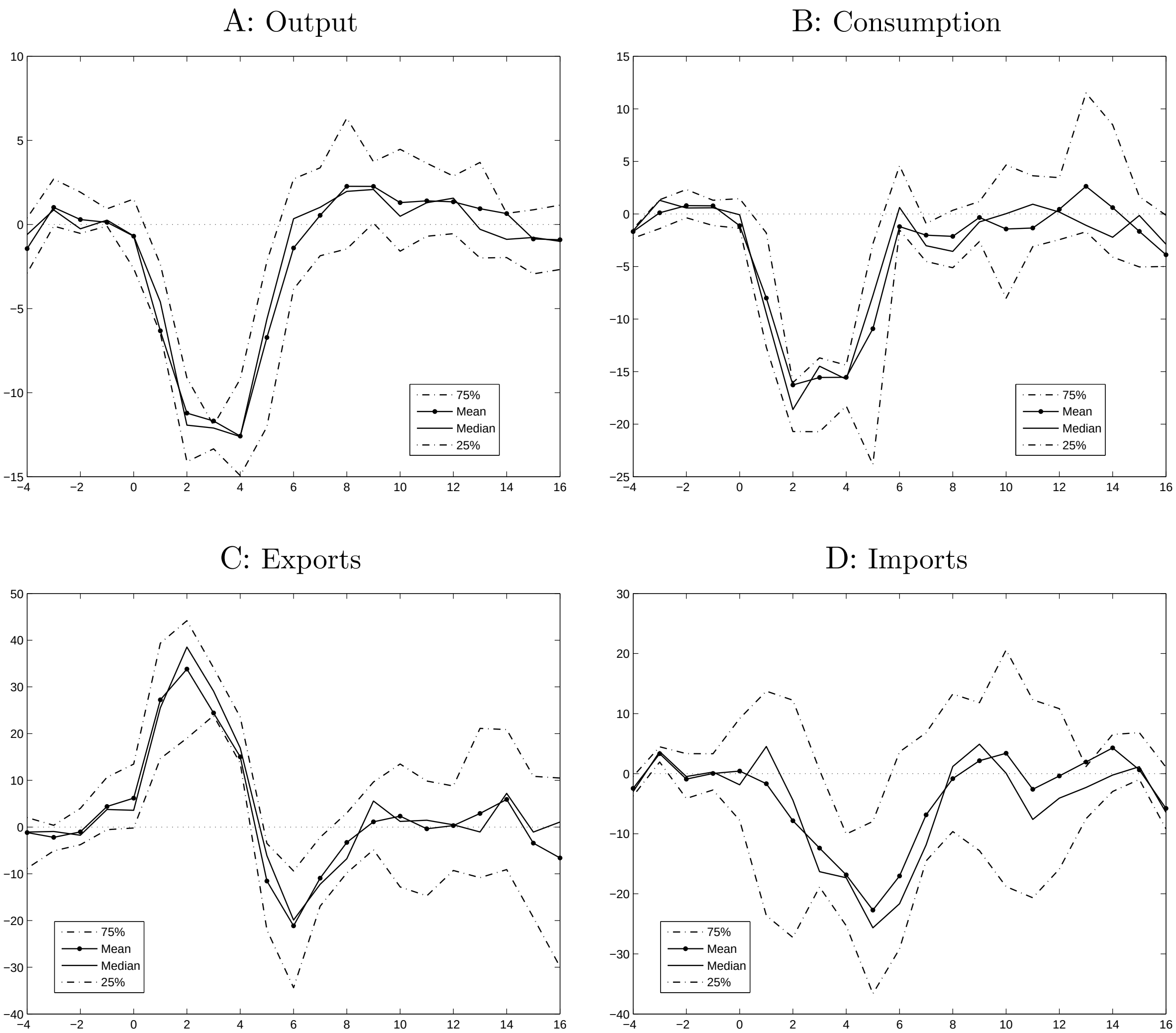
Sources: (1) Calvo and Reinhart (1999) (2) using data from IMF/IFS

Figure 1: Path of the financial account [1]



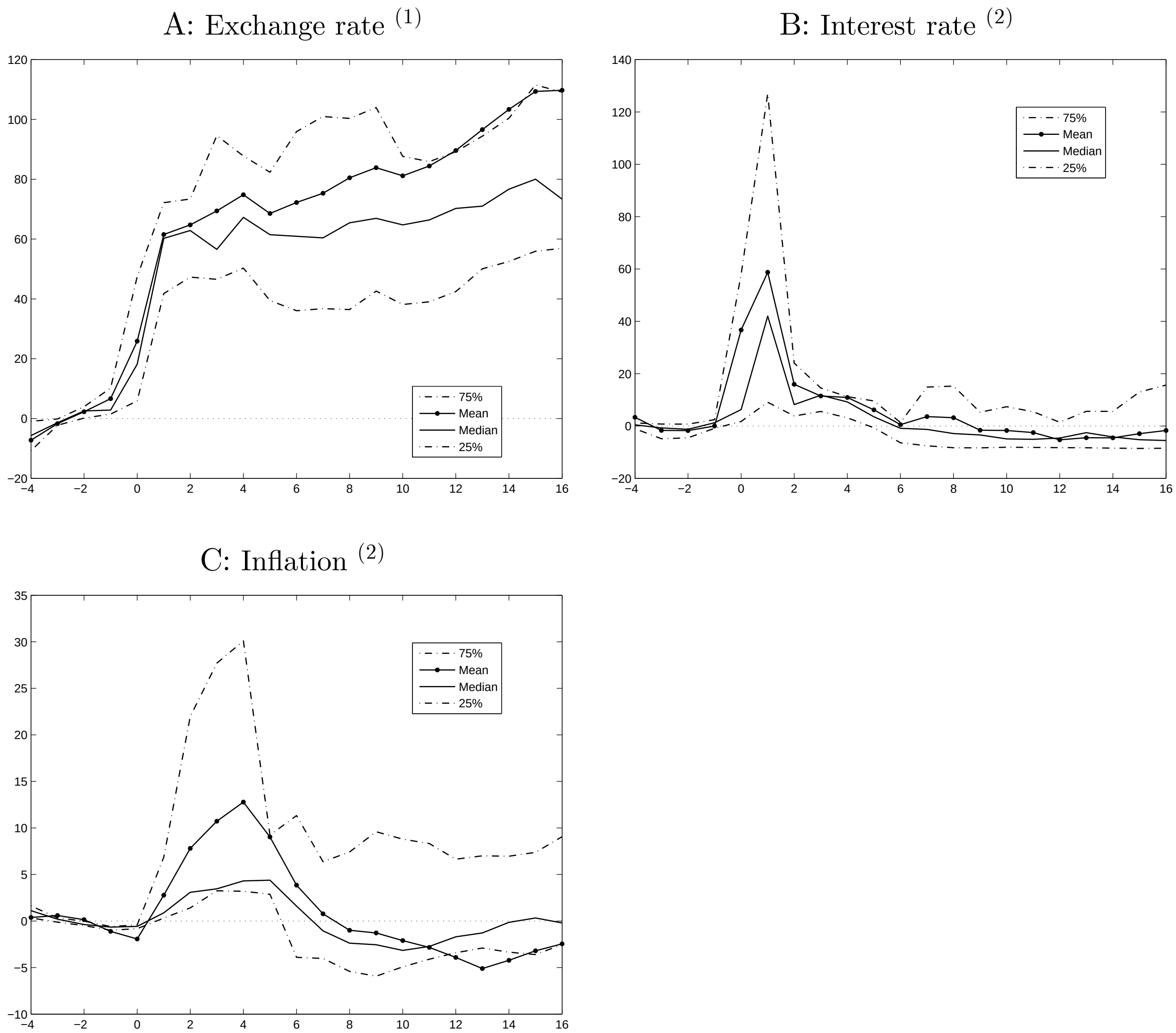
(1) deviations from pre-crisis average (percentage points of initial GDP)

Figure 2: Responses[1] to sudden stop shocks in the sample



(1) change in the four-quarters growth rate from pre-crisis average

Figure 3: Responses to sudden stop shocks in the sample



(1) Log deviations from pre-crisis average

(2) change from pre-crisis average (percentage points)

Table 2: Decomposition of gross external debt by sectors

%	Government	Monetary Authority	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 3: Decomposition of imports

%	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 4: Currency denomination of gross external debt

%	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 5: Bond spreads in Latin America and East Asia

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

%	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)

B Variables and parameters

Table 7: Variables present in the model

P_t	consumption price index (CPI)	Π_t	CPI inflation rate
$P_{H,t}$	domestic price index (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
R_t	domestic interest rate	R_t^r	real interest rate
R_t^*	foreign risk free interest rate	λ_t	risk premium term
P_t^*	foreign CPI(1)	Π_t^*	foreign CPI inflation
$P_{F,t}^*$	foreign goods price(1)	$p_{F,t}^*$	foreign goods relative price
$P_{Z,t}^*$	price of imported inputs(1)	$p_{Z,t}^*$	relative price of imported inputs
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	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	$R_{Z,t}^r$	net real returns on imported inputs
A_t	total factor productivity	κ_t	misperception factor
$\omega_t(j)$	imported input productivity shock	$\omega_t^*(j)$	foreigners perceptions about $\omega_t(j)$
$\bar{\omega}_t(j)$	default threshold	$R_{B,t}(j)$	gross interest rate in debt contract

(1) defined in foreign currency

Table 8: Parameters 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 labor and imported inputs in production
α	share of labor to the production of the domestic goods under unit elasticity of substitution
σ_ω^2	variance of the log-normal distribution of ω
μ	monitoring costs
δ_n	probability of exit from sudden stop
κ_{ss}	misperception factor during sudden stop
η	elasticity of substitution among the different varieties of the domestic goods
ν^*	foreign demand price elasticity
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 9: Calibrated parameters

β	0.98401	ϕ	1	α_p	0.75	A	1
σ	1	α	0.55	η	6	C^*	10
ψ	2	μ	0.019065	ν^*	0.6	Π^*	1
ν	1	σ_ω	0.392202	γ^*	0.1	p_Z^*	1
γ	0.75	δ_n	0.125			p_F^*	1
		κ_{ss}	0.75			R^*	1.01

Table 10: Policy rule coefficients

	ϕ_π	ϕ_{DPI}	ϕ_y	ϕ_s
Peg	0	0	0	∞
Benchmark Taylor rule	2	0	0.75	0
DPI Taylor rule	0	2	0.75	0
Alternative inflation responses	$\{1.1, \infty\}$	0	0.75	0
Augmented rule	2	0	0.75	$\{0.5, 2\}$

C Simplification of the participation constraint

The participation constraint of the foreign lenders is given by

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

Recall that

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

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

$$F^*(\bar{\omega}) = \Pr(\omega\kappa \leq \bar{\omega}) = \Pr\left(\omega \leq \frac{\bar{\omega}}{\kappa}\right) = F\left(\frac{\bar{\omega}}{\kappa}\right). \tag{C.1}$$

Define now

$$G(\bar{\omega}) \equiv \int_0^{\bar{\omega}} \omega dF(\omega), \tag{C.2}$$

and note that the above expression is equivalent to

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

It then follows that

$$\begin{aligned} G^*(\bar{\omega}) &= F^*(\bar{\omega}) E[\omega^* | \omega^* < \bar{\omega}] \\ &= F\left(\frac{\bar{\omega}}{\kappa}\right) E\left[\omega | \omega \leq \frac{\bar{\omega}}{\kappa}\right] \\ &= \kappa G\left(\frac{\bar{\omega}}{\kappa}\right). \end{aligned} \tag{C.3}$$

Combining the participation constraint with these two results, (C.1) and (C.3), it is possible to write

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

Using the equation for the default threshold, (3.15) to substitute out $R_{B,t}(j) B_t(j)$, and the balance sheet equation, (3.13), to replace $B_t(j)$ by the net worth and purchases of imported input, the participation constraint becomes

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

and reorganize into

$$E_t \left[\Omega(\bar{\omega}_{t+1}(j); \kappa_t) R_{Z,t+1} \frac{S_t}{S_{t+1}} P_{Z,t}^* Z_t(j) \right] = R_t^* \left(P_{Z,t}^* Z_t(j) - \frac{N_t(j)}{S_t} \right), \tag{C.4}$$

with

$$\Omega(\bar{\omega}; \kappa) \equiv \kappa \left[\Gamma\left(\frac{\bar{\omega}}{\kappa} \right) - \mu G\left(\frac{\bar{\omega}}{\kappa} \right) \right], \tag{C.5}$$

$$\Gamma(\bar{\omega}) \equiv [1 - F(\bar{\omega})] \bar{\omega} + \int_0^{\bar{\omega}} \omega dF(\omega). \tag{C.6}$$

D Solving the wholesale firms problem

Firms maximize the discounted sum of cash flows, subject to the participation constraint, (3.16), and the default threshold definition, (3.15), with respect to $Z_t(j)$, $\bar{\omega}_t(j)$, $R_{B,t-1}(j)$ and $N_t(j)$. But one can solve (3.15) for $\bar{\omega}_t(j)$

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

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

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

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

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

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

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 $N_t(j)$

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

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

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

and

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

Define now

$$\lambda_t(j)=\frac{\Gamma'\left(\bar{\omega}_t(j)\right)}{E_{t-1}\left[\Omega'\left(\bar{\omega}_t(j);\kappa_{t-1}\right)\right]}, \tag{D.2}$$

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

$$R_t E_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}}\right] = R_t^* E_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \frac{S_{t+1}}{S_t} \lambda_{t+1}(j)\right]. \tag{D.3}$$

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,

$$E_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \left[1 - \Gamma\left(\bar{\omega}_{t+1}(j)\right)\right] R_{Z,t+1}\right] = \left(1 - b_t(j)\right) R_t^* E_t \left[\frac{C_{t+1}^{-\sigma}}{P_{t+1}} \frac{S_{t+1}}{S_t} \lambda_{t+1}(j)\right], \tag{D.4}$$

where I used the participation constraint.

E All equations describing the economy

We can summarize all the equations of the economy:

$$C_t^{-\sigma} = \beta E_t \left[C_{t+1}^{-\sigma} \frac{R_t}{\Pi_{t+1}} \right] \tag{E.1}$$

$$C_t^{-\sigma} = \beta E_t \left[C_{t+1}^{-\sigma} R_t^r \right] \tag{E.2}$$

$$w_t = L_t^{\psi} C_t^{\sigma} \tag{E.3}$$

$$C_{H,t} = \gamma p_{H,t}^{-\nu} C_t \tag{E.4}$$

$$C_{F,t} = (1-\gamma) \left(s_t p_{F,t}^* \right)^{-\nu} C_t \tag{E.5}$$

$$\begin{aligned} 1 &= \left[\gamma p_{H,t}^{1-\nu} + (1-\gamma) \left(s_t p_{F,t}^* \right)^{1-\nu} \right]^{\frac{1}{1-\nu}}, \text{ if } \nu \neq 1 \\ 1 &= p_{H,t}^{\gamma} \left(s_t p_{F,t}^* \right)^{1-\gamma}, \text{ if } \nu = 1 \end{aligned} \tag{E.6}$$

$$\begin{aligned} Y_t &= A_t \left[\alpha^{\frac{1}{\phi}} L_t^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} Z_{t-1}^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \text{ if } \phi \neq 1 \\ Y_t &= A_t \left(\frac{L_t}{\alpha} \right)^{\alpha} \left(\frac{Z_{t-1}}{1-\alpha} \right)^{1-\alpha}, \text{ if } \phi = 1 \end{aligned} \tag{E.7}$$

$$L_t = \alpha A_t^{\phi-1} Y_t \left(\frac{w_t}{p_{w,t}} \right)^{-\phi} \tag{E.8}$$

$$R_{Z,t}^r = (1-\alpha)^{\frac{1}{\phi}} A_t^{1-\frac{1}{\phi}} \left(\frac{Z_{t-1}}{Y_t} \right)^{-\frac{1}{\phi}} \frac{p_{w,t}}{s_{t-1} p_{Z,t-1}^*} \tag{E.9}$$

$$\bar{\omega}_t = \frac{R_{B,t-1}/\Pi_t^*}{R_{Z,t}^r} \frac{s_t}{s_{t-1}} b_{t-1} \tag{E.10}$$

$$E_t \left[\Omega \left(\bar{\omega}_{t+1}; \kappa_t \right) R_{Z,t+1}^r \frac{s_t}{s_{t+1}} \Pi_{t+1}^* \right] = R_t^* b_t \tag{E.11}$$

$$\beta E_t \left[C_{t+1}^{-\sigma} \left[1 - \Gamma \left(\bar{\omega}_{t+1} \right) \right] R_{Z,t+1}^r \right] = (1-b_t) C_t^{-\sigma} \tag{E.12}$$

$$\beta E_t \left[C_{t+1}^{-\sigma} \lambda_{t+1} \frac{s_{t+1}}{s_t} \frac{R_t^*}{\Pi_{t+1}^*} \right] = C_t^{-\sigma} \tag{E.13}$$

$$\lambda_t = \frac{\Gamma' \left(\bar{\omega}_t \right)}{E_{t-1} \left[\Omega' \left(\bar{\omega}_t; \kappa_{t-1} \right) \right]} \tag{E.14}$$

$$n_t = (1-b_t) s_t p_{Z,t}^* Z_t \tag{E.15}$$

$$Y_t = C_{H,t} + C^*_{H,t} \tag{E.16}$$

$$C^*_{H,t} = \gamma^* \left(\frac{p_{H,t}}{s_t}\right)^{-\nu^*} C^*_t \tag{E.17}$$

$$p_{H,t} = \left[(1-\alpha_p)\left(\frac{\eta}{\eta-1}\frac{F_t}{K_t}\right)^{1-\eta} + \alpha_p\left(\frac{p_{H,t-1}}{\Pi_t}\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{E.18}$$

$$F_t = C_t^{-\sigma} Y_t p^{\eta}_{H,t} p_{w,t} + \alpha_p \beta E_t\left[\Pi^{\eta}_{t+1} F_{t+1}\right] \tag{E.19}$$

$$K_t = C_t^{-\sigma} Y_t p^{\eta}_{H,t} + \alpha_p \beta E_t\left[\Pi^{\eta-1}_{t+1} K_{t+1}\right] \tag{E.20}$$

$$0 = p_{H,t} C^*_{H,t} - s_t p^*_{F,t} C_{F,t} - \Gamma\left(\bar{\omega}_t\right) R^r_{Z,t} s_{t-1} p^*_{Z,t-1} Z_{t-1} - (1-b_t)\, s_t p^*_{Z,t} Z_t \tag{E.21}$$

$$\frac{R_t}{R} = (\Pi_t)^{\phi_\pi}\left(\frac{Y_t}{Y}\right)^{\frac{\phi_y}{4}}\left(\frac{p_{H,t}}{p_{H,t-1}}\Pi_t\right)^{\phi_{DPI}}\left(\frac{s_t}{s_{t-1}}\frac{\Pi_t}{\Pi^*_t}\right)^{\phi_s} \tag{E.22}$$

Notice the addition of two artificial variables, F_t and K_t to allow for a recursive formulation of domestic relative prices.

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

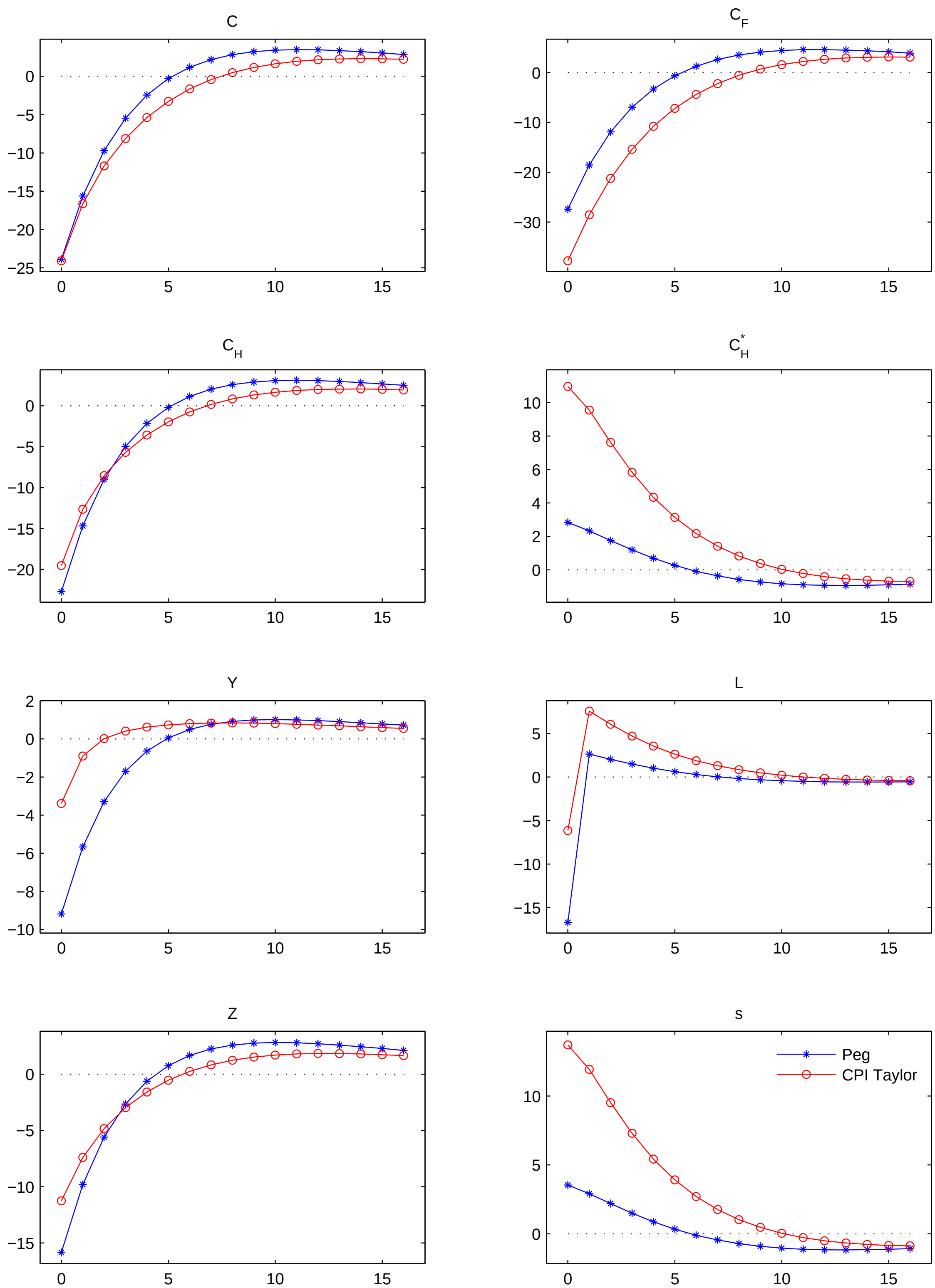


Figure 5: Responses to sudden stop under a peg and a CPI Taylor rule (continued)

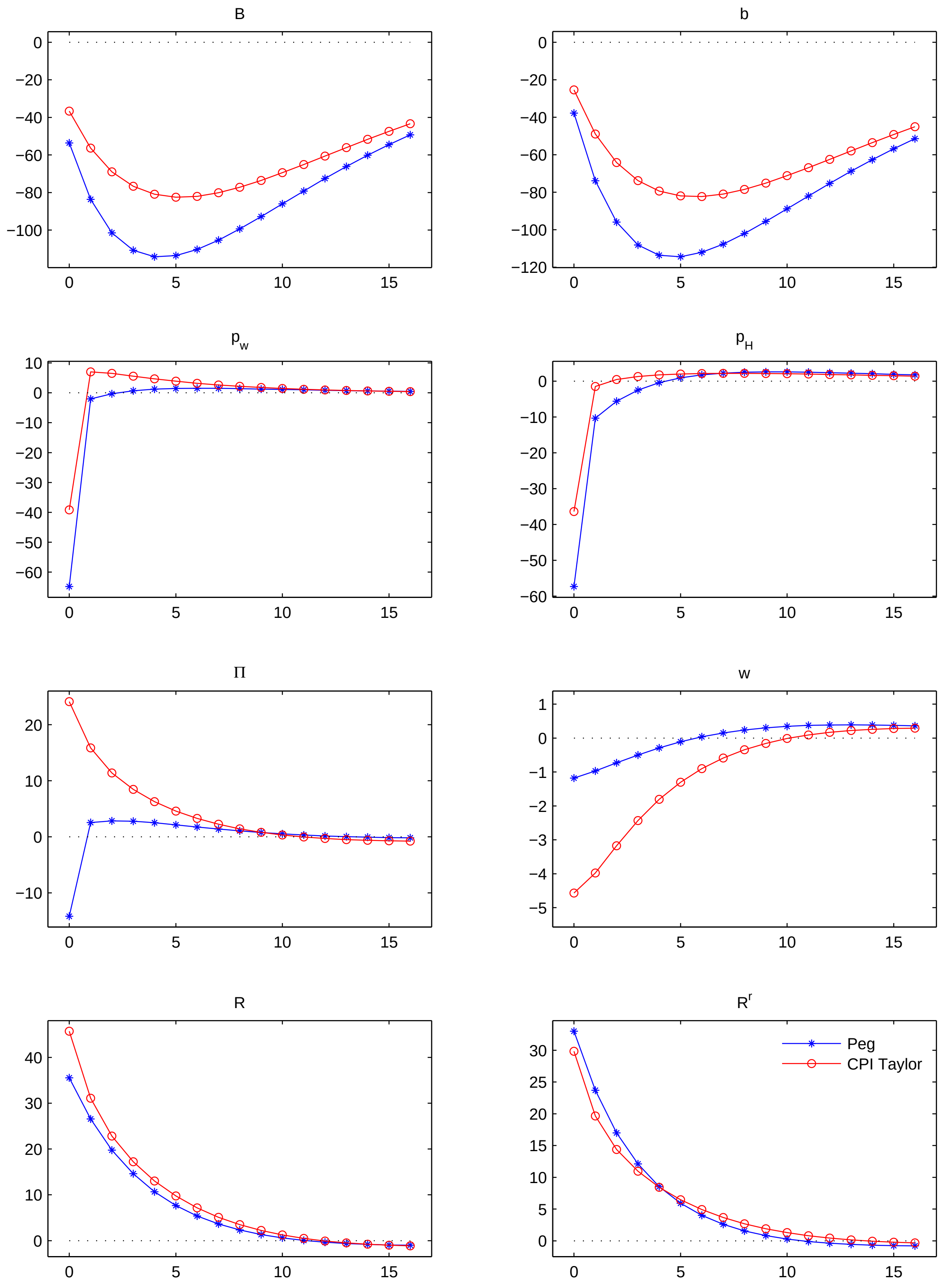


Figure 6: Responses to sudden stop for different foreign demand elasticities

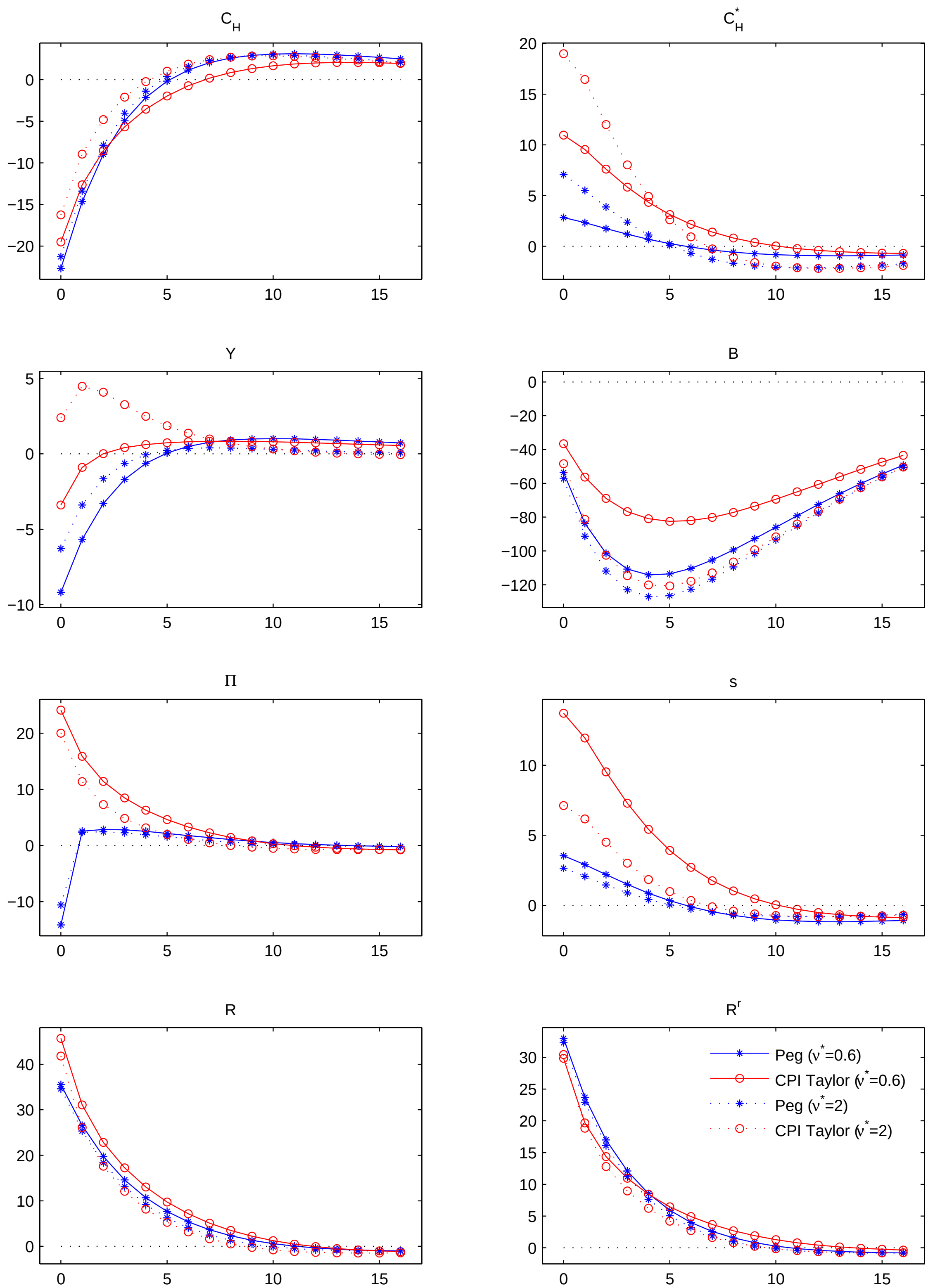


Figure 7: Responses to sudden stop for different degrees of interest rate reaction to CPI

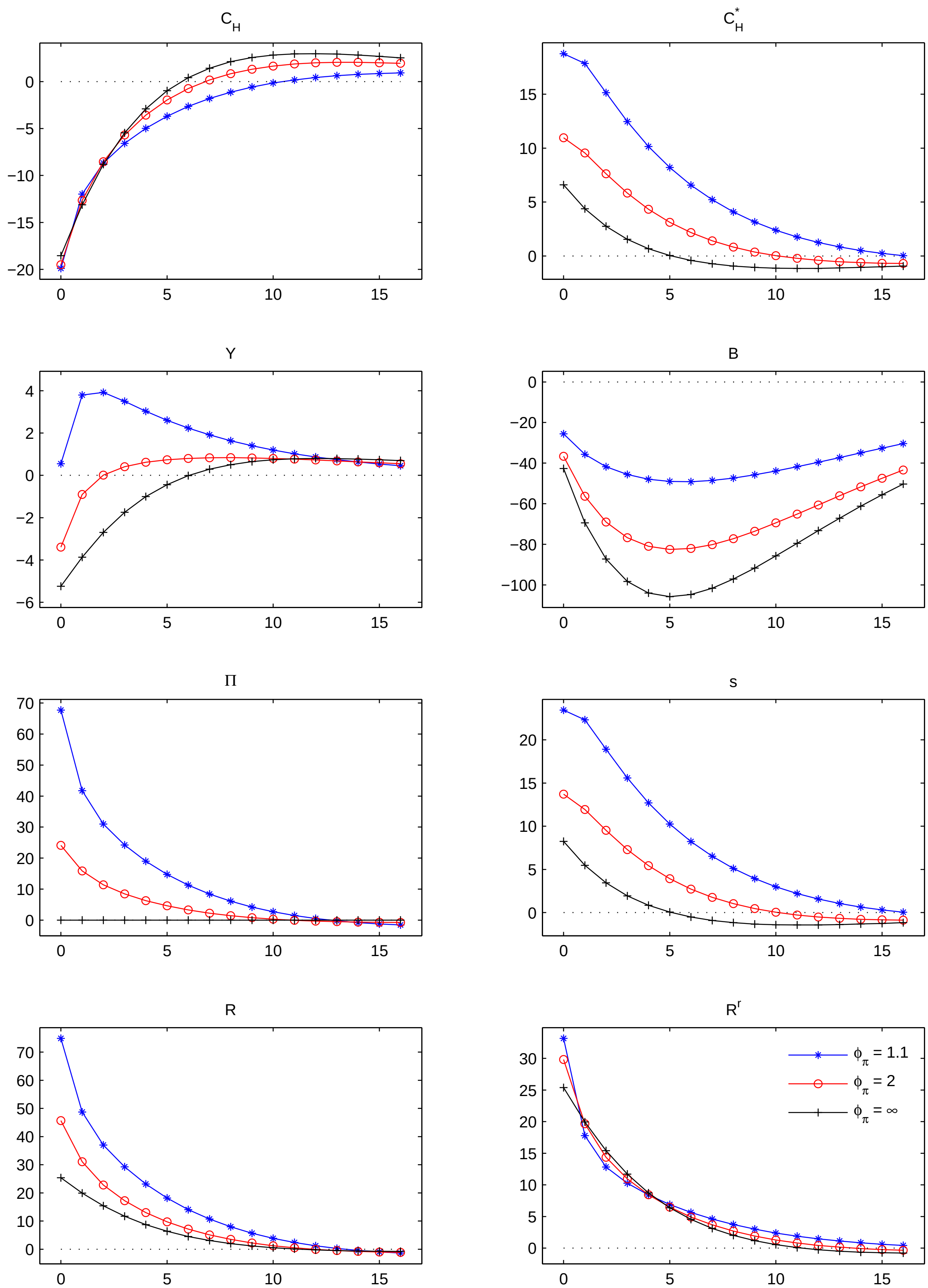


Figure 8: Responses to sudden stop under CPI and DPI Taylor rules

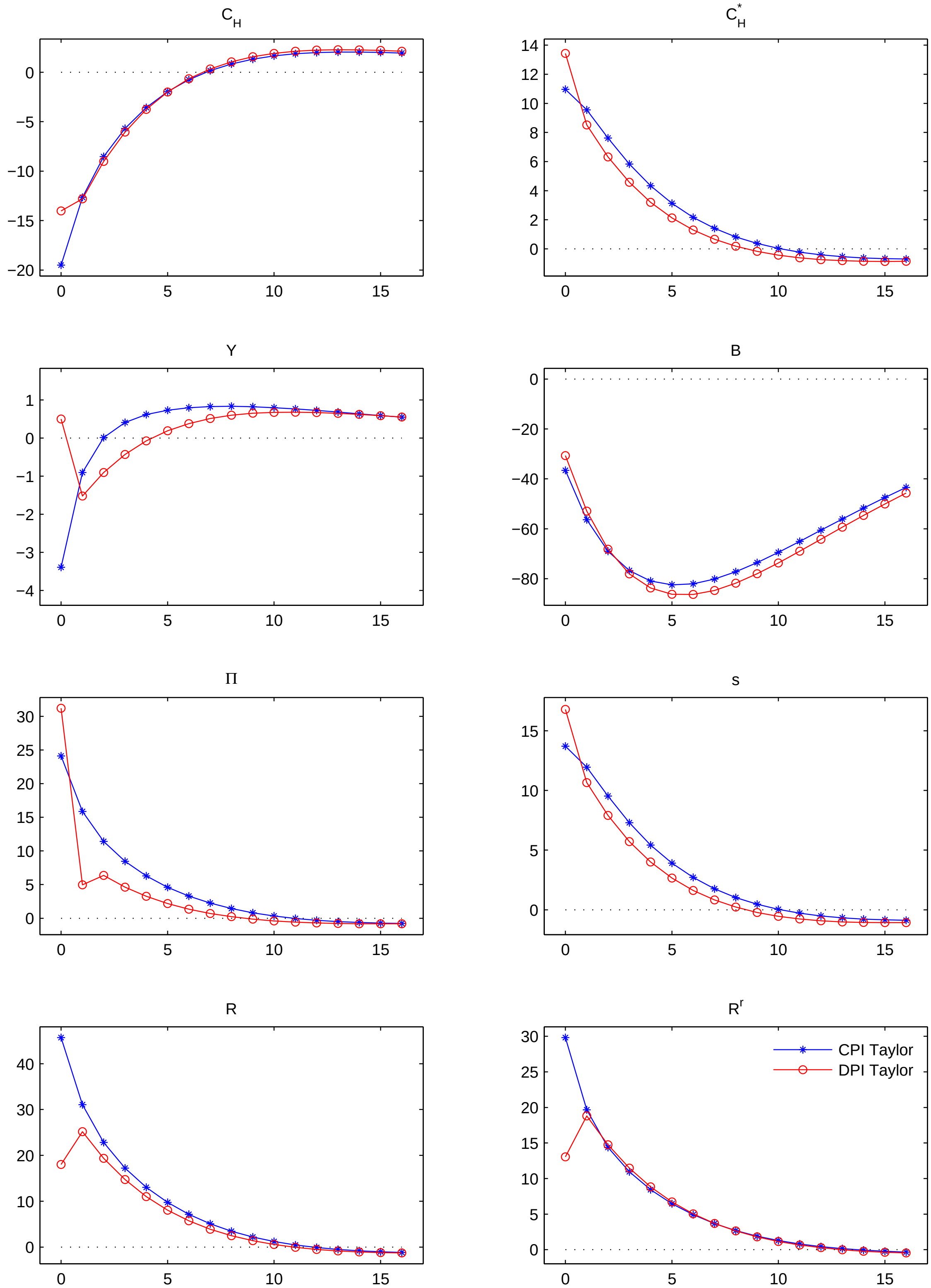


Figure 9: Responses to sudden stop under Taylor rule reacting to nominal exchange rate

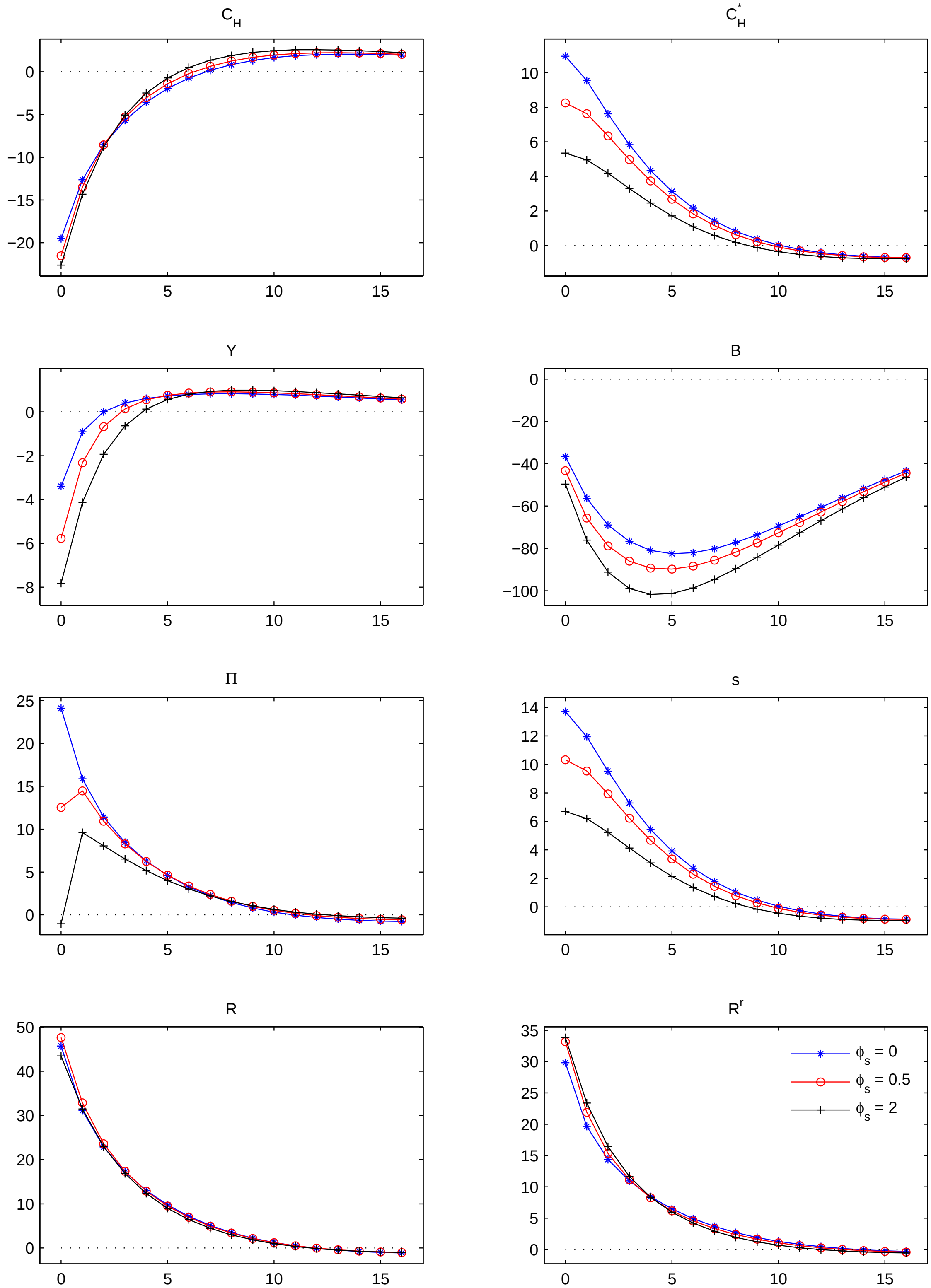


Figure 10: Responses to sudden stop under peg that is abandoned one quarter after shock

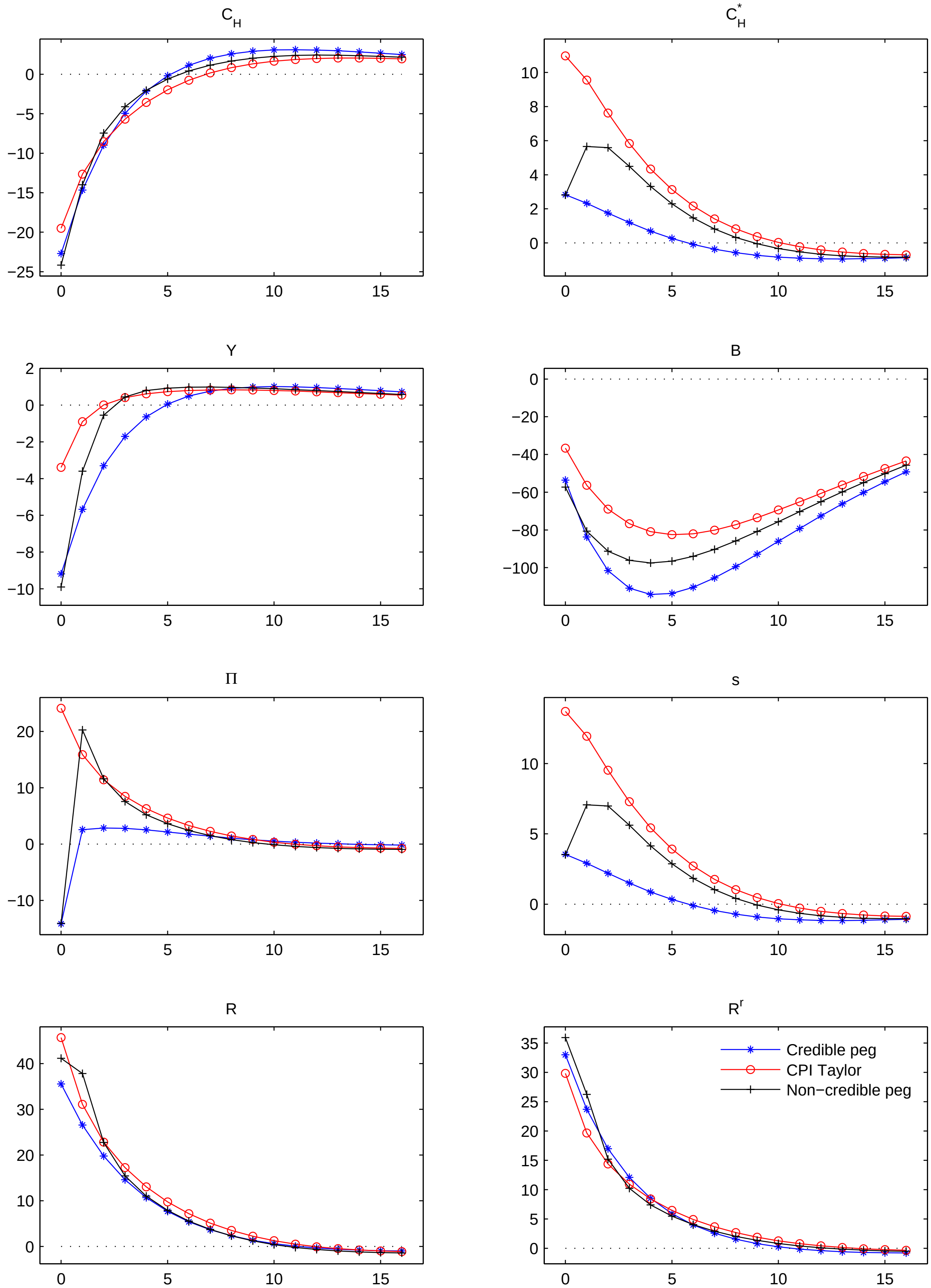


Figure 11: Responses to sudden stop under peg without full credibility

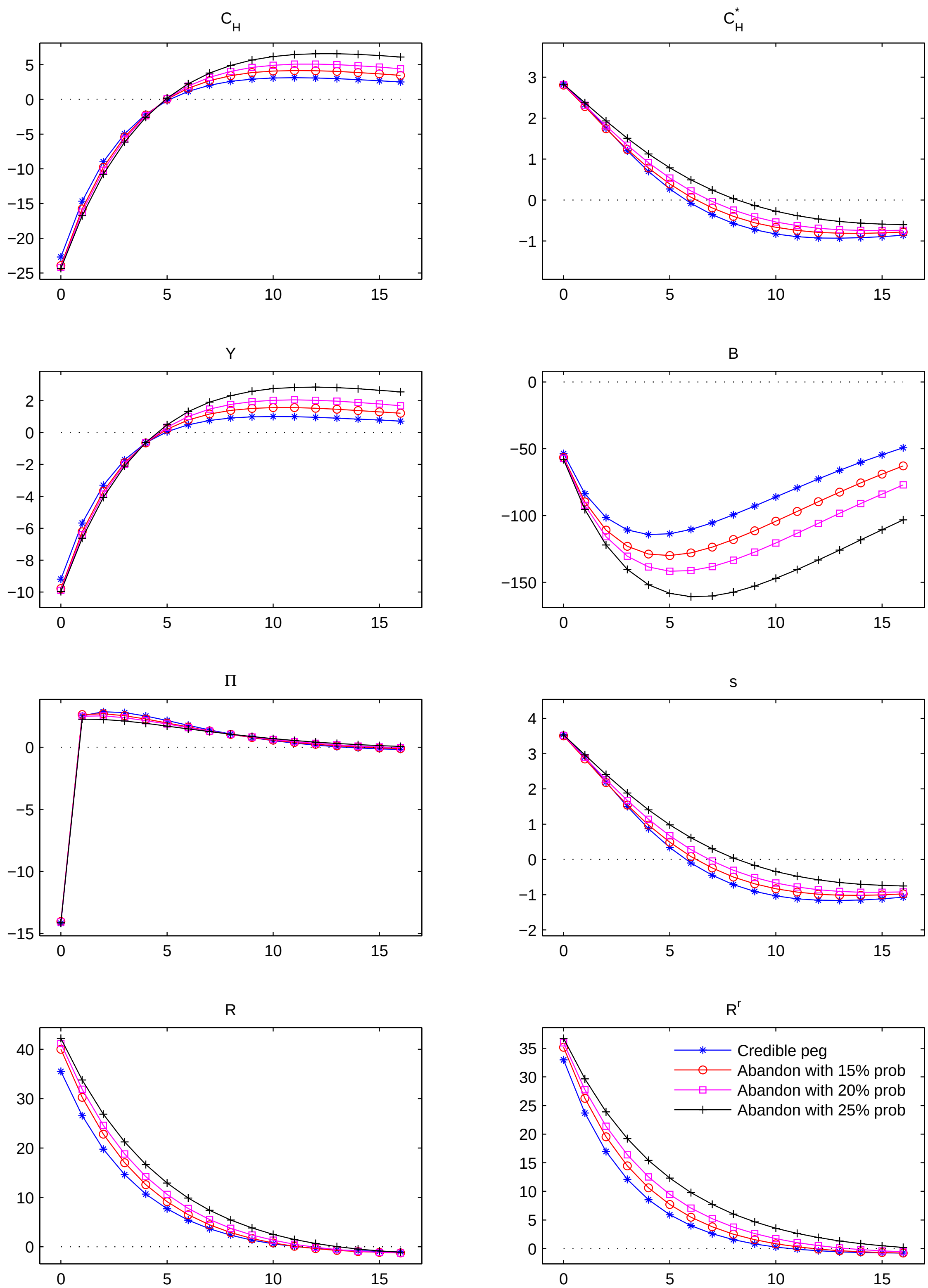


Figure 12: Responses to sudden stop under peg without full credibility (loose alternative policy)