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Exchange rate overshooting and the costs of floating[1]

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ABSTRACT

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

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

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1. Introduction

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

Several recent episodes of currency crises in emerging markets (such as Mexico, Thailand, Korea, Indonesia, Russia, Brazil, Turkey and Argentina) have had a number of common features.[2] Specifically, collapses of fixed exchange rate regimes have been associated with a sudden stop of capital inflows into the country and a sharp short-run overshooting of the nominal and real exchange rate well above their fundamental value; only over the medium run have the real exchange rates shown a tendency to return to their long-run equilibrium values. A similar pattern is observed for asset prices: stock markets fall sharply and their foreign currency values overshoot their long run values; only over time does the real value of stocks recover. Moreover, while traditional economic theory suggested that depreciations should have stimulated demand and output through their effects on competitiveness, many currency crises have been associated in the short-run with sharp output contractions rather than economic expansions.[3]

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.[4] 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

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

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

[4]Aguiar and Gopinath (2003) provide evidence on the 'fire sale' effect in the East Asian crisis of 1997-98.

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

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

This paper is also related to a recent analytical literature on balance sheet effects and output contractions.[5] This literature has stressed the role of "balance sheet effects" in explaining the contractionary effects of depreciations: when liabilities are in foreign currency while assets are in local currency, a real depreciation has sharp balance sheet effects that can lead to a firm's illiquidity, financial distress and, in the extreme, bankruptcy; in these papers, the output effects of depreciations are modeled as deriving from "financial accelerator effects" on investment.

Regarding the empirical literature, there is still little work on the output effects of currency crises. Contributions include Milesi-Ferretti and Razin (2000), and Gupta, Mishra and Sahay (2003).[6] These studies use a much larger data set than our paper as they consider: (a) crises in the 1970s-1990s period rather than just the 1990s, as this paper does; (b) take a very broad definition of a currency crisis that includes not only the breaks of pegs but also modest depreciations under semi-flexible exchange rates; and (c) consider both countries with capital account restrictions and those open to international capital markets. As we like to concentrate on the balance sheet effects of sudden and sharp reduction in currency values in economies open to international capital markets, we have a much smaller sample that covers only the crises since the 1990s. Gupta, Mishra and Sahay (2003) find that crises that are preceded by large capital inflows, that occur at the height of an economic boom, under a relatively free capital mobility regime, and in countries that trade less with the rest of the world, are more likely to be contractionary in the short-run. These results confirm and extend results found by Milesi-Ferretti and Razin (2000). Our empirical study below uses a similar set of regressors but concentrates on the effects of liability dollarization and its interaction with exchange rate overshooting. While a measure of liability dollarization was not significant in the Gupta, Mishra and Sahay (2003), we find that such a variable is highly significant and dominates alternative regressors in the output regression.

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

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

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

2. Empirical Analysis

In this section we present our main empirical findings. As the object of our investigation is the behavior of the real exchange rate after a crisis, our first task is to identify currency crises episodes in the data. We restrict our analysis to the last decade and to countries with reasonably liberalized capital accounts.[7] We examine all countries in the JPMorgan real effective exchange rate universe and obtain monthly nominal exchange rate series in local currency versus the US dollar or the DM (for Euro area countries). We define dep_{it} as the 3-month nominal depreciation in month t for country i and we identify period t as the start of a crisis if the following two conditions are met

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

These criteria leave us with 24 crisis episodes, and the countries and crisis dates are reported in Table 1.[8]

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:

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

[8] 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.[9]

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[10] 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.

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

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

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.

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 α_2 and β_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.

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

[10] 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.

Small Sample Inference. Since our regressions are based on only 24 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 α_2 and β_2 excluding each episode singularly, all possible couples of episodes, all possible triples and finally all possible quadruples. We found 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.[11] We then conclude that our main empirical findings are not biased by the small size of our sample.

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.[12] 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, and the point estimates are similar in magnitude to the OLS estimates. Quantitatively, an increase in a country's net debt/GDP ratio by 10 percentage points increases overshooting by about 11.8%.

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 40%. 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 1.6%, through its direct effect on output and its indirect effect through overshooting.

[11] These results are available upon request.

[12] 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.

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

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.[13] 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;[14] 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[15] 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.

[13] 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).

[14] See Rodrik and Velasco (2000) and Sachs and Radelet (1999). Kim and Kim (2001) presents an empirical analysis of the role of financial panic and relative interest rates in affecting exchange rate overshooting in currency crises

[15] See Goldman Sachs (2000).

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.[16]

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.[17]

Yet another possible explanation of overshooting and output contraction focuses on expansions in bank credit and credit boom phenomena.[18] 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.[19] 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

[16] See Calvo and Reinhart (1999) for some evidence on this hypothesis. See also Arellano and Mendoza (2002) for an analytical overview of the sudden stop phenomenon.

[17] See, for example Gupta, Mishra and Sahay (2003).

[18] See Gourinchas, Valdes and Landerrechte (2001) for a study of credit booms and their consequences.

[19] See Mishkin (1999).

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.

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.[20] 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 specifications, and they do not affect the coefficients on the original explanatory variables.

[20]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.

Gupta, Mishra and Sahay (2003) 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 capital buildup variable is never significant and it does not substantially affect the other coefficients. A better measure of the sudden stop or reversal of capital flows, however, 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 4 and 5 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 (2003) 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 the second equation and in both equations, as shown in Tables 6 and 7. The inclusion of this variable slightly attenuates the coefficients on the other variables, but debt and balance sheet effects remain significant.

Tests for the effects of banking crises on output uncovered a significant endogeneity problem. There are 13 cases of twin crises in the sample, where a currency crisis is concurrent with a banking crisis. In many of these episodes it is clear from the history of events that the banking crisis was triggered in part by the balance sheet effects of currency mismatches in the banking system and/or 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, a simple probit model of banking crisis is estimated where a banking crisis dummy variable is regressed on the measure of balance sheet effects. As reported in Table 8, 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 banking crisis itself 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, the small sample size of only 24 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, outlying observations are identified by a procedure in which the model is re-estimated 24 times, once without each observation. At each iteration, standardized residuals are computed for each of the 23 remaining observations and in both equations. A "predicted" residual for the omitted observation is then computed. In this way, unusual observations can be identified even if their outlier status had been masked in the benchmark model by the fact that the observation had substantially altered the coefficient estimates. Standardized residuals from equations 1 or 2 that are greater than 1.65 in absolute value in any of the 24 re-estimations are then selected as outliers. It turns out that 3 crisis episodes have outlying residuals under these criteria: Bulgaria 1996, Indonesia 1997, and Turkey 2001. The benchmark system is now re-estimated 7 times, excluding all possible combinations of these 3 potential outlier countries. It turns out that the 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 .01 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 9. 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 10 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 11.

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 foreign exchange 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 12, both α_2 and β_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 13. Once again, α_2 and β_2 have the expected signs and remain significant at the .001 level, though α_2 drops a bit from 1.2 to 0.9. Finally, we experiment with measuring overshooting as the sum of deviations of the REER from the equilibrium level over the 24 months following the crisis. This measure of depreciation accounts 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 this measure of depreciation is substantially different from that of the benchmark model, the coefficient on the redefined variable in Table 14 changes substantially, but the sign is 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, as shown in Table 15.

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 model of exchange rate overshooting

In this section we present a model economy that helps to understand better the mechanism that links the overshooting of the exchange rate to the level of foreign debt. The model is a version of an open economy framework with nominal rigidities and monopolistic competition (as in Céspedes, Chang and Velasco, 2004, and Gertler, Gilchrist and Natalucci, 2003), with the addition of a particular type of financial imperfection, namely margin constraints as in Aiyagari and Gertler (1999) and Mendoza and Smith (2002). We also find the model useful to analyze the choice of exchange rate regime in an environment with margin constraints.

We consider a small open economy populated by a representative household, a continuum of monopolistically competitive firms indexed by $i \in [0,1]$, and a monetary authority. Each domestic firm produces a single differentiated brand of a home good, hence also indexed by $i \in [0,1]$. Firms choose the price for their own product one period in advance, and, at that preset price, meet any unanticipated change in demand. Home goods can be either consumer domestically or exported. We assume no impediments to trade in goods so that the law of one price holds. Domestic firms are owned by the representative household and by a risk neutral foreign investor, and their stocks, defined as claims to the corresponding dividend payments, are traded internationally. In addition to domestic stocks, the household holds domestic currency issued by the monetary authority and an international discount bond denominated in foreign currency.

Time is discrete and each period is indexed by t. The household derives utility from consumption and from holding real money balances while it receives disutility from supplying labor to domestic firms. Its preferences are given by

$$(3) \qquad E_t \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t, L_t\right) + v\left(\frac{M_t}{P_t}\right) \right],$$

where β is the discount factor, u and v are well behaved utility functions, C_t is a CES aggregator of domestic consumption of home and foreign goods, denoted respectively by $C_{H,t}$ and $C_{F,t}$, L_t is labor used in the production of the home goods, M_t is the household's nominal holdings of domestic currency accumulated at the end of period t and carried over into period $t+1$ and P_t is the price of one unit of the consumption basket C_t in terms of the domestic currency. The function u is increasing and concave in C_t and decreasing and concave in L_t. The function v is increasing and concave in its argument and it represents utility gains arising from liquidity services provided by real money holdings. The consumption basket C_t is defined as

$$(4) \qquad C_t = \left[\omega C_{H,t}^{\frac{\rho-1}{\rho}} + (1-\omega) C_{F,t}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}},$$

where ω is a parameter that represents the share of the home goods in the consumption basket and ρ is the elasticity of substitution between home and foreign goods. $C_{H,t}$ is a CES index of consumption across home goods $C_{H,t}(i)$ and it is given by

$$(5) \qquad C_{H,t} = \left[\int_0^1 C_{H,t}(i)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}},$$

where θ is the elasticity of substitution across home goods. The consumption-based price index (CPI) expressed in units of the domestic currency is

$$(6) \qquad P_t = \left[\omega^\rho P_{H,t}^{1-\rho} + (1-\omega)^\rho P_{F,t}^{1-\rho}\right]^{\frac{1}{1-\rho}};$$

$P_{H,t}$ is the home currency price of one unit of the the consumption bundle $C_{H,t}$ and it is given by

$$(7) \qquad P_{H,t} = \left[\int_0^1 P_{H,t}(i)^{1-\theta} di\right]^{\frac{1}{1-\theta}},$$

where $P_{H,t}(i)$ is the domestic currency price of the home good i and $P_{F,t}$ is the domestic currency price of the foreign good. We normalize the foreign-currency price of the foreign good to 1 so that $P_{F,t}$ is equal to the price of foreign currency in terms of the domestic currency, i.e., the nominal exchange rate, E_t. We denote by $Z_t = E_t/P_{H,t}$ the terms of trade, the relative price of foreign goods in terms of the home goods. We also define the real exchange rate RX_t as the ratio of the foreign price level relative to the domestic price level both expressed in terms of the home currency. Following Krugman (1999) and Céspedes, Chang and Velasco (2004), we assume that the foreign expenditure share in domestic goods is negligible. Hence the real exchange rate is equal to E_t/P_t, and, also proportional to Z_t:

$$(8) \qquad RX_t = \left[\omega^\rho Z_t^{\rho-1} + (1-\omega)^\rho\right]^{\frac{1}{\rho-1}}.$$

An increase in the terms of trade Z_t (i.e. a terms of trade deterioration as an increase in Z_t represent an increase in the relative price of imported foreign goods) leads to an increase in the real exchange rate, i.e. a real depreciation. As the the relative price of foreign good in terms of the home good increases, other things being equal, the foreign consumption basket becomes more expensive relative to the domestic consumption basket, so that the foreign price level increases relative to the domestic price level and the real exchange rate depreciates.

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

$$(9)\qquad \frac{W_t}{P_t}L_t+\frac{Q_t+D_t}{P_t}S_t+\frac{E_t}{P_t}B_t+\frac{M_{t-1}}{P_t}+\frac{T_t}{P_t}-\frac{P_{H,t}}{P_t}C_{H,t}-\frac{E_t}{P_t}C_{F,t}-\frac{E_t}{P_t}\frac{B_{t+1}}{R_t^n}-\frac{Q_t}{P_t}S_{t+1}-\frac{M_t}{P_t}\geq 0,$$

$$(10)\qquad E_t\frac{B_{t+1}}{R_t^n}+\kappa Q_t S_{t+1}\geq 0,\quad 0\leq \kappa_t\leq 1,$$

and to initial conditions for S_0 and B_0. The first equation is a standard budget constraint (denominated in units of the consumption basket C_t) where W_t and D_t denote, respectively, the nominal wage and the dividends paid by the domestic firms, denominated in home currency, S_t are the stocks of firms owned by the domestic household at the end of period $t-1$ and carried over into period t, Q_t is the domestic currency price of this stock, B_t denotes the foreign-currency international bond position accumulated by the household at the end of period $t-1$ and carried over into period t, with (exogenous) gross nominal interest rate equal to R_t^n, and T_t is a lump-sum domestic currency transfer from the monetary authority. The second equation, expressed in units of the domestic currency, 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 $\left(-E_t\frac{B_{t+1}}{R_t^n}\right)$ to assets (Q_tS_{t+1}) ratio of the financial sector has to be below a certain threshold κ.

Output $Y_t(i)$ of the generic brand i is produced by firm i using labor $L_t(i)$ with a decreasing returns to scale technology

$$(11)\qquad Y_t(i)=L_t(i)^{\alpha},\quad 0<\alpha<1.$$

Dividend payments to shareholders are given by

$$(12)\qquad D_t(i)=P_{H,t}(i)\,Y_t(i)-W_tL_t(i),$$

In period $t-1$ firm i chooses the price at which its own product will be sold in period t, $P_{H,t}(i)$, so as to maximize (12) subject to (11) and to a negatively sloped demand curve given by

$$(13)\qquad C_{H,t}(i)=\left[\frac{P_{H,t}(i)}{P_{H,t}}\right]C_{H,t}$$

taking $C_{H,t}$ and $P_{H,t}$ as given. The price chosen by the monopolistically competitive firm $P_{H,t}(i)$ is then a mark-up μ over nominal marginal cost, and it is given by

$$(14)\qquad P_{H,t}(i)=\mu MC_t^n(i),\quad \mu=\theta/(\theta-1),$$

where nominal marginal cost $MC_t^n(i)$ is given by

$$(15) \quad MC_t^n(i) = \frac{1}{\alpha} W_t L_t(i)^{1-\alpha}.$$

In the short-run therefore prices for the home goods are fixed at their preset level. With an unanticipated change in demand, the first order condition for the firm (14) does not hold and output becomes determined by demand conditions, provided that nominal marginal cost does not exceed the predetermined price. After one period, in the absence of other shocks, prices adjust fully according to (14) and output settles to its flexible-price level. In the symmetric equilibrium all firms make identical decisions, so that $P_{H,t}(i) = P_{H,t}$, $Y_t(i) = Y_t$, $L_t(i) = L_t$, $C_{H,t}(i) = C_{H,t}$, $D_t(i) = D_t$ and $MC_t(i) = MC(t)$ for all $i \in [0,1]$.

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^*

$$(16) \quad S_{t+1}^* - S_t^* = \frac{1}{a}\left[\frac{Q_t^f}{Q_t} - 1\right],$$

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

$$Q_t^f = \sum_{i=1}^{\infty} \beta^i D_{t+i},$$

and a is a parameter reflecting the portfolio adjustment cost of the international trader. Equation (16) plus the equilibrium in the markets for stocks ($S_t + S_t^* = 1$) implies the following law of motion for domestic stocks

$$(17) \quad S_t - S_{t+1} = \frac{1}{a}\left[\frac{Q_t^f}{Q_t} - 1\right].$$

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

$$(18) \quad C_{H,t} + Z_t X_t = Y_t.$$

Lastly, seignorage revenues from domestic currency creation are rebated to the household, so that the budget constraint of the monetary authority denominated in units of the domestic currency, is given by

$$(19) \quad M_t - M_{t-1} = T_t.$$

Finally, we consider both a regime of fixed and flexible exchange rates. Under flexible exchange rate, the nominal money supply is given and the model determines the price of foreign currency in terms of domestic currency, i.e. the exchange rate. Under a regime of fixed exchange rates, the nominal exchange rate is given exogenously and the money supply is endogenously determined so as to maintain the exchange rate fixed.

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 functions we assume the following functional form

$$\begin{aligned} u(C_t, L_t) &= \frac{\left(C_t - \frac{L_t^{\nu}}{\nu}\right)^{1-\sigma}}{1-\sigma}, \\ v\left(\frac{M_t}{P_t}\right) &= \frac{\omega_m}{1-\varepsilon}\left(\frac{M_t}{P_t}\right)^{1-\varepsilon}. \end{aligned}$$

These preferences have the desirable property that they do not imply wealth effects on labor supply.[21] Many authors have documented that, especially in small open economy models, this property is necessary for the model to reproduce the business cycle facts.[22] The parameter ν is set equal to 3.5 to generate a realistic wage elasticity of labor supply. We set the elasticity of substitution between domestic and foreign good to the value of 1.2, which lies in the middle of the range of

[21] 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.

[22] See for example Mendoza (1991), Correia, Neves and Rebelo (1995), and Perri and Neumeyer (2004).

empirical estimates for Europe and US (see Backus, Kehoe and Kydland, 1994). We set θ, the elasticity of substitution across home goods, to 6 so as to generate a mark-up, μ, equal to 1.2 as in Gertler, Gilchrist and Natalucci (2003). The remaining parameters and initial conditions value are summarized in Table 16 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 less empirical guidance so we set them to economically reasonable values and we then experiment with various possible values for them. Since our quantitative results *do* depend on the particular parameter values, the findings we present do not provide a complete evaluation of the quantitative properties of the model. Some discussion of the implications of alternative parameters and functional forms is provided below.

Table 16. Baseline parameter values

Name	Symbol	Value
Yearly discount factor	β	0.9
International rate	R	$1/\beta$
Labor exponent	ν	3.5
Labor share	α	0.6
Risk Aversion	σ	3
Elasticity of substitution between C_H and C_F	ρ	1.2
Elasticity of substitution across $C_H(i)$	θ	6
Share of foreign good	ω	0.5
Utility weight on $v(\cdot)$	ω_m	0.01
Real balances exponent	ϵ	9
Adjustment costs of foreign trader	a	1.0
Margin limit	κ	0.14
Domestic stock owned by residents	s_0	90%

We consider the following experiment. We follow an economy with an initial debt to output ratio equal to 65%. Up to period $t = 0$ we assume this economy is at its symmetric flexible-price steady state where agents expect no shock and no margin constraint is imposed: we think of these as normal times. In period $t = 1$ 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 economy. 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 addition to the friction imposed by the margin constraint, the economy is characterized by nominal rigidities. At the time of the shock, home good prices are predetermined and firms commit to supply any quantity demanded at the given fixed prices. One period after the shock, in period $t = 2$, prices are free to adjust fully according to (14) and the margin constraint is lifted. The economy therefore sets to its new long-run flexible-price frictionless equilibrium.

In figure 4 we analyze the reaction to these shocks for the main macro variables in a version of the model economy without the margin constraint. In Figure 4 we compare therefore the flexible-price economy (solid line) with the sticky price-economy (dashed line) when the margin constraint is not binding. We find it useful to discuss these results first as they give a measure of the fundamental adjustments required in a world without the financial friction and allow to consider the pure effects of price stickiness in a model of monopolistic competition. For the time being, we are considering an economy under a flexible exchange rate regime.

In period $t = 1$, at the time of the shock, as exports fall the demand for the domestic good will fall; under flexible prices, the shocks requires a real depreciation. Domestic consumption of the home good increases relative to foreign to absorb the excess of supply. This increase in consumption can be achieved only with a fall in the relative price of the domestic good, Z_t; with predetermined prices, on the other hand, the price of home goods does not adjust as required and it remains excessively high. Output adapts to the new demand conditions and falls below its flexible-price level. As supply of home goods falls together with demand, the terms of trade also does not adjust fully in the short run, but it remains below its flexible-price level. The terms of trade is below its new equilibrium value, and so is domestic consumption of the home good. As the domestic good production drops, so do both the labor income of domestic households and the price of domestic stocks. As domestic residents are now poorer, they must also reduce consumption. Notice that the debt to assets ratio $-\frac{E_t B_{t+1}}{R_t^n Q_t S_{t+1}}$ of domestic consumers rises for two reasons: because the terms of trade Z_t increases and because the price of domestic equity falls. Finally observe that the stock position of the domestic household changes: as in period $t = 1$ output is be lower than its long-run flexible-price level, the stock price will be below its fundamental level. International investors therefore will increase their position in domestic stocks.

Consider next the effects of the export shock when the margin constraint is imposed in an economy with nominal rigidities and flexible exchange rates, as shown in Figure 5; in the figure the case with no binding constraint is represented by the solid line while the case with binding constraint is represented by the dashed line. Observe that now the debt to asset ratio has to be reduced to satisfy the margin constraint below the level that would prevail in the long-run and in the absence of the type of financial friction that we consider. This reduction in debt can be achieved through sales of domestic stocks and a substantial fall in domestic consumption of the foreign good relative to consumption of the home good. The home good therefore needs to depreciates substantially relative to the long-run depreciation that would obtain in the no-constraint case. The fall in the price of the home good therefore must exceed the drop that would obtain in the absence of the margin constraint, and the exchange rate must depreciate above the level that would obtain in the frictionless long-run equilibrium. This is exchange rate overshooting. Similarly the market clearing condition for stock (equation 17) implies that the sales of domestic stock force stock prices below their fundamental level: this is asset price overreaction. The output drops less than it does in the case without the constraint. The exchange rate is overshooting, and with foreigners' expenditure on domestic goods fixed in terms of the domestic currency, a depreciation leads to an increase in foreigners' real demand for domestic output. Given that output does not fall as much as in the no constraint case, correspondingly, total consumption does not fall as much as well. However, in the long-run given that there was a fire sale of domestic stocks, consumption settles at a level which is lower than the one obtained in the frictionless case. In this economy therefore the short-run reduction in output and consumption are smaller while in the long run the consumption fall is larger than the frictionless case as the fire sale effect of the binding constraint hits the economy.

To conclude, this model generates exchange rate overshooting and asset price overreaction in response a tightening of credit conditions during financial crises episodes. The model is not entirely consistent with the evidence about output, as a frictionless economy display a drop in output larger than the one obtained in an economy where the margin constraint binds, while the data suggest that economies hit by a financial crisis and a credit crunch should suffer larger drops. However, one of the aspects of the data is confirmed by the model; when the constraint is binding, a large initial value of the foreign currency debt leads to a larger output contraction.[23] One way to reconcile better the model and the data for what concerns the output effects of financing constraints would be to think

[23]This comparative statics exercise is not shown in the figures in the paper but is available upon request.

about alternative 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.[24]

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 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 through a contraction in the money supply can have a negative demand effect and thus exacerbates the initial output drop. We can use a simple variant of our model to analyze these issues more formally.

We now consider the same economy subject to the same shock but in which the exchange rate does not immediately adjust after the shock. In particular, in period $t = 1$ when agents learn about the shock the exchange rate is kept fixed at the period $t = 0$ level through a reduction in the money supply, while in period $t = 2$ we let it adjust freely. With nominal rigidities and monopolistic competition therefore, this small open economy can temporarily affect its terms of trade through exchange rate policy carried out with a reduction in money supply. This monetary contraction causes a fall in consumption, and, given predetermined prices and demand-determined output, a larger drop in consumption with respect to the flexible exchange rate case.

In Figure 5 we consider the response to the same export shock for a fixed (dashed line) and for a flexible exchange rate (solid line) economy with preset prices and binding margin constraint at the time of the shock. 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 similar consumption level in the long run under the fixed exchange rate regime (see the consumption panel) despite the larger short-run drop in output. Also, at the same time though, under fixed exchange rates, the foreign demand of domestic good is

[24] Also, the result matching the empirical evidence that output contraction is larger when the constraint is binding can be found with other parameters values for the model'simulation. For, example the result is obtained in the version of the model where prices are flexible and, instead of monopolistic competition, the economy is characterized by perfect competition. Thus, the relative short-run output contraction with or without margin constraints depends on parameter values.

reduced more upon the impact of the shock, and so output and domestic consumption drop more on impact.

We use this model economy to analyze the choice of exchange rate regime in an environment with margin constraints. We perform welfare calculations and compare the utility obtained by the household under the two alternative exchange rate regimes. Since in period $t = 1$, at the time of the unanticipated drop in export demand, prices are fixed and the margin constraint binds, for just one period, we compute welfare by distinguishing between the short-run $(t = 1)$ and the long-run $(t \geq 2)$. The welfare is computed as the sum of utility in the short-run and discounted present value of utility attained in the new flexible-price frictionless steady state.

In the case with the parameter values equal to those for Figure 6, the welfare comparison shows a very small dominance of fixed exchange rates. Since the long run value of consumption in the fixed and flexible exchange rates are almost the same, this result depends on the short-run effects in period $t = 1$, where consumption is lower under fixed rates but leisure is higher. 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 in our sensitivity analysis, our model implies that fixed exchange rates are preferable. This in contrast with the finding of Céspedes, Chang and Velasco (2004) that found that, even in an economy with significant liability dollarization, flexible exchange rates dominate fixed rates in spite of the balance sheet effects of a depreciation.[25] The reason for the different finding lies in the presence of the margin constraint in our model compared to the investment financing constraints of their model. In our model, as in theirs, the fixed exchange rate does not eliminate the change in relative prices but only delays it, and thus the fixed exchange rate distorts goods' markets; this effect should make flexible exchange rates preferable to fixed ones as the exchange rate flexibility partly undoes the effects of short run price stickiness. The difference is that in our model, the delay in the change in relative prices under fixed rates is important as it reduces the distortionary impact of the margin constraint on the agent utility profile, i.e. it dampens the negative balance sheet effect of a sharp real depreciation by avoiding the fire sale that occurs under flexible exchange rates. 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 thus avoid and/or dampen balance sheet effects of a real depreciation,

[25]See also Devereux (2004) for another recent study comparing the welfare features of fixed and flexible exchange rates in a model with short run wage rigidities.

and then let it float once prices become flexible.

In order to assess the relevance of the margin constraint for our finding on the welfare characteristics of different exchange rate regimes, we also compare fixed and flexible exchange rate in a case in which the required debt to asset ratio is lower and the margin constraint is more binding ($\kappa = 0.10$). In Figure 7 we plot the response of the economy to an export shock both under fixed (dashed line) and flexible exchange rate (solid line) for the lower value of the margin constraint. In this case the overshooting of the exchange rate and the drop in asset prices are larger than the ones obtained with a higher value of the margin limit under flexible exchange rate. Because of this stronger reaction of the exchange rate, the terms of trade overshoots as well its long-run flexible-price frictionless level. In the long-run consumption is higher under fixed than under flexible exchange rates, as fixed exchange rates allow the economy to shield from the fire-sale consequences of the imposition of the margin constraint. This allows the ranking between fixed and flexible exchange rates to be even more favorable to fixed exchange rates, pointing out to the fact that when financial frictions are more important the choice of the exchange rate regime tilts more in support of fixed exchange rate. Note, however, that in this last example the short-run response of output in the flexible exchange rates case is somewhat unusual as output goes up when the export shock occurs. The result depends on the fact that in this parameter case the real depreciation is so large that export demand is significantly increased more than the fall in consumption of domestic goods. Since output is demand determined in the short run, this large increase in total exports leads to an output increase. Still, the welfare comparison favors fixed rates as the sharp negative fire sale and balance sheet effects of the shock under flexible rates lead to lower wealth and consumption in the long run compared to the case of fixed rates where such short-run fire sale is avoided.

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, a model with monopolistic competition and short-run price stickiness of an open economy, shows that financial distortions deriving from a lack of hedging and margin constraints lead to overshooting of both 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 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 - based on a welfare criterion - by a policy of keeping the exchange rates fixed, at least for a short 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. 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. Finally, a more systematic analysis and welfare comparison of alternative exchange rate regimes - including dollarization - based on the structural characteristics of the economy would be useful. We leave these extensions to future work.

5. Tables

1. Benchmark Regression Data

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3. Benchmark IV Regression Results

4. Robustness to Capital Reversal in Equation 2

5. Robustness to Capital Reversal in Equations 1 and 2

6. Robustness to Real Credit Contraction in Equation 2

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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/$, %	%
	Argentina	Jan-02	73.1	11.0	90.6	111.5	-12.8
	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	4.5	24.2	29.8	-22.7
	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		40.1	15.5	34.3	54.5	-5.2

Table 2: OLS Regression

Estimation Method: Ordinary Least Squares
Included observations: 24

	Coefficient	Std. Error	t-Statistic	Prob.
${}_1$	-13.80098	14.96509	-0.922212	0.3614
${}_2$	1.197558	0.333628	3.589497	0.0008
${}_1$	21.85757	7.260255	3.010579	0.0043
${}_2$	-3.744861	0.989373	-3.785086	0.0005

Equation: OVERSHOOT = ${}_1$+ ${}_2$*NET_DEBT

R-squared	0.369347	Mean dependent var	34.27947
Adjusted R-squared	0.340681	S.D. dependent var	40.26296
S.E. of regression	32.69290	Sum squared resid	23514.16

Equation: GDP = ${}_1$+ ${}_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

R-squared	0.394388	Mean dependent var	-5.240300
Adjusted R-squared	0.366860	S.D. dependent var	7.435140
S.E. of regression	5.916148	Sum squared resid	770.0178

Table 3: Benchmark IV Regression

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
${}_1$	-13.21579	14.27017	-0.926113	0.3594
${}_2$	1.182982	0.317815	3.722234	0.0006
${}_1$	17.69377	7.430503	2.381235	0.0216
${}_2$	-3.169434	1.014230	-3.124966	0.0031

Equation: OVERSHOOT = ${}_1$+ ${}_2$*NET_DEBT

R-squared	0.369293	Mean dependent var	34.27947
Adjusted R-squared	0.340624	S.D. dependent var	40.26296
S.E. of regression	32.69432	Sum squared resid	23516.20

Equation: GDP = ${}_1$+ ${}_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

R-squared	0.385076	Mean dependent var	-5.240300
Adjusted R-squared	0.357125	S.D. dependent var	7.435140
S.E. of regression	5.961457	Sum squared resid	781.8575

Table 4: Robustness to Capital Reversal in Equation 2

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-13.19541	14.32055	-0.921432	0.3620
$_2$	1.182475	0.319218	3.704287	0.0006
$_1$	15.82294	5.932310	2.667248	0.0107
$_2$	-2.431372	0.858944	-2.830654	0.0070
$_3$	0.718576	0.190422	3.773597	0.0005

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT

R-squared	0.369289	Mean dependent var	34.27947
Adjusted R-squared	0.340620	S.D. dependent var	40.26296
S.E. of regression	32.69442	Sum squared resid	23516.35

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION) + $_3$*CAPITAL_REVERSAL

R-squared	0.633758	Mean dependent var	-5.240300
Adjusted R-squared	0.598878	S.D. dependent var	7.435140
S.E. of regression	4.708988	Sum squared resid	465.6659

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 5: Robustness to Capital Reversal in Equations 1 and 2

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-19.40012	14.10440	-1.375466	0.1763
$_2$	1.106217	0.306244	3.612212	0.0008
$_3$	-1.919015	1.168737	-1.641955	0.1081
$_1$	15.80075	5.931508	2.663867	0.0109
$_2$	-2.409207	0.858907	-2.804969	0.0076
$_3$	0.747195	0.191281	3.906273	0.0003

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT+ $_3$*CAPITAL_REVERSAL

R-squared	0.432419	Mean dependent var	34.27947
Adjusted R-squared	0.378363	S.D. dependent var	40.26296
S.E. of regression	31.74490	Sum squared resid	21162.52

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION)
\+ $_3$*CAPITAL_REVERSAL

R-squared	0.634170	Mean dependent var	-5.240300
Adjusted R-squared	0.599329	S.D. dependent var	7.435140
S.E. of regression	4.706337	Sum squared resid	465.1417

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 6: Robustness to Real Credit Contraction 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 REAL_CRED2YR
REAL_CRED2YR^2 REAL_CRED2YR^3 C

	Coefficient	Std. Error	t-Statistic	Prob.
$_1$	-12.12820	14.86389	-0.815950	0.4192
$_2$	1.135404	0.343735	3.303139	0.0020
$_1$	10.67409	7.904929	1.350309	0.1843
$_2$	-2.047370	1.124184	-1.821206	0.0759
$_3$	0.091766	0.042405	2.164066	0.0363

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT

R-squared	0.317896	Mean dependent var	31.83232
Adjusted R-squared	0.285415	S.D. dependent var	39.30057
S.E. of regression	33.22199	Sum squared resid	23177.71

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION)
+ $_3$*REAL_CRED2YR

R-squared	0.467880	Mean dependent var	-4.912609
Adjusted R-squared	0.414668	S.D. dependent var	7.422924
S.E. of regression	5.679058	Sum squared resid	645.0340

Argentina 2002 is excluded from this regression because its real credit data 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 7: Robustness to Real Credit Contraction 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 REAL_CRED2YR REAL_CRED2YR^2 REAL_CRED2YR^3 C

	Coefficient	Std. Error	t-Statistic	Prob.
$_{1}$	-4.170771	14.58369	-0.285989	0.7764
$_{2}$	0.820641	0.365714	2.243943	0.0304
$_{3}$	-0.417608	0.231830	-1.801352	0.0792
$_{1}$	9.845696	7.917706	1.243504	0.2209
$_{2}$	-1.915758	1.126478	-1.700662	0.0968
$_{3}$	0.103004	0.042902	2.400902	0.0211

Equation: OVERSHOOT = $_{1}$+ $_{2}$*NET_DEBT+ $_{3}$* REAL_CRED2YR

R-squared	0.403085	Mean dependent var	31.83232
Adjusted R-squared	0.343394	S.D. dependent var	39.30057
S.E. of regression	31.84573	Sum squared resid	20283.01

Equation: GDP = $_{1}$+ $_{2}$*log(NET_DEBT*TOTAL_DEPRECIATION) + $_{3}$*REAL_CRED2YR

R-squared	0.466629	Mean dependent var	-4.912609
Adjusted R-squared	0.413291	S.D. dependent var	7.422924
S.E. of regression	5.685730	Sum squared resid	646.5505

Argentina 2002 is excluded from this regression because its real credit data 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 8: Endogeneity of Banking Crises and Balance Sheet Effects

Dependent Variable: BANKCRISIS
Method: ML - Binary Probit
Included observations: 24

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.951329	0.508763	-1.869888	0.0615
NET_DEBT*TOTAL_ DEPRECIATION	0.000570	0.000279	2.039560	0.0414
Mean dependent var	0.541667	S.D. dependent var		0.508977
S.E. of regression	0.413902	Akaike info criterion		1.119277
Sum squared resid	3.768924	Schwarz criterion		1.217448
Log likelihood	-11.43133	Hannan-Quinn criter.		1.145322
Restr. log likelihood	-16.55210	Avg. log likelihood		-0.476305
LR statistic (1 df)	10.24155	McFadden R-squared		0.309373
Probability(LR stat)	0.001373			
Obs with Dep=0	11	Total obs		24
Obs with Dep=1	13			

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 9: Robustness to Competitiveness Effects

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-14.11633	14.32636	-0.985340	0.3298
$_2$	1.205413	0.319380	3.774231	0.0005
$_1$	-0.461661	2.267697	-0.203581	0.8396
$_2$	-0.087701	0.035009	-2.505110	0.0160

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT

R-squared	0.369331	Mean dependent var	34.27947
Adjusted R-squared	0.340665	S.D. dependent var	40.26296
S.E. of regression	32.69331	Sum squared resid	23514.76

Equation: GDP = $_1$+ $_2$*TOTAL_DEPRECIATION

R-squared	0.318850	Mean dependent var	-5.240300
Adjusted R-squared	0.287888	S.D. dependent var	7.435140
S.E. of regression	6.274271	Sum squared resid	866.0624

Table 10: Robustness to World Growth

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-12.99412	14.20084	-0.915025	0.3653
$_2$	1.177461	0.315883	3.727526	0.0006
$_1$	11.50903	6.965186	1.652365	0.1057
$_2$	-4.038207	0.952818	-4.238174	0.0001
$_3$	4.662980	1.641507	2.840671	0.0069

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT

R-squared	0.369243	Mean dependent var	34.27947
Adjusted R-squared	0.340573	S.D. dependent var	40.26296
S.E. of regression	32.69559	Sum squared resid	23518.04

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION) + $_3$*WORLD_GROWTH

R-squared	0.503930	Mean dependent var	-5.240300
Adjusted R-squared	0.456686	S.D. dependent var	7.435140
S.E. of regression	5.480431	Sum squared resid	630.7376

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

Table 11: Robustness to Redefining Net Debt

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-2.787155	11.34359	-0.245703	0.8071
$_2$	1.212498	0.310191	3.908881	0.0003
$_1$	7.992523	6.066152	1.317561	0.1945
$_2$	-1.947144	0.872827	-2.230847	0.0308

Equation: OVERSHOOT = $_1$+ $_2$*NET_DEBT2

R-squared	0.400807	Mean dependent var	34.27947
Adjusted R-squared	0.373570	S.D. dependent var	40.26296
S.E. of regression	31.86705	Sum squared resid	22341.19

Equation: GDP = $_1$+ $_2$*log(NET_DEBT2*TOTAL_DEPRECIATION)

R-squared	0.266080	Mean dependent var	-5.240300
Adjusted R-squared	0.232720	S.D. dependent var	7.435140
S.E. of regression	6.512776	Sum squared resid	933.1576

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

Table 12: Robustness to Redefining the Equilibrium REER at 36 Months

Estimation Method: Three-Stage Least Squares
Included observations: 22
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.
$_{1}$	-19.09180	11.32593	-1.685672	0.0996
$_{2}$	1.391423	0.262261	5.305489	0.0000
$_{1}$	18.41207	6.130671	3.003272	0.0046
$_{2}$	-3.146507	0.846047	-3.719070	0.0006

Equation: OVERSHOOT2 = $_{1}$+ $_{2}$*NET_DEBT

R-squared	0.546685	Mean dependent var	34.29372
Adjusted R-squared	0.524020	S.D. dependent var	37.07419
S.E. of regression	25.57798	Sum squared resid	13084.66

Equation: GDP = $_{1}$+ $_{2}$*log(NET_DEBT*TOTAL_DEPRECIATION)

R-squared	0.482302	Mean dependent var	-4.103550
Adjusted R-squared	0.456417	S.D. dependent var	6.476992
S.E. of regression	4.775364	Sum squared resid	456.0820

In this specification, the equilibrium real effective exchange rate is defined as the REER prevailing 36 months after a crisis. Turkey 2001 and Argentina 2002 are excluded because their data are not yet available.

Table 13: Robustness to Redefining the Equilibrium REER as 5-Year Average

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-0.449243	11.67056	-0.038494	0.9695
$_2$	0.920283	0.260092	3.538305	0.0010
$_1$	21.97697	7.374679	2.980058	0.0047
$_2$	-3.761362	1.006546	-3.736900	0.0005

Equation: OVERSHOOT3 = $_1$+ $_2$*NET_DEBT

R-squared	0.335920	Mean dependent var	36.49897
Adjusted R-squared	0.305734	S.D. dependent var	32.00488
S.E. of regression	26.66730	Sum squared resid	15645.19

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

R-squared	0.394380	Mean dependent var	-5.240300
Adjusted R-squared	0.366852	S.D. dependent var	7.435140
S.E. of regression	5.916186	Sum squared resid	770.0276

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 14: Robustness to Redefining Overshooting

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	-73.76079	118.8247	-0.620753	0.5380
$_2$	6.451476	2.749068	2.346787	0.0236
$_1$	18.10388	7.462835	2.425872	0.0195
$_2$	-3.226159	1.018704	-3.166924	0.0028

Equation: OVERSHOOT4 = 1+ 2*NET_DEBT

R-squared	0.193239	Mean dependent var	175.7856
Adjusted R-squared	0.154822	S.D. dependent var	288.2413
S.E. of regression	264.9905	Sum squared resid	1474619.

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

R-squared	0.386821	Mean dependent var	-5.240300
Adjusted R-squared	0.358950	S.D. dependent var	7.435140
S.E. of regression	5.952991	Sum squared resid	779.6382

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

Table 15: Robustness to Redefining the Equilibrium REER as 5-Year Pre-Crisis Average

Estimation Method: Three-Stage Least Squares
Included observations: 24
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.
$_1$	5.026068	17.79554	0.282434	0.7789
$_2$	1.034398	0.396661	2.607767	0.0124
$_1$	19.98154	7.924556	2.521472	0.0154
$_2$	-3.485598	1.083403	-3.217268	0.0024

Equation: OVERSHOOT5 = $_1$+ $_2$*NET_DEBT

R-squared	0.218165	Mean dependent var	46.55584
Adjusted R-squared	0.182627	S.D. dependent var	44.94459
S.E. of regression	40.63380	Sum squared resid	36324.33

Equation: GDP = $_1$+ $_2$*log(NET_DEBT*TOTAL_DEPRECIATION)

R-squared	0.392497	Mean dependent var	-5.240300
Adjusted R-squared	0.364884	S.D. dependent var	7.435140
S.E. of regression	5.925374	Sum squared resid	772.4213

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

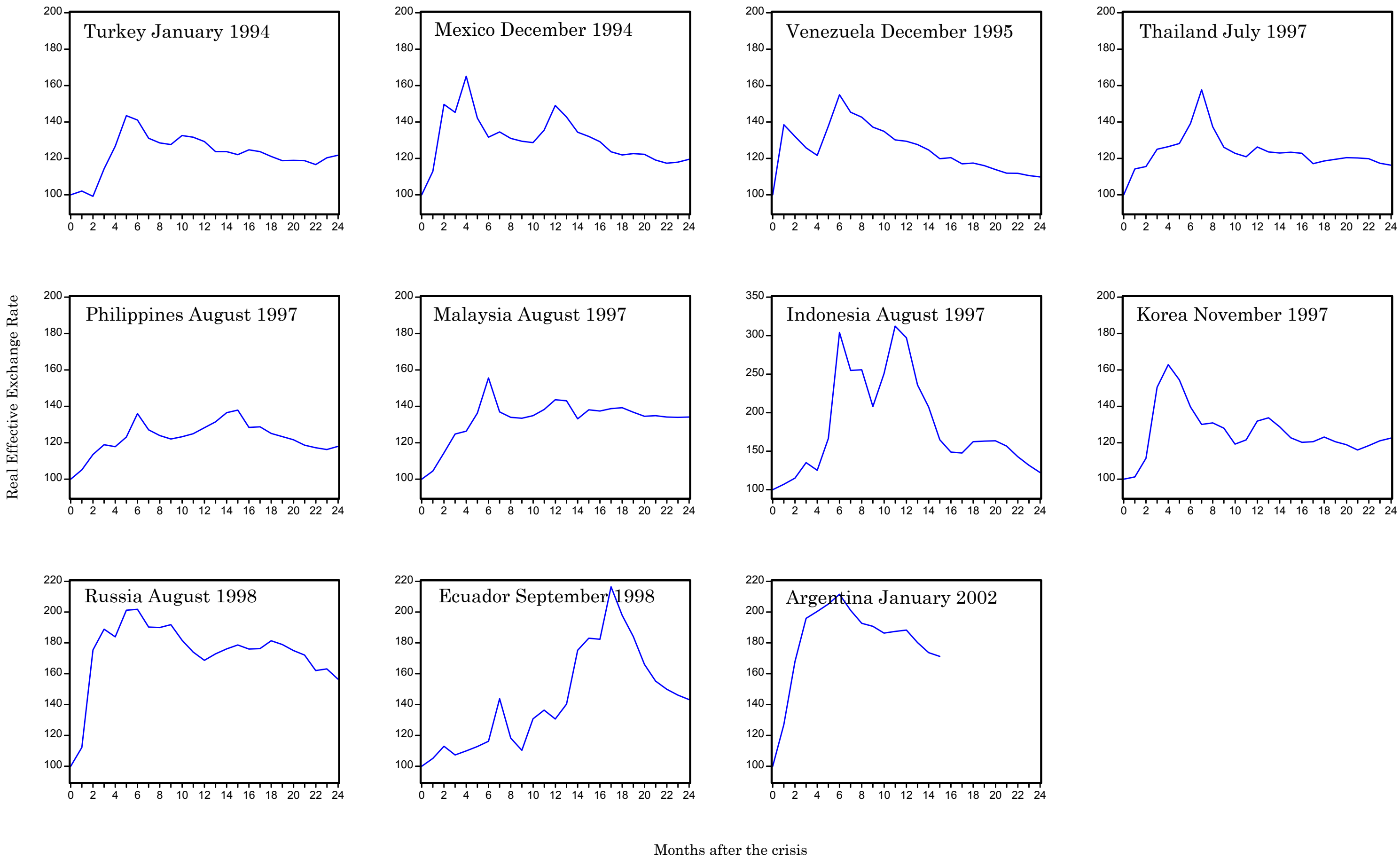

Figure 1b: Real Effective Exchange Rates for "European Style" Crises, t0=100

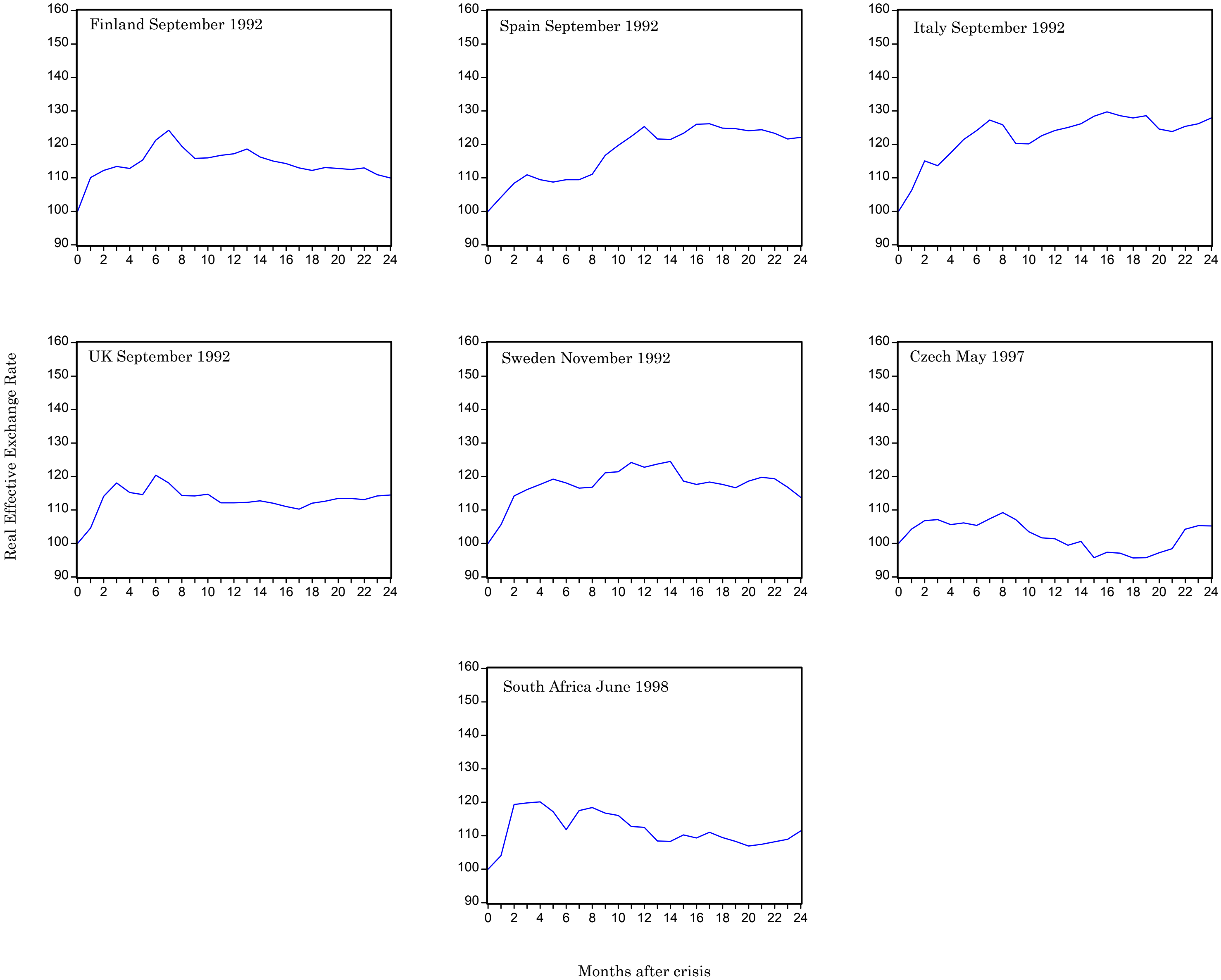

Figure 1c: Real Effective Exchange Rates for "Other Style" Crises, t0=100

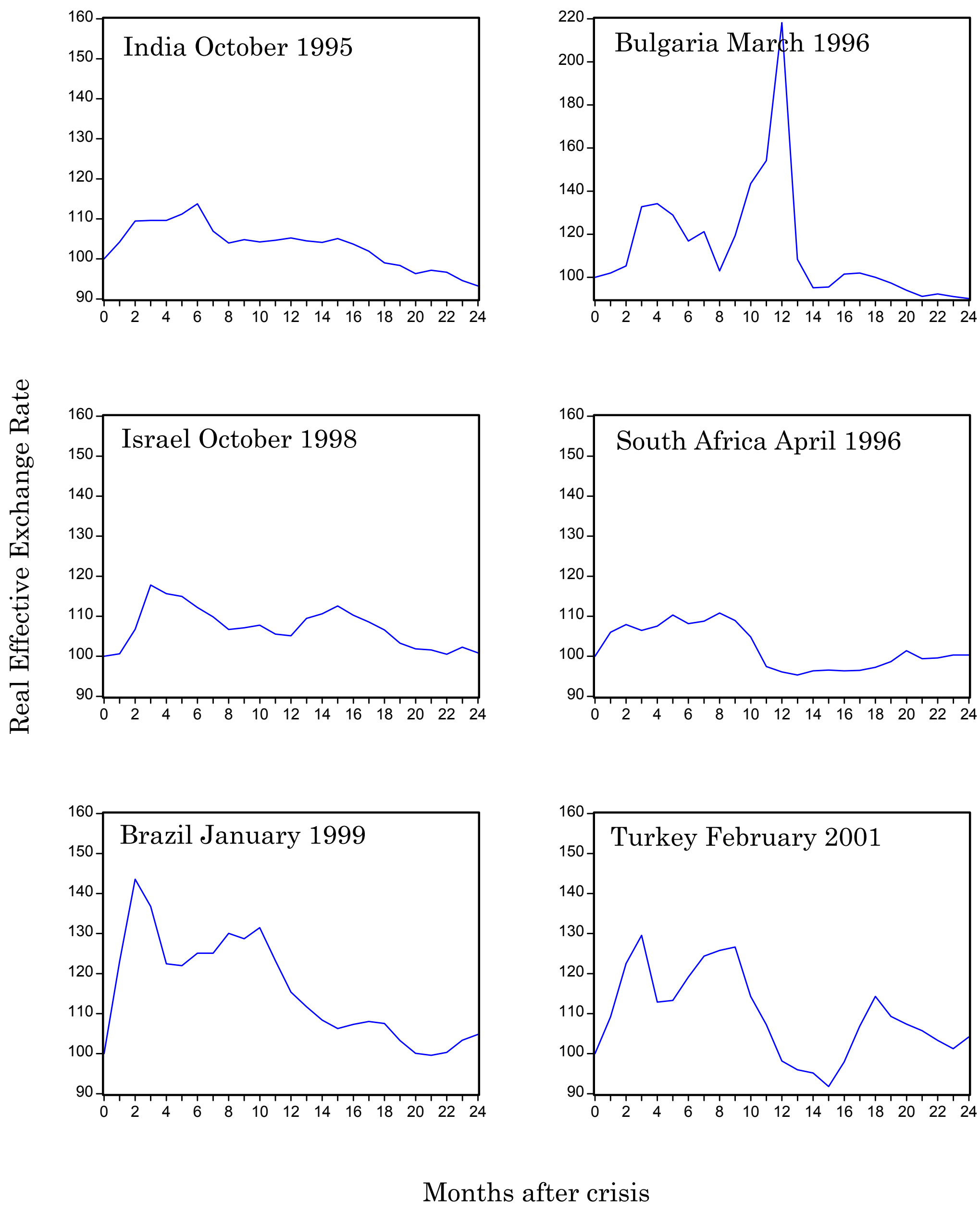

Figure 2: Net Debt and Real Exchange Rate Overshooting

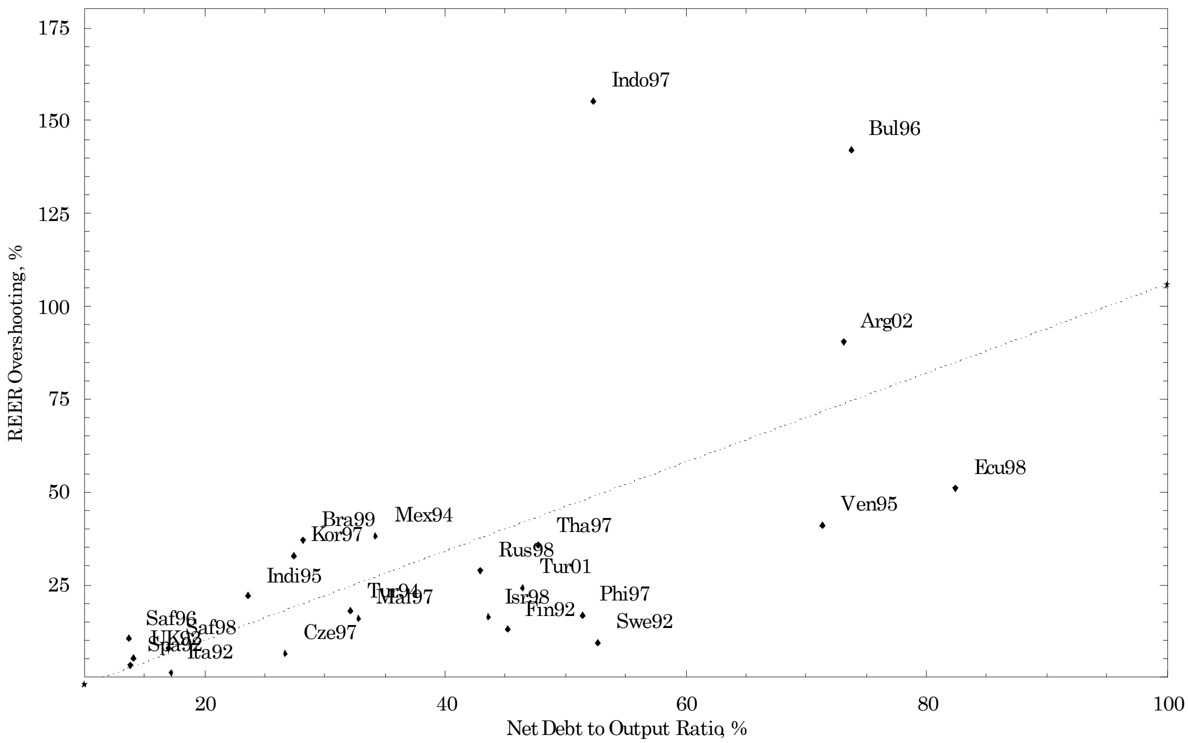

Figure 3: Contractionary Impact of Balance Sheet Effects

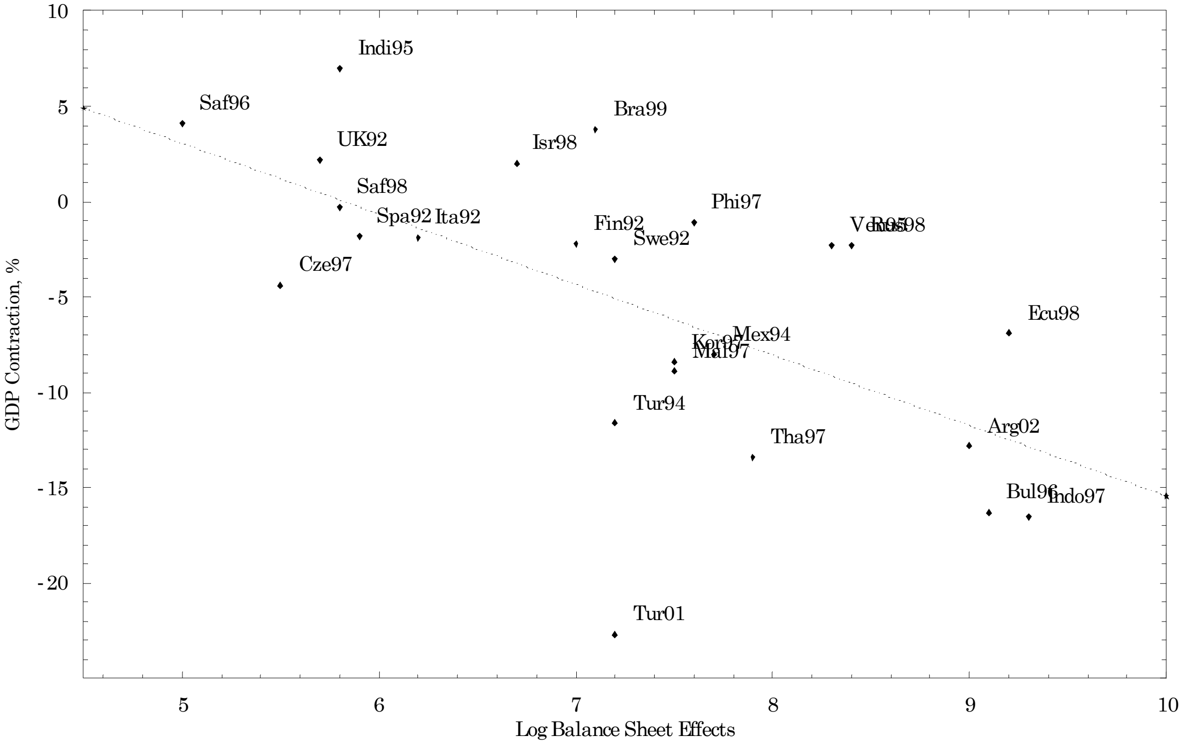

Figure 4: Effects of a reduction in export expenditure: Flexible vs. Sticky Prices, $\kappa = 0.14$

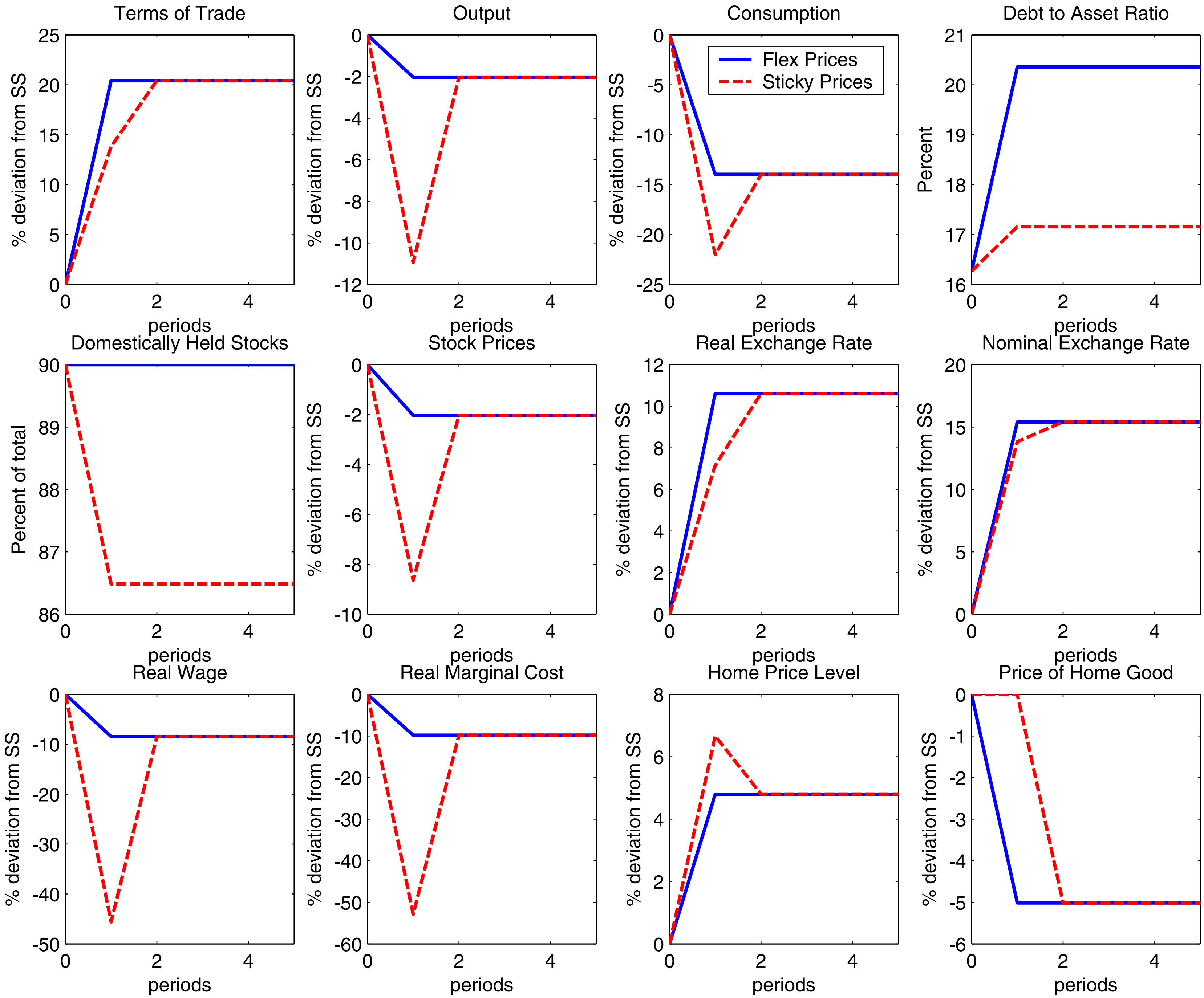

Figure 5: Effects of a 20% permanent reduction in export expenditure, $\kappa = 0.14$

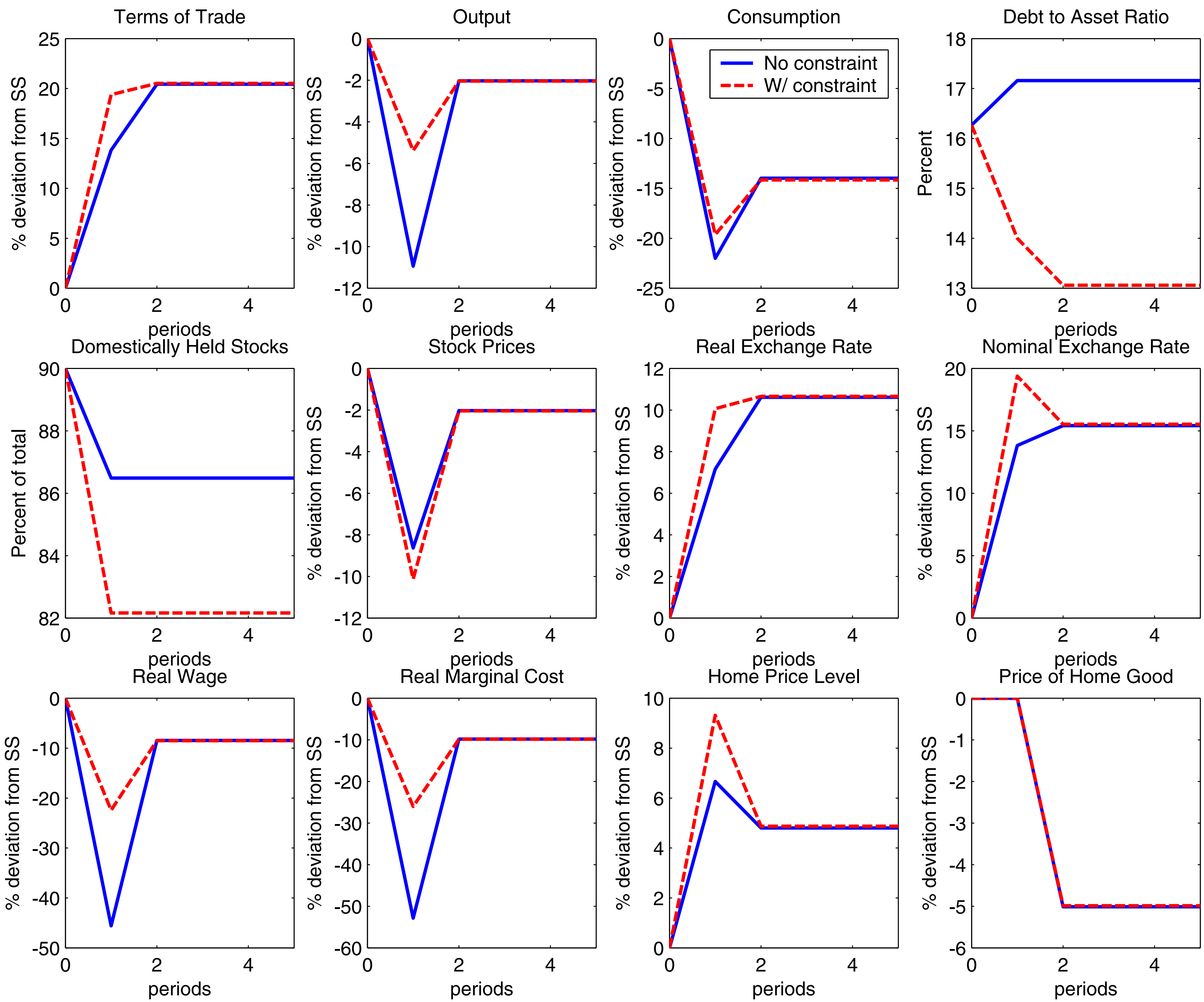

Figure 6: Effects of a reduction in export expenditure: Flex v/s Fixed, $\kappa = 0.14$

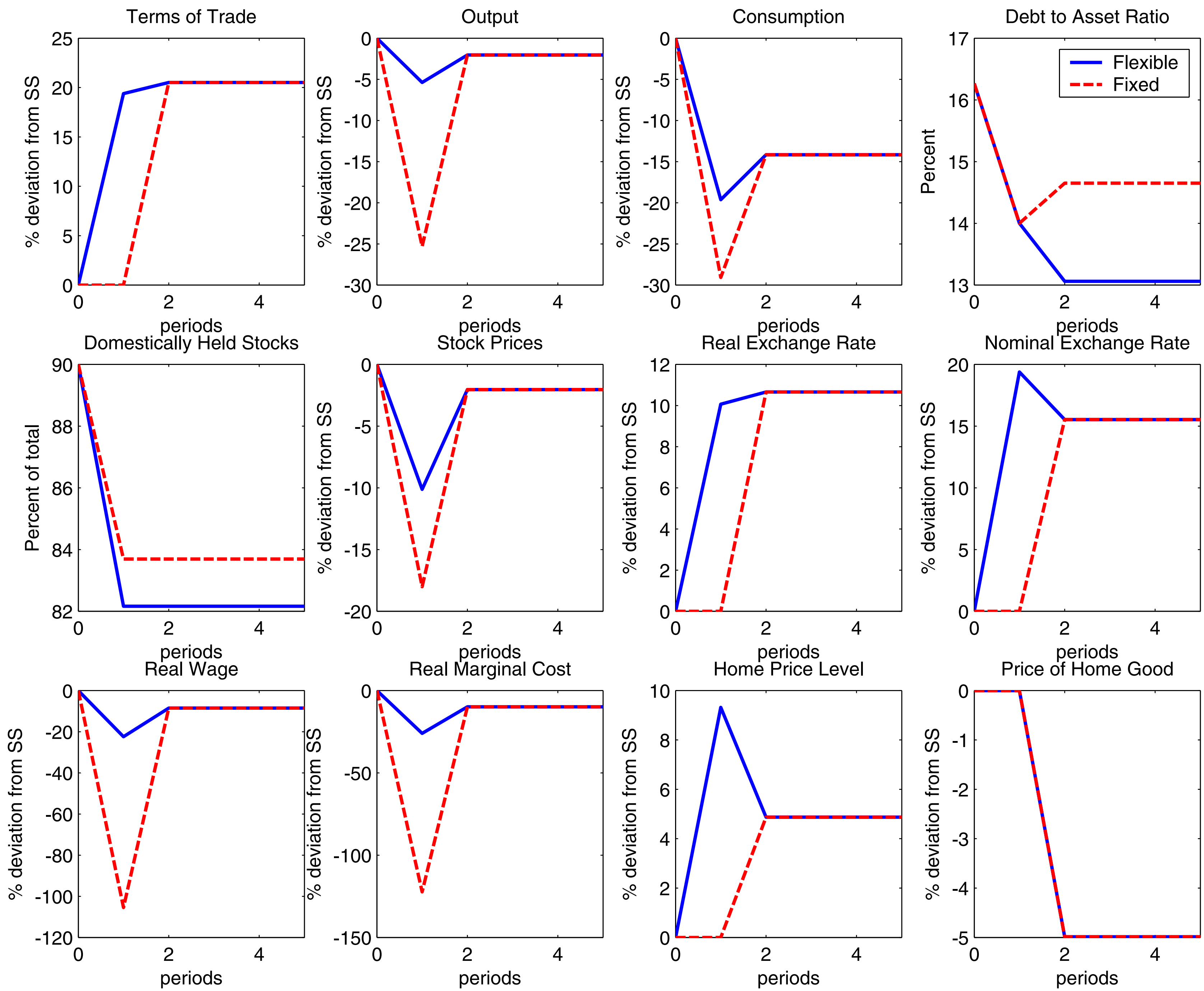

Figure 7: Effects of a reduction in export expenditure: Flex v/s Fixed, $\kappa = 0.10$