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# Exchange rate overshooting and the costs of floating[1]

Michele Cavallo
New York University

Kate Kisselev
New York University

Fabrizio Perri
New York University, NBER and CEPR

Nouriel Roubini
New York University, NBER and CEPR

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 currency crises that helps 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 v/s flexible regime; 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.

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

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## 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, 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. 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 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 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. 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 (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 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 selloff 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, 2000, and Gertler, Gilchrist and Natalucci, 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 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, 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. 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.[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), and Gupta, Mishra and Sahay (2001).[3] 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

[2] See Kiyotaki and Moore (1997), Krugman (1999), Aghion, Banerjee and Bacchetta (2000), Céspedes, Chang and Velasco (2000), Caballero and Krishnamurty (2002), Christiano, Gust and Roldos (2002) and Mendoza (2002).

[3] 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.

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 (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 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.

## 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.[4] 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

[4] We focus on what Dornbusch (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.

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 23 crisis episodes, and the countries and crisis dates are reported in Table 1.[5]

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:

[5] 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.

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[6] relation between output contractions and debt/depreciation products, suggesting an important role for these effects.

***Regression analysis***

Now we provide a regression analysis of the empirical relation between net debt, overshooting and output contraction. The equations we wish to estimate are of the following form.

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

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

All real effective exchange rates are measured so that increases are depreciations. We hypothesize 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.

[6] 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.

**Ordinary Least Squares.** In table 2 we present results obtained using estimating 1 and 2 separately using ordinary least squares. The estimation results strongly support our hypotheses, despite the relatively small size of the sample. Both $\alpha_2$ and $\beta_2$ have the expected signs and are significant at the 1% 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. 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. The results from the OLS regression need to be taken with caution, however, because of two potential problems: the small sample size and endogeneity. We address these concerns below.

**Small Sample Inference.** Since our regressions are based on only 23 observations, a legitimate concern is whether the asymptotic arguments that permit inference truly hold up in such a small sample. As a check on our results, we re-estimate the coefficients and derive standard errors using a jackknife procedure. In particular, we compute the entire frequency distribution of the coefficients $\alpha_2$ and $\beta_2$ excluding each episode singularly, all possible couples of episodes, all possible triples and finally all possible quadruples.[7] The distributions of the coefficients $\alpha_2$ and $\beta_2$, are reported in figures 4 and 5, respectively. Notice that the coefficients never take the wrong sign and that the distribution is centered around the estimate using the full sample. Moreover, the jackknife standard errors are even smaller than the OLS standard errors. We then conclude that our main empirical findings are not biased by the small size of our sample.

[7] The total number of regressions is given by $\sum_{j=1}^{4} \frac{23!}{(23-j)!} = 10902$.

**Endogeneity.** 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 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.[8] The results are reported in table 3. Notice that the coefficients still have the expected sign and they are still significant at the 1% level, though the point estimates are slightly different from the OLS estimates. Quantitatively, an increase in a country's net debt/GDP ratio by 10 percentage points increases overshooting by about 11.5%.

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 percentage point increase in an average country's net debt/GDP ratio yields an additional output contraction of 1.7%, 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

[8] 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 non-linear way, we also include non-linear functions of the exogenous variables in our sets of instruments as Kelejian (1971) recommends.

country increases by 10 percentage points, we would expect output to contract by an additional 0.8%.

Since Argentina's recent crisis has developed entirely outside of our sample period, we can use our estimates to do a very simple exercise in out-of-sample prediction. Our model predicts that with Argentina's net debt/GDP ratio of 55%, the country can expect 50% overshooting, on top of market estimates of 11% fundamental devaluation.[9] If the market's estimates of overvaluation are on target, then our model predicts a maximum output contraction of 5.5% over the 2 years following this hypothetical crisis. This prediction rests between the Argentine government's prediction of a 5% contraction and market forecasts of a 7-10% output contraction.

**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.[10] 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;[11] 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"

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

[10] Corsetti, Pesenti and Roubini (1999) develop a model where the currency crash and sharp depreciation are the results 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).

[11] See Rodrik and Velasco (2000) and Sachs and Radelet (1999).

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[12] 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. According to a similar 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. It is important to note, however, that a large current account to GDP ratio often mirrors substantial capital inflows. To the extent that these pre-crisis inflows are debt, rather than equity, then the effects of a large or protracted current account deficit may already be captured by the net debt to GDP variable.

As suggested by Calvo (1998) a "sudden stop" or a reversal of capital inflows could adversely affect output if less international credit is available to finance productive enterprises.[13]

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.[14]

Yet another possible explanation of overshooting and output contraction focuses on expansions in bank credit and credit boom phenomena.[15] 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.

[12] See Goldman Sachs (2000).
[13] See Calvo and Reinhart (1999) for some evidence on this hypothesis.
[14] See, for example Gupta, Mishra and Sahay (2001).
[15] See Gourinchas, Valdes and Landerrechte (2001) for a study of credit booms and their consequences.

Finally, a sharp output fall may be the result of a banking crisis.[16] Weaknesses in bank loan portfolios before a crisis may be exacerbated by the balance sheet effects of a devaluation when many bank liabilities are in foreign currency. In this case, a sharp depreciation may trigger a banking crisis, a credit crunch and a fall in economic activity.

One point to observe is that these alternative explanations of overshooting and output contraction are not necessarily inconsistent with the balance sheet effects that we stress in this paper. For example, we explore the possibility that banking crises themselves are partly the result of balance sheet effects; a mismatch in the currency composition of banks' own assets and liabilities could directly lead to bank failures, while similar mismatches on the books of corporate debtors could lead to a deterioration of bank asset quality and could indirectly lead to bank failures. In cases like this, the output effects 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. 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 flow reversals may be triggered by the balance sheet effects of sharp devaluations, rather than being autonomous causes of an output fall. Or, in the presence of currency mismatches, a reversal of capital flows may depress the exchange rate and exacerbate balance sheet effects, thus contributing to a decline in output through the channels emphasized in this paper.

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.

[16] See Mishkin (1999).

First, we use the average annual inflation rate over the five years preceding a crisis as a 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.[17] In our final test of the 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 reserve adequacy is also insignificant in all three specifications, and its inclusion in the regression still does not affect the other coefficients.

Next, to determine 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 specifica-

[17] 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.

tions, 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 re-estimate our model 6 times, with each variable in the first equation, then the second equation, then in both equations. The one-year capital buildup is significant at the 10% level when it is included only in the second equation, but it does not substantially affect the coefficient on balance sheet effects. This result is shown in Table 4. The 3-year capital buildup is a significant determinant of output when included only in equation 2 (Table 5) and when included in both equations (Table 6). While the 3-year capital buildup does not affect the significance of the benchmark variables, its inclusion does increase the sensitivity of output to balance sheet effects; the coefficient on balance sheet effects rises by about one standard deviation when the 3-year capital buildup is included in the model.

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 7 and 6 indicate that balance sheet effects are an important determinant of output even after controlling for capital reversal. When our version of the capital reversal variable is significant, it does not change the significance of the coefficients in the benchmark model, but it does slightly attenuate the impact of balance sheet effects on output.

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 Landerretche (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.

We also explore the idea that a sharp contraction in real bank credit to the private sector could fuel overshooting or exacerbate an output contraction. We measure this change in credit over the one year following each crisis, then over the two years following each crisis, and include the variable in the first equation, in the second equation, and then in both equations. The one-year variable is never significant, but the two-year change in real private sector credit is significant when included in both equations, as shown in Table 9. The inclusion of this variable slightly attenuates the coefficients on the benchmark variables, but it does not affect their significance.

While testing for the effects of banking crises on output, we found a significant endogeneity problem. In our sample, there are 12 cases of twin crises, when 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 corporate system. When banks are net foreign currency debtors, a sharp fall in the home currency's value leads to sharp balance sheet effects and financial distress. Even if banks try to hedge 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 occurs, mismatched households and firms become distressed and default on their obligations to local banks, thus triggering a banking crisis. In this way, banking crises can be triggered directly or indirectly by the balance sheet effects of sharp currency movements. To test for this, we estimated a simple probit model of banking crisis where a banking crisis dummy variable is regressed on our measure of balance sheet effects. In one regression, the banking crisis dummy variable takes the value 1 whenever there is a concurrent banking crisis. In another regression, the dummy variable takes the value 1 only if the banking crisis erupted after the onset of the currency crisis. These results are reported in Tables 10 and 11. In both regressions, the balance sheet variable has a significant effect on the probability of a banking crisis. Thus, while regressions that include the banking crisis dummy in the output equation do suggest that a banking crisis has a significant effect on output, our results imply that the impact of the banking crisis can be traced back to balance sheet effects: an output contraction can be driven in part by a banking crisis that is the result of the balance sheet effects of a devaluation. Banks fail because they are exposed to direct and indirect balance sheet effects, and when bank failures lead to a credit crunch, output falls as a result.

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 have substantial influence over the coefficient estimates or the standard errors. To test the robustness of the model to outliers, we first identify outliers by re-estimating the model 23 times, once without each observation. At each iteration, we compute standardized residuals in each equation for the included 22 variables and we compute a "predicted" residual for the observation that was omitted. In this way, we can look for unusual observations whose outlier status is masked by the fact that the observation has substantially altered the coefficient estimates. We then look for standardized residuals from equations 1 or 2 that are greater than 1.65 in absolute value in any of the 23 re-estimations. It turns out that 5 crisis episodes have outlying residuals under these criteria: Turkey 1993, India 1995, Bulgaria 1996, Indonesia 1997, and Brazil 1999. We then re-estimate the benchmark system 31 times, excluding all possible combinations of these 5 potential outlier countries. Our results are highly robust to these outliers. The coefficients of interest vary in magnitude a bit, but they are always statistically significant at least at the .02 level.

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 (linearly and not interacted with net debt) in the second equation and report these results in Table 12. 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.

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. Table 13 shows that while world growth is significant, its inclusion does not affect the other coefficients substantially.

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.

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.

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 $\alpha_2$ and $\beta_2$ retain the expected signs and are significant at the .001 level. 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, $\alpha_2$ and $\beta_2$ have the expected signs and remain significant at the .01 level, though $\alpha_2$ drops a bit from 1.2 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 $t_0$ 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. There is a potential problem with our use of post-crisis data to measure the equilibrium REER, however. For our model to be econometrically identified, both of our instruments–net debt and fundamental depreciation–must be exogenous. Yet it is theoretically possible that fundamental depreciation could be partly endogenous in our model. For example, if the degree of overshooting, the size of the debt, or the output contraction induces a government policy in the initial stages of a crisis that changes the equilibrium REER, then our specification might not be valid. To ensure that fundamental depreciation is not endogenous, we run regress fundamental depreciation on overshooting, net debt, and output contraction, and we find that these variables are never significant. To eliminate the timing problem altogether, we also redefine the equilibrium REER as the average REER during the 5 years preceding a crisis and then re-run our benchmark IV regression. With this redefinition, fundamental depreciation is fully determined prior to the crisis, and cannot be endogenously determined by developments as the crisis unfolds. Our results hold up under this alternate definition of fundamental depreciation.

In summary, our results and robustness tests establish that the extent of overshooting is related to a country's foreign currency debt burden (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.

## 3. A simple model of real exchange rate overshooting

In this section we 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 Céspedes *et al.* (2000) or by Gertler *et al.* (2000), 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

$$(3) \qquad w_t l_t + (q_t + d_t)\, s_t + p_t b_t - c_{H,t} - c_{F,t} p_t - \frac{p_t b_{t+1}}{R_t} - q_t s_{t+1} \geq 0,$$

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

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, $q_t$ 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 ($-\frac{p_t b_{t+1}}{R_t}$) to assets ($q_t s_{t+1}$) ratio of the financial sector has to be below a certain threshold $\kappa_t$.

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 $s_t^*$

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

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 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 assume that foreign expenditure on domestic goods (denominated in foreign currency) is exogenously given (as in Céspedes *et al.*, 2000) by $x_t$ so the goods market clearing condition is

$$(7) \qquad c_{H,t} + p_t x_t = y_t.$$

**A. 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.[18] Many authors have documented that, especially in small open economy models, this property is necessary for the model to reproduce the business cycle facts.[19] 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

[18] 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.

[19] See for example Mendoza (1991), Correia *et al.* (1995), and Perri and Neumeyer (2001).

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 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 $\kappa$) 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 parameters and functional forms is provided below.

Table 20. Baseline parameter values

| Name | Symbol | Value |
|---|---|---|
| Yearly discount factor | $\beta$ | 0.9 |
| International rate | $R$ | $1/\beta$ |
| Labor exponent | $v$ | 3.5 |
| Labor share | $\alpha$ | 0.6 |
| Risk Aversion | $\sigma$ | 3 |
| Elasticity of Substitution between $c_H$ and $c_F$ | $\rho$ | 1.2 |
| Share of foreign good | $\omega$ | 0.5 |
| Adjustment costs of foreign trader | $a$ | 1.0 |
| Margin limit | $\kappa$ | 0.1 |
| Domestic stock owned by residents | $s_0$ | 90% |

We consider the following experiment. We follow two economies, one with a high debt to output ratio (65%) and one with a low debt to output ratio (45%). 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% ) 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 6 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 $-\frac{p_t b_{t+1}}{R q_t s_{t+1}}{}_t$ 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 6) 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 6. 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 7) 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 6) 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[20] output drops while the data suggest that countries with heavier debts and larger depreciations 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, 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.

**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 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

[20] 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.

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 7 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 *et al.* (2000); 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. OLS regression Results

3. Benchmark IV Regression Results

4. Robustness to 1-Year Capital Buildup

5. Robustness to 3-Year Capital Buildup in Equation 2

6. Robustness to 3-Year Capital Buildup in Both Equations

7. Robustness to Capital Reversal in Equation 2

8. Robustness to Capital Reversal in Equations 1 and 2

9. Robustness to Real Credit Contraction in Both Equations
10. Endogeneity of All Banking Crises and Balance Sheet Effects
11. Endogeneity of Subsequent Banking Crises and Balance Sheet Effects
12. Robustness to Competitiveness Effects
13. Robustness to World Growth
14. Robustness to Redefining Net Debt
15. Robustness to Redefining the Equilibrium REER at 36 Months
16. Robustness to Redefining the Equilibrium REER as 5-Year Average
17. Robustness to Redefining Overshooting
18. Robustness to Redefining Overshooting and Total Depreciation
19. Robustness to Redefining the Equilibrium REER as 5-Year Pre-Crisis Average
20. Baseline parameters

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Table 1: 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 | -9.5* |
| | 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 | -4.33 |
| | *Maximum drop after 1 year | | | | | | |

## Table 2: OLS Regression

Estimation Method: Ordinary Least Squares
Included observations: 23

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -11.99915 | 15.82278 | -0.758347 | 0.4525 |
| $\alpha_2$ | 1.115920 | 0.366150 | 3.047713 | 0.0040 |
| $\beta_1$ | 21.88785 | 6.041304 | 3.623034 | 0.0008 |
| $\beta_2$ | -3.663324 | 0.832472 | -4.400539 | 0.0001 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306669 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273653 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.70249 | Sum squared resid | 23853.02 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.479744 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.454970 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.745058 | Sum squared resid | 472.8270 |

## Table 3: Benchmark IV Regression

Estimation Method: Three-Stage Least Squares
Included observations: 23
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2
NET_DEBT^3 (NET_DEBT*FUND)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -13.37570 | 14.98749 | -0.892458 | 0.3772 |
| $\alpha_2$ | 1.151473 | 0.346068 | 3.327306 | 0.0018 |
| $\beta_1$ | 19.45707 | 6.169206 | 3.153902 | 0.0030 |
| $\beta_2$ | -3.323787 | 0.851493 | -3.903481 | 0.0003 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306358 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273327 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.71006 | Sum squared resid | 23863.73 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.475623 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.450652 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.763815 | Sum squared resid | 476.5726 |

Table 4: Robustness to 1-Year Capital Buildup

Estimation Method: Three-Stage Least Squares
Included observations: 23
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2
NET_DEBT^3 (NET_DEBT*FUND)^3 CAP_BUILDUP1YR
CAP_BUILDUP1YR^2 CAP_BUILDUP1YR^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -13.87617 | 14.93814 | -0.928909 | 0.3584 |
| $\alpha_2$ | 1.164399 | 0.344642 | 3.378580 | 0.0016 |
| $\beta_1$ | 25.32170 | 6.457936 | 3.921020 | 0.0003 |
| $\beta_2$ | -3.891497 | 0.838818 | -4.639260 | 0.0000 |
| $\beta_3$ | -0.158864 | 0.088862 | -1.787763 | 0.0812 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306090 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273047 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.71656 | Sum squared resid | 23872.93 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)
+ $\beta_3$*CAP_BUILDUP1YR

| | | | |
|---|---|---|---|
| R-squared | 0.519182 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.471100 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.674316 | Sum squared resid | 436.9846 |

CAP_BUILDUP1YR is the inflow of capital divided by GDP in the year preceding a crisis.

## Table 5: Robustness to 3-Year Capital Buildup 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 NET_DEBT^3 (NET_DEBT*FUND)^3 CAP_BUILDUP3YR CAP_BUILDUP3YR^2 CAP_BUILDUP3YR^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -14.43728 | 14.99548 | -0.962776 | 0.3413 |
| $\alpha_2$ | 1.178891 | 0.346298 | 3.404264 | 0.0015 |
| $\beta_1$ | 26.91852 | 6.202966 | 4.339621 | 0.0001 |
| $\beta_2$ | -4.125275 | 0.812881 | -5.074883 | 0.0000 |
| $\beta_3$ | -0.443956 | 0.239560 | -1.853212 | 0.0711 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.305692 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.272630 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.72622 | Sum squared resid | 23886.61 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) + $\beta_3$*CAP_BUILDUP3YR

| | | | |
|---|---|---|---|
| R-squared | 0.536790 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.490469 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.587927 | Sum squared resid | 420.9814 |

CAP_BUILDUP3YR is the inflow of capital divided by GDP in the 3 years preceding a crisis.

## Table 6: Robustness to 3-Year Capital Buildup in Both Equations

Estimation Method: Three-Stage Least Squares
Included observations: 23
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 NET_DEBT^3 (NET_DEBT*FUND)^3 CAP_BUILDUP3YR CAP_BUILDUP3YR^2 CAP_BUILDUP3YR^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -11.89909 | 19.22432 | -0.618960 | 0.5395 |
| $\alpha_2$ | 1.153247 | 0.366061 | 3.150427 | 0.0031 |
| $\alpha_3$ | -0.398048 | 1.908168 | -0.208602 | 0.8358 |
| $\beta_1$ | 26.76062 | 6.252396 | 4.280059 | 0.0001 |
| $\beta_2$ | -4.111412 | 0.815947 | -5.038823 | 0.0000 |
| $\beta_3$ | -0.428848 | 0.250416 | -1.712546 | 0.0945 |

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT+$\alpha_3$*CAP_BUILDUP3YR

| | | | |
|---|---|---|---|
| R-squared | 0.307791 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.238570 | S.D. dependent var | 39.54485 |
| S.E. of regression | 34.50682 | Sum squared resid | 23814.41 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) + $\beta_3$*CAP_BUILDUP3YR

| | | | |
|---|---|---|---|
| R-squared | 0.536945 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.490640 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.587158 | Sum squared resid | 420.8405 |

CAP_BUILDUP3YR is the inflow of capital divided by GDP in the 3 years preceding a crisis.

## Table 7: 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 NET_DEBT^3 (NET_DEBT*FUND)^3 CAPITAL_REVERSAL CAPITAL_REVERSAL^2 CAPITAL_REVERSAL^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -11.91285 | 15.09137 | -0.789382 | 0.4344 |
| $\alpha_2$ | 1.113691 | 0.349066 | 3.190485 | 0.0027 |
| $\beta_1$ | 16.58569 | 5.155844 | 3.216871 | 0.0025 |
| $\beta_2$ | -2.576168 | 0.758153 | -3.397953 | 0.0015 |
| $\beta_3$ | 0.543690 | 0.163419 | 3.326967 | 0.0019 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306668 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273652 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.70252 | Sum squared resid | 23853.06 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) +$\beta_3$*CAPITAL_REVERSAL

| | | | |
|---|---|---|---|
| R-squared | 0.672450 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.639695 | S.D. dependent var | 6.427339 |
| S.E. of regression | 3.858035 | Sum squared resid | 297.6887 |

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.

## Table 8: 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 NET_DEBT^3 (NET_DEBT*FUND)^3 CAPITAL_REVERSAL CAPITAL_REVERSAL^2 CAPITAL_REVERSAL^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -18.77232 | 14.52591 | -1.292333 | 0.2037 |
| $\alpha_2$ | 1.020647 | 0.328846 | 3.103724 | 0.0035 |
| $\alpha_3$ | -2.292753 | 1.224884 | -1.871812 | 0.0686 |
| $\beta_1$ | 16.55953 | 5.153975 | 3.212963 | 0.0026 |
| $\beta_2$ | -2.539387 | 0.758146 | -3.349469 | 0.0018 |
| $\beta_3$ | 0.595665 | 0.166091 | 3.586372 | 0.0009 |

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT+$\alpha_3$*CAPITAL_REVERSAL

| | | | |
|---|---|---|---|
| R-squared | 0.398239 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.338063 | S.D. dependent var | 39.54485 |
| S.E. of regression | 32.17350 | Sum squared resid | 20702.68 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) +$\beta_3$*CAPITAL_REVERSAL

| | | | |
|---|---|---|---|
| R-squared | 0.674267 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.641694 | S.D. dependent var | 6.427339 |
| S.E. of regression | 3.847322 | Sum squared resid | 296.0377 |

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.

## Table 9: Robustness to Real Credit Contraction in Both Equations

Estimation Method: Three-Stage Least Squares
Included observations: 22
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 NET_DEBT^3 (NET_DEBT*FUND)^3 REAL_CRED2YR REAL_CRED2YR^2 REAL_CRED2YR^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -5.628787 | 14.51553 | -0.387777 | 0.7003 |
| $\alpha_2$ | 0.886009 | 0.361986 | 2.447634 | 0.0191 |
| $\alpha_3$ | -0.441727 | 0.236780 | -1.865556 | 0.0698 |
| $\beta_1$ | 15.16812 | 6.339020 | 2.392817 | 0.0218 |
| $\beta_2$ | -2.615061 | 0.899265 | -2.907997 | 0.0060 |
| $\beta_3$ | 0.064378 | 0.035552 | 1.810832 | 0.0781 |

Equation: OVERSHOOT = $\alpha_1+\alpha_2$*NET_DEBT+$\alpha_3$* REAL_CRED2YR

| | | | |
|---|---|---|---|
| R-squared | 0.424662 | Mean dependent var | 32.20044 |
| Adjusted R-squared | 0.364100 | S.D. dependent var | 40.18060 |
| S.E. of regression | 32.04135 | Sum squared resid | 19506.32 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) +$\beta_3$*REAL_CRED2YR

| | | | |
|---|---|---|---|
| R-squared | 0.546941 | Mean dependent var | -4.103560 |
| Adjusted R-squared | 0.499250 | S.D. dependent var | 6.476992 |
| S.E. of regression | 4.583357 | Sum squared resid | 399.1361 |

Turkey 2001 is excluded from this regression because its real credit data for 2003 were not yet available. REAL_CRED2YR is the percent change in real credit to the private sector over the two years following a crisis.

## Table 10: Endogeneity of All Banking Crises 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 or following the currency crisis and 0 if not.

## Table 11: Endogeneity of Subsequent Banking Crises and Balance Sheet Effects

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

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| C | -1.226068 | 0.417497 | -2.936712 | 0.0033 |
| NET_DEBT*TOTAL_ DEPRECIATION | 0.000150 | 9.07E-05 | 1.653353 | 0.0983 |

| | | | |
|---|---|---|---|
| Mean dependent var | 0.217391 | S.D. dependent var | 0.421741 |
| S.E. of regression | 0.402456 | Akaike info criterion | 1.100182 |
| Sum squared resid | 3.401386 | Schwarz criterion | 1.198921 |
| Log likelihood | -10.65210 | Hannan-Quinn criter. | 1.125015 |
| Restr. log likelihood | -12.04249 | Avg. log likelihood | -0.463135 |
| LR statistic (1 df) | 2.780780 | McFadden R-squared | 0.115457 |
| Probability(LR stat) | 0.095402 | | |
| Obs with Dep=0 | 18 | Total obs | 23 |
| Obs with Dep=1 | 5 | | |

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

## Table 12: 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 NET_DEBT^3 (NET_DEBT*FUND)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -12.54698 | 15.09545 | -0.831176 | 0.4106 |
| $\alpha_2$ | 1.130069 | 0.349184 | 3.236316 | 0.0024 |
| $\beta_1$ | 0.988273 | 1.824890 | 0.541552 | 0.5910 |
| $\beta_2$ | -0.102417 | 0.029597 | -3.460328 | 0.0013 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306619 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273601 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.70369 | Sum squared resid | 23854.71 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.438603 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.411870 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.929102 | Sum squared resid | 510.2170 |

## Table 13: Robustness to World Growth

Estimation Method: Three-Stage Least Squares
Included observations: 23
Instruments: NET_DEBT NET_DEBT*FUND NET_DEBT^2 (NET_DEBT*FUND)^2 NET_DEBT^3 (NET_DEBT*FUND)^3 WORLD_GROWTH WORLD_GROWTH^2 WORLD_GROWTH^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -13.02014 | 14.88823 | -0.874526 | 0.3869 |
| $\alpha_2$ | 1.142290 | 0.343198 | 3.328373 | 0.0019 |
| $\beta_1$ | 14.38180 | 6.107805 | 2.354659 | 0.0234 |
| $\beta_2$ | -3.694019 | 0.838602 | -4.404974 | 0.0001 |
| $\beta_3$ | 2.908666 | 1.354341 | 2.147661 | 0.0377 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.306498 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.273474 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.70665 | Sum squared resid | 23858.91 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION) +$\beta_3$*WORLD_GROWTH

| | | | |
|---|---|---|---|
| R-squared | 0.517033 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.468736 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.684750 | Sum squared resid | 438.9377 |

WORLD_GROWTH is the annual average percent GDP growth for the world in during the 2 years following a crisis.

## 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
NET_DEBT2^3 (NET_DEBT2*FUND)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -3.483347 | 11.94435 | -0.291631 | 0.7720 |
| $\alpha_2$ | 1.197965 | 0.344246 | 3.479966 | 0.0012 |
| $\beta_1$ | 8.913907 | 5.142128 | 1.733506 | 0.0903 |
| $\beta_2$ | -1.976955 | 0.749685 | -2.637048 | 0.0117 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.334281 | Mean dependent var | 31.20698 |
| Adjusted R-squared | 0.302580 | S.D. dependent var | 39.54485 |
| S.E. of regression | 33.02457 | Sum squared resid | 22903.07 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT2*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.305394 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.272318 | S.D. dependent var | 6.427339 |
| S.E. of regression | 5.482797 | Sum squared resid | 631.2824 |

NET_DEBT2 is gross external debt minus external assets of the government, bank, and corporate sectors as a share of GDP.

## Table 15: Robustness to Redefining the 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
NET_DEBT^3 (NET_DEBT*FUND2)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -19.14378 | 11.64529 | -1.643907 | 0.1077 |
| $\alpha_2$ | 1.352164 | 0.269107 | 5.024625 | 0.0000 |
| $\beta_1$ | 18.75092 | 6.198007 | 3.025314 | 0.0042 |
| $\beta_2$ | -3.225149 | 0.855562 | -3.769624 | 0.0005 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.514180 | Mean dependent var | 33.20924 |
| Adjusted R-squared | 0.491045 | S.D. dependent var | 36.59329 |
| S.E. of regression | 26.10604 | Sum squared resid | 14312.03 |

Equation: GDP = $\beta_1$+$\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.472880 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.447779 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.776255 | Sum squared resid | 479.0649 |

In this specification, the equilibrium real effective exchange rate is defined as the REER prevailing 36 months after a crisis.

## Table 16: Robustness to Redefining the 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
NET_DEBT^3 (NET_DEBT*FUND3)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | 1.752448 | 11.90531 | 0.147199 | 0.8837 |
| $\alpha_2$ | 0.839402 | 0.274828 | 3.054279 | 0.0039 |
| $\beta_1$ | 18.79104 | 6.102285 | 3.079345 | 0.0036 |
| $\beta_2$ | -3.230754 | 0.842075 | -3.836659 | 0.0004 |

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

| | | | |
|---|---|---|---|
| R-squared | 0.273806 | Mean dependent var | 34.25236 |
| Adjusted R-squared | 0.239225 | S.D. dependent var | 30.72834 |
| S.E. of regression | 26.80201 | Sum squared resid | 15085.30 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.473055 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.447962 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.775465 | Sum squared resid | 478.9063 |

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.

### 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 NET_DEBT^3 (NET_DEBT*FUND)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -78.86921 | 120.2847 | -0.655688 | 0.5156 |
| $\alpha_2$ | 6.439816 | 2.782932 | 2.314040 | 0.0256 |
| $\beta_1$ | 19.58942 | 6.229403 | 3.144671 | 0.0031 |
| $\beta_2$ | -3.342274 | 0.860002 | -3.886357 | 0.0004 |

Equation: OVERSHOOT4 = $\alpha$1+$\alpha$2*NET_DEBT

| | | | |
|---|---|---|---|
| R-squared | 0.184033 | Mean dependent var | 170.4672 |
| Adjusted R-squared | 0.145177 | S.D. dependent var | 290.2406 |
| S.E. of regression | 268.3467 | Sum squared resid | 1512209. |

Equation: GDP = $\beta$1+$\beta$2*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.476059 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.451110 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.761831 | Sum squared resid | 476.1758 |

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

## 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 NET_DEBT^3 (NET_DEBT*FUND)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | -66.27730 | 120.2045 | -0.551371 | 0.5843 |
| $\alpha_2$ | 6.114595 | 2.780619 | 2.199005 | 0.0334 |
| $\beta_1$ | -1.561431 | 1.663299 | -0.938755 | 0.3532 |
| $\beta_2$ | -0.000104 | 4.50E-05 | -2.311960 | 0.0258 |

Equation: OVERSHOOT4 = α1+α2*NET_DEBT

| | | | |
|---|---|---|---|
| R-squared | 0.183830 | Mean dependent var | 170.4672 |
| Adjusted R-squared | 0.144965 | S.D. dependent var | 290.2406 |
| S.E. of regression | 268.3800 | Sum squared resid | 1512585. |

Equation: GDP = β1+β2*log(NET_DEBT*TOTAL_DEPRECIATION2)

| | | | |
|---|---|---|---|
| R-squared | 0.229308 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.192608 | S.D. dependent var | 6.427339 |
| S.E. of regression | 5.775284 | Sum squared resid | 700.4320 |

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.

## Table 19: Robustness to Redefining the Equilibrium REER as 5-Year Pre-Crisis Average

Estimation Method: Three-Stage Least Squares
Included observations: 23
Instruments: NET_DEBT NET_DEBT*FUND4 NET_DEBT^2 (NET_DEBT*FUND4)^2 NET_DEBT^3 (NET_DEBT*FUND4)^3 C

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| $\alpha_1$ | 8.436805 | 18.35294 | 0.459698 | 0.6481 |
| $\alpha_2$ | 0.915940 | 0.424259 | 2.158918 | 0.0366 |
| $\beta_1$ | 17.30153 | 6.715887 | 2.576209 | 0.0136 |
| $\beta_2$ | -3.022695 | 0.928518 | -3.255397 | 0.0022 |

Equation: OVERSHOOT5 $=\alpha_1+\alpha_2$*NET_DEBT

| | | | |
|---|---|---|---|
| R-squared | 0.167332 | Mean dependent var | 43.90013 |
| Adjusted R-squared | 0.127681 | S.D. dependent var | 43.98719 |
| S.E. of regression | 41.08317 | Sum squared resid | 35444.36 |

Equation: GDP = $\beta_1+\beta_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

| | | | |
|---|---|---|---|
| R-squared | 0.465073 | Mean dependent var | -4.338188 |
| Adjusted R-squared | 0.439600 | S.D. dependent var | 6.427339 |
| S.E. of regression | 4.811499 | Sum squared resid | 486.1609 |

In this specification, the equilibrium REER is defined as the average REER during the 5 years preceding a crisis.

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

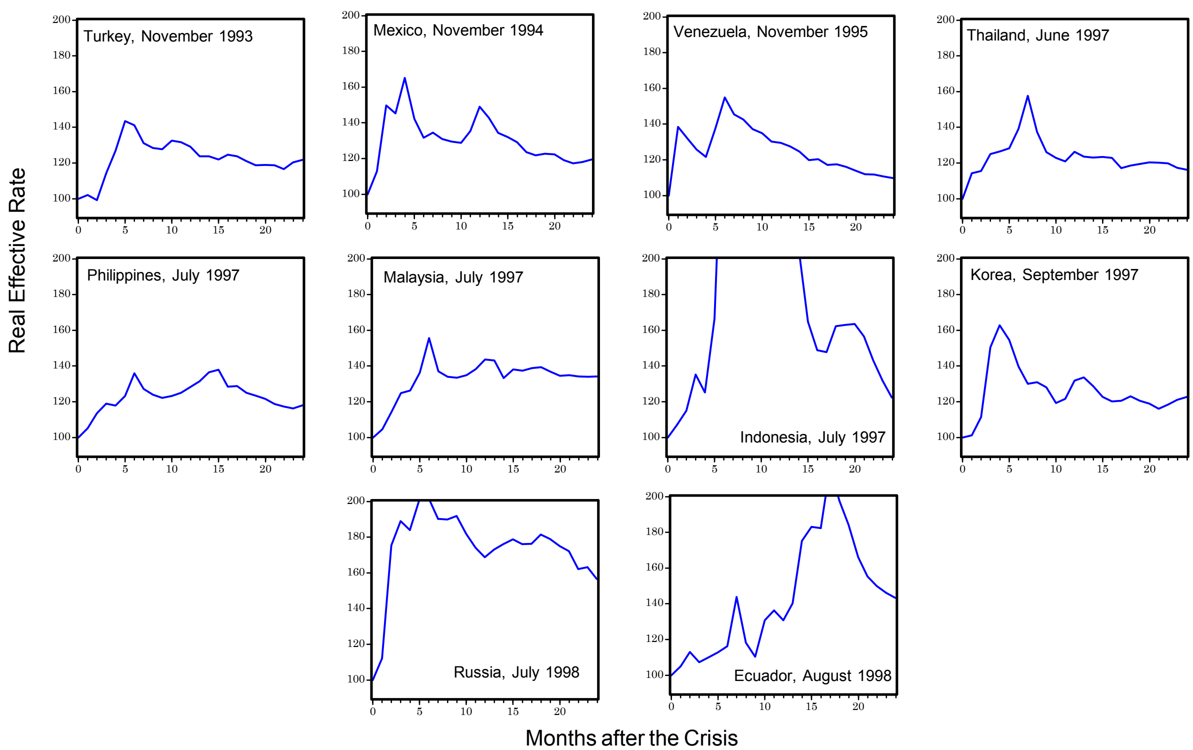


Figure 1b: Real Effective Exchange Rates for "European Style" Crises, t0=100

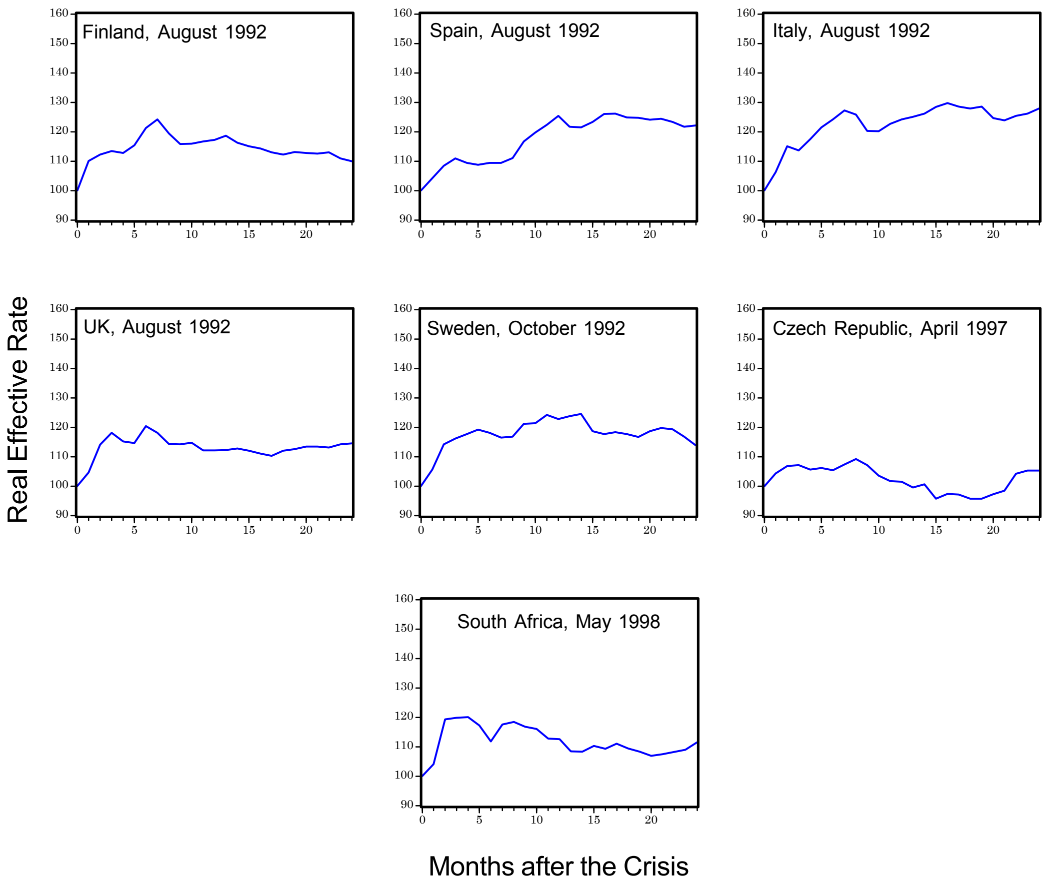


Figure 1c: Real Effective Exchange Rates for "Other Style" Crises, t0=100

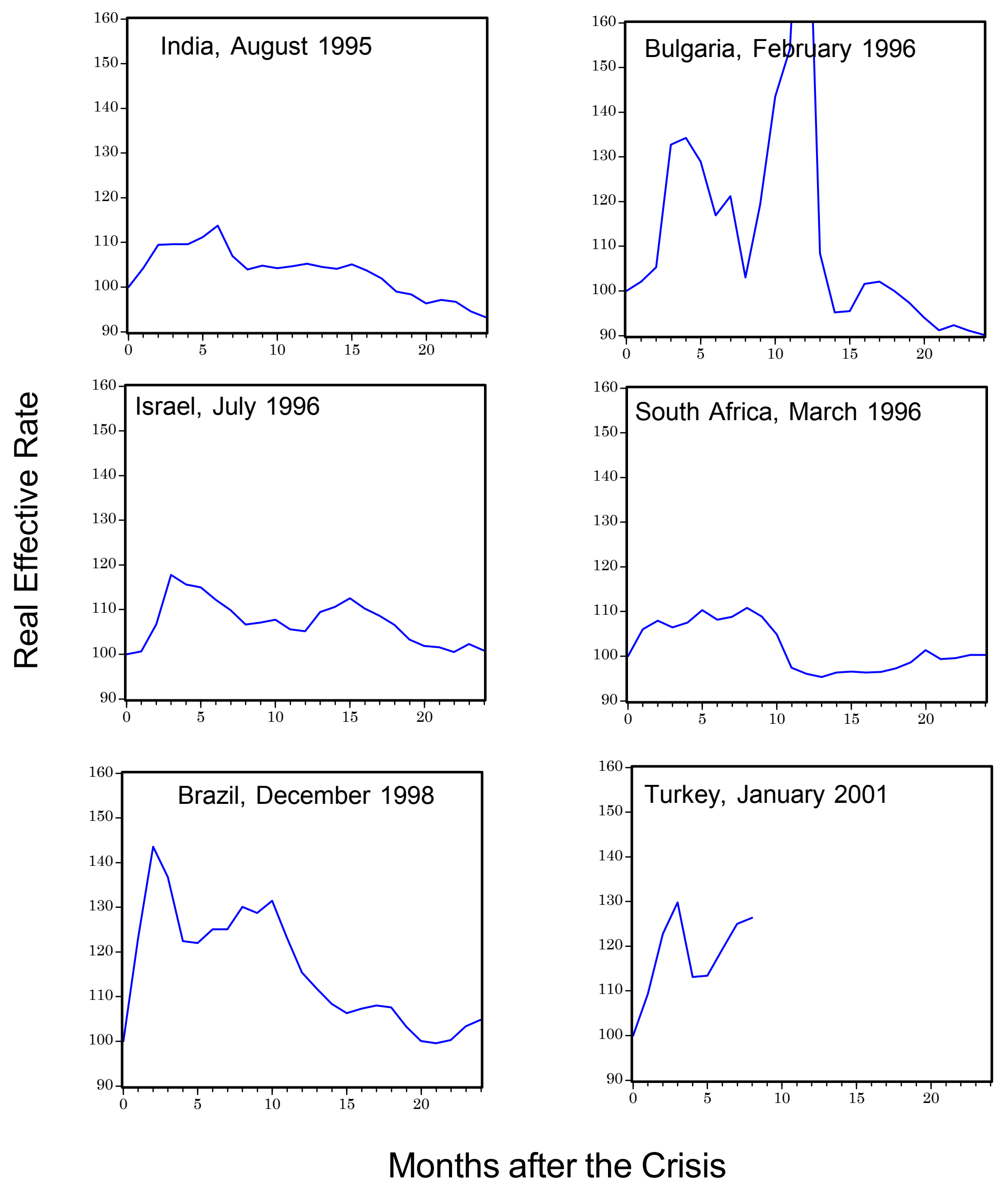


Figure 2. Foreign Debt and Real Exchange Rate Overshooting

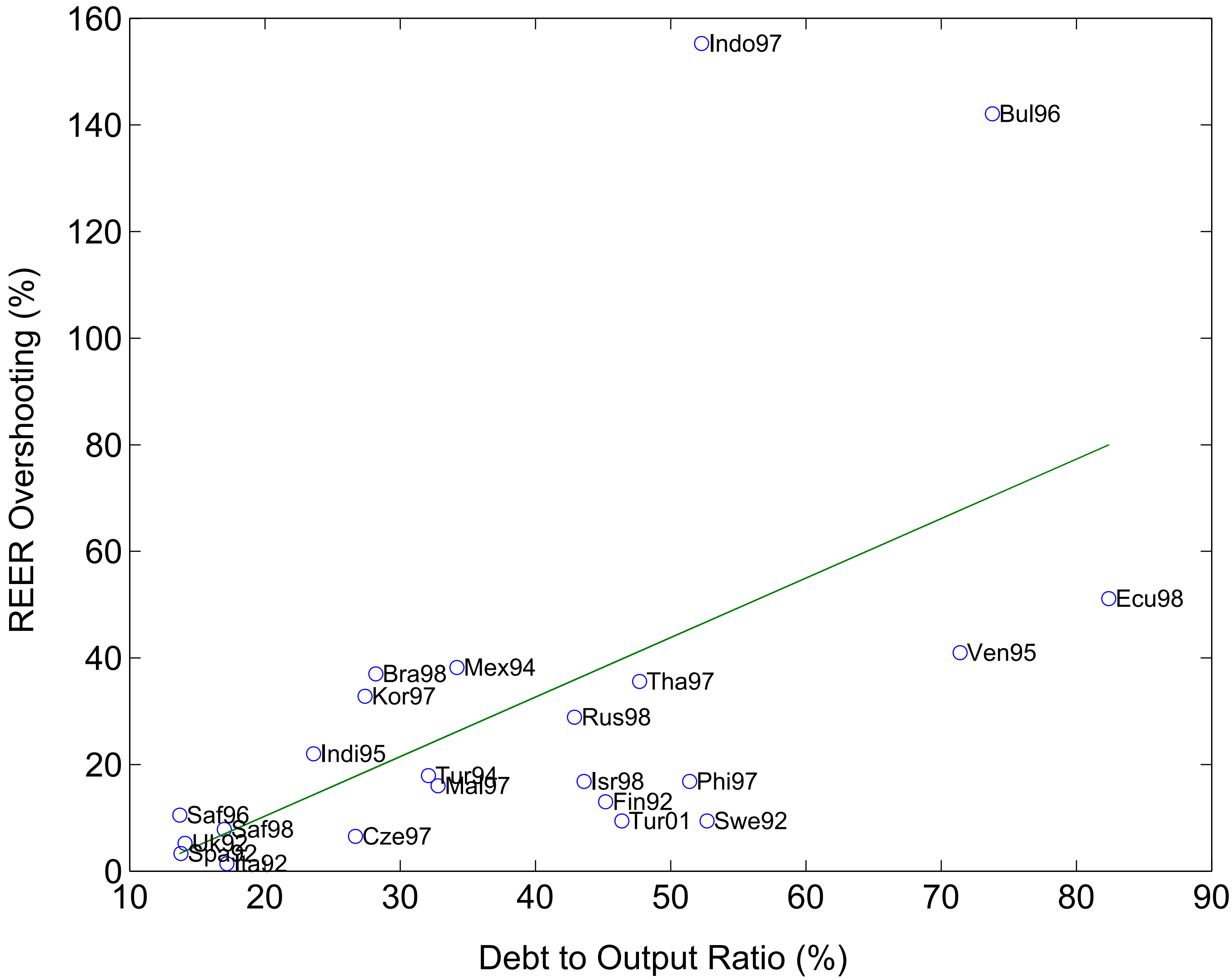


Figure 3. Contractionary effects of balance sheet effects

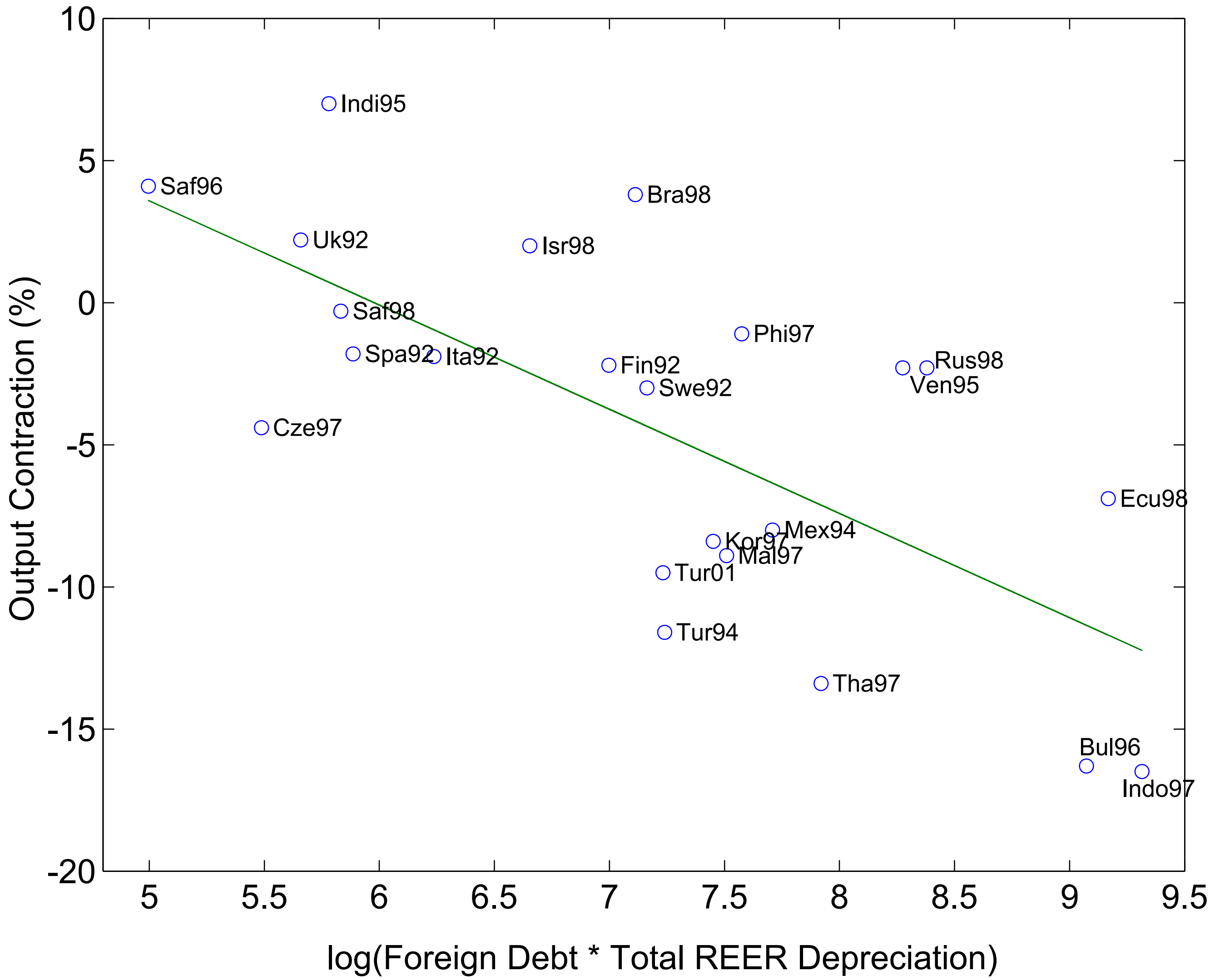


Figure 4. Frequency distribution of $\alpha_2$ (10902 regression, ≤ 4 outliers exclusion)

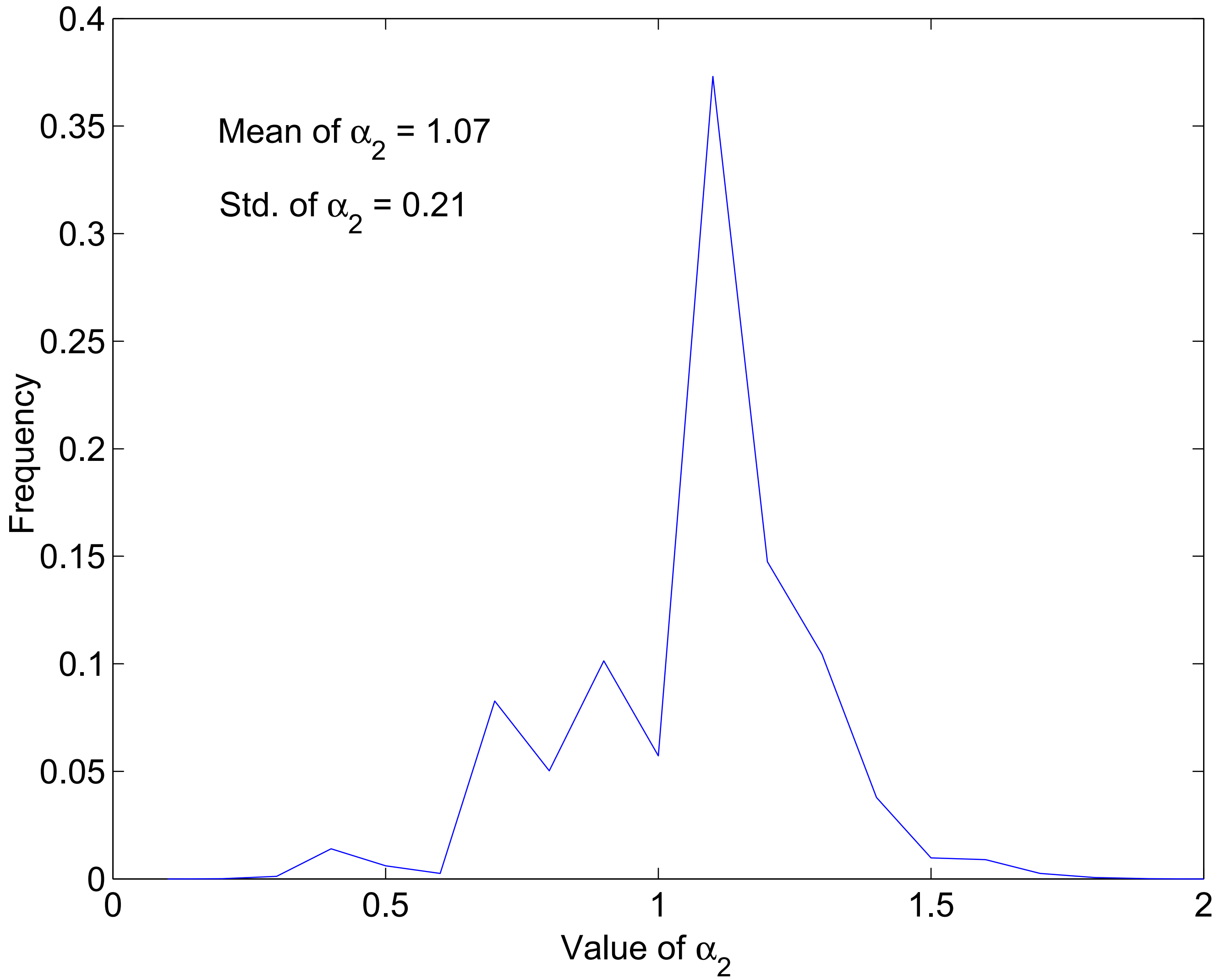
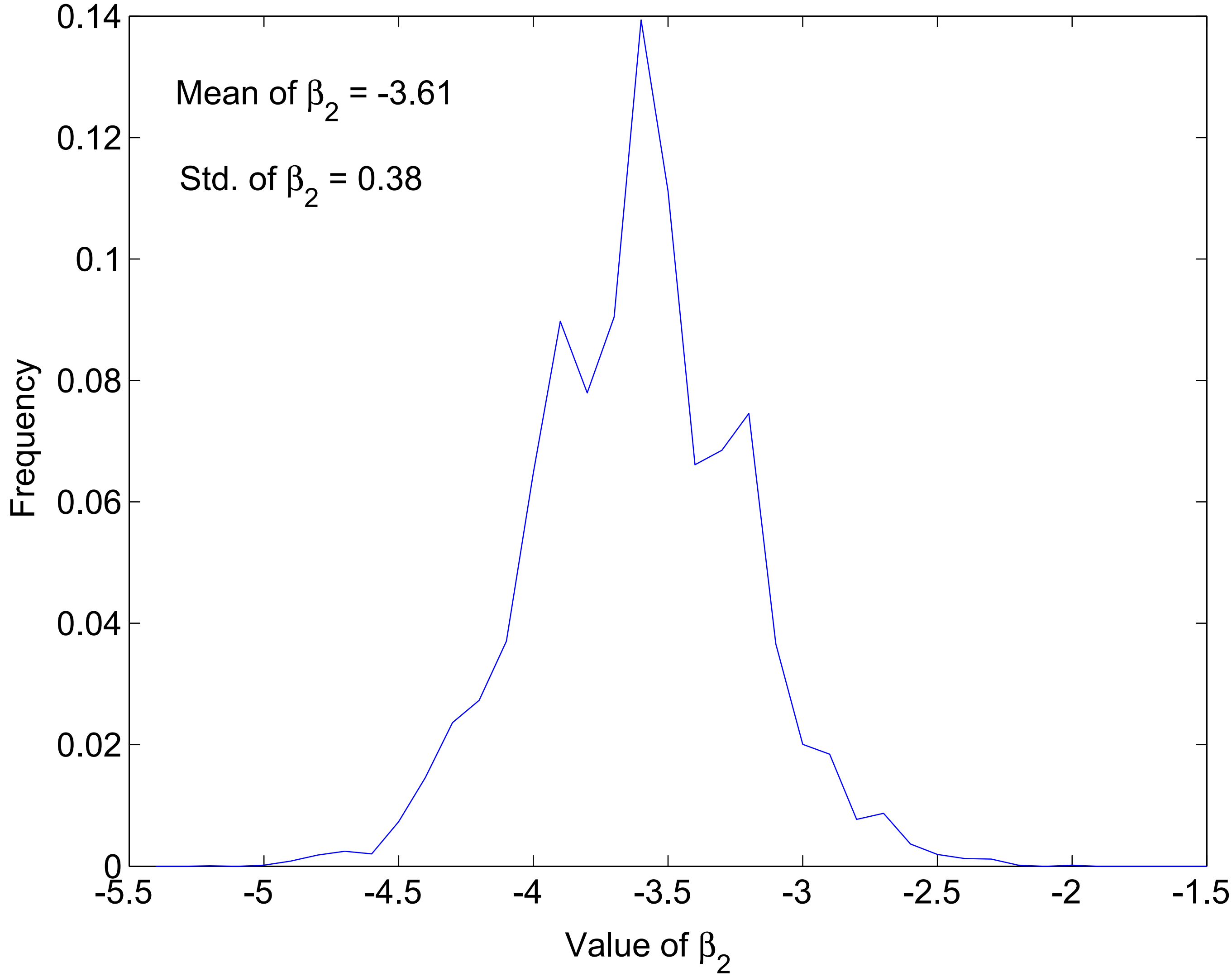


Figure 5. Frequency distribution of $\beta_2$ (10902 regressions, $\leq$ 4 outliers exclusion)



# Figure 6. Effects of a 20% permanent reduction in export expenditure

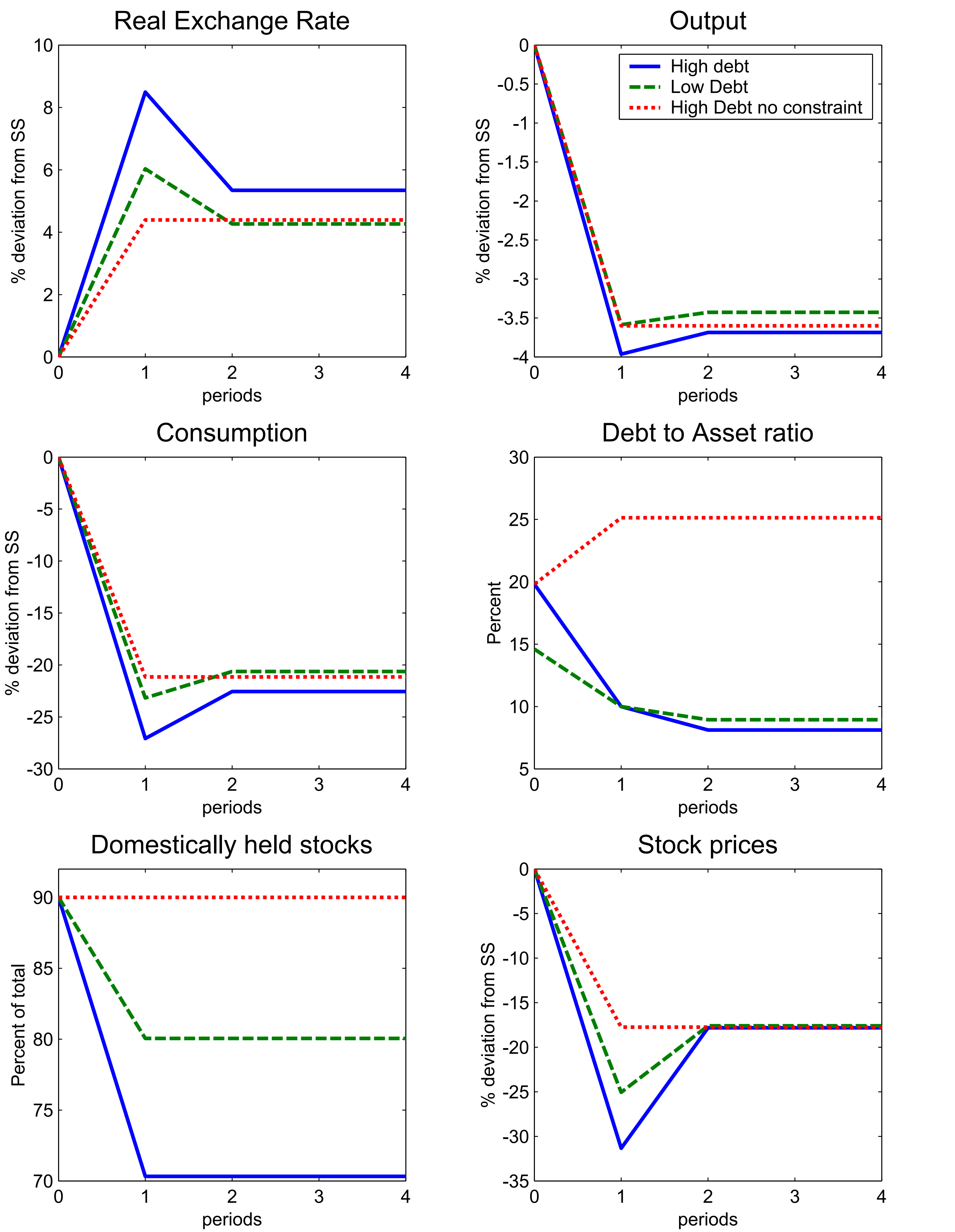


Figure 7. Effects of a reduction in export expenditure: Flex v/s Fixed