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Exchange rate overshooting and the costs of floating

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ABSTRACT

Currency crises are usually associated with large nominal and real depreciations. In some countries depreciations are perceived to be very costly ("fear of floating"). In this paper we try to understand the reasons behind this fear. We first look at episodes of currency crises in the 1990s and establish that countries entering a crisis with high levels of foreign debt tend to experience large real exchange rate overshooting (devaluation in excess of the long-run equilibrium level) and large output contractions. We then develop a model of a small open economy that helps to explain this evidence. The key element of the model is the presence of a margin constraint on the domestic country. Real devaluations, by reducing the value of domestic assets relative to international liabilities, make countries with high foreign debt more likely to hit the constraint. When countries hit the constraint they are forced to sell domestic assets, and this causes a further devaluation of the currency (overshooting) and a reduction of their stock prices (overreaction). This fire sale can have a significant negative wealth effect. The model highlights a key tradeoff when considering fixed versus flexible exchange rate regimes; a fixed exchange regime can, by avoiding exchange rate overshooting, mitigate the negative wealth effect but at the cost of additional distortions and output drops in the short run. There are plausible parameter values under which fixed exchange rates dominate flexible exchange rates from a welfare perspective.

KEYWORDS: Balance sheet effects; Currency crises; Exchange rate policy

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1 Introduction

Currency crises are usually associated with large nominal and real exchange rate depreciations. In some countries these depreciations are perceived to be very costly (Calvo and Reinhart, 2002, call it "fear of floating"). In this paper we try to understand some of the reasons behind this fear.

Several recent episodes of currency crises in emerging markets (such as Mexico, Thailand, Korea, Indonesia, Russia, Brazil, Turkey and Argentina) have had a number of common features.[1] Specifically, collapses of fixed exchange rate regimes have been associated with a sudden stop of capital inflows into the country and a sharp short-run overshooting of the nominal and real exchange rate well above their fundamental value; only over the medium run have the real exchange rates shown a tendency to return to their long-run equilibrium values. A similar pattern is observed for asset prices: stock markets fall sharply and their foreign currency values overshoot their long run values; only over time does the real value of stocks recover. Moreover, while traditional economic theory suggested that depreciations should have stimulated demand and output through their effects on competitiveness, many currency crises have been associated in the short-run with sharp output contractions rather than economic expansions.[2]

A key piece of evidence, to be shown below, suggests that the overshooting of exchange rates, the sudden stop of capital flows and the output drop can be related to the size of foreign currency debt of the country (the degree of liability dollarization), pointing to the important role of balance sheet effects in explaining the currency behavior and the output response. Specifically, it appears that large foreign currency debt, and the need to hedge open foreign currency positions once a peg breaks, may be behind the overshooting of exchange rates and of stock prices observed once the peg collapses. In turn, such currency overshooting (beyond what is the required to adjust an overvalued/misaligned currency) interacts with the existence of a large amount of foreign currency debt to create large balance sheet effects on firms, banks and governments (and the fire sale of equity assets to reduce exposure to such foreign currency liabilities) that are behind the severity of the output contraction.[3] After establishing this evidence in a more formal way, by estimating a joint relation between foreign debt, overshooting and output contractions, we go on to develop an

[1] See Roubini and Setser (2004) for a systematic overview of the emerging market crises of the last decade and the way that such crises were resolved.

[2] See Gupta, Mishra and Sahay (2003) for a recent study. For early studies of the effects of devaluation on output and other macro variables, see Connolly (1983), Edwards (1986), Taylor and Rosenzweig (1990).

[3] Aguiar and Gopinath (2005) provide evidence on the 'fire sale' effect in the East Asian crisis of 1997-98.

analytical framework that explains the overshooting phenomenon and can be used to evaluate the costs of a currency crisis in a country with a high level of foreign currency debt. The key mechanism of the model is the presence of a margin constraint (as in Aiyagari and Gertler, 1999) imposed on the domestic country. We find the margin constraint a simple and convenient way of modeling the sudden stop of capital inflows and the subsequent portfolio adjustment.

We model a crisis as a shock that forces both a depreciation of the exchange rate and an adjustment of the portfolio holdings of the country. If in the wake of the crisis the country abandons the peg there will be an immediate depreciation of the exchange rate. The fall in the value of the currency makes the margin constraint more likely to bind (the greater is the stock of initial foreign currency debt) and thus forces the country to sell domestic stocks to buy back some of its external debt. The stock sell-off further depresses domestic stock prices relative to the foreign currency debt making the margin constraint even more binding. The final effect of the move to a float is a large depreciation (with balance sheet effects) and a net loss of wealth because of the fire sale of assets. In this paper we use a model and the empirical evidence to show that these costs might be substantial. The paper also suggest that, in face of real shocks and margin constraints, it could be better to maintain a peg, at least for a period, as a temporary peg would reduce the distortionary pressure of the margin constraint. This complements a recent literature on balance sheet effects and currency regimes suggesting that flexible exchange rates are superior to fixed exchange rates even once one takes into consideration the balance sheet effects of liability dollarization (Céspedes, Chang and Velasco, 2004, and Gertler, Gilchrist and Natalucci, 2003). These studies find that flexible exchange rate regimes dominate fixed rate regimes even when one considers the balance sheet effects deriving from liability dollarization. The intuition for this result is simple: if an external shock -such as an increase in the world interest rate or a fall in the demand for exports - requires a real devaluation, such devaluation can occur in two ways: (a) through a nominal depreciation under flexible exchange rates; or (b) through a domestic deflation under fixed exchange rates. Thus, under both regimes there are going to be negative balance sheet effects when a shock hits the economy; these effects imply contractions in output under both regimes. However, under fixed rates the output effects of the shock will be larger because with nominal rigidities deflation exacerbates the contraction in output and employment. Our paper shares the same elements of those papers but adds a type of financial friction, the margin constraint. This mechanism makes it more worthwhile for policymakers to keep the real exchange fixed, and thus it generates a meaningful trade-off between fixed and flexible regimes.

This paper is also related to a recent analytical literature on balance sheet effects and output contractions.[4] This literature has stressed the role of "balance sheet effects" in explaining the contractionary effects of depreciations: when liabilities are in foreign currency while assets are in local currency, a real depreciation has sharp balance sheet effects that can lead to a firm's illiquidity, financial distress and, in the extreme, bankruptcy; in these papers, the output effects of depreciations are modeled as deriving from "financial accelerator effects" on investment.

Regarding the empirical literature, there is still little work on the output effects of currency crises. Contributions include Milesi-Ferretti and Razin (2000), and Gupta, Mishra and Sahay (2003).[5] These studies use a much larger data set than our paper as they consider: (a) crises in the 1970s-1990s period rather than just the 1990s, as this paper does; (b) take a very broad definition of a currency crisis that includes not only the breaks of pegs but also modest depreciations under semi-flexible exchange rates; and (c) consider both countries with capital account restrictions and those open to international capital markets. As we like to concentrate on the balance sheet effects of sudden and sharp reduction in currency values in economies open to international capital markets, we have a much smaller sample that covers only the crises since the 1990s. Gupta, Mishra and Sahay (2003) find that crises that are preceded by large capital inflows, that occur at the height of an economic boom, under a relatively free capital mobility regime, and in countries that trade less with the rest of the world, are more likely to be contractionary in the short-run. These results confirm and extend results found by Milesi-Ferretti and Razin (2000). Our empirical study below uses a similar set of regressors but concentrates on the effects of liability dollarization and its interaction with exchange rate overshooting. While a measure of liability dollarization was not significant in the Gupta, Mishra and Sahay (2003), we find that such a variable is highly significant and dominates alternative regressors in the output regression.

The structure of the paper is as follows. Section 2 presents the stylized facts regarding exchange rate overshooting, balance sheet exposure and output contraction during crisis episodes and establishes their links through a simultaneous equation estimation. Section 3 presents a basic model of overshooting and our numerical results. Section 4 concludes.

[4] See Kiyotaki and Moore (1997), Krugman (1999), Aghion, Banerjee and Bacchetta (2000), Céspedes, Chang and Velasco (2004), Caballero and Krishnamurty (2003), Christiano, Gust and Roldos (2004) and Mendoza (2002). Allen et al. (2002) integrate the balance sheet approch in a policy framework. See Roubini and Setser (2004) for a broder survey of this "balance sheet" literature to financial crises.

[5] Ahmed, Gust, Kamin and Huntley (2002) find for a sample of selected developing economies that real exchange rate devaluations tend to be contractionary. However, their results suggest the cause of the perverse effects of a devaluation is not the abandonment of a peg *per se*, but rather the interaction between the change in the exchange rate regime and the structural characteristics of developing economies.

2 Empirical Analysis

In this section we present our main empirical findings. As the object of our investigation is the behavior of the real exchange rate after a crisis, our first task is to identify currency crises episodes in the data. We restrict our analysis to the last decade and to countries with reasonably liberalized capital accounts.[6] We examine all countries in the JPMorgan real effective exchange rate universe and obtain monthly nominal exchange rate series in local currency versus the US dollar or the DM (for Euro area countries). We define dep_{it} as the 3-month nominal depreciation in month t for country i and we identify period t as the start of a crisis if the following two conditions are met

- dep_{it} >10% and $dep_{it} - dep_{it-3}$ >10%
- An official peg or crawling peg broke

These criteria leave us with 24 crisis episodes, and the countries and crisis dates are reported in Table 1.[7]

We define fundamental depreciation as the weakening of the real effective exchange rate (REER) that brings the exchange rate back to equilibrium, while overshooting is any weakening above and beyond the fundamental depreciation. Specifying an equilibrium REER will enable us to measure these two components of total depreciation. We assume that when a country begins to experience a crisis, its REER may be overvalued, but that after the crisis, the REER eventually adjusts to its equilibrium level. Indeed, in the episodes we study, the post-crisis REERs tend to stabilize at a level about 16% weaker than their pre-crisis values. The amount of time that elapses before the exchange rate stabilizes varies across countries, so for consistency across countries, we define the REER prevailing 24 months after a crisis as the equilibrium level and we check the robustness of this assumption later. We can now define fundamental depreciation as the percent deviation of the equilibrium REER from the observed pre-crisis REER. In other words, the fundamental depreciation is equal to the ex ante misalignment of the REER. Overshooting is the additional depreciation above and beyond fundamental depreciation, so it is measured as the percent deviation of the REER at its weakest point during the 24 months following a crisis from the equilibrium level. Figures 1a, 1b and 1c report the path for the real effective exchange rates for each crisis in our sample. We can observe three patterns:

[6] We focus on what Dornbusch (2002) has called *new style crises,* whose central aspect is the focus of balance sheet and capital flights. This type of crisis is typical of the 1990s.

[7] These criteria are similar to the ones used by Frankel and Rose (1996).

i) An 'Asian style' crisis with large equilibrium devaluation and large overshooting; this is observed for most Asian crises of 1997 and for other cases such as Mexico in 1994.

ii) A 'European style' crisis with a relatively large equilibrium devaluation (around 20%) but a very small overshooting; this pattern is observed for the European countries that experienced a currency crisis during the 1992 EMS turbulence period.

iii) Crises with no substantial change in the long run value of the real exchange rate but with overshooting that can be substantial (labeled 'Other Style'). These episodes include India in 1995, Bulgaria in 1998 and Israel in 1998.

Figure 2 provides evidence that crises episodes in countries with high net debt indeed resulted in higher overshooting. More specifically, our measure of net debt includes all sectors' foreign currency obligations and nets out foreign currency assets of the banking system. Where possible, we also net out foreign currency assets of the corporate sector. These data are generally not available for the emerging markets in our sample, but are likely to be quite small relative to the other figures involved for these countries. We do not net out the reserves of the monetary authority since these assets will not necessarily be made available to agents wishing to hedge, and we test the robustness of this assumption below.

So far we have shown that overshooting is related to net debt and in the model we will argue that this relation arises because of a sharp adjustment of country portfolios during the crises. Therefore crises with higher overshooting are, in sense to be made precise later, more costly. Another reason for which large depreciation together with large debt is costly is the presence of so called "balance sheet effects": devaluation in presence of large foreign currency liabilities can increase the value of debt relative to revenues, crippling insufficiently hedged debtors and leading to business failures and output contractions.

To test that the output contraction is related to balance sheet effects, we first need to quantify the severity of the output contraction. We use seasonally-adjusted quarterly GDP data for the 2 years following each crisis and define the output contraction as the percent deviation of the lowest output level during that 2-year period from the pre-crisis output level. In this way, we capture the worst of the crisis damage in each country without needing to control for different speeds of exchange rate pass-through across countries. For countries that do not experience a post-crisis contraction, we use the (positive) percent deviation of the GDP level one year after the crisis from the pre-crisis

output level.[8]

Finally, we need to measure balance sheet effects. The logic behind the concept suggests that the potential for balance sheet effects should come from the increase in the real value of the foreign debt to GDP ratio that is measured by the product of net debt position times the total real exchange rate depreciation. Figure 3 indeed shows convincing evidence of a log-linear[9] relation between output contractions and debt/depreciation products, suggesting an important role for these effects.

2.1 Regression analysis

In this subsection, motivated by the suggestive evidence in Figures 2 and 3, we provide an econometric analysis of the empirical relationship between net debt, real exchange rate overshooting, and output contraction. The equations we estimate are the following:

(1) $$overshooting = \alpha_1 + \alpha_2 net\_debt$$

(2) $$gdp\_change = \beta_1 + \beta_2 \log\left(net\_debt \cdot total\_depreciation\right).$$

Equation (1) regresses exchange rate overshooting on our measure of net debt, while equation (2) regresses output contraction on our measure of balance sheet effects. We expect that $\alpha_2 > 0$, i.e., a heavier foreign currency debt burden implies more overshooting. We also expect $\beta_2 < 0$. Larger balance sheet effects, as measured by the product of heavier burdens and more depreciation, imply steeper contractions in output. We report our benchmark results in Table 2.

In column (1) we present the results obtained by estimating equations (1) and (2) separately using ordinary least squares (OLS). Despite the relatively small size of the sample, the estimation results strongly support our hypotheses. Both α_2 and β_2 have the expected signs and are significant at the 1 percent level. Our findings imply that the heavier a country's foreign currency debt burden, the more overshooting one can expect during a crisis. The results, furthermore, support the view that the severity of a country's post-crisis output contraction depends on balance sheet effects. The more depreciation a country experiences and the greater its foreign currency debt burden, the deeper

[8] In considering the effects of currency crises on output and other macro variable one need to decide which post-crisis window to consider. Some studies, like ours, analyze the short and medium term effects of the crisis and consider a post-crisis window up to two years (see Gupta, Mishra and Sahay, 2003, and Bordo, Eichengreen and Klingebiel, 2001). Other studies consider long-run effects of the crisis and thus longer post-crisis windows (see Aziz, Caramazza and Salgado, 2000).

[9] Even though a log-linear relation provides a better statistical description of the relation, we find a strong and significantly negative association between the two variables even when we use a simple linear relation.

its post-crisis output contraction will be. The results from the OLS regression, however, need to be taken with caution. Two potential problems are the small sample size and endogeneity. We address these concerns below.

First, since our regressions are based on only 24 observations, a legitimate concern is whether the asymptotic arguments that permit statistical inference truly hold up with such a small sample size. As a check on our findings, we reestimate coefficients and standard errors using a median regression, and present the results in column (2) of Table 2. We find that the coefficients, α_2 and β_2, have the correct sign and are still significant at the 1 percent level. We conclude that our main empirical findings are not biased by the small size of our sample.

Second, one problem with using OLS to estimate equations (1) and (2) separately is that the overshooting variable in equation (1) enters as part of the total depreciation variable in equation (2):

$$(3) \qquad total\_depreciation = fundamental + overshooting + fundamental * overshooting$$

Therefore, OLS estimation of the two equations separately will be inconsistent if the covariance matrix of the residuals from the two equations is not diagonal. A nondiagonal covariance matrix implies that the explanatory variables in the second equation are correlated with the residuals from the same equation, violating the assumptions of OLS. To address this problem, we use three-stage least squares (3SLS) to estimate equations (1) and (2) as a system of simultaneous equations. Three-stage least squares involves regressing the endogenous variable from the first equation on a set of instruments and then using the predicted values—rather than the original data—in estimating the second equation.[10] We report the results in column (3) of Table 2. Coefficients still have the expected sign and are still significant at the 1 percent level. In addition, point estimates are similar in magnitude to the OLS estimates.

Quantitatively, we interpret our results as follows. Suppose that a country at the average of our data set has a fundamental depreciation of 15.5 percent and a net foreign currency debt/GDP ratio of 40 percent. Then, an increase in a country's net foreign currency debt/GDP ratio by 10 percentage points increases overshooting by about 11.8 percent, while yielding an additional output contraction of 1.6 percent, through its direct effect on output and its indirect effect through overshooting. We can also measure the impact on output of changes in the other exogenous variable,

[10]We follow convention by including all the exogenous variables from the simultaneous equations system in our set of instruments. Since the overshooting variable enters equation (2) in a nonlinear way, we also include nonlinear functions of the exogenous variables in our sets of instruments as Kelejian (1971) recommends.

fundamental depreciation. According to our results, if the fundamental depreciation of an "average country" increases by 10 percentage points, we would expect output to contract by an additional 0.8 percent.

2.2 Robustness Tests

In this subsection we verify the strength of our findings. The findings of the previous subsection can be potentially criticized on two grounds. First, our hypotheses that foreign currency exposure fuels overshooting and that balance sheet effects induce output contractions are, of course, only one set of the possible explanations for these phenomena. Our first set of tests, therefore, consists of evaluating the robustness of our model to competing theories. We do so by including additional regressors to our system of two equations, and reestimating our model. In addition, we explore the possibility that one of the alternative explanations of the postcrisis output contractions, namely, the presence of a banking crisis, may itself be a variant of the balance sheet story we stress in this paper. The second ground for criticism is that our regression results may be sensitive to the definitions of the variables we use. In our second set of tests, therefore, we check whether our findings are robust to changes in the definitions of our regression variables. We find that our results are robust to both these sets of tests.

Table 3 presents the results we obtain by modifying our benchmark specification with the inclusion of additional regressors. Its columns correspond to the modifications that we consider.

First, we include a measure of reversal of financial inflows in equation (2), and then in both equations (1) and (2). As suggested by Calvo (1998), a "sudden stop", or reversal of financial inflows, could adversely affect output if less international credit is available to finance productive enterprises.[11] We measure the reversal in financial inflows by computing the difference between the financial inflows in the 12 months following a crisis and the financial inflows in the 12 months preceding a crisis, and then dividing it by the precrisis output. Columns (1) and (2) show that this variable is significant at the 1 percent level. However, including this variable does not change the significance of the coefficients in the benchmark model, although it does slightly attenuate the impact of balance sheet effects on output. These results indicate that balance sheet effects are an important determinant of output even after controlling for reversals of financial inflows.

Second, we explore the idea that a sharp contraction in real bank credit to the private sector

[11] See Calvo and Reinhart (2002) for some evidence on this hypothesis and Arellano and Mendoza (2003) for an analytical overview of the "sudden stop" phenomenon.

could exacerbate a postcrisis output contraction. Hence, we compute the change in real bank credit over the two years following each crisis, and include this variable in equation (2), and then in both equations (1) and (2). As shown in columns (3) and (4) of Table 3, the two-year change in real credit to the private sector is significant at the 5 percent level. The inclusion of this variable slightly attenuates the coefficients on the other variables, but debt and balance sheet effects remain significant.

Third, we include a measure of world growth in equation (2). By doing so we acknowledge that world growth may play some role in the magnitude of output contraction following a crisis. Specifically, countries that experience a crisis when the world market is booming could find it easier to recover, whereas when a crisis in a small open economy coincides with world recession, weak foreign demand could exacerbate a recession. To test this idea, we compute world growth over the two years following a crisis and add this variable to the output equation (2). Column (5) of Table 3 shows that while world growth is significant at the 1 percent level, its inclusion does not affect the other coefficients substantially.

Finally, a sharp output fall could be the result of a banking crisis. Indeed, in our sample, there are 13 cases of twin crises, where a currency crisis is concurrent with a banking crisis. In many of these episodes it is clear from the history of events that the banking crisis was triggered in part by the balance sheet effects of currency mismatches in the banking system and/or the corporate and the household sector.[12] In cases like these, the output effects of the banking crisis are consistent with—and the consequence of—the balance sheet argument presented in this paper. For this reason, we explore the possibility that banking crises themselves are partly the result of balance sheet effects. To test for this, we estimate a simple binary probit model of banking crisis with the method of maximum likelihood. As our dependent variable, we use an indicator function which takes on the value of one whenever a banking crisis is concurrent with or follows a currency crisis and zero otherwise, and we regress it on our measure of balance sheet effects. As reported in Table 4, the balance sheet variable has a significant effect on the probability of a banking crisis. This result suggests that the banking crisis itself can be traced back to balance sheet effects.

We also test the robustness of our benchmark results to changes in the definitions of our regression variables and we report the results in Table 5. Its columns correspond to the alternative

[12]See Mishkin (1996) for the effects of a devaluation on the balance sheets of domestic banks in emerging market countries. Kaminsky and Reinhart (1999) discuss briefly the possible theoretical links between banking and currency crises and analyze empirically their interaction.

definitions of the regression variables.

We first change our measure of net debt by taking out government assets in addition to banking system and corporate external assets. Column (1) in Table 5 shows that our benchmark results hold up under the alternative definition of net debt/GDP.

Next, we consider three alternative definitions of the equilibrium REER. When we redefine the equilibrium REER as the REER that prevails 36 months after a crisis, both α_2 and β_2 retain the expected signs and are significant at the 1 percent level, as shown in column (2) of Table 5. When we redefine the equilibrium REER as the average REER that prevails during the three years preceding and the two years following a crisis, once again, α_2 and β_2 have the expected signs and remain significant at the 1 percent level, as reported in column (3) of Table 5, though α_2 drops from 1.2 to 0.9. For our last alternative, we redefine the equilibrium REER as the average REER during the 5 years preceding a crisis. By doing so, we address a potential problem of endogeneity with our use of postcrisis data to measure the equilibrium REER. It is theoretically possible that one of our instruments, fundamental depreciation, could be partly endogenous in our model. This could be the case if, for example, the degree of overshooting, the size of net debt, or the output contraction induce policy changes in the initial stages of a crisis that modify the equilibrium REER. This would invalidate our specification. For our model to be econometrically identified, both of our instruments—net foreign currency debt and fundamental depreciation—must be exogenous. With this redefinition, fundamental depreciation is fully determined prior to the crisis and cannot be endogenously determined by further developments as the crisis unfolds. When we rerun our benchmark IV regression, column (4) of Table 5 indicates that our results hold up under this alternative definition of fundamental depreciation.

Finally, we experiment with measuring overshooting as the sum of deviations of the REER from the equilibrium level over the 24 months following the crisis. This alternative measure is intended to account for the idea that an overshooting that lasts for a day or two may not have the same effect as an overshooting that lasts for months or years. As this measure of overshooting is substantially different from that of the benchmark model, the coefficient on the redefined variable in column (5) of Table 5 changes substantially, but the sign remains correct.

We conclude, therefore, that our regression results are robust to changes in the definition of our regression variables.

In summary, our benchmark results and robustness tests establish that the amount of exchange rate overshooting is related to a country's foreign currency debt burden and that the con-

tractionary effect of a crisis is related to a country's vulnerability to balance sheet effects.

3 A simple model of real exchange rate overshooting

In this section we discuss a simple model of currency crisis in order to understand better the mechanism that links the overshooting of the exchange rates to the level of foreign debt. The model is a simplified version of the model presented by Céspedes, Chang and Velasco (2004) and by Gertler, Gilchrist and Natalucci (2003), with the addition of a particular type of financial imperfection, namely margin constraints. We also find the model useful to analyze the choice of exchange rate regime in an environment with margin constraints. In this subsection we focus on a real economy that can be interpreted as a monetary economy with flexible exchange rates.

We consider a small open economy that produces a homogeneous good that can be used for local consumption or for export. Preferences of the representative home consumer are given by

$$\sum_{t=0}^{\infty} \beta^t u\left[G(c_{H,t}, c_{F,t}), l_t\right],$$

where u is a well behaved utility function, G is a CES aggregator of domestic and foreign consumption, $c_{H,t}$ and $c_{F,t}$ are domestic consumption of the home and foreign goods and l_t is labor used in the production of the home good. Output of the domestic good y_t is produced by firms using labor with a decreasing returns to scale technology

$$y_t = l_t^{\alpha}, \quad 0 < \alpha < 1.$$

Firms are owned by domestic consumers and foreigners and their stocks are traded internationally. In the rest of the paper we are going to normalize the price of the home good to 1 and denote by p_t the price of the foreign good relative to the home good (the real exchange rate is then proportional to p_t).

The domestic representative consumer maximizes expected utility subject to the following constraints

$$w_t l_t + (q_t + d_t)\, s_t + p_t b_t - c_{H,t} - c_{F,t} p_t - \frac{p_t b_{t+1}}{R_t} - q_t s_{t+1} \geq 0, \tag{4}$$

$$\frac{p_t b_{t+1}}{R_t} + \kappa_t q_t s_{t+1} \geq 0, \quad 0 \leq \kappa_t \leq 1, \tag{5}$$

and to initial conditions for s_0 and b_0.The first equation is a standard budget constraint (all in units of the local good) where d_t are the dividends paid by the firms, w_t is the real wage , s_t are the stocks of firms owned by domestic households, q_t is the price of this stock, b_t is the stock of foreign

assets of the household sector and R is the (exogenous) interest rate that domestic consumers face on the international market. The second equation represents what Aiyagari and Gertler (1999) call a "margin constraint". The assumption underlying the margin constraint is the existence of a domestic financial sector which holds the financial assets and liabilities of the country. At each point in time the debt $(-p_t b_{t+1}/R_t)$ to assets $(q_t s_{t+1})$ ratio of the financial sector has to be below a certain threshold κ_t.

Firms choose employment so as to maximize dividend payments to their shareholders that are given by

$$d_t = l_t^{\alpha} - w_t l_t.$$

An equilibrium is characterized by the first order conditions for the households and firms and by market clearing in the goods, labor and asset markets. Regarding the market for stocks of firms, we follow Aiyagari and Gertler (1999) and Mendoza and Smith (2002) and assume that the demand for domestic stocks is not infinitely elastic. In particular, we assume that changes in the position of domestic stocks can only be achieved through a reduction in stock prices to below their fundamental price (implicitly we are assuming the existence of a risk neutral international stock trader who faces an information processing cost so that she is willing to buy large amounts of stocks of the domestic country only at a discount). This assumption generates the following international demand for domestic stocks s_t^*

$$s_{t+1}^* - s_t^* = \frac{1}{a}\left[\frac{q_t^f}{q_t} - 1\right], \tag{6}$$

where q_t^f is the fundamental price for a risk neutral trader's stocks and is given by

$$q_t^f = \sum_{i=1}^{\infty} \beta^j d_{t+i},$$

and a is a parameter reflecting the portfolio adjustment cost of the international trader. Equation 6 plus the equilibrium in the markets for stocks $(s_t + s_t^* = 1)$ implies the following law of motion for domestic stocks

$$s_t - s_{t+1} = \frac{1}{a}\left[\frac{q_t^f}{q_t} - 1\right]. \tag{7}$$

The goods market clearing condition requires that the production of the domestic goods is equal to the domestic consumption plus exports. We assume that foreign expenditure on domestic goods (denominated in foreign currency) is exogenously given (as in Céspedes, Chang and Velasco, 2004) by x_t so the goods market clearing condition is

$$c_{H,t} + p_t x_t = y_t. \tag{8}$$

3.1 The experiment

In this section we make assumptions about the functional forms and parameter values for the model and conduct simple numerical policy experiments. For the utility function and aggregator of foreign and domestic consumption we assume the following functional form

$$\begin{aligned} u(G, l_t) &= \frac{\left(G - \frac{l_t^\nu}{\nu}\right)^{1-\sigma}}{1-\sigma}, \\ G(c_{H,t}, c_{F,t}) &= \left[\omega c_{H,t}^{\frac{\rho-1}{\rho}} + (1-\omega) c_{F,t}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}. \end{aligned}$$

These preferences have the desirable property that they do not imply wealth effects on labor supply.[13] Many authors have documented that, especially in small open economy models, this property is necessary for the model to reproduce the business cycle facts.[14] The parameter v is set equal to 3.5 to generate a realistic wage elasticity of labor supply. The aggregator G is standard and we set the elasticity of substitution between domestic and foreign good to the value of 1.2, which lies in the middle of the range of empirical estimates for Europe and US (see Backus, Kehoe and Kydland, 1994). The remaining parameters and initial conditions value are summarized in Table 6 below. Many of the parameter values are chosen to generate empirically plausible values for steady state ratios (In particular import, export to output ratios plus labor shares) but for some parameters (in particular a and κ) we have much less empirical guidance so we set them to arbitrary values and we experiment with many possible values. Since our quantitative results *do* depend on the particular parameter values, the findings we present are only suggestive and do not provide a complete evaluation of the quantitative properties of the model. Some discussion on alternative

[13] As pointed out by Mendoza (2002), in a one-good model these preferences would imply that the marginal rate of substitution between consumption and labor effort would depend only on the marginal disutility of labor. In the two-good model version of this paper however, the marginal rate of substitution depends also on the marginal utility of the home good, which in turn depends on the relative price of the foreign good. Hence movements in the relative price affect labor supply.

[14] See for example Mendoza (1991), Correia, Neves and Rebelo (1995), and Neumeyer and Perri (2005).

parameters and functional forms is provided below.

Table 6. Baseline parameter values

Name	Symbol	Value
Yearly discount factor	β	0.9
International rate	R	$1/\beta$
Labor exponent	v	3.5
Labor share	α	0.6
Risk Aversion	σ	3
Elasticity of Substitution between c_H and c_F	ρ	1.2
Share of foreign good	ω	0.5
Adjustment costs of foreign trader	a	1.0
Margin limit	κ	0.1
Domestic stock owned by residents	s_0	0.9

We consider the following experiment. We follow two economies, one with a high debt to output ratio (65 percent) and one with a low debt to output ratio (45 percent). Up to period 0 we assume that both economies are at their steady states and no margin constraint is imposed: we think of these as normal times. In period 1 domestic households face a large, unexpected but permanent decline in export demand (x_t is reduced by 20 percent) and at the same time the margin constraint is imposed on the economies. We believe this a simple way to capture two key elements of a crisis period, namely the presence of negative real shocks and the reduction in confidence of international investors. In figure 4 we analyze the reaction to these shocks for the main macro variables in the two economies and in a version of the high debt economy in which the margin constraint is not imposed (the dotted line). We find it useful to first discuss the results for the latter economy as they give a measure of the fundamental adjustments required in a world without the financial friction. As exports fall the demand for the domestic good will fall; if production were held constant then domestic consumption would have to increase to absorb the entire output, but this increase in consumption can be achieved only with a fall in the relative price of the domestic good. As the

domestic good's price drops, its production will also drop and so will the labor income of domestic residents and the price of domestic equity. As domestic residents are now poorer, they must also reduce consumption. Notice that the debt to assets ratio, $-p_t b_{t+1}/Rq_t s_{t+1}$, of domestic consumers rises for two reasons: because the real exchange rate p_t increases and because the price of domestic equity falls. Finally observe that the stock position of the domestic household is not changed and this implies (from equation 7) that the stock price does not deviate from its fundamental level.

Consider now the same high-debt economy when the margin constraint is imposed, as shown by the solid line in Figure 4. Observe that now the debt to asset ratio has to be reduced to satisfy the margin constraint. The reduction in debt is effected via a fall in consumption and sales of domestic stocks. Because of the preferences we have assumed, however, the output response and export reduction are rather similar in the economies with and without the margin constraint. In this context, market clearing (equation 8) implies that when consumption falls by more than in the no-constraint case, the exchange rate must depreciate more: this is exchange rate overshooting. Similarly the market clearing condition for stock (equation 7) implies that the sales of domestic stock force stock prices below their fundamental level: this is asset price overreaction.

In the economy with lower initial debt (the dashed line) the required reduction in consumption and stock position is smaller and hence the overshooting and the overreaction are smaller.

To conclude, this simple model is consistent with evidence in the first part of this paper that relates the external debt burden to exchange rate overshooting. The model is not entirely consistent with the evidence about output, as economies with different levels of debt and different real exchange rate depreciation display rather quantitatively similar output drops while the data suggest that countries with heavier debts and larger depreciations should suffer larger drops.[15] One way to reconcile the model and the data would be to assume that the causality runs in the opposite direction, that is, greater overshooting is caused by larger export shocks that in turn cause deeper output drops. Alternatively, one can think about mechanisms through which a friction in the financial side of the economy, such as a binding margin constraint, spills over into the real side, for example through a reduction in investment or productivity, or also a reduction in the imports of an intermediate input that enters the production function of the home good.

[15]The fact that output responses are, to some degree, similar across economies depends crucially on the preferences we assumed. With preferences that display wealth effects on labor supply (as Cobb Douglas in consumption and leisure) the discrepancy between data and theory would be worse. The model in fact would predict that countries with larger overshooting would actually be associated with smaller output drops, as the negative wealth effect following the shock would make labor supply and equilibrium employment increase.

3.2 Exchange rate policy

The model we have analyzed so far suggests that the presence of margin constraints forces domestic agents to sell domestic stocks at a discount (fire sale) and this has negative consequences for their long run consumption. This suggests a possible role for exchange rate policy. If real exchange rate depreciation is contained, the debt to asset ratio remains lower and this can dampen the stock fire sale. At the same time though, avoiding the exchange rate depreciation has a negative demand effect and thus exacerbates the initial output drop. We can use a simple variant of our model to analyze these issues more formally. As noted above, the economy we analyzed can be interpreted as a flexible exchange rates economy.

We now consider the same economy subject to the same shock but in which the real exchange rate does not immediately adjust after the shock. In particular, in period 1 when agents learn about the shock the real exchange rate is kept fixed at the period 0 level, while in period 2 we let it adjust freely. Notice that since in period 1 one price is fixed, we cannot have market clearing in all markets and we choose to leave labor markets in disequilibrium. In general, at the equilibrium wage and consumption levels, the marginal utility of leisure will be lower than the marginal utility of consumption times the wage, meaning that agents would be willing to work more but firms would not hire them because there is not enough demand for their products. We will consider this as our fixed exchange rate economy.

In figure 5 the response to the same export shock for a fixed (solid line) and for a flexible exchange rate (dashed line) economy is considered. Notice that in the fixed exchange rate economy there is no exchange rate movement on impact and this reduces the growth of the debt to asset ratio and thus reduces the fire sale of stocks (see the panel with the domestically held stocks). The fact that the fire sale is avoided allows domestic agent to maintain a higher consumption level in the long run under the fixed exchange rate regime (see the consumption panel). At the same time though, under fixed exchange rates, the foreign demand of domestic good is reduced more upon the impact of the shock, and so output and domestic consumption drop more on impact. In general, which exchange rate system is preferable from a welfare point of view is ambiguous but for most of the parameters we have experimented with, our model implies that fixed exchange rates are preferable. This in contrast with the finding of Céspedes, Chang and Velasco (2004); the reason for the different finding lies in the presence of the margin constraint. In our model, as in theirs, the fixed exchange rate does not eliminate the change in relative prices but only delays it, and as in theirs, the fixed exchange rate distorts labor markets. The difference is that in our model, the delay of the change

in relative prices is important as it reduces the distortionary impact of the margin constraint on the agent utility profile. Interestingly we also find that keeping the exchange rate fixed for more than one period is always suboptimal, suggesting that in some cases the optimal exchange rate policy could be to keep the exchange rate fix in the initial periods of the crisis, allowing people to adjust their portfolios, and then let it float.

4 Conclusion

In this paper we present a theoretical and empirical analysis of exchange rate overshooting, balance sheet effects and output contraction. Our empirical analysis suggests that overshooting of the real exchange rate following currency crises is severe in countries with high levels of foreign debt and that severe output contractions are associated with overshooting. The econometric estimates can also be used to forecast the amount of exchange rate overshooting and output contraction to be expected in ongoing episodes of turmoil.

The analytical framework shows that financial distortions deriving from a lack of hedging and margin constraints lead to overshooting of both real exchange rates and asset prices under flexible exchange rates once a crisis occurs. The margin constraint leads to a fire sale of assets to reduce foreign currency liability exposure and causes a negative wealth effect that adversely affects long run consumption and welfare. Under fixed exchange rates such a short-run overshooting of the real exchange rate is prevented and thus the overshooting of equity prices is contained, at the cost of a larger short-run contraction. This framework–unlike previous results in the literature on fixed versus flexible exchange rates under liability dollarization–suggests that currency crises and the sudden move to flexible rates can be dominated by a policy of keeping the exchange rates fixed, at least for a period of time.

There are many possible extensions of this work. First, one could consider a large sample of currency crisis episodes. Second, one may want to test whether currency crises have different effects when the capital account is heavily restricted and the domestic financial system not liberalized; this may imply comparing the overshooting and output effects of currency crises in the 1990s when capital markets were liberalized with those in previous decades when such liberalization had not occurred yet and crises were driven more by current account developments than by capital account developments. Also, as more and more emerging markets have adopted flexible exchange rate regimes in the last decade, one could make an integrated study of overshooting, balance sheet effects and the performance of ensuing flexible exchange rate regimes. Finally, the model we consider is too

simple to capture the effects of financial frictions on the real side of the economy. One natural way of doing so would be to explicitly model investment decisions. We leave these extensions to future work.

5 Tables

1. Benchmark Regression Data
2. Main Regression Results
3. Robustness to Inclusion of Additional Regressors
4. Endogeneity of Banking Crises and Balance Sheet Effects
5. Robustness to Redefining Regression Variables
6. Baseline parameters

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Table 1
Benchmark Regression Data

Country	Crisis Date	REER Fundamental Depreciation[a] (1)	REER Overshooting[a] (2)	REER Total Depreciation[a] (3)	Net Foreign Currency Debt/GDP[b] (4)	Real GDP Change[c] (5)
		local/$, % of t_0	local/$, % of t_{24}	local/$, %	%	%
Argentina	Jan-02	11	90.6	111.5	73.1	-12.8
Brazil	Jan-99	4.8	37	43.6	28.2	3.8
Bulgaria	Mar-96	-9.9	142.1	118.2	73.8	-16.3
Czech	May-97	2.4	6.5	9	26.7	-4.4
Ecuador	Sep-98	43.3	51.1	116.5	82.4	-6.9
Finland	Sep-92	10	13	24.2	45.2	-2.2
India	Oct-95	-6.8	22	13.7	23.6	7
Indonesia	Aug-97	22.4	155.3	212.3	52.3	-16.5
Israel	Oct-98	1.3	16.3	17.8	43.6	2
Italy	Sep-92	27.9	1.4	29.7	17.2	-1.9
Korea	Nov-97	22.6	32.8	62.9	27.4	-8.4
Malaysia	Aug-97	34.1	16	55.6	32.8	-8.9
Mexico	Dec-94	19.5	38.2	65.1	34.2	-8
Philippines	Aug-97	18	16.8	37.9	51.4	-1.1
Russia	Aug-98	56.5	28.9	101.8	42.9	-2.3
South Africa	Jun-98	11.4	7.8	20.1	17	-0.3
South Africa	Apr-96	0.3	10.5	10.8	13.7	4.1
Spain	Sep-92	22.1	3.3	26.2	13.8	-1.8
Sweden	Nov-92	13.8	9.4	24.5	52.7	-3
Thailand	Jul-97	16.3	35.6	57.7	47.7	-13.4
Turkey	Jan-94	21.7	17.9	43.5	32.1	-11.6
Turkey	Feb-01	4.5	24.2	29.8	46.4	-22.7
UK	Sep-92	14.5	5.2	20.4	14.1	2.2
Venezuela	Dec-95	9.9	41	54.9	71.4	-2.3
Average		**15.5**	**34.3**	**54.5**	**40.1**	**-5.2**

[a] JPMorgan
[b] BIS, IMF, World Bank
[c] DRI, IFS

Table 2
Main Regression Results

	OLS (1)	QR (2)	IV (3)
α_1	-13.8	-2.57	-13.22
	(14.97)	(7.77)	(14.27)
α_2	1.20***	0.61***	1.18***
	(0.33)	(0.17)	(0.32)
β_1	21.86***	26.40***	17.69***
	(7.26)	(7.21)	(7.43)
β_2	-3.74***	-4.46***	-3.17***
	(0.99)	(0.99)	(1.01)
R^2 (1st Eq.)	0.37	0.17	0.37
R^2 (2nd Eq.)	0.39	0.3	0.39
N. of Obs.	24	24	24

OLS: Ordinary Least Squares Results
QR: Quintile Regression Results
IV: Instrumental Variables Results
***, ** and * indicate significance at the 1%, 5% and 10% levels respectively
Standard errors are in parentheses

Table 3
Robustness to Inclusion of Additional Regressors

	RFF2 (1)	RFF12 (2)	RCC2 (3)	RCC12 (4)	WG (5)
α_1	-13.2	-19.4	-12.13	-4.17	-12.99
	(14.32)	(14.1)	(14.86)	(14.58)	(14.2)
α_2	1.18***	1.11***	1.14***	0.82**	1.18***
	(0.32)	(0.31)	(0.34)	(0.37)	(0.32)
α_3	–	-1.92	–	-0.42*	–
		(1.17)		(0.23)	
β_1	15.82**	15.80**	10.67	9.85	11.51
	(5.93)	(5.93)	(7.9)	(7.92)	(6.97)
β_2	-2.43***	-2.41***	-2.05*	-1.92*	-4.04***
	(0.86)	(0.86)	(1.12)	(1.13)	(0.95)
β_3	0.72***	0.75***	0.092**	0.10**	4.66***
	(0.19)	(0.19)	(0.042)	(0.043)	(1.64)
R^2 (1st Eq.)	0.37	0.43	0.32	0.4	0.37
R^2 (2nd Eq.)	0.63	0.63	0.47	0.47	0.5
N. of Obs.	24	24	23	23	24

RFF2: Robustness to Financial Flows Reversal in Equation 2
RFF12: Robustness to Financial Flows Reversal in Equations 1 and 2
RCC2: Robustness to Real Credit Contraction in Equation 2
RCC12: Robustness to Real Credit Contraction in Equations 1 and 2
WG: Robustness to World Growth
***, ** and * indicate significance at the 1%, 5% and 10% levels respectively
Standard errors are in parentheses

Table 4
Endogeneity of Banking Crises and Balance Sheet Effects

Dependent Variable: BANKCRISIS	
Constant	-0.95*
	(0.51)
NET_DEBT*TOTAL_ DEPRECIATION	0.00057**
	(0.00028)
Log likelihood	-11.43
Akaike info criterion	1.12
Schwarz criterion	1.22
McFadden R-squared	0.31
Obs with Dep=0	11
Obs with Dep=1	13
N. of Obs	24

BANKCRISIS is an indicator function taking on the value 1 if there is a banking crisis concurrent with or following the currency crisis and 0 otherwise.

Table 5
Robustness to Redefining Regression Variables

	RNFCD (1)	RX36 (2)	RX5 (3)	RX5PCA (4)	RO (5)
α_1	-2.79	-19.09*	-0.45	5.03	-73.76
	(11.34)	(11.33)	(11.67)	(17.8)	(118.82)
α_2	1.21***	1.39***	0.92***	1.03**	6.45**
	(0.31)	(0.26)	(0.26)	(0.4)	(2.75)
β_1	7.99	18.41**	21.98***	19.98**	18.10**
	(6.07)	(6.13)	(7.37)	(7.92)	(7.46)
β_2	-1.95**	-3.15***	-3.76***	-3.49***	-3.23***
	(0.87)	(0.85)	(1.01)	(1.08)	(1.02)
R^2 (1st Eq.)	0.4	0.55	0.34	0.22	0.19
R^2 (2nd Eq.)	0.27	0.48	0.39	0.39	0.39
N. of Obs.	24	22	24	24	24

RNFCD: Robustness to Redefining Net Foreign Currency Debt
RX36: Robustness to Redefining the Equilibrium REER at 36 Months
RX5: Robustness to Redefining the Equilibrium REER as 5-Year Average
RO: Robustness to Redefining Overshooting
RX5PCA: Robustness to Redefining the Equilibrium REER as 5-Year Pre-Crisis Average
***, ** and * indicate significance at the 1%, 5% and 10% levels respectively
Standard errors are in parentheses

Figure 1a: Real Effective Exchange Rates for "Asian Style" Crises, t0=100

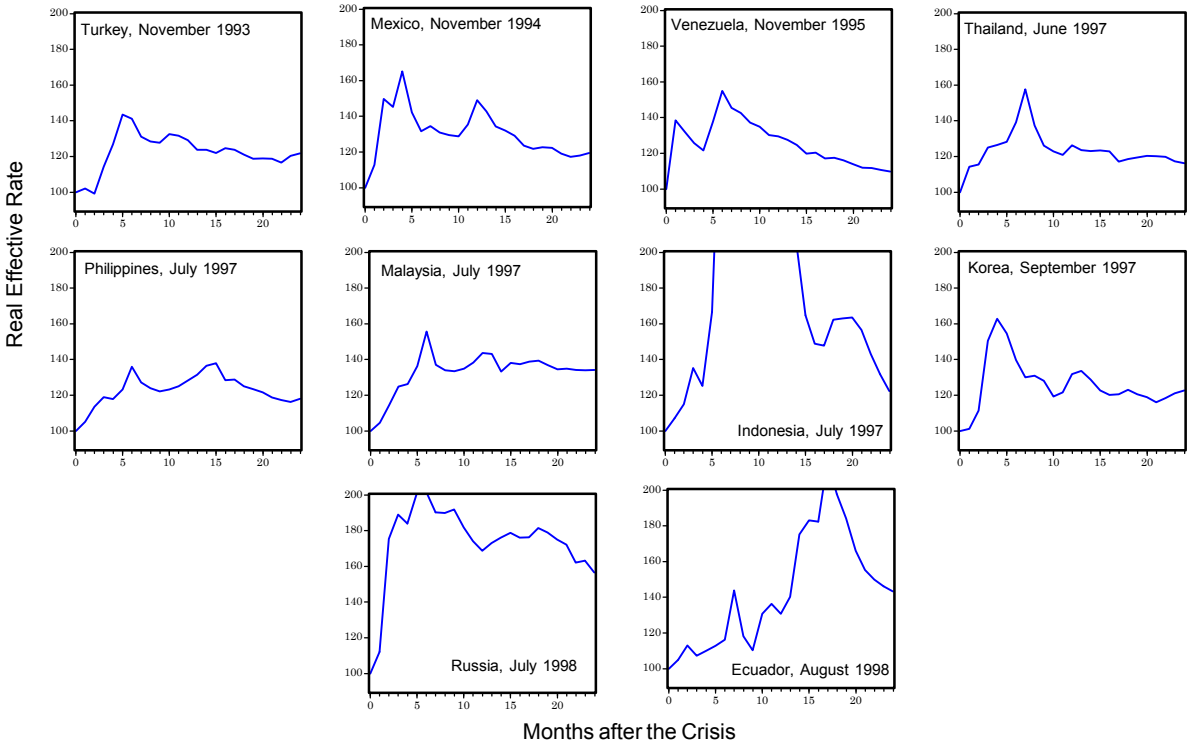

Figure 1b: Real Effective Exchange Rates for "European Style" Crises, t0=100

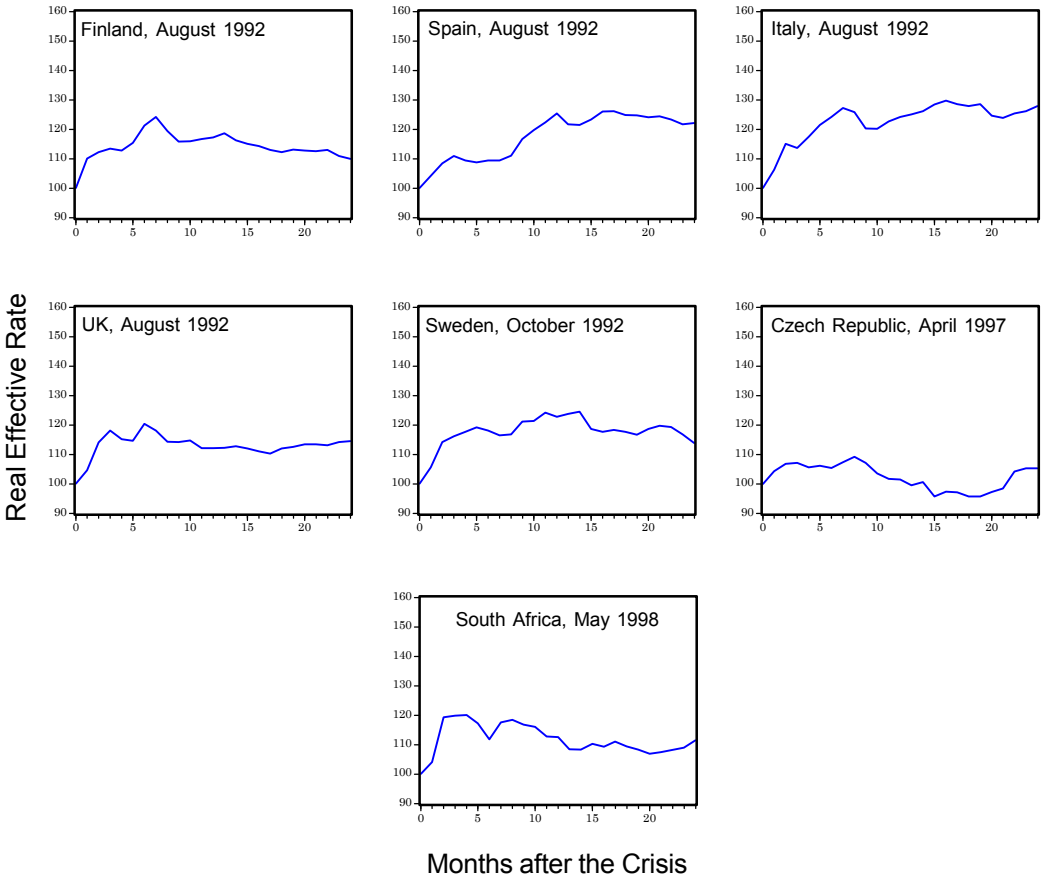

Figure 1c: Real Effective Exchange Rates for "Other Style" Crises, t0=100

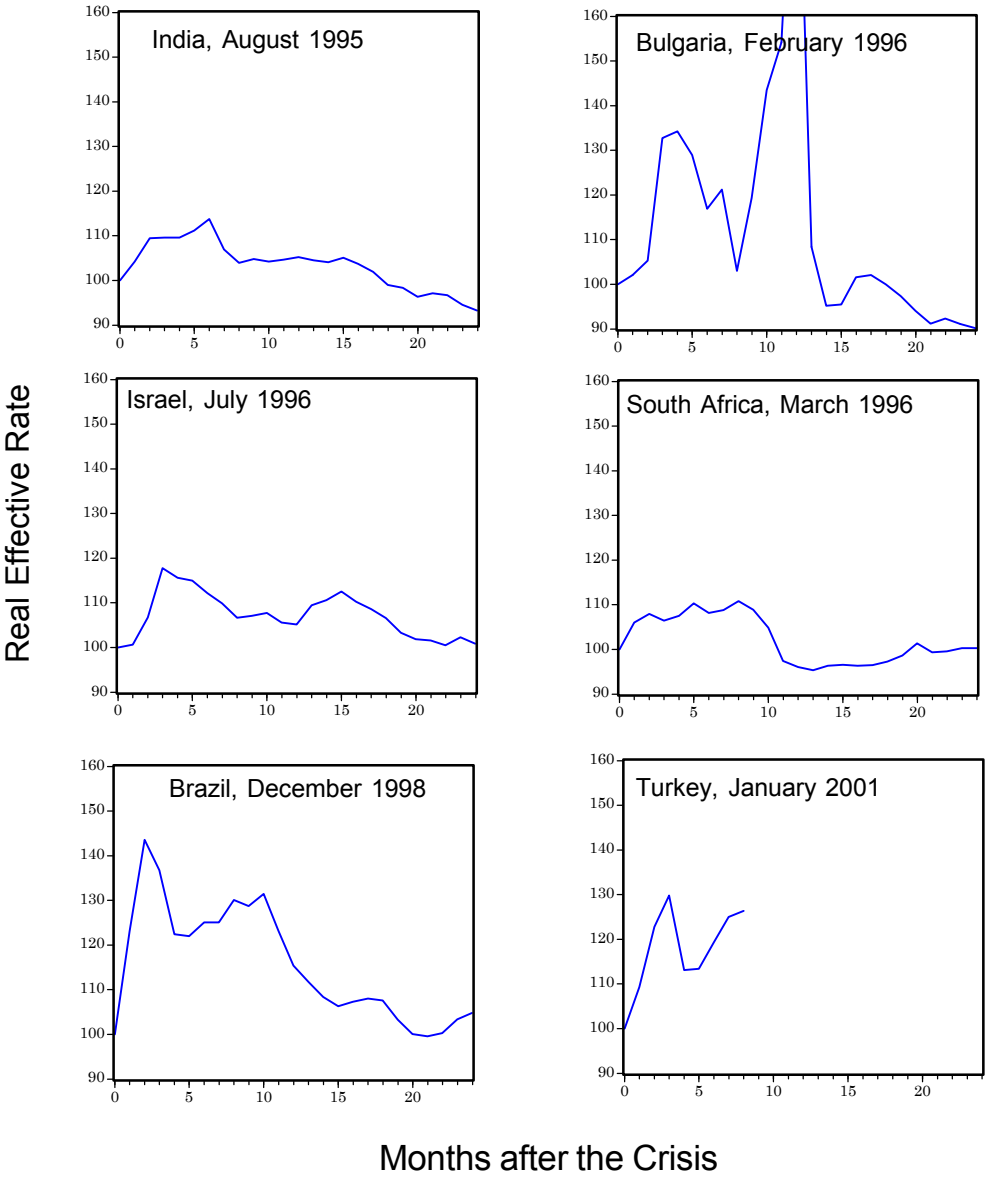

Figure 2. Foreign Debt and Real Exchange Rate Overshooting

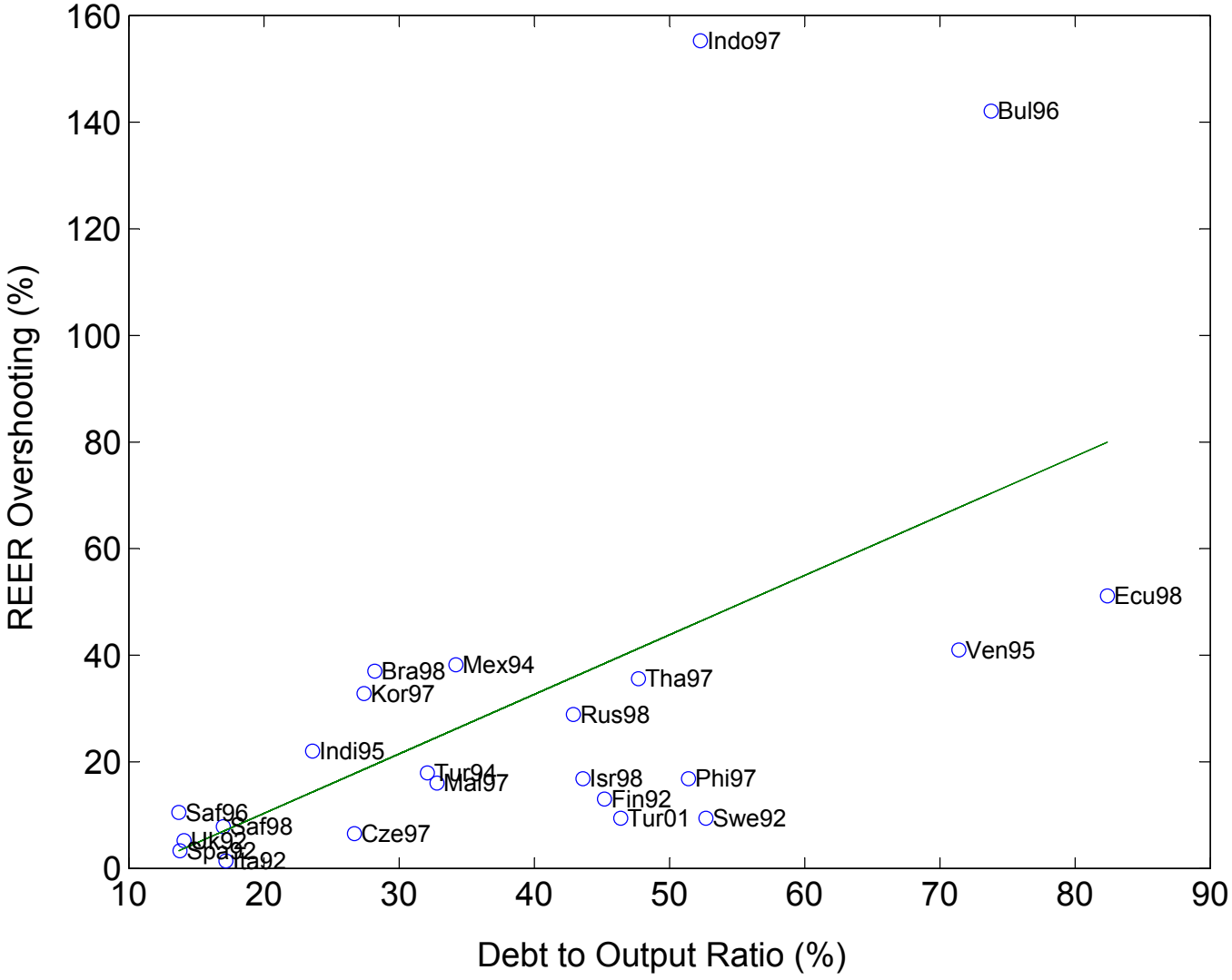

Figure 3. Contractionary effects of balance sheet effects

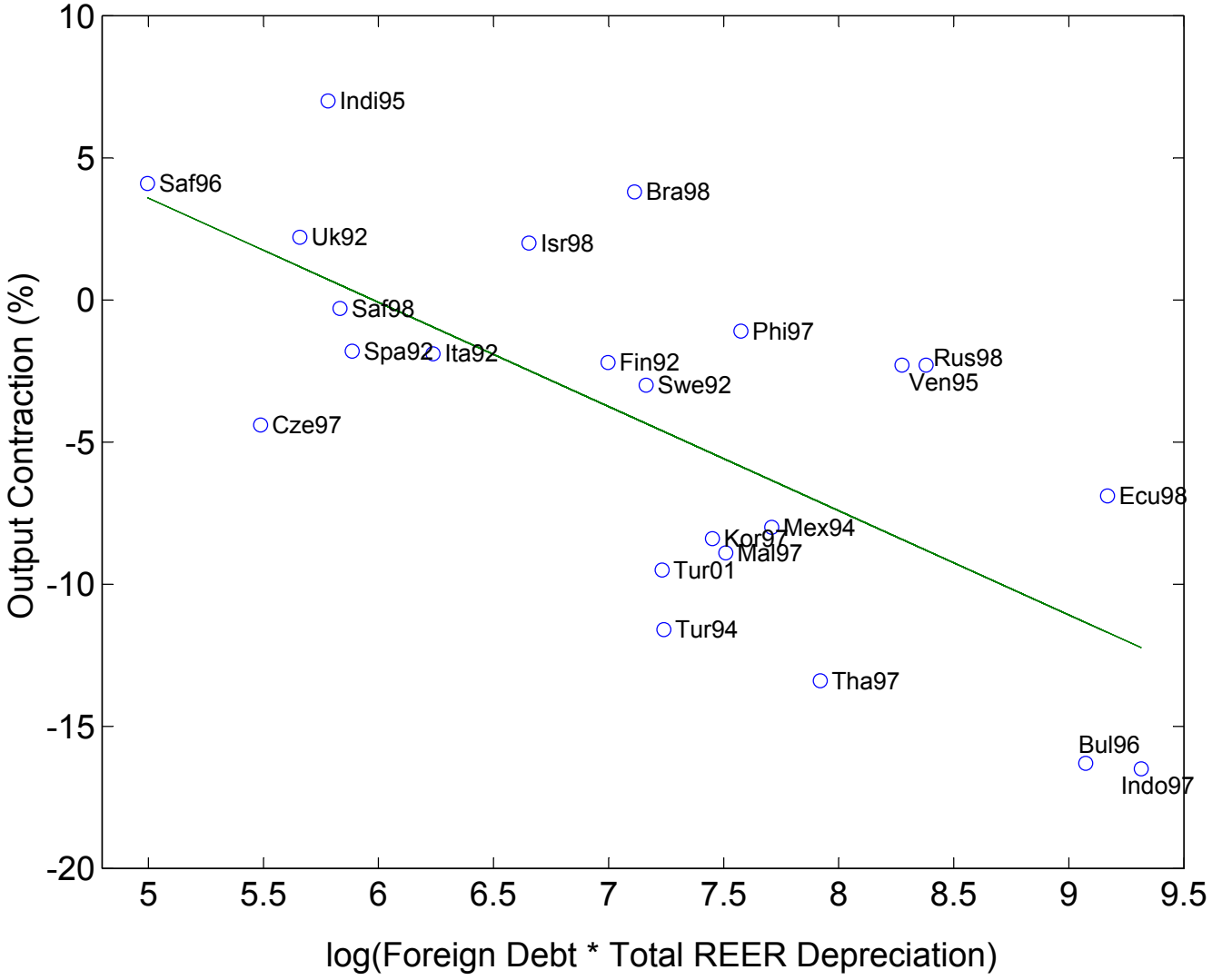

Figure 4. Effects of a 20% permanent reduction in export expenditure

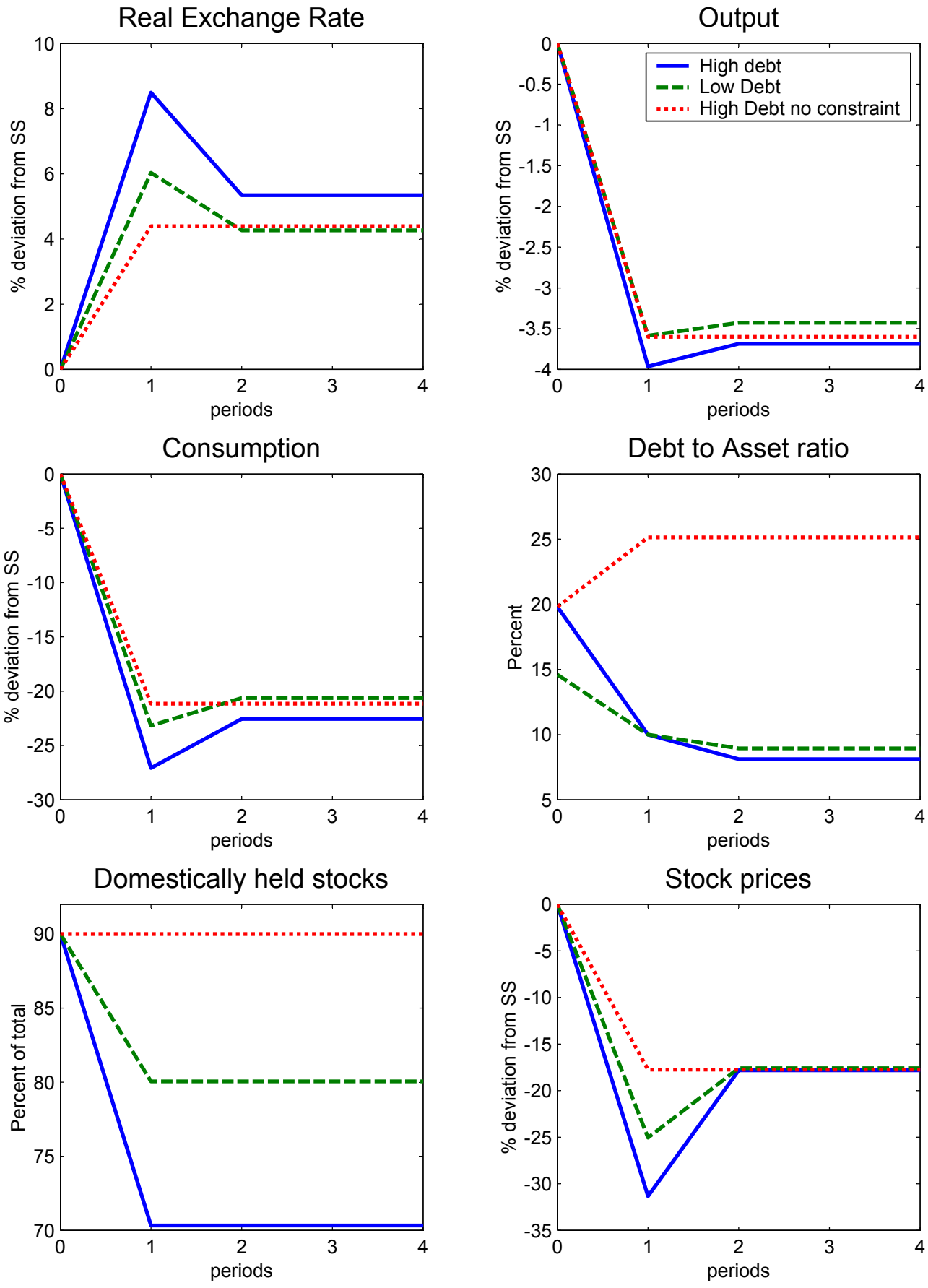

Figure 5. Effects of a reduction in export expenditure: Flex v/s Fixed