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Exchange rates overshooting and the costs of floating[1]

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ABSTRACT

Currency crises are usually associated with large real depreciations. In some countries real 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 '90s and establish that countries entering a crisis with high levels of foreign debt tend to experience large real exchange rate overshooting (devaluation in addition of the long run equilibrium level) and large output contractions. We develop a model of currecy crises that helps understanding 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 cause 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 v/s flexible regime; a fixed exchange regime 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 values for the parameter under which fixed exchange rates dominates flexible.

KEYWORDS: Balance sheet effects, Currency Crises, Exchange rate policy

JEL CLASSIFICATION CODES :F31,F32

[1] **PRELIMINARY**

1. Introduction

Currency crises are usually associated with large real exchange rate depreciations. In some countries these real depreciations are perceived to be very costly (Calvo and Reinhart (2000) 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. 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, the real exchange rates have 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 value overshoots its long run value; only over time the real value of stocks recovers. Moreover, while economic theory suggests that depreciations should have stimulated demand and output through their effects on competitiveness, many currency crises have been associated with short-run sharp output contractions rather than economic expansions.

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 collapse. 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. 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 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 (á la Aiyagari and Gertler, 1998) 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 real 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 real 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 sellout 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 suggests that flexible exchange rates are superior to fixed exchange rate even once one takes into consideration the balance sheet effects of liability dollarization. (Cespedes, Chang and Velasco (2000), Gilchrist et al.(2000)). 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) via a nominal depreciation under flex exchange rates; or b) via a domestic deflation under fixed exchange rates. Thus, under both regimes there are going to be negative balance sheet effects when shock hit the economy; these effects imply contractions in output in both regimes. However, under fixed rates the output effects of the shock will be larger because, if nominal wages are rigid, 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, that makes a mechanism that keep the real exchange fixed valuable and thus introduce a meaningful trade-off between fixed and flexible.

This paper is also related to a recent analytical literature on balance sheet effects and output contractions.[2] 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), Gupta, Mishra and Sahay (2001). These studies include a much larger data set than our paper as they consider: a. crises in the 1970s-1990s period rather than just the 1990s as our study; 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

[2] See Krugman (1999), Aghion, Banerjee and Bachetta (2000), Cespedes, Chang and Velasco (2000), Mendoza (2000). Caballero and Krishnamurty (2000), Kiyotaki and Moore (1997).

sudden and sharp reduction in currency values in economies open to international capital markets we have a much smaller sample that covers only the 1990s crises. Gupta, Mishra and Sahay (2001) 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 (2001), 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 crises episodes and establish their links thorough a simultaneous equation estimation. Section 3 presents a basic model of overshooting and our numerical results. Section 4 concludes.

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 a reasonably liberalized capital account [3]. 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

[3] We focus on what Dornbush(2001) 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.

- dep_{it} >10% and $dep_{it} - dep_{it-3}$ >10%

- An official peg or crawling peg broke

These criteria leave us with 23 crisis episodes (the countries and crisis dates are reported in the appendix).

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. Figure 1 reports the path for the real effective exchange rates for each crisis in our sample. We can observe three patterns:

i) 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.

ii) 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.

iii) Crises with no substantial change in the long run value of the real exchange rate but with overshooting that can be substantial. 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". According to these 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.

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 interaction (in product form) between debt position and the total real exchange rate depreciation. Figure 3 indeed shows that output contractions are bigger in countries with bigger debt depreciation products, suggesting an important role of these effects.

Regression analysis

Now we provide a more formal analysis of the empirical relation between net debt, overshooting and output contraction. The hypotheses we wish to test are of the following form.

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

(2) $$gdp\_change = \beta_1 + \beta_2 * net\_debt * total\_depreciation$$

All real effective exchange rates are measured so that increases are depreciations. We expect that $\alpha_2 > 0$, or that heavier debt burdens imply more overshooting, and we expect $\beta_2 < 0$, so that heavier debt burdens and more depreciation imply steeper contractions in output.

We are unable to use OLS to estimate these equations separately because the overshooting variable in equation 1 enters as part of the total depreciation variable in equations 2.

$$total\_depreciation = fundamental + overshooting + \frac{fundamental * overshooting}{100}$$

Indeed, OLS estimation of the equations in either system separately will be inconsistent if the covariance matrix of the residuals from the two equations is not diagonal; a non-diagonal 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 3-stage least squares 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. We follow convention by including all the exogenous variables from the simultaneous equations system in our set of instruments. Since the overshooting variable enters equations 2 in a non-linear way, we also include non-linear functions of the exogenous variables in our sets of instruments as Kelejian (1971) recommends.

Results Our empirical results strongly support our hypotheses, despite the relatively small size of our sample. In the regressions reported in Table 1, both α_2 and β_2 have the expected signs and are significant at the .02 level. Our findings imply that the heavier a country's debt burden is (or the more demand for hedging there is), the more overshooting one can expect during a crisis. Quantitatively, an increase in a country's net debt/GDP ratio by 10% increases overshooting by about 11%. Moreover, the results 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 heavier its debt burden, the deeper its post-crisis output contraction will be.

For example, suppose that a country has a net debt ratio and fundamental depreciation at the average of our dataset, so that its fundamental depreciation is 16% and its net debt/GDP ratio is 39%. Then our results imply that a 10% increase in an average country's net debt/GDP ratio yields an additional output contraction of 1%, 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, fundamental depreciation. According to our results, if the fundamental depreciation of an average country increases by 10%, we would expect output to contract by an additional 0.5%.

Robustness Tests Our hypothesis that foreign currency exposure and the ensuing hedging demand fuels overshooting and that balance sheet effects induce output contractions are, of course, only one set of possible explanations for these phenomena.

It is possible overshooting will occur if there is substantial uncertainty about future monetary policy or if agents are concerned that the monetary authorities will embark on a highly inflationary program after a currency break, for example to finance the fiscal deficits resulting from an output fall and/or the costs of bailing out the financial system.[4] As agents gain confidence that the monetary authorities will adopt prudent policies, the real effective exchange rate could recover over time to a less depreciated level.

Alternatively, overshooting and output contraction might be the result of a liquidity run and crunch in the immediate aftermath of a shock[5]; if a country has a heavy short-term debt burden or a high M2/reserves ratio, a liquidity run where agents attempt to liquidate debts and "dollarize" cash assets might trigger a currency crisis and fuel overshooting; the ensuing liquidity crunch may also sharply increase real interest rates and lead to a sharp fall in output.

Market participants[6] have suggested that overshooting might also be driven by the size of the external imbalance; if a country runs a very large current account deficit relative to the size of its economy, it might have more difficulty narrowing that deficit than would a country with a smaller current account/GDP ratio. Also, a large current account deficit may signal an overvalued and misaligned currency that requires a greater fundamental depreciation once a currency crisis is

[4] Corsetti, Pesenti and Roubini (2000) develop a model where the currency crash and sharp depreciation is the result of the need to monetize the fiscal costs of a banking crisis driven by moral hazard. Another variant of this fiscal theory is in Burnside, Eichenbaum and Rebelo (2001).

[5] Se Rodrik and Velasco (2000) and Sachs and Radelet (1999).

[6] See Goldman Sachs (2000).

triggered. But such overvaluation may not explain overshooting unless fundamental depreciation and overshooting interact together.

According to another argument, countries that are more open to trade as measured by trade/GDP ratios will find it easier to balance the current account after a crisis and therefore should experience less overshooting.

As suggested by Calvo (1998) a "sudden stop", i.e a reversal of capital inflows could adversely affect output if less international credit is available to finance productive enterprises.[7]

A terms-of-trade shock concurrent with a crisis could adversely affect a country's output because the shock would offset the beneficial competitiveness effect of a devaluation on exports.[8]

Yet another possible explanation of overshooting and output contraction focuses on expansions in bank credit and credit boom phenomena[9]. During a boom, credit to the private sector may expand as banks aggressively seek out new business and as the net worth of potential borrowers rises. Once a crisis begins, however, the net worth of some borrowers collapses. To the extent that these borrowers race to convert assets into foreign currency in order to protect themselves, they may fuel overshooting. To the extent that these borrowers go bankrupt, an output contraction could ensue.

Finally, a sharp output fall may be the result of a banking crisis[10]. Weaknesses in the banks' loan portfolio before a crisis may be exacerbated by the balance sheet effects of a devaluation when many bank liabilities are in foreign currency. Then, a sharp depreciation may trigger a banking crisis that will lead to a credit crunch and a fall in economic activity.

One point to observe is that some of these other explanations of overshooting and output contraction are not inconsistent with the balance sheet effect that we stress in this paper. For

[7] See Calvo and Reinhart (1999) for some evidence on this hypothesis.
[8] See, for example Gupta, Mishra and Sahay (2001).
[9] See Gourinchas, Valdes and Landerrechte (2001) for a study of credit booms and their consequences.
[10] See Mishkin (1999).

example, unless the banking crisis precedes the currency crisis and is not exacerbated by balance sheet effects in the presence of deposit dollarization, the banking crisis may be partly the result of the currency overshooting triggered by currency mismatches; then, the output effect of the banking crisis are consistent with, and the consequence of, the balance sheet argument presented in our paper.

This endogeneity (to the balance sheet effects of a devaluation) is common to a number of the alternative explanations of output contraction presented above. For example, it is possible that a liquidity run is not exogenous but driven by balance sheet effects in the presence of short term foreign currency debt. Similarly, sudden stops and capital flows reversals may be triggered by the balance sheet effect of sharp devaluations, rather than being autonomous causes of an output fall. Or, in the presence of currency mismatches, the effect on output of a capital reversal may be through the effects of this reversal on the exchange rate and the ensuing negative balance sheet effects of such devaluation on output.

Thus, keeping in mind that some of the alternative explanations of overshooting and output contraction may be themselves a variant of a balance sheet story, we establish the robustness of our model to these competing theories by re-estimating our model several times.

First, we use the average annual inflation rate over the five years preceding a crisis as proxy for uncertainty about future monetary policy. If the monetary authorities' commitment to fighting inflation has been checkered in the recent past, agents may have legitimate questions about the future direction of policy. When we re-estimate the system with average inflation in the first equation, however, we find that the inflation variable is not significant and its inclusion does not change the magnitude or significance of the other coefficients. This result suggests that uncertainty about future monetary policy may not be driving overshooting.

Next, to test the hypothesis that a liquidity crunch drives overshooting and potentially exacerbates the output contraction, we calculate pre-crisis M2/reserves ratios and re-estimate our model three times, with the added variable in the first equation, in the second equation, and then in both equations. M2/reserves is not significant in any of these specifications, and the inclusion of this variable does not affect the explanatory power of the other explanatory variables. As a second test of the liquidity crunch hypothesis, we compute pre-crisis short-term debt/reserves ratios and include this variable in the first equation, in the second equation, and then in both equations. Once again, the competing explanation fails, as the short-term debt/reserves ratio is not significant in any of these specifications.[11] In our final test of liquidity hypothesis, we include the pre-crisis reserves/import ratio in the first equation, in the second equation, and then in both equations. Unsurprisingly, this traditional measure of foreign reserves adequacy is also insignificant in all three specifications, and its inclusion in the regression still does not affect the other coefficients.

Next, to test for the role of current account imbalances and openness, we compute pre-crisis current account/GDP and trade/GDP ratios and include these variables in our first equation separately and then together. These variables are never significant in any of these three specifications, and they do not affect the coefficients on the original explanatory variables.

Gupta, Mishra and Sahay (2001) test the idea that a ”sudden stop” or reversal of capital flows can play a role in output by measuring the buildup of capital over a given period prior to the crisis. Parallel to their method, we compute total capital inflows as a share of GDP in the three years prior to each crisis and in the one year prior to each crisis. We then reestimate our model 6 times, with each variable in the first equation, then the second equation, then in both equations. The three-year capital buildup is never significant in any of these specifications. The one-year capital buildup is significant at the fairly weak .10 level when it is included only in the

[11] Note that severeal analyses of early warning indicators of currency crises suggest that indicators of liquidity risk help to predict the onset of crises. Here, we do not test whether liquidity mismatches affect the probability of a currency crisis. We instead test whether, given a currency crisis, its depth and intensity is affected by liquidity variables.

second equation, but it does not affect the coefficient on balance sheet effects. This result is shown in Table 2. A better measure of the sudden stop or reversal of capital flows is the difference between pre-crisis and post-crisis capital flows. We compute the capital inflow in the 4 quarters following a crisis and subtract the capital inflow in the 4 quarters preceding a crisis, then divide by pre-crisis output to get a measure of the actual observed reversal in financing flows. We then include this variable in the first equation, in the second equation, and in both equations. Tables 3-5 indicate that while our version of the capital reversal variable is always significant, it does not change the significance or magnitude of the coefficients in the benchmark model; balance sheet effects are an important determinant of output even after controlling for capital reversal.

Gupta, Mishra and Sahay (2001) also examine whether shifts in the terms of trade affect output during a crisis. Parallel to their method, we compute the percentage change in the terms of trade in the year after a crisis from the year before the crisis and include the variable in the output equation. The change in the terms of trade is not significant and does not affect the other coefficients.

To explore the theory that recent credit expansions may play a role in driving overshooting or output contractions in a crisis, we use the methodology developed in Gourinchas, Valdes, and Landerrechte (2001) and measure the relative and absolute deviation of actual bank credit to the private sector from the trend credit level in each country just prior to the crisis. For both the relative deviation and absolute deviation measures, we re-estimate our model three times, with the added variable in the first equation, in the second equation, and then in both equations. The credit boom variables are never significant and they do not affect the coefficients on the other variables substantially.

Finally, we tried to test for the effects of banking crises on output but we found a significant endogeneity problem. In our sample, there are 12 cases of twin crises, currency crisis associated with banking crises. In many of these episodes it is clear from the history of these events that banking crises were in part triggered by the balance sheet effects of currency mismatches in the banking system and/or corporate system: when banks are mismatched with open net foreign currency liability position, a sharp fall in currency value leads to sharp balance sheet effects and financial distress. Even if banks are hedged by borrowing in foreign currency and lending in foreign currency to corporations and households, the exchange rate is risk only transferred to the non-financial private sector. Then, if a currency crisis occur mismatched households and firms (in the non traded sector) go into distress and their loans from local banks become non-performing thus triggering a banking crisis. Thus, banking crises are often triggered directly or indirectly by the balance sheet effects of sharp currency movements. To test for this, we estimated for our sample a simple probit model of banking crisis where the banking crisis dummy variable is regressed against our measure of balance sheet effect (foreign currency debt as a share of GDP times the total depreciation rate). These results are reported in Table 6. We find a strong and significant effect of this balance sheet variable on the probability of a banking crisis. We thus interpret the effects of banking crises on output (found in separate regressions of the banking crisis dummy on output) as being driven by these balance sheet effects rather than being autonomous. Thus, the study of banking crises confirms the importance of the hypothesis that output contraction is driven by the balance sheet effect of a devaluation, in part via a credit crunch and a bank distress channel.

Most emerging markets with open capital markets have liberalized capital flows fairly recently, and therefore the set of currency crises that are of interest to this study is quite small. Indeed, our small sample size of only 23 crises raises the concern that erratic real exchange rate behavior in one or two countries may be driving our results. To test the robustness of the model to outliers, we identify outliers in the overshooting equation as residuals greater than 36% in absolute value, and we identify outliers in the output equation as residuals greater than 8%. These criteria identify six outlier countries: three outliers from the overshooting equation (Bulgaria, Indonesia, and Sweden) and three outliers from the output equation (Turkey 1994, India, and Thailand). We then re-estimate the simultaneous equations 1 and 2 six times, each time without one of the "outlier" countries. Our results are robust to these outliers. As shown in Tables 7-12, the coefficients of interest are always statistically significant at least at the .10 level, and in all the re-estimations, the coefficients are roughly the same magnitude as in the full regression.

Our model does not explicitly account for any kind of competitiveness effect, according to which a currency depreciation makes a country's exports cheaper and imports more expensive relative to world prices, so that a corresponding rise in exports and fall in imports gives a boost to GDP and mitigates the contractionary balance sheet effects. To test the idea that competitiveness effects are important, we include total depreciation alone (not interacted with net debt) in the second equation and report these results in Table 13. While the coefficient on total depreciation is highly significant, it has the wrong sign for a competitiveness effect. According to our results, the more depreciation a country experiences, the greater the output contraction will be, at odds with the competitiveness story.

Finally, we test the robustness of our variable definitions. First, we change the net debt definition by netting out government assets in addition to banking system and corporate external assets. Our benchmark model holds up under the alternate definition of net debt/GDP, as shown in Table 14, though the coefficient on net debt in the first equation rises slightly, from 1.1 to 1.2.

The net debt/GDP ratio is only a proxy for the potential hedging demand during a crisis, and this measure might not be valid if debtors already hedge their net foreign currency obligations using off-balance-sheet FX derivative contracts. In the absence of detailed information on the actual hedging behavior of net debtors in each country, the spread between local currency and foreign currency bonds could also be informative about hedging behavior. The larger this spread is, the more expensive it may be for agents to hedge foreign currency obligations, and the more remiss they may be in doing so. Thus, a large spread could represent another source of overshooting. When we include the spread in equation 1, however, its coefficient is insignificant and does not affect the other coefficients of interest.

World growth may play some role in the degree of output contraction following a crisis; countries that experience crisis when the world market is booming could find it easier to recover, whereas when small country crises coincide 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. World growth is not significant, however, and its inclusion does not affect the other coefficients.

Finally, we change our definition of the equilibrium real effective exchange rate. First, we redefine the equilibrium as the REER that prevails 36 months after a crisis. As shown in Table 15, both α_2 and β_2 retain the expected signs and are significant at the .01 level, but α_2 rises slightly, from 1.1 to 1.3. We then redefine the equilibrium as the average REER that prevails during the five years surrounding a crisis, specifically the three years preceding and two years following a crisis, and report results in Table 16. Once again, α_2 and β_2 have the expected signs and remain significant at the .01 level, though α_2 drops a bit from 1.1 to 0.8. 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. We also try measuring total depreciation by calculating the percent deviation of the REER from the t0 level in each month and then summing over the 24 months that follow a crisis. These measures of depreciation account for the idea that an overshooting that lasts for a day or two may not have the same effect on an economy as an overshooting that lasts for months or years. Because these measures of depreciation are substantially different from those in the benchmark model, the coefficients on the redefined variables in Tables 17-18 change substantially, but the signs are correct and the intuition remains the same: a heavier net debt burden implies a greater expected overshooting, and greater balance sheet effects imply a deeper output contraction.

In summary, our results and robustness tests establish that the extent of overshooting is related to the exposure to foreign currency debt (or the implicit demand for hedging during a crisis) and that the contractionary effect of a crisis is related to a country's vulnerability to balance sheet effects.

Out-of-Sample Observations Turkey's most recent financial crisis erupted in February 2001 when the authorities floated the lira, and this crisis has unfolded partially outside of our sample of countries. Because the ultimate degree of the Turkish output contraction was not known at the time of writing, we could not include this crisis in the estimation of the second equation, which gauges the impact of balance sheet effects on output. Our results allow us to forecast the Turkish output contraction, however, and undertake a preliminary analysis of the performance of our model based on this out-of-sample observation. With Turkey's net debt/GDP ratio of 46%, fundamental depreciation of 19% and overshooting of 20%, the estimates from equations 1 and 2 suggest that Turkey can expect a maximum decline in output of 3.4% over the 2 years following February 2001. This figure underestimates the maximum quarterly contraction that is implied by the IMF's estimate of a 8.5% contraction in the full year 2001.

Argentina's recent crisis has developed entirely outside of our sample period. Our model predicts that with Argentina's net debt/GDP ratio of 55%, the country can expect 49% overshooting, on top of market estimates of 11% fundamental devaluation[12]. If the market's estimates of overvaluation are on target, then our model predicts a maximum output contraction of 5.1% over the 2 years following this hypothetical crisis. This prediction rests between the Argentine government's

[12] This is an estimate from Goldman Sachs (2001).

prediction of a 5% contraction and market forecasts of a 7-10% output contraction.

3. A simple model of real exchange rate overshooting

In this section we will discuss a simple model of currency crisis in order to better understand 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 Cespedes et al. (2001) or by Gertler et al. (2000), with the addition of a particular type of financial imperfection, namely the existence of margin constraints. We also find the model useful to analyze the issue of the choice of exchange rate regime in an environment with margin constraints. In this subsection we will focus on a real economy that can be interpreted as a monetary economy with flexible exchange rates.

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

$$\sum_{t=0}^{\infty} \beta^t u\left(G(c_t, c_t^*), l_t\right)$$

where u is a well behaved utility function, G is a CES aggregator of domestic and foreign consumption, c_t is domestic consumption, c_t^* is consumption of a foreign good 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

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

Firms are owned domestic consumers and by 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

$$(3) \qquad w_t l_t + [q_t + d_t]\, s_t + p_t b_t - c_t - c_t^* p_t - \frac{p_t b_{t+1}}{R_t} - q_t s_{t+1} \geq 0.$$

$$(4) \qquad \frac{p_t b_{t+1}}{R_t} + \kappa_t q_t s_{t+1} \geq 0,\ \ 0 \leq \kappa_t \leq 1$$

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 id the price of these stock, b_t is the stock of foreign debt of the household sector, c_t and c_t^* are domestic consumption of the home and foreign goods and R is the (exogenous) interest rate that domestic consumers face on the international market. The second equation represent what Aiyagari and Gertler (1999) call "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 ($-\frac{p_t b_{t+1}}{R_t}$) 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 to maximize dividend payments to their shareholders that are given by

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

An equilibrium is characterized by the first order conditions for the households and for the firms and by market clearing in the goods, labor and asset markets. Regarding the market for stocks of firms we are going to follow Aiyagari and Gertler (1999) and Mendoza and Smith (2001) and assume that the demand for domestic stocks is not infinitely elastic. In particular we are going to assume that changes in the position of domestic stocks can only be achieved through a reduction in the stock prices to below their fundamental price (implicitly we are assuming the existence of a risk neutral international stock trader that 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^*

$$(5) \qquad s_{t+1}^* - s_t^* = \frac{1}{a}\left[\frac{q_t^f}{q_t} - 1\right]$$

where q^f is the fundamental price for a risk neutral trader stocks given by

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

and a is a parameter reflecting the portfolio adjustment cost of the international trader . Equation 5 plus the equilibrium in the markets for stocks ($s_t + s_t^* = 1$) implies the following law of motion for domestic stocks

$$(6) \qquad s_t - s_{t+1} = \frac{1}{a}\left[\frac{q_t^f}{q_t} - 1\right]$$

The goods market clearing condition requires that the production of the domestic goods is equal to the domestic consumption plus exports. We are going to assume that foreign expenditure on domestic goods is exogenously given (as in Cespedes et al. 2001) by x_t so the goods market clearing condition is

$$(7) \qquad c_t + p_t x_t = y_t$$

A. The experiment

In this section we are going to make assumption on 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 are going to assume the following functional form

$$u(G,l) = \frac{(G - l^{1-v})^{1-\sigma}}{1-\sigma}$$

$$G(c,c^*) = (\omega c^{\frac{\rho-1}{\rho}} + (1-\omega)c^{\frac{\rho-1}{\rho}})^{\frac{\rho}{\rho-1}}$$

The utility function has the property that, in equilibrium, labor supply is independent of consumption and many authors have documented that, especially in small open economy models, this property is necessary for the model to reproduce the business cycles facts[13]. 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 that lies in the middle of the range of empirical estimates for Europe and US (see Backus Kehoe and Kydland, 1995). The remaining parameters and initial conditions value are summarized in table 20 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 we choose the finding we present are only suggestive and do not provide a complete evaluation of the quantitative properties of the model. Some discussion on alternative

[13] See for example Mendoza 1991, Correia et. al.1995, and Perri and Neumeyer.2001.

parameters and functional forms is provided below.

Table 20. 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 and c^*	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	90%

We consider the following experiment. We follow two economies, one with high level of debt to output ratio (65%) and one with low debt to output ratio (45%). Up to period 0 we assume 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%) 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 constant the domestic consumption would have to increase to absorb the additional output; that can be achieved only with a fall in the relative price of the domestic good; as its price drops its production will also drop and so the labor income of the domestic residents and the stock price. As domestic residents are now poorer they will also reduce consumption. Notice that the debt to assets ratio $\frac{-p_t b_{t+1}}{Rq_t s_{t+1}}_t$ of the domestic consumers raise both because the real exchange rate p_t increases and because the price of domestic stock falls. Finally observe that the stock position of the domestic household is not changed and this implies (from 6) that stock price does not deviate from its fundamental level.

Consider now the same economy (high debt) when the margin constraint is imposed (the solid line). Observe that now the debt to asset ratio has to be reduced to satisfy the margin constraint. The reduction of the debt is obtained by reducing consumption and selling domestic stocks. Since output response (because of the preference we have assumed) and export reduction are the same in the economy with and without the constraint, market clearing (equation 7) implies that when consumption is reduced more that in the no constraint case the exchange rate will depreciate more (overshooting of exchange rates). Similarly the market clearing for the stock (equation 6) implies that the sales of domestic stock forces the stock prices below its fundamental (overreaction of asset prices).

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 presented in the first part of this paper that relates size of the foreign debt to exchange rate overshooting. The model as it is not entirely consistent with the evidence about output, as economies with the different levels of debt and different real exchange rate depreciation display similar[14] output drops while the data suggest that

[14] The fact that output response are similar across economies depends crucially on the preferences we assumed. With preference that display wealth effects on labor supply (as Cobb Douglas in consumption and leisure) the discrepancy

country with higher debt and higher depreciation should suffer larger drops. One way to reconcile the model and the data would be to assume that the causality runs in the opposite direction, that is larger overshooting are caused by larger export shocks that in turn cause larger output drops. Alternatively one can think about mechanisms through which frictions in the financial side of the economy (the binding margin constraint) spills over into the real side (for example through reduction in investment or in productivity).

B. 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 reduced, the debt to asset ratio is maintained lower and this can reduce the stock fire sale. At the same time though avoiding the exchange rate depreciation has a negative demand effect and thus exacerbates the initial the output drop. We can use a simple variant of our model to analyze these issues more formally. As we mentioned 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, 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

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between data and theory would be worse. The model infact 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.

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 fixed exchange rate regime (see the consumption panel). At the same time though under fixed exchange rate on impact the foreign demand of domestic good is reduced more and so output and domestic consumption on impact drop more. 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 we find that fixed exchange rate is preferable. This in contrast with the finding of Cespedes et al. (2001); the reason for the different finding lies in the presence of the margin constraint. In our model, as in theirs, fixed exchange rate does not avoid the change in relative price but only delays it, and as in theirs, 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 presented a theoretical and empirical analysis of exchange rate overshooting, balances sheet effects and output contraction. Our empirical analysis suggests that overshooting of the real exchange rate following currency crises is severe in country with high level of foreign debt and that severe output contraction are associated with overshooting. The econometric estimates also allow us to forecast the amount of exchange rate overshooting and output contraction to be expected in recent episodes of countries in turmoil, specifically Turkey that has already experienced a currency crisis in 2001 and Argentina that may soon experience one. We find the overshooting and output contraction in Argentina would be severe.

The analytical framework showed that financial distortions deriving from lack of hedging and margin constraints lead to overshooting of 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 effects that negatively affect long run consumption and welfare. Under fixed exchange rates such a short-run overshooting of the real exchange is prevented and thus the overshooting of asset prices (equity claims) is reduced, at the cost of a larger short run contraction. The framework, unlike recent results of the recent literature on fix versus flexible exchange rates under liability dollarization, suggest that currency crises and the sudden move to flex 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 not open and the domestic financial system not liberalized yet; this may imply comparing the overshooting and output effects of currency crises in the 1990s when capital markets where liberalized with those in the 1980s and before when such liberalization had not occurred yet and crises were more current account rather than capital account driven. Also, as more and more emerging markets have moved to flexible exchange rate regimes in the last decade, one could study possible overshooting, balance sheet effects and the performance of such flexible exchange rate regimes. Finally the model we have considered is too simple to capture well the effects of financial frictions on the real side of the economy: one natural way of doing so would be to explicitly model investment decision. We leave these extension to future work.

5. Tables

17. Robustness to Redefining Overshooting

18. Robustness to Redefining Overshooting and Total Depreciation

19. Benchmark Regression Data

20. Baseline parameters

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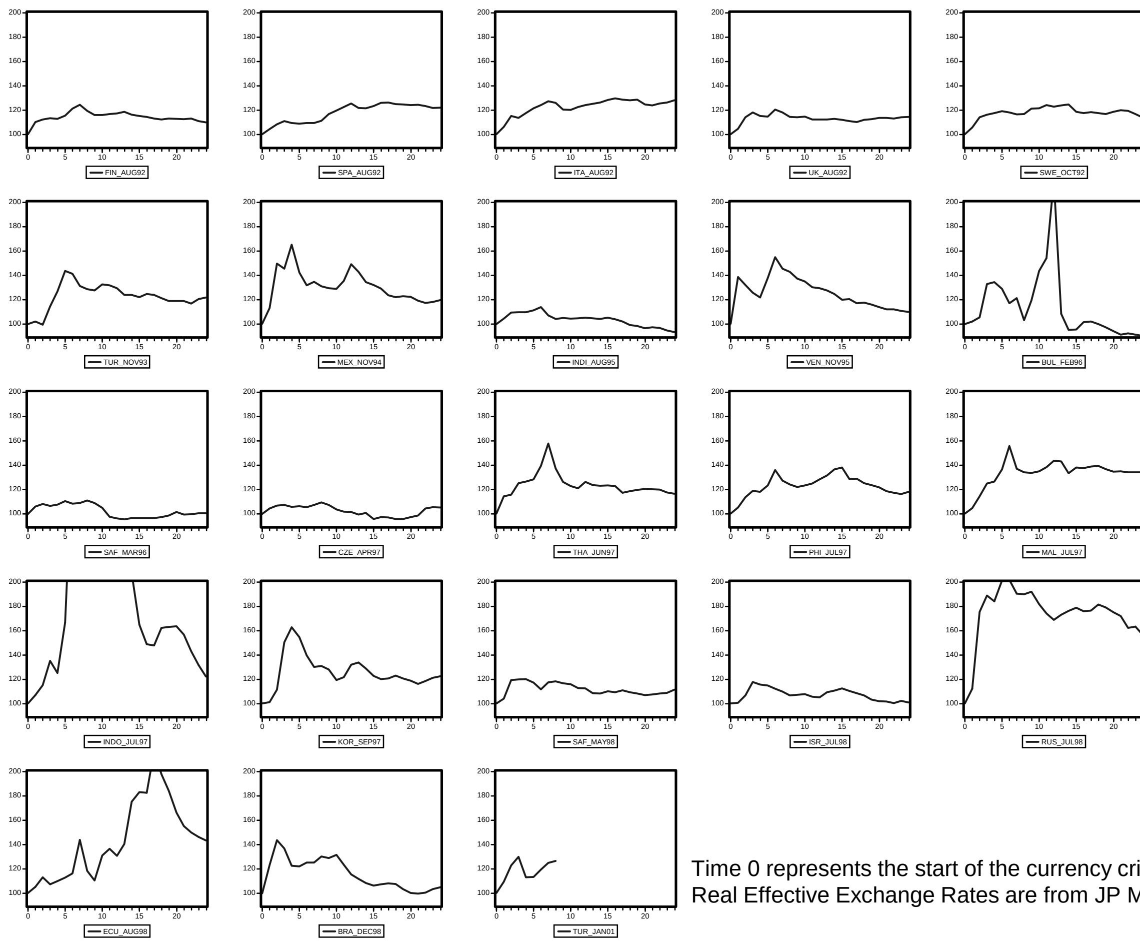
Figure 1. Real Effective Exchange Rates, t_0=100



Time 0 represents the start of the currency crisis.
Real Effective Exchange Rates are from JP Morgan.

Figure 2. Foreign Debt and Real Exchange Rate Overshooting

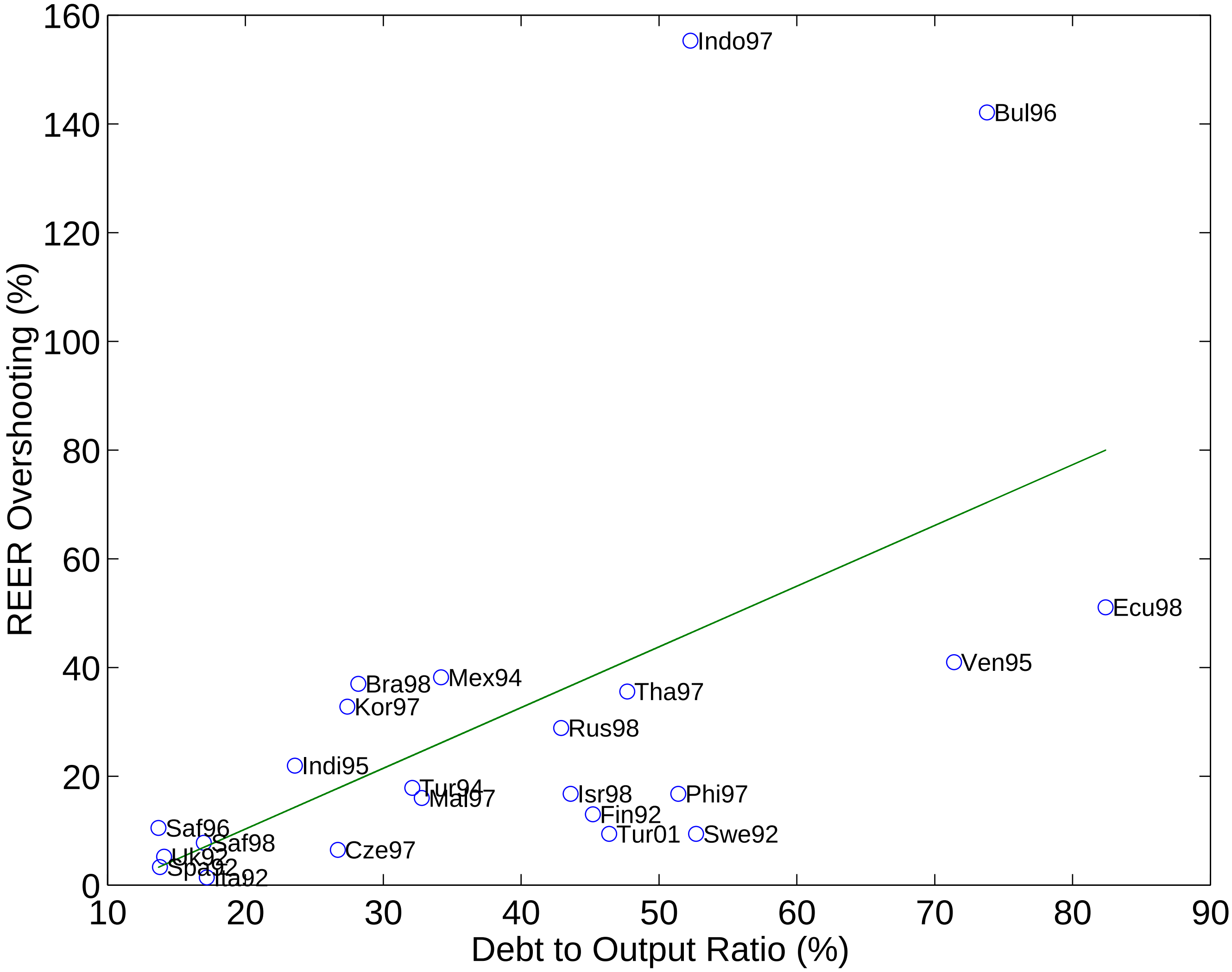


Figure 3. Contractionary effects of balance sheet effects

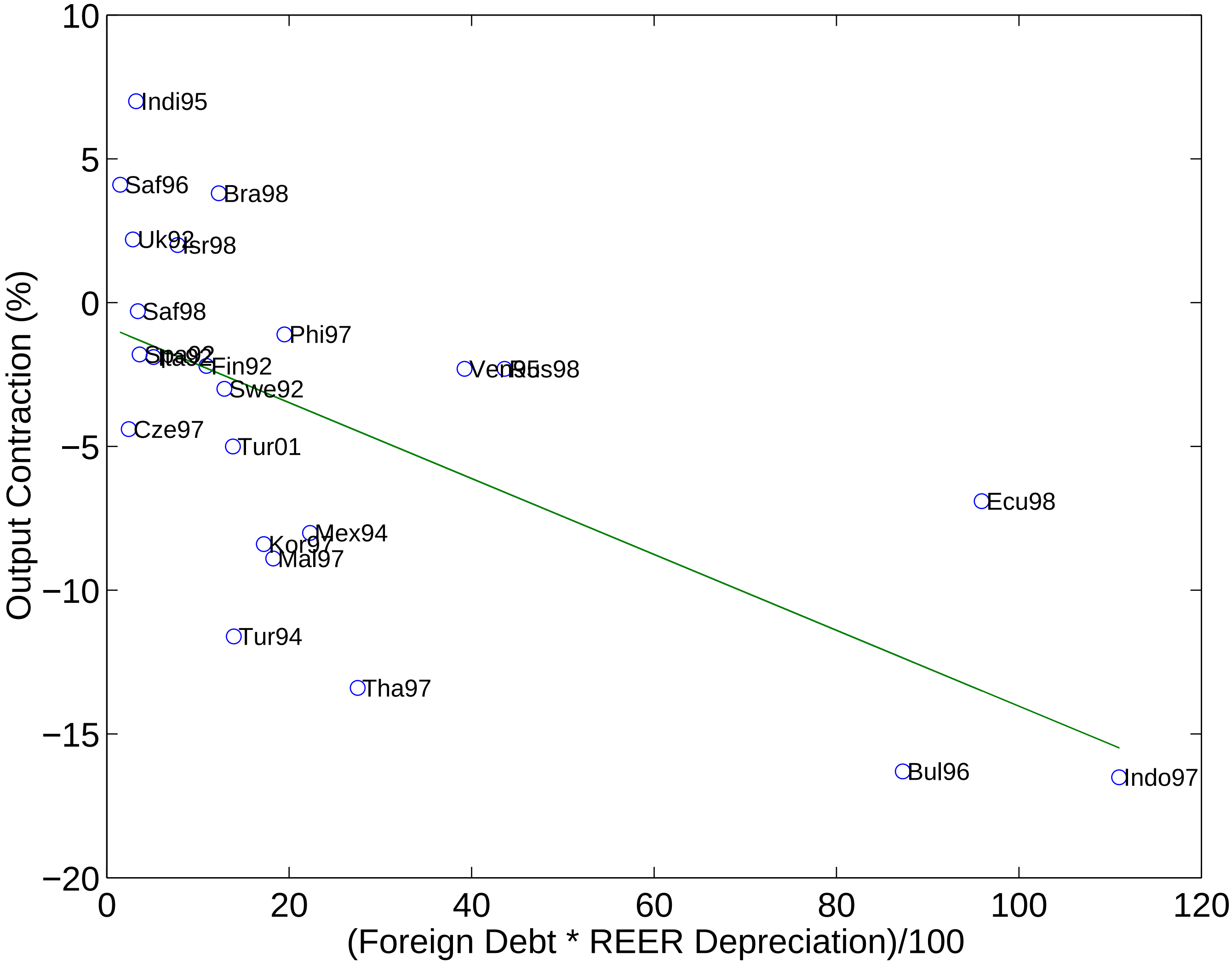


Figure 4. Effects of a reduction in export expenditure

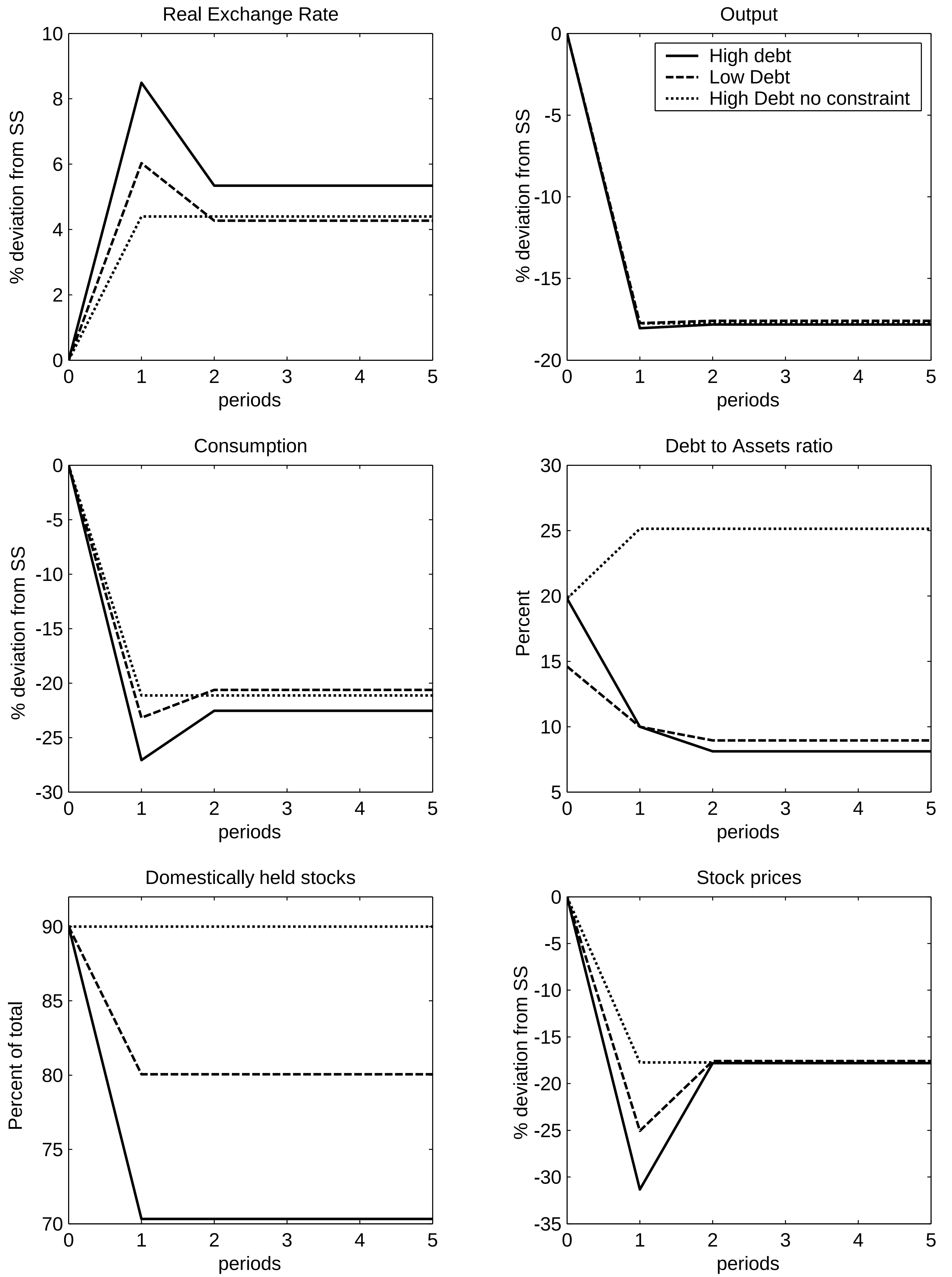


Figure 5. Effects of a reduction in export expenditure: Flex v/s Fixed

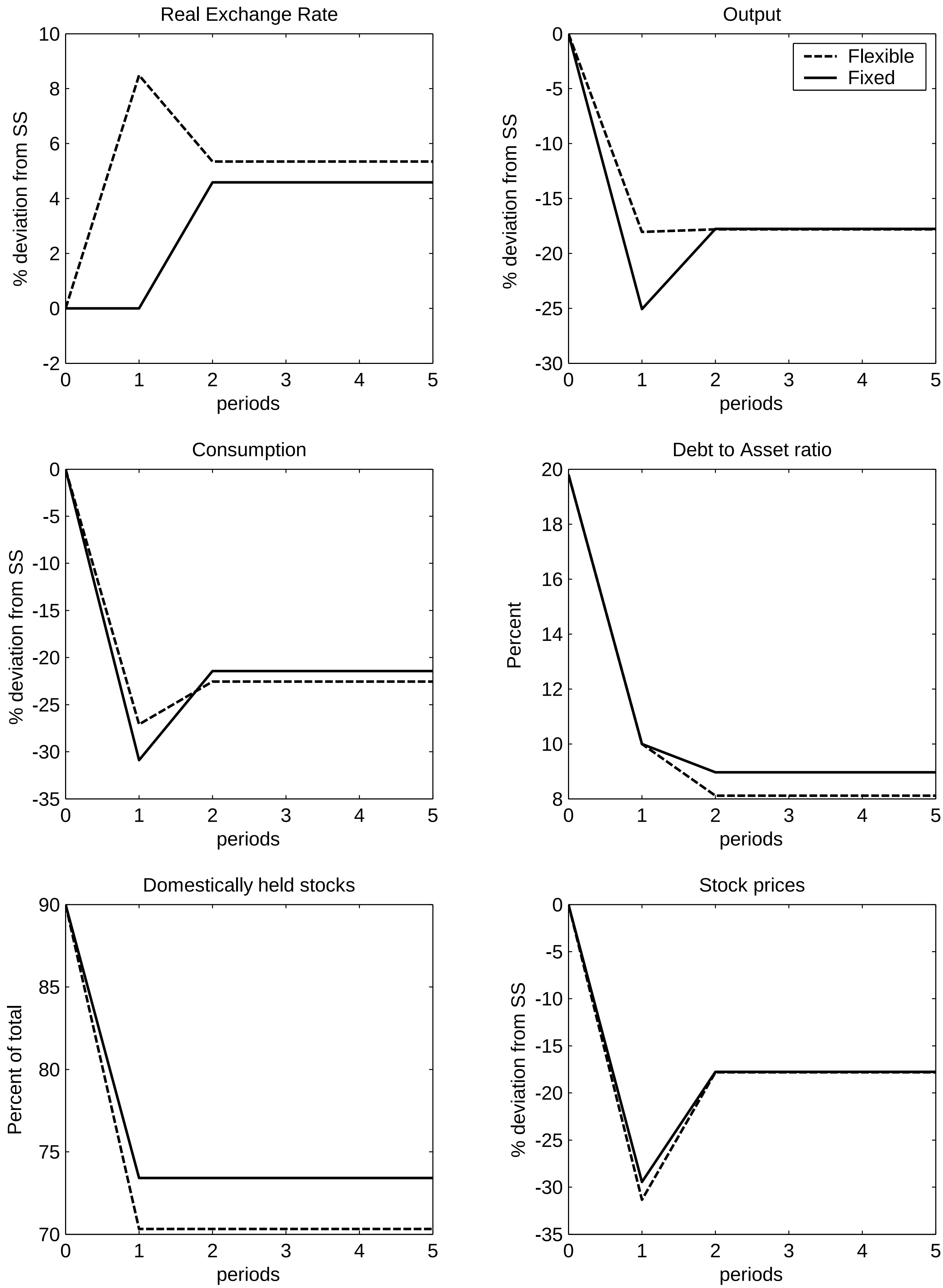


Table 1: Benchmark Regression

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-10.47594	15.08694	-0.694371	0.4914
α_2	1.074397	0.348865	3.079696	0.0037
β_1	-1.340428	1.492453	-0.898137	0.3744
β_2	-0.001061	0.000421	-2.521051	0.0157

Equation: OVERSHOOT =$\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.306239	Mean dependent var	31.20698
Adjusted R-squared	0.273203	S.D. dependent var	39.54485
S.E. of regression	33.71293	Sum squared resid	23867.79

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.410662	Mean dependent var	-4.103560
Adjusted R-squared	0.381195	S.D. dependent var	6.476992
S.E. of regression	5.095069	Sum squared resid	519.1946

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 2: Robustness to Capital Buildup

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 CAP_BUILDUP1YR C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-10.86137	15.09161	-0.719696	0.4759
α_2	1.084412	0.349001	3.107185	0.0035
β_1	1.435999	2.220215	0.646784	0.5215
β_2	-0.001359	0.000443	-3.068738	0.0038
β_3	-0.175529	0.103913	-1.689199	0.0990

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.306420	Mean dependent var	31.20698
Adjusted R-squared	0.273392	S.D. dependent var	39.54485
S.E. of regression	33.70854	Sum squared resid	23861.58

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
+ β_3*CAP_BUILDUP1YR
Observations: 22

R-squared	0.487218	Mean dependent var	-4.103560
Adjusted R-squared	0.433241	S.D. dependent var	6.476992
S.E. of regression	4.876100	Sum squared resid	451.7507

CAP_BUILDUP1YR is the inflow of capital in the year preceding a crisis.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 3: Robustness to Capital Reversal in Equation 1

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 CAPITAL_REVERSAL C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-19.59236	14.54154	-1.347337	0.1855
α_2	0.985241	0.328964	2.994983	0.0047
α_3	-2.768067	1.215634	-2.277056	0.0282
β_1	-0.399674	1.430929	-0.279311	0.7814
β_2	-0.001462	0.000392	-3.731824	0.0006

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT+α_3*CAPITAL_REVERSAL
Observations: 23

R-squared	0.394204	Mean dependent var	31.20698
Adjusted R-squared	0.333624	S.D. dependent var	39.54485
S.E. of regression	32.28120	Sum squared resid	20841.52

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.424467	Mean dependent var	-4.103560
Adjusted R-squared	0.395690	S.D. dependent var	6.476992
S.E. of regression	5.035043	Sum squared resid	507.0331

CAPITAL_REVERSAL is the capital inflow in the year following a crisis minus the capital inflow in the year preceding a crisis, all divided by pre-crisis GDP.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 4: Robustness to Capital Reversal in Equation 2

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 CAPITAL_REVERSAL C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-11.61218	15.11654	-0.768177	0.4469
α_2	1.105810	0.349788	3.161373	0.0030
β_1	1.231446	1.083695	1.136341	0.2626
β_2	-0.000892	0.000307	-2.908967	0.0059
β_3	0.670285	0.151280	4.430772	0.0001

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.306644	Mean dependent var	31.20698
Adjusted R-squared	0.273627	S.D. dependent var	39.54485
S.E. of regression	33.70310	Sum squared resid	23853.88

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION +β_3*CAPITAL_REVERSAL
Observations: 22

R-squared	0.707681	Mean dependent var	-4.103560
Adjusted R-squared	0.676911	S.D. dependent var	6.476992
S.E. of regression	3.681582	Sum squared resid	257.5268

CAPITAL_REVERSAL is the capital inflow in the year following a crisis minus the capital inflow in the year preceding a crisis, all divided by pre-crisis GDP.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 5: Robustness to Capital Reversal in Equations 1 and 2

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 CAPITAL_REVERSAL C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-18.43674	14.54947	-1.267176	0.2126
α_2	1.011203	0.329637	3.067627	0.0039
α_3	-2.297994	1.224952	-1.875987	0.0682
β_1	1.288345	1.084137	1.188360	0.2419
β_2	-0.000887	0.000307	-2.892945	0.0062
β_3	0.685081	0.151511	4.521662	0.0001

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT+α_3*CAPITAL_REVERSAL
Observations: 23

R-squared	0.398209	Mean dependent var	31.20698
Adjusted R-squared	0.338030	S.D. dependent var	39.54485
S.E. of regression	32.17431	Sum squared resid	20703.72

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
+β_3*CAPITAL_REVERSAL
Observations: 22

R-squared	0.707717	Mean dependent var	-4.103560
Adjusted R-squared	0.676950	S.D. dependent var	6.476992
S.E. of regression	3.681358	Sum squared resid	257.4955

CAPITAL_REVERSAL is the capital inflow in the year following a crisis minus the capital inflow in the year preceding a crisis, all divided by pre-crisis GDP.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 6: Endogeneity of Banking Crisis and Balance Sheet Effects

Dependent Variable: BANKCRISIS
Method: ML - Binary Probit
Included observations: 23

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.951034	0.509448	-1.866793	0.0619
NET_DEBT*TOTAL_ DEPRECIATION	0.000570	0.000280	2.033158	0.0420

Mean dependent var	0.521739	S.D. dependent var	0.510754
S.E. of regression	0.423653	Akaike info criterion	1.167932
Sum squared resid	3.769114	Schwarz criterion	1.266670
Log likelihood	-11.43121	Hannan-Quinn criter.	1.192764
Restr. log likelihood	-15.92064	Avg. log likelihood	-0.497009
LR statistic (1 df)	8.978850	McFadden R-squared	0.281988
Probability(LR stat)	0.002731		
Obs with Dep=0	11	Total obs	23
Obs with Dep=1	12		

BANKCRISIS is a dummy variable taking the value 1 if there is a banking crisis concurrent with the currency crisis and 0 if not.

Table 7: Robustness to Bulgaria Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-1.970635	13.72965	-0.143531	0.8866
α_2	0.757638	0.332421	2.279149	0.0282
β_1	-0.841024	1.465025	-0.574068	0.5692
β_2	-0.001177	0.000454	-2.594773	0.0133

Equation: OVERSHOOT =α_1+α_2*NET_DEBT
Observations: 22

R-squared	0.187374	Mean dependent var	26.16860
Adjusted R-squared	0.146743	S.D. dependent var	32.04057
S.E. of regression	29.59648	Sum squared resid	17519.04

Equation: GDP = β_1+β_2*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.333753	Mean dependent var	-3.522778
Adjusted R-squared	0.298688	S.D. dependent var	6.021392
S.E. of regression	5.042577	Sum squared resid	483.1241

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 8: Robustness to Indonesia Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-7.701207	10.52894	-0.731432	0.4689
α_2	0.871264	0.245854	3.543830	0.0010
β_1	-1.788833	1.464423	-1.221528	0.2292
β_2	-0.000772	0.000456	-1.694684	0.0981

Equation: OVERSHOOT =α_1+α_2*NET_DEBT
Observations: 22

R-squared	0.389068	Mean dependent var	25.56842
Adjusted R-squared	0.358521	S.D. dependent var	29.53292
S.E. of regression	23.65362	Sum squared resid	11189.87

Equation: GDP = β_1+β_2*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.256695	Mean dependent var	-3.512800
Adjusted R-squared	0.217574	S.D. dependent var	5.998927
S.E. of regression	5.306341	Sum squared resid	534.9879

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 9: Robustness to Sweden Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-11.81387	14.95900	-0.789750	0.4344
α_2	1.153442	0.349873	3.296750	0.0021
β_1	-1.180327	1.542710	-0.765099	0.4488
β_2	-0.001116	0.000422	-2.646315	0.0117

Equation: OVERSHOOT $=\alpha_1+\alpha_2$*NET_DEBT
Observations: 22

R-squared	0.340650	Mean dependent var	32.19862
Adjusted R-squared	0.307682	S.D. dependent var	40.18168
S.E. of regression	33.43343	Sum squared resid	22355.88

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.416330	Mean dependent var	-4.156863
Adjusted R-squared	0.385611	S.D. dependent var	6.631995
S.E. of regression	5.198356	Sum squared resid	513.4352

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 10: Robustness to Turkey 1994 Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-9.819867	15.60765	-0.629170	0.5329
α_2	1.064311	0.357237	2.979286	0.0050
β_1	-0.745605	1.427337	-0.522375	0.6044
β_2	-0.001129	0.000395	-2.861922	0.0067

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 22

R-squared	0.303430	Mean dependent var	31.81379
Adjusted R-squared	0.268601	S.D. dependent var	40.36570
S.E. of regression	34.52149	Sum squared resid	23834.66

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.475349	Mean dependent var	-3.747632
Adjusted R-squared	0.447735	S.D. dependent var	6.412688
S.E. of regression	4.765558	Sum squared resid	431.5003

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 11: Robustness to India Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-10.71726	15.84322	-0.676457	0.5027
α_2	1.070403	0.360432	2.969776	0.0051
β_1	-2.097488	1.487254	-1.410309	0.1664
β_2	-0.000925	0.000409	-2.259475	0.0295

Equation: OVERSHOOT $=\alpha_1+\alpha_2$*NET_DEBT
Observations: 22

R-squared	0.305839	Mean dependent var	31.62561
Adjusted R-squared	0.271131	S.D. dependent var	40.42325
S.E. of regression	34.51087	Sum squared resid	23820.00

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.396778	Mean dependent var	-4.629968
Adjusted R-squared	0.365029	S.D. dependent var	6.135786
S.E. of regression	4.889305	Sum squared resid	454.2008

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 12: Robustness to Thailand Outlier

Estimation Method: Three-Stage Least Squares
Included observations: 22*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-10.52447	15.40184	-0.683325	0.4984
α_2	1.080509	0.357762	3.020191	0.0044
β_1	-0.983380	1.414831	-0.695051	0.4911
β_2	-0.001027	0.000395	-2.601701	0.0130

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 22

R-squared	0.306799	Mean dependent var	31.00854
Adjusted R-squared	0.272139	S.D. dependent var	40.46372
S.E. of regression	34.52154	Sum squared resid	23834.74

Equation: GDP = $\beta_1+\beta_2$*NET_DEBT*TOTAL_DEPRECIATION
Observations: 21

R-squared	0.446996	Mean dependent var	-3.663254
Adjusted R-squared	0.417891	S.D. dependent var	6.290516
S.E. of regression	4.799417	Sum squared resid	437.6538

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 13: Robustness to Competitiveness Effects

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-12.11715	15.11871	-0.801468	0.4275
α_2	1.118950	0.349854	3.198336	0.0027
β_1	1.131924	2.014957	0.561761	0.5773
β_2	-0.098834	0.033367	-2.962064	0.0051

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.306667	Mean dependent var	31.20698
Adjusted R-squared	0.273651	S.D. dependent var	39.54485
S.E. of regression	33.70255	Sum squared resid	23853.09

Equation: GDP = $\beta_1+\beta_2$*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.488858	Mean dependent var	-4.103560
Adjusted R-squared	0.463301	S.D. dependent var	6.476992
S.E. of regression	4.745029	Sum squared resid	450.3060

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 14: Robustness to Redefining Net Debt

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT2 NET_DEBT2*FUND NET_DEBT2^2 (NET_DEBT2*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-2.883399	12.07645	-0.238762	0.8125
α_2	1.170281	0.349594	3.347544	0.0018
β_1	-1.845772	1.464548	-1.260302	0.2147
β_2	-0.001055	0.000478	-2.206427	0.0330

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT2
Observations: 23

R-squared	0.334111	Mean dependent var	31.20698
Adjusted R-squared	0.302402	S.D. dependent var	39.54485
S.E. of regression	33.02878	Sum squared resid	22908.90

Equation: GDP = $\beta_1+\beta_2$* NET_DEBT2*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.349294	Mean dependent var	-4.103560
Adjusted R-squared	0.316759	S.D. dependent var	6.476992
S.E. of regression	5.353778	Sum squared resid	573.2587

NET_DEBT2 is gross external debt minus external assets of the government, bank, and corporate sectors as a share of GDP.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 15: Robustness to Redefining Equilibrium REER at 36 Months

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND2 NET_DEBT^2
(NET_DEBT*FUND2)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-17.25794	11.62951	-1.483978	0.1455
α_2	1.301673	0.268611	4.845934	0.0000
β_1	-1.478997	1.351139	-1.094630	0.2801
β_2	-0.001002	0.000343	-2.920262	0.0057

Equation: OVERSHOOT2 = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.513877	Mean dependent var	33.20924
Adjusted R-squared	0.490729	S.D. dependent var	36.59329
S.E. of regression	26.11416	Sum squared resid	14320.93

Equation: GDP = $\beta_1+\beta_2$* NET_DEBT*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.402065	Mean dependent var	-4.103560
Adjusted R-squared	0.372169	S.D. dependent var	6.476992
S.E. of regression	5.132097	Sum squared resid	526.7684

In this specification, the equilibrium real effective exchange rate is defined as the REER prevailing 36 months after a crisis.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 16: Robustness to Redefining Equilibrium REER as 5-Year Average

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND3 NET_DEBT^2
(NET_DEBT*FUND3)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	3.005181	11.94680	0.251547	0.8026
α_2	0.805395	0.275975	2.918366	0.0057
β_1	-1.039270	1.384483	-0.750656	0.4571
β_2	-0.001179	0.000367	-3.214860	0.0025

Equation: OVERSHOOT3 = $\alpha_1+\alpha_2$*NET_DEBT
Observations: 23

R-squared	0.273879	Mean dependent var	34.25236
Adjusted R-squared	0.239302	S.D. dependent var	30.72834
S.E. of regression	26.80065	Sum squared resid	15083.77

Equation: GDP = $\beta_1+\beta_2$* NET_DEBT*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.422788	Mean dependent var	-4.103560
Adjusted R-squared	0.393927	S.D. dependent var	6.476992
S.E. of regression	5.042381	Sum squared resid	508.5121

In this specification, the equilibrium real effective exchange rate is defined as the REER prevailing in the 5 years surrounding a crisis. Specifically, it is the average REER in the 3 years before and the 2 years after a crisis.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 17: Robustness to Redefining Overshooting

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-71.62468	120.3582	-0.595096	0.5550
α_2	6.251449	2.785001	2.244685	0.0302
β_1	-1.360745	1.494673	-0.910397	0.3679
β_2	-0.001069	0.000422	-2.533415	0.0152

Equation: OVERSHOOT4 = α1+α2*NET_DEBT
Observations: 23

R-squared	0.184033	Mean dependent var	170.4672
Adjusted R-squared	0.145178	S.D. dependent var	290.2406
S.E. of regression	268.3466	Sum squared resid	1512208.

Equation: GDP = β1+β2* NET_DEBT*TOTAL_DEPRECIATION
Observations: 22

R-squared	0.411768	Mean dependent var	-4.103560
Adjusted R-squared	0.382356	S.D. dependent var	6.476992
S.E. of regression	5.090289	Sum squared resid	518.2209

In this specification, overshooting is defined as the sum of REER deviations from the equilibrium REER during the 24 months following a crisis.

*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 18: Robustness to Redefining Overshooting and Total Depreciation

Estimation Method: Three-Stage Least Squares
Included observations: 23*
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2
(NET_DEBT*FUND)^2 C

	Coefficient	Std. Error	t-Statistic	Prob.
α_1	-61.54298	119.9786	-0.512950	0.6107
α_2	5.987786	2.773928	2.158595	0.0368
β_1	-1.378931	1.716835	-0.803182	0.4265
β_2	-0.000100	4.66E-05	-2.153970	0.0372

Equation: OVERSHOOT4 = α1+α2*NET_DEBT
Observations: 23

R-squared	0.183488	Mean dependent var	170.4672
Adjusted R-squared	0.144607	S.D. dependent var	290.2406
S.E. of regression	268.4362	Sum squared resid	1513218.

Equation: GDP = β1+β2* NET_DEBT*TOTAL_DEPRECIATION2
Observations: 22

R-squared	0.241944	Mean dependent var	-4.103560
Adjusted R-squared	0.204041	S.D. dependent var	6.476992
S.E. of regression	5.778548	Sum squared resid	667.8324

In this specification, overshooting is defined as the sum of REER deviations from the equilibrium REER during the 24 months following a crisis. Total depreciation is defined as the sum of percent deviations of the REER from the t0 level during the 24 months following a crisis.
*Turkey 2001 is included in the overshooting equation but not the output equation.

Table 19: Benchmark Regression Data

Variable	Country	Crisis Date	Net Debt/GDP	REER Fundamental Depreciation	REER Overshooting	REER Total Depreciation	Real GDP Change
Source			BIS, World Bank, IMF	JP Morgan	JP Morgan		IFS, DRI
Units			%	local/$, % of t0	local/$, % of t24	local/$, %	%
	Brazil	Jan-99	28.2	4.8	37.0	43.6	3.8
	Bulgaria	Mar-96	73.8	-9.9	142.1	118.2	-16.3
	Czech	May-97	26.7	2.4	6.5	9.0	-4.4
	Ecuador	Sep-98	82.4	43.3	51.1	116.5	-6.9
	Finland	Sep-92	45.2	10.0	13.0	24.2	-2.2
	India	Oct-95	23.6	-6.8	22.0	13.7	7.0
	Indonesia	Aug-97	52.3	22.4	155.3	212.3	-16.5
	Israel	Oct-98	43.6	1.3	16.3	17.8	2.0
	Italy	Sep-92	17.2	27.9	1.4	29.7	-1.9
	Korea	Nov-97	27.4	22.6	32.8	62.9	-8.4
	Malaysia	Aug-97	32.8	34.1	16.0	55.6	-8.9
	Mexico	Dec-94	34.2	19.5	38.2	65.1	-8.0
	Philippines	Aug-97	51.4	18.0	16.8	37.9	-1.1
	Russia	Aug-98	42.9	56.5	28.9	101.8	-2.3
	South Africa	Jun-98	17.0	11.4	7.8	20.1	-0.3
	South Africa	Apr-96	13.7	0.3	10.5	10.8	4.1
	Spain	Sep-92	13.8	22.1	3.3	26.2	-1.8
	Sweden	Nov-92	52.7	13.8	9.4	24.5	-3.0
	Thailand	Jul-97	47.7	16.3	35.6	57.7	-13.4
	Turkey	Jan-94	32.1	21.7	17.9	43.5	-11.6
	Turkey	Feb-01	46.4	18.7	9.4	29.8	NA
	UK	Sep-92	14.1	14.5	5.2	20.4	2.2
	Venezuela	Dec-95	71.4	9.9	41.0	54.9	-2.3
	Average		38.7	16.3	31.2	52.0	-4.1