The Effects of Real Exchange Rate Shocks in an Economy with Extreme Liability Dollarization*

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March 19, 2009

Abstract
This paper studies the effects of real exchange rate (RXR) shocks in an economy with extreme liability dollarization using vector autoregression (VAR) methods. Bolivia’s extreme liability dollarization makes it an interesting case for empirical testing of the contractionary-depreciations hypothesis. In contrast to the previous contractionary-depreciations literature, the paper uses identification assumptions which are inspired by modern macroeconomic theory and common in the empirical VAR literature on the effects of monetary policy. I find that a RXR depreciation has negligible effects on output, since a contractionary balance-sheet effect on investment is counteracted by the standard expansionary effect on net exports. Furthermore, I find that a RXR depreciation has inflationary effects.

Keywords: Real exchange rate, VAR, liability dollarization, balance sheet effects, contractionary depreciation.

JEL codes: E44, F41, G15.

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*The author gratefully acknowledges helpful comments and suggestions by Fernando Escobar, Martin Floden, Jesper Lindé, Lars Ljungqvist, Pablo Mendieta, Juan Antonio Morales, and seminar participants at the Stockholm School of Economics and Banco Central de Bolivia. All remaining errors are mine. I am also grateful to Banco Central de Bolivia for data and hospitality, and Jan Wallander’s and Tom Hedelius’ Research Foundation for financial support.

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1 Introduction

In standard small-open economy models, such as, for example, the model by Svensson (2000), a real exchange rate (RXR) depreciation has an expansionary effect on aggregate demand and output. Depreciation increases the demand for domestically produced goods by reducing their relative price. Such expenditure-switching effects are familiar from the traditional Mundell-Fleming-Dornbusch models and generally remain valid in more modern New Open Economy Macro (NOEM) models.¹

However, the impact of depreciation on output could be reversed in an economy with substantial liability dollarization. When liabilities are denominated in foreign currency, but revenues in domestic currency, the possibility of contractionary depreciations arises. Currency depreciation increases the domestic-currency value of foreign-currency liabilities and the debt service burden, while firm revenues are denominated in domestic currency. Thus, there is an adverse effect on firms’ balance sheet position. In the presence of financial frictions of the Bernanke-Gertler type, a balance sheet deterioration causes the external finance premium to increase and, consequently, investment to decrease. If this negative effect of depreciation on investment outweighs the positive effect on net exports, then a real depreciation has contractionary effects rather than the standard expansionary effects.

This possibility has long been recognized in the literature, but the Asian crisis in the late 1990’s created a renewed interest in the possible negative balance sheet effects of depreciation.² An indication that the topic is perceived as relevant by both researchers and policymakers is the title of a recent IMF Mundell-Fleming lecture by Jeffrey Frankel (2005): “Contractionary Currency

¹See Dornbusch (1976) for the original model and Lane (2001) for a survey of the modern NOEM literature.
²See Cooper (1971) for an early discussion. Krugman (1999) and Aghion, Bacchetta, and Banjeree (2000) are examples of papers inspired by the Asian crisis.
Crashes in Developing Countries”. Possible adverse balance-sheet effects of depreciation in countries with debts denominated in foreign currency is also a key topic in the current international financial crisis. For example, the case of Latvia, whose IMF program does not require an abandonment of the currency peg, has been much discussed. According to the IMF report, the risk of large adverse balance sheet effects was one of the main arguments for keeping the peg (see International Monetary Fund (2009)).

There is an extensive empirical literature which investigates whether real depreciations are expansionary or contractionary (see Bahmani-Oskooee and Miteza (2003) for a survey). However, no paper has studied the Bolivian economy, which is a particularly interesting case given its extreme liability dollarization. Around 96 percent of the outstanding bank loans to households and firms were denominated in dollars during the period 1990-2003. In contrast, only around one quarter of the debt was denominated in foreign currency in the 1997-98 Korean crisis. Bolivia’s financial dollarization is also extreme in comparison with other countries. However, most goods and services are priced in the local currency, the boliviano, so real dollarization is limited (see Morales (2003)). This is a key difference compared to fully dollarized countries such as Ecuador.

The purpose of this paper is to empirically test the contractionary depreciations hypothesis using Bolivian data and vector autoregression (VAR) methods. As succinctly stated by Bagliano and Favero (1998), VAR models are estimated to “provide empirical evidence on the response of macroeconomic variables to monetary policy impulses in order to discriminate between alternative theoretical models of the economy.” Accordingly, I estimate VAR models and investigate the impulse response functions to RXR depreciation shocks to test the contractionary-depreciations hypothesis, which states that a real depreciation

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3See Escobar (2003) and Gertler, Gilchrist, and Natalucci (2007), respectively.
shock causes an increase in net exports, but an even larger decrease in investment, and, hence, a fall in output. The main finding is that the two opposite effects on output approximately cancel out, which constitutes evidence against the contractionary-depreciations hypothesis. I also find that a RXR depreciation has significant inflationary effects, regardless of the definition of inflation.

This paper makes the following three contributions to the literature on contractionary depreciations. First, I suggest a method for identification of RXR shocks which is more closely related to modern macroeconomic theory and the previous empirical VAR literature than an alternative method by Kamin and Rogers (2000) which is often used in the contractionary-depreciations literature. Second, I study the Bolivian case, which is particularly interesting given the country’s extreme liability dollarization. If liability dollarization makes depreciations contractionary in developing countries, this effect should be particularly strong in Bolivia. Third, while most other papers on contractionary depreciations only study the response of aggregate output, I also investigate the response of various sub-components of output. This helps to distinguish between the benchmark theoretical model with no financial frictions or liability dollarization, on the one hand, and the alternative model where RXR depreciations have contractionary effects, on the other hand.

The rest of this paper is organized as follows. Section 2 provides a theoretical background and Section 3 discusses the previous empirical evidence. In Section 4, I present some cross-country data showing that the Bolivian case is particularly interesting for empirical testing of the contractionary-depreciations hypothesis. Section 5 suggests an improved method for identification of real exchange rate shocks. Section 6 presents the empirical analysis, including robustness checks, while Section 7 concludes the paper.
2 Contractionary depreciations: theoretical background

Before describing the theory behind contractionary depreciations, in subsection 2.1 I first present a modern macroeconomic model where a real exchange rate depreciation has the standard expansionary effect. Then, in subsection 2.2, I discuss possible deviations from the standard case due to the balance sheet effects arising from liability dollarization. There are other, alternative models of contractionary depreciations but the balance sheet channel has received most attention in the academic literature and policy debate. For example, Frankel (2005) argues that the balance sheet channel is the most important. Partly for this reason, and partly since liability dollarization is the motivation for studying the Bolivian case, I do not discuss other possible reasons for contractionary depreciations (see the survey by Bahmani-Oskooee and Miteza (2003)).

2.1 Benchmark model where a real exchange rate depreciation has expansionary effects

This section presents a model by Svensson (2000) where a real exchange rate depreciation has expansionary effects. The framework is a standard small-open economy model with microfoundations and forward-looking expectations. I present the main equations and focus on the economic intuition (see the paper and especially the working paper version for further details). For simplicity, I only discuss the case where monetary policy follows a Taylor rule. The RXR $q_t$ is defined such that an increase denotes a real depreciation.

There are four main equations in the model. First, there is an aggregate
supply equation (Phillips curve) for inflation (equation (1) in Svensson (2000)):

\[
\pi_{t+2} = \alpha_\pi \pi_{t+1} + (1 - \alpha_\pi)E_t \pi_{t+3} + \alpha_y [E_t y_{t+2} + \beta_y (y_{t+1} - E_t y_{t+1})] + \alpha_q E_t q_{t+2} + \varepsilon^\text{CP}_{t+2}
\]  

(1)

where \( \pi_t \) denotes domestic inflation in period \( t \), \( y_t \) is the output gap, \( q_t \) is the real exchange rate, \( \varepsilon^\text{CP}_t \) is a cost-push shock and, for any variable \( x \), \( E_t x_{t+\tau} \) is the rational expectation of \( x_{t+\tau} \), given the information available in period \( t \).

Thus, domestic inflation depends on lagged inflation and previous expectations of output and inflation. Inflation is predetermined two periods in advance–that is, the desired prices for period \( t + 2 \) are determined at time \( t \), but the actual inflation for the period is also affected by output at time \( t + 1 \) and the cost-push shock which is realized at time \( t + 2 \).

Second, there is an aggregate demand equation (IS curve) for output (equation (7) in the paper):

\[
y_{t+1} = \beta_y y_t - \beta_s y_t^* + \beta_y E_t y_{t+1}^* + \beta_q E_t q_{t+1} - (\gamma^n_y - \beta_y) y_t^n + \varepsilon^\text{AD}_{t+1}
\]  

(2)

where \( \rho_t = \sum_{\tau=0}^\infty E_t r_{t+\tau} \) summarizes current and future real interest rates, \( y_t^* \) is the foreign output gap and \( \varepsilon^\text{AD}_t \) is a combination of aggregate demand and productivity shocks. Thus, output depends on previous expectations of the real interest rate path, foreign output and the real exchange rate. Output is predetermined one period in advance–that is, the desired output quantity for period \( t + 1 \) is determined at time \( t \), before the shocks are realized at time \( t + 1 \).

The third equation is the Taylor rule for the instrument of monetary policy, i.e. the nominal interest rate \( i_t \):

\[
i_t = \gamma_\pi \pi_t + \gamma_y y_t + \varepsilon^\text{MP}_t
\]  

(3)
where $\varepsilon^M_P$ is a monetary policy shock which arises since the instrument rule is not followed perfectly. Interest rates can react contemporaneously to the observed values of output and inflation.

Fourth and finally, there is also an uncovered interest parity condition:

$$i_t - i^*_t = E_t s_{t+1} - s_t + \varphi_t$$

where $i^*_t$ is the foreign nominal interest rate, $s_t$ is the nominal exchange rate and $\varphi_t$ is the foreign-exchange risk premium.

The model can be used as a basis for the necessary identification assumptions regarding the timing of relationships between variables. Monetary policy has a contemporaneous effect on real interest rates which affect output with a one-period lag (as shown in equation (2)). In turn, output affects inflation with another one-period lag, as can be seen in equation (1). The real exchange rate affects output with a one-period lag (see equation (2)). By making domestic goods relatively cheaper, a real depreciation stimulates net exports and output. Naturally, this has an indirect effect on inflation with a further one-period lag. In addition to this indirect, delayed effect of the RXR on domestic inflation, there is also a direct, contemporaneous effect on CPI inflation. A real depreciation increases the domestic-currency price of imports, which affects CPI inflation contemporaneously (but not domestic inflation).\(^4\)

In sum, the model suggests that the effect of output shocks on inflation occurs with a shorter lag than the effect of inflation shocks on output. Moreover, interest rates can react to contemporaneous values of output and inflation. Finally, the real exchange rate is an asset price and should be allowed to respond to the other variables within the period.

\(^4\) CPI inflation is given by $\pi^*_t = \pi_t + \omega(q_t - q_{t-1})$ where $\omega$ is the share of imports in the CPI.
2.2 Liability dollarization, balance sheet effects and contractionary depreciations

Balance sheet effects have been extensively studied in a closed-economy context. An overview of the literature, as well as a modern general-equilibrium macroeconomic model with financial frictions, is given by Bernanke, Gertler, and Gilchrist (1999). The key assumption is imperfect information between borrowers and lenders, which gives rise to an external finance risk premium for borrowing firms. External financing is more expensive than internal financing and the premium is particularly high when firms’ balance sheets are in poor condition. The status of balance sheets affects the required rate of return for investment, and, hence, the quantity of investment.

In many emerging and developing countries, liabilities are to a large extent denominated in foreign currency. As is well known in the literature, financial frictions may have larger effects in open economies with extensive liability dollarization than in closed economies. Examples of early papers on adverse balance sheet effects of currency depreciation in countries with foreign-currency liabilities are Cooper (1971), Gylfason and Risager (1984), van Wijnbergen (1986) and Lizondo and Montiel (1989). The Asian crisis caused a renewed interest in the role of balance sheet effects in currency crises. Some examples are the papers by Krugman (1999) and Aghion, Bacchetta, and Banjeree (2000). However, these papers only presented simple one- or two period models which were not empirically evaluated.

Cespedes, Chang, and Velasco (2004) develop a dynamic general-equilibrium model with liability dollarization where the country risk premium depends on the value of investment relative to net worth. Holding income constant, a real depreciation increases the debt burden, which has a negative effect on net worth and thereby increases the risk premium. However, a real depreci-
oration also causes an expansion of net exports and output through the standard expenditure-switching mechanism. This has the opposite effects on net worth and the risk premium. Whether the risk premium goes up or down depends on the steady-state ratio of foreign debt to net worth. Real depreciations only have contractionary effects in a “theoretically possible but empirically implausible” case (when an adverse foreign interest rate shock causes a domestic appreciation and an expansion of domestic output). Similarly, Chang and Velasco (2001) study contractionary depreciations in a simplified version of the model in Cepeda, Chang, and Velasco (2004). They also find that contractionary balance sheet effects are not sufficiently large to offset the standard expansionary effects of a real depreciation.

In these papers, liability dollarization does not reverse the standard expansionary effect of real exchange rate changes. In contrast, Cook (2004) finds that a real depreciation causes a persistent contraction in output, and conjectures that the difference in results is due to differences in the modeling of nominal rigidities. Thus, it is not unambiguously clear from economic theory whether depreciations are expansionary or contractionary in the presence of financial frictions and liability dollarization.

3 Previous empirical evidence on the effects of the real exchange rate on output and inflation

3.1 Previous international evidence

An important paper in the literature on contractionary depreciations is by Kamin and Rogers (2000). They estimate a number of different VAR models using Mexican quarterly data for the period 1980-1996. The real exchange rate, inflation and real GDP are included in all models, and other control vari-
ables are the nominal US interest rate, government spending, money, the capital account and oil prices. Even when control variables are included, real depreciations still make output decrease and inflation increase. Thus, real depreciations are found to be contractionary and inflationary.

A number of recent papers have applied the Kamin-Rogers (henceforth KR) methodology to other developing countries. Some examples are the papers by Ahmed, Ara, and Hyder (2006) for Pakistan, Berument and Pasaogullari (2003) for Turkey, Shi (2006) for China, and Vinh and Fujita (2007) for Vietnam. The estimated effects on output are mixed. Real depreciations are expansionary in China and Vietnam, but contractionary in Pakistan and Turkey. As for the effects on inflation, real depreciations are inflationary in Vietnam, Pakistan and Turkey (no evidence is reported for China).

Ahmed (2003) extends the KR methodology to a panel setting. He estimates a panel VAR model using annual data from Argentina, Brazil, Chile, Colombia and Mexico for the period 1983-1999, and finds that real depreciations are contractionary. The effect on prices is negative, but not statistically significant.

There also exist some panel studies of both developed and developing countries. Kamin and Klau (2003) use pooled annual data from 27 countries for the period 1970-1996. They find that real depreciations have contractionary effects in the short run, but insignificantly expansionary effects in the long run. A puzzling result is that real depreciations are (weakly) contractionary for developed countries, both in the short and long run. Another paper by Ahmed, Gust, Kamin, and Huntley (2002) finds more intuitively plausible results. The authors estimate panel VAR’s for different groups of developed and developing countries using similar methods as those in Ahmed (2003). They find depreciations to be contractionary in developing countries, but expansionary in developed countries (as would be expected). In both cases, depreciations cause inflation. A paper
by Kamin (1998) specifically focuses on the short-run effect of real depreciations on inflation. He uses a panel with annual data from 38 countries. Real depreciations are found to be inflationary in all cases, but the effect is stronger in Asia and especially Latin America than in developed countries.

To sum up, real depreciations are often found to have contractionary effects on output in developing countries, but there are some cross-country differences. In almost all cases, real depreciations are found to cause higher inflation.

### 3.2 Previous evidence from Bolivia

Some progress in understanding the effects of real exchange rate changes in Bolivia has already been made by central bank economists. Mendiesta and Escobar (2006) estimate a Vector Error Correction model using quarterly data for the period 1990-2005. They find that a real depreciation has an expansionary effect on output in the short run, but a contractionary effect in the long run. However, they do not investigate the effects on inflation. Other studies focus on the effects of nominal, rather than real, depreciations. Orellana, Lora, Mendoza, and Boyán (2000) estimate VAR models using monthly data for the period 1990-1999 and study the effects of nominal depreciations. They find that a nominal depreciation does not affect output, but makes inflation increase. A similar IMF study by Jaramillo (2007) reaches the same conclusions.

Another IMF paper by Leiderman, Maino, and Parrado (2006) finds evidence of real depreciations having negative effects on company balance sheets in financially dollarized countries. Specifically, the authors show that the real exchange rate Granger causes nonperforming loans in Peru (where dollarization is high) but not in Chile (where dollarization is low), which is consistent with adverse balance sheet effects due to real depreciation. The authors also estimate monetary policy reaction functions for a number of countries. When discussing
the results for Bolivia, they claim that “In view of its expansionary impact, an [real] exchange rate depreciation leads to ... a slowing down of the rate of crawl [depreciation] in Bolivia” (p. 17). However, the paper does not present any evidence of real depreciations indeed being expansionary in Bolivia.

4 Why is the Bolivian case especially interesting?

This section discusses in some more detail why we should be especially interested in the Bolivian case, by comparing Bolivia to a number of other countries in Latin America. There are three key results. Bolivia has (i) an extreme degree of liability dollarization, (ii) an above-average level of financial development and (iii) a below-average level of openness.

Table 1 presents data from a paper by Barajas and Morales (2003) which empirically studies the determinants of liability dollarization in a sample of Latin American countries. The first column shows dollar-denominated bank loans as a percentage of total bank loans. As previously discussed, the Bolivian economy exhibits extreme liability dollarization; 97 percent of the bank loans are denominated in dollars, as compared to an average across countries of 40 percent. The measure of financial development is the outstanding credit to the private sector relative to GDP, which is presented in the second column. If financial development had been very low for Bolivia, there would only have been minor balance sheet effects of depreciations, regardless of the currency composition of private sector liabilities. In an economy with few loans, the currency denomination of loans is of little importance. In fact, Bolivia has an above-average credit-to-GDP ratio: 57 percent as compared to an average of 35 percent. For example, the ratio is higher than Argentina’s (22 percent) and
Table 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Liability dollarization (percent of total)</th>
<th>Financial development (percent of GDP)</th>
<th>Openness (percent of GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>59</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Bolivia</td>
<td>97</td>
<td>57</td>
<td>34</td>
</tr>
<tr>
<td>Chile</td>
<td>19</td>
<td>64</td>
<td>47</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>16</td>
<td>19</td>
<td>73</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>12</td>
<td>31</td>
<td>76</td>
</tr>
<tr>
<td>El Salvador</td>
<td>7</td>
<td>38</td>
<td>52</td>
</tr>
<tr>
<td>Haiti</td>
<td>26</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Honduras</td>
<td>26</td>
<td>35</td>
<td>81</td>
</tr>
<tr>
<td>Jamaica</td>
<td>20</td>
<td>29</td>
<td>65</td>
</tr>
<tr>
<td>Mexico</td>
<td>24</td>
<td>18</td>
<td>56</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>70</td>
<td>42</td>
<td>90</td>
</tr>
<tr>
<td>Paraguay</td>
<td>31</td>
<td>26</td>
<td>82</td>
</tr>
<tr>
<td>Peru</td>
<td>62</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Uruguay</td>
<td>83</td>
<td>38</td>
<td>27</td>
</tr>
<tr>
<td>Average</td>
<td>40</td>
<td>35</td>
<td>55</td>
</tr>
</tbody>
</table>

Note: the data are from Tables 1 and 6 in a paper by Barajas and Morales (2003). The sample periods vary somewhat across countries and variables. The data for Bolivia are from 1989-2001 (column 1) and 1995-2001 (columns 2 and 3), respectively.

Mexico’s (18 percent). Finally, the third column in Table 3 shows economic openness, defined as the sum of exports and imports relative to GDP. Bolivia is somewhat less open than the average economy (34 percent as compared to 55 percent). However, it is not an extreme outlier, which makes it reasonable to assume that the standard, expansionary effect of a real depreciation on the economy works in similar ways as in other economies.

If anything, Table 1 probably underestimates the extreme nature of liability dollarization in Bolivia. A recent study by Kamil and Sutton (2008) uses firm-level data from more advanced Latin American economies and finds that firms’ foreign-currency exposure has been reduced over the past 10 years. One of the reasons behind the reduction has been a rapid development of currency-derivative markets. In contrast, liability dollarization in Bolivia only started to
decrease in 2006, which does not affect the results in this paper (see Jaramillo (2007)). Furthermore, there is no currency-derivative market in Bolivia, so it is not possible to hedge currency-risk exposure.

5 Identification of real exchange rate shocks in the contractionary-depreciations literature: a suggestion for improvement

It is well known that different identification assumptions may produce different results (see, for example, the discussion in Christiano, Eichenbaum, and Evans (1999)). Kamin and Rogers (2000) identify real exchange rate shocks by a standard Cholesky decomposition. They assume the following recursive ordering for the main variables: RXR, inflation and output. This implies that the real exchange rate may affect both inflation and output contemporaneously, but not vice versa, and that inflation may affect output within the period, but not vice versa.\(^5\) The assumed recursive ordering is inspired by a simple model where a real exchange rate adjustment alters the nominal price level which, in turn, causes changes in output. However, it is not clear that the model is appropriate for imposing contemporaneous restrictions, since all variables are simultaneously determined in a static environment.

A more serious cause for concern is that the assumed Cholesky ordering (RXR, inflation, output) departs from the standard theoretical small-open economy model, as well as the standard recursive ordering in the empirical VAR literature on the effects of monetary policy shocks (output, inflation, RXR). The theoretical model by Svensson (2000), which is outlined in subsection 2.1,\(^5\) When studying the effects of RXR shocks, it is only the ordering of the RXR relative to the other variables which may affect the impulse responses of output and inflation.
suggests the latter ordering.\textsuperscript{6} Intuitively, the RXR is an asset price and should therefore be allowed to respond contemporaneously to other variables. Examples of empirical VAR studies using the standard recursive ordering are those by Eichenbaum and Evans (1995) and Peersman and Smets (2003). Based on modern open-economy macro models and following standard practice in the empirical VAR literature on the effects of monetary policy, this paper uses the standard recursive ordering (output, inflation, RXR) rather than the reverse KR ordering (RXR, inflation, output).

Bolivia has a fixed nominal exchange rate against the U.S. dollar which is gradually adjusted by the central bank in response to economic conditions (crawling peg). In fact, Banco Central de Bolivia uses the nominal boliviano-dollar exchange rate as the main instrument of monetary policy. McCallum (2006) argues that “use of [the nominal exchange rate] as the policy-rule instrument rather than the more standard [interest rate], is perfectly sensible and coherent. Which of the two instrument/indicator variables would be more desirable will be determined by quantitative aspects of the economy under consideration” (pp. 7-8). Parrado (2004) and Leiderman, Maino, and Parrado (2006) estimate monetary policy reaction functions with the nominal exchange rate as the policy instrument. Moreover, Jaramillo (2007) finds that the interest rate controlled by Banco Central de Bolivia has insignificant effects on output and inflation.

In the Bolivian case, the economic meaning of the RXR being ordered last is that Banco Central de Bolivia may change the nominal exchange rate contemporaneously in response to observed output and inflation. In a sticky-price environment, changes in the nominal exchange rate have short-run effects on the real exchange rate. However, the RXR should not be interpreted as a policy in-

\textsuperscript{6}A minor difference between the theoretical model and the empirical VAR models is that inflation is predetermined two periods in advance in the theoretical model, but only one period in advance in the empirical models.
strument. It is also assumed that the RXR does not have any contemporaneous effects on output or inflation.

An alternative empirical specification would be to use the nominal boliviano-dollar exchange rate instead of the RXR, which would allow a clearer interpretation of the residuals in the exchange rate equation as deviations from the central bank’s instrument rule. A problem with such an approach is that the trade-weighted RXR may change even when the bilateral boliviano-dollar exchange rate is constant. This paper uses the trade-weighted RXR, which also facilitates a comparison with the rest of the literature, in particular the contractionary-depreciations literature.

As discussed above, the recursive-ordering identification method imposes zero-restrictions on the contemporaneous relationships between variables. In fact, several alternative methods have been suggested in the literature. For example, a recent paper by Bjornland (2008) allows contemporaneous two-way effects between the interest rate and the exchange rate, but adds the restriction that interest rate shocks have no effect on the long-run level of the real exchange rate. While alternatives to the recursive-ordering method are useful, the recursive method remains widely used, not least because of its simplicity. Among all possible recursive orderings, the standard ordering is preferable to alternative recursive orderings, such as that used by Kamin and Rogers (2000) and subsequent papers in the contractionary-depreciations literature.

6 Empirical VAR analysis of the effects of real exchange rate shocks in Bolivia

The main empirical relationships of interest are those between the RXR and output and between the RXR and inflation. Figure 1 depicts the relationships
graphically for the sample period 1990:Q1-2006:Q3. The trade-weighted RXR is defined such that an increase signifies a real depreciation. Output is the output gap in percent, which is calculated using an HP filter to remove the trend from the log real GDP. Inflation is the annualized log difference in the quarterly CPI. As can be seen in Figure 1, there is no clear relationship between the RXR and output, while RXR depreciations seem to be associated with increases in inflation.

In addition to the modifications of the Kamin-Rogers approach discussed in Section 5, this paper also differs in two other respects. First, while KR estimate a VAR in first differences, I estimate a VAR in levels. As pointed out by Sims, Stock, and Watson (1990) and Hamilton (1994), if the true process is not a VAR in first differences, then estimates from a VAR in first differences will be inconsistent. My procedure avoids inconsistent estimates, but at the cost of reduced efficiency. Second, KR estimate a single VAR over four different exchange rate regimes. This may be problematic since their Granger causality tests show that the relationship between the RXR and real GDP is different in different parts of the sample. In contrast, I use a sample with only one exchange rate regime. As demonstrated by Bagliano and Favero (1998) using US data, unless the VAR is estimated over a sample with a single monetary regime, the estimates may suffer from parameter instability.

Another issue is which measure of output to include in the VAR. Most empirical papers use the level of output but as argued by Giordani (2004), it is more consistent with the theoretical models to use the output gap. However, the output gap is difficult to measure since the level of potential output is unobservable. Following Lindé (2003) and Bjornland (2006), I use the level of output but include an exogenous linear trend. As a robustness check, I also estimate a model with a measure of the output gap.
Figure 1: Upper graph: RXR (left scale, inverse index, increase=depreciation) and output (right scale, percent output gap using HP-trend). Lower graph: RXR (left scale, inverse index, increase=depreciation) and inflation (right scale, percent).
Given the limited number of observations, it is necessary to limit the number of variables included in each VAR model. Following Kamin and Rogers, I first estimate a baseline model with the main variables and then estimate a number of alternative models with one additional control variable for each model. Detailed variable definitions and sources are given in the appendix. The exogenous variables which are included in all specifications are a U.S. interest rate and the trade-weighted external GDP. The main endogenous variables are output, CPI inflation and the trade-weighted RXR. The additional control variables are the terms of trade, the capital account balance and dummy variables for periods affected by social unrest and the weather phenomenon El Niño. I also check for robustness using a measure of GDP which excludes the mining and hydrocarbons sectors. While KR only investigate the effects of the exchange rate on aggregate GDP, I also study the effects on exports, imports, investment and consumption (inspired by Mojon and Peersman (2003)). All the following VAR models are estimated with two lags, as suggested by standard lag length criteria, and using the sample period 1990:Q1-2006:Q3.

Figure 2 presents the baseline impulse responses of output and inflation to a real exchange rate depreciation shock. The upper row uses CPI inflation and the lower row uses GDP deflator inflation. However, the results do not depend on the definition of inflation. There is a minor and gradual increase in output, but it is small and not statistically significant. In contrast, there is a significant and persistent increase in inflation, regardless of the definition of inflation. The peak effect on inflation is reached two quarters after the shock, and the increase in inflation remains significant during 1.5-2 years.

Figure 3 presents the impulse responses of output and CPI inflation to a real exchange rate depreciation shock when including a number of additional control variables (one for each row). The main results are very robust. There
is no significant change in output for any specification, and the response of inflation is always positive, significant and persistent.

Figure 4 shows the impulse responses of GDP components: exports, imports, investment and consumption. There is a significant increase in exports and imports remain relatively unchanged. This creates a significant increase in net exports (not shown). Thus, there is evidence of a standard expansionary effect of real depreciations. Furthermore, there is a significant decrease in investment, as predicted by the balance sheet channel. Consumption remains relatively unchanged. Combined with the evidence for exports and imports, the decrease in investment indicates that the standard positive effect and the
Figure 3: Impulse responses of output (percent) and inflation (percentage points) to RXR shock. Confidence intervals: plus/minus two Monte Carlo standard errors (500 repetitions).
negative balance-sheet effect tend to cancel each other out, which helps explain the lack of a significant response of aggregate GDP.

Figure 5 investigates how the baseline results change when using the output gap rather than the level of output. In general, the effects of RXR shocks are similar but less significant.

Finally, Figure 6 presents impulse responses for estimates based on the Kamin-Rogers recursive ordering. As compared to the results presented above, the responses of output and its components are similar. However, there are notable differences in the response of inflation. In all models presented above, inflation increases significantly in the short term. In contrast, with the Kamin-
Rogers ordering of variables, there is an immediate decrease in inflation which is counter-intuitive. A possible justification for ordering the real exchange rate before inflation would be to allow for an immediate inflationary impact of depreciation. The observed deflationary impact of depreciation is puzzling and suggests model misspecification. Thus, the empirical results are different for different variable orderings, which shows the importance of using appropriate identification assumptions. However, the more general arguments in favor of the ordering used in this paper remain valid irrespective of how the results depend on identification assumptions in the specific case of Bolivia.
7 Conclusions

As in most of the empirical literature, real exchange rate depreciations are found to be inflationary in Bolivia. However, depreciations are not contractionary, since the negative balance-sheet effects are not sufficiently large to outweigh the standard positive effects on international competitiveness. Thus, the adverse balance-sheet effects of currency depreciation are of limited size, even in an economy with extreme liability dollarization. Another result is that the identification assumptions affect the results, and that the recursive ordering used in
this paper produces more reasonable results than the alternative ordering used in the previous contractionary-depreciations literature.

An interesting extension of the analysis in this paper would be to study countries with different degrees of liability dollarization to investigate if the strength of adverse balance-sheet effects varies with liability dollarization. It would also be interesting to study the importance of recursive-ordering assumptions for the results in a broader set of countries.
Appendix

The following variables were seasonally adjusted using the X-12 method (multiplicatively): GDP, consumption, investment, government spending, exports, imports, CPI and GDP deflator.

The variables used in the paper are defined as follows.

Output: real gross domestic product (GDP). Source: Banco Central de Bolivia (BCB).

Consumption: real private consumption. Source: BCB.

Investment: real gross fixed capital formation. Source: BCB.

Government spending: real government spending. Source: BCB.

Exports: real exports. Source: BCB.

Imports: real imports. Source: BCB.

The consumer price index (CPI) and the GDP deflator are also from BCB.

U.S. interest rate: nominal interest rate on 3-month Treasury Bills. A quarterly series was constructed by averaging monthly data. Source: Federal Reserve Bank of St. Louis.

Terms of trade: unit value of exports divided by the unit value of imports. Source: Instituto Nacional de Estadísticas.

Real exchange rate (RXR): multilateral trade-weighted RXR based on relative CPI. The original series is defined such that an increase in the series signifies a real appreciation. For pedagogical purposes, I inverted the series so that an increase means a real depreciation. Source: IMF International Financial Statistics.

Foreign output: export-weighted average of real GDP in the ten most important Bolivian export markets (Argentina, Belgium, Brazil, Chile, Colombia, Peru, Switzerland, Venezuela, the United Kingdom and the United States). The Bolivian export weights are from 2000. In the few cases where only annual real GDP was available, I used the same annual index value for all quarters of the year. Source: IMF International Financial Statistics (foreign GDP) and BCB (Bolivian export weights).


Dummy variable for social unrest: during quarters with substantial economic effects of social unrest, the variable takes the value 1, otherwise it takes the value 0. Source: Mendieta and Escobar (2006).

Dummy variable for the weather phenomenon El Niño: during quarters with substantial economic effects of El Niño, the variable takes the value 1, otherwise it takes the value 0. Source: Mendieta and Escobar (2006).
References


