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Abstract

We use a simple financial friction in an economy with high degree of liability dollarization to show that the negative balance-sheet effect of an exchange rate depreciation may be observable only if the magnitude of the depreciation is large enough. This result justifies the difficulty to find strong empirical evidence for balance-sheet effects and suggests the convenience of including a "large depreciation" term in empirical analyses.

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Keywords: Large depreciation, dollarization, balance-sheet effect, investment, currency mismatch.

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1 Introduction

The literature on liability dollarization and currency mismatch (Krugman, 1994; Cespedes et al., 2004; Choi and Cook, 2004; Magud, 2004; Batini et al., 2007; Bleakley and Cowan, 2008; Carranza et al., 2008) has studied the balance-sheet effect of exchange rate depreciations: when liabilities are denominated in a foreign currency, a depreciation may lead to a reduction in firms' net worth that contracts investment and goes counter the traditional competitiveness effect of the depreciation. This balance-sheet effect may therefore be disinflationary and contractionary. However, empirical analyses have found only weak evidence for this effect, and usually only in the context of quite large nominal depreciations. This empirical result suggests that the aggregate investment function may present a nonlinearity in its dependence on the (real) exchange rate:

$$\Delta i_t = I(z_t) + (\lambda + \chi\rho)\,\Delta e_t;\;\; \chi = \mathbf{1}\left[\Delta e_t > \varphi\right] \tag{1}$$

where $I(z_t)$ contains the effect of relevant variables other than the real exchange rate, Δe_t is the change in the real exchange rate, λ is the sensitivity of investment to "regular" real depreciations and ρ is the additional impact of a real depreciation that is "large" (i.e. greater than some threshold φ); finally, $\mathbf{1}[\cdot]$ is an indicator function that takes value one if the change in the real exchange rate is larger than φ. The coefficient λ may be positive or negative, since it stems from both the competitiveness effect (a real depreciation increases the output of firms that sell tradables) and the negative impact from the increase in relative worth of foreign currency liabilities. We argue, however, that the coefficient ρ is negative. We show how a simple financial friction may lead to this investment function, which explains the difficulty in finding

robust empirical evidence for the balance-sheet effect of real depreciations. Some recent empirical analyses (Leiderman et al., 2006; Carranza et al., 2003, 2008) seem to give support to this nonlinear effect, both in output and in aggregate prices.

2 Investment and large exchange rate depreciations

We use a simple model in the line of Bleakley and Cowan (2008). Assume a small country with a continuum of firms that produce tradables and of firms that produce nontradables.[1] There are two periods. Firm i enters period one with some long-term debt, which may be denominated in foreign (L_i^*) or local (L_i) currency. The ratio L_i^*/L_i is a measure of the degree of currency mismatch at the firm level, and the aggregate ratio a measure of total liability dollarization.

We assume that short-term debt in period one, $S_{i,1}$, is equal to 0. For simplicity we also assume that all short-term debt is contracted in foreign currency and the level of long-term indebtedness is given. The real exchange rate e_0 at which the foreign debt L_i^* was contracted is equal to one and no variation is anticipated. Initial period capital for firm i, $K_{i,1}$, is also equal to 0. We assume that capital goods are imported.[2]

During the initial period, after an unexpected real exchange rate depreciation has occurred (i.e., $e_1 > 1$), firms make their investment decisions taking into account their budget and borrowing constraints. Firm i chooses next period capital, $K_{i,2}$, and the short term borrowing in foreign currency contracted at the initial period and payable

[1] Alternatively, we could think of firms producing a share of tradables and a share of nontradables. The results would be the same and we believe that keeping both separate facilitates the interpretation.

[2] This assumption is not unreasonable in the case of emerging markets, which are also the main countries that present high degrees of liability dollarization.

at the last period, $S_{i,2}$, to maximize profits. Now the distinction arises between firms that produce nontradables (i.e., their flow of income is denominated in local currency) and firms that produce tradables (i.e., their flow of income can be denominated in foreign currency). We assume that all firms are price-takers and they can sell their whole production $F(K_{i,2})$. We thus abstract from competitiveness effects of exchange rate changes (which, in any case, would favor our argument).

2.1 *Nontradable firms*

The problem for a firm i that produces nontradables is:

$$Max\left\{F\left(K_{i,2}\right)-e_2L_i^*-L_i-e_2rS_{i,2}\right\} \tag{1}$$

$$s.t.\ K_{i,2}\leq S_{i,2} \tag{2}$$

$$e_2rS_{i,2}\leq\theta\left(F\left(K_{i,2}\right)-e_2L_i^*-L_i\right) \tag{3}$$

where e_2 is the expected real exchange rate in the second period and r is the gross interest rate on short term debt. Note that L_i^* and L_i are contracted before the depreciation takes place and are repayable at the last period and that we abstract from the interest rate on long-term debt, so that L_i^* and L_i can be taken as the gross final value repayable at the last period. Firms can borrow a fraction $0\leq\theta\leq 1$ of their necessities. The price of nontradable goods is normalized and used as a numeraire in the second period. Given that payments and output are realized at period two, the change in e_1 must influence the level of e_2. Otherwise, e_1 will not have any impact on investment decisions. Thus, we assume that the real exchange rate exhibits persistence so that $e_2=\mu\left(e_1\right)$ and $\dfrac{\partial\mu\left(e_1\right)}{\partial e_1}>0$.

Equation (2) is a budget constraint: new capital expenditures are financed by short-term borrowing. Given that short-term debt is costly, this constraint will hold

with equality. Equation (3) is a borrowing constraint: the maximum short-term borrowing is a fraction θ of the firm's final net worth. The idea behind the parameter θ is to make explicit that credit imperfections are due to an enforcement problem: lenders can not force their borrowers to repay their debt, but they can seize a fraction of the borrower's final net worth (see Kiyotaki and Moore, 1997, and Aghion et al. 2001).

For firms that are credit constrained (equation (3) is binding), the choice of $K_{i,2}$ depends on credit availability rather than on optimality conditions. In that case $K_{i,2}$ is determined by replacing (3) into (2):

$$K_{i,2} = \frac{\theta}{e_2 r} \left(F\left(K_{i,2}\right) - e_2 L_i^* - L_i \right) \tag{4}$$

The solution to (4) is a fixed point, $K_{i,2} = K^*$ which can be represented as in Figure 1, Panel A, where $G(K) = \frac{\theta}{e_2 r} \left(F\left(K\right) - e_2 L^* - L \right)$ and $I(K) = K$.

[FIGURE 1 HERE]

The level of $K_{i,2}$ depends not only on r but also on the net worth of firm i (given by L_i^* and L_i) and the real exchange rate, e_2. We denote it by $K_{i,2} = K_2^R \left(r, e_2; L_i^*, L_i\right)$ where R means a "restricted" firm i. It can easily be proved that an increase in today's real exchange rate, e_1, will produce a fall in the investment of firm i. Taking implicit derivatives with respect to e_1 we obtain:

$$\frac{\partial K_{i,2}}{\partial e_1} = \frac{-\mu'\left(e_1\right)}{e_2 r - \theta F'\left(K_{i,2}\right)} \left(\theta L_i^* + r K_{i,2} \right) < 0 \tag{6}$$

where the impact of a real depreciation on investment is negative because of higher financial costs and the balance-sheet effect.[3]

[3] The first and second derivatives of $F\left(\cdot\right)$ and $\mu\left(\cdot\right)$ are denoted as $F'\left(\cdot\right)$ and $\mu'\left(\cdot\right)$, and $F''(\cdot)$.

If firms are not credit constrained, equation (3) is not binding and the solution is given by:

$$F'(K_{i,2}) = e_2 r \tag{7}$$

where investment now only depends on the interest rate and the real exchange rate, $K_{i,2} = K_2^U(r, e_2)$, and K_2^U stands for next period capital of the "unrestricted" firm i. Given that capital is imported, it is still the case that an increase in the real exchange rate causes a drop in investment (a "financial cost" effect), but this effect is smaller than in the previous case:

$$\frac{\partial K_{i,2}}{\partial e_1} = \frac{r}{F''(K_{i,2})}\mu'(e_1) < 0 \tag{9}$$

Panel B of Figure 1 shows that for a highly indebted firm, a large enough real exchange rate depreciation ($e > e^{**}$) could generate a strong negative balance-sheet effect that led to the financial collapse of the firm: the G-curve would not intersect the I-curve, investment collapses and the firm's liquidation follows. In this case, a discontinuity appears in the firm's investment function, shown in Panel C of Figure 1.

We assume that the only difference among nontradable firms is their level of foreign debt L_i^*.[4] Then, given the technology and institutions, there must be a critical level $L^*(e_1)$, which depends on the real exchange rate, beyond which firms are constrained. When a real *depreciation* occurs, the fraction of unconstrained firms is reduced and so $\frac{dL^*(e_1)}{de_1} < 0$. Letting $H(L^*)$ be the cumulative distribution of firms with foreign debt less than L^*, and $h(L^*)$ the density distribution function, we can obtain the

[4] This assumption and the parallel one that is made next in the case of tradables are merely to avoid the double integration over the distribution of both L_i and L_i^*, which would make the algebra unnecessarily cumbersome and would add no insight.

aggregate investment function of nontradable firms, I_t^{NT}:

$$I_t^{NT} = \int_{-\infty}^{L^*(e_1)} K_2^U(r, e_2)\, dH(L^*) + \int_{L^*(e_1)}^{\infty} K_2^R(r, e_2; L_i^*, L_i)\, dH(L^*) \tag{10}$$

Taking the derivative of aggregate investment with respect to e_1 gives the following expression:

$$\begin{aligned} \frac{\partial I_t^{NT}}{\partial e_1} &= \int_{-\infty}^{L^*(e_1)} \frac{\partial K_2^U(r, e_2)}{\partial e_1} dH(L^*) \\ &+ \int_{L^*(e_1)}^{\infty} \frac{\partial K_2^R(r, e_2; L_i^*, L_i)}{\partial e_1} dH(L^*) + \left(K_2^U - K_2^R\right) h(L^*(e_1)) \frac{dL^*(e_1)}{de_1} < 0 \end{aligned} \tag{11}$$

which is negative given that all three terms are negative. The sign of the second derivative $\frac{\partial^2 I_t^{NT}}{\partial e_1^2}$ will depend on $H(L^*)$, but it will most likely be negative, so that a large change in the real exchange rate could imply a large negative change in the derivative of investment with respect to e_1.

2.2 *Tradable firms*

For a firm producing tradables, we assume that the revenues are given in foreign currency and so firm i's problem becomes:

$$Max\left\{e_2 F(K_{i,2}) - e_2 L_i^* - L_i - e_2 r S_{i,2}\right\} \tag{12}$$

$$s.t.\ K_{i,2} \leq S_{i,2} \tag{13}$$

$$e_2 r S_{i,2} \leq \theta\left(e_2 F(K_{i,2}) - e_2 L_i^* - L_i\right) \tag{14}$$

For credit constrained firms $K_{i,2}$ is determined by:

$$K_{i,2} = \frac{\theta}{e_2 r}\left(e_2 F(K_{i,2}) - e_2 L_i^* - L_i\right) = \frac{\theta}{r}\left(F(K_{i,2}) - L_i^* - \frac{L_i}{e_2}\right) \tag{15}$$

where the solution is a fixed point $K_{i,2} = K_2^R(r, e_2; L_i^*, L_i)$ that depends on r, on the net worth of firm i (given by L_i^* and L_i) and the real exchange rate e_2. Now, however,

an increase in the real exchange rate e_1 produces an increase in investment, since the relative value of *domestic* debt falls with respect to the value of revenues and the net worth of the company increases:

$$\frac{\partial K_{i,2}}{\partial e_1} = \frac{\theta \mu' (e_1) L_i}{e_2^2 [r - \theta F' (K_{i,2})]} > 0 \tag{16}$$

If firms are not constrained, equation (14) is not binding and the solution is:

$$F' (K_{i,2}) = r \tag{17}$$

where investment $K_{i,2} = K_2^U (r)$ only depends on the interest rate and therefore its derivative with respect to e_1 becomes:

$$\frac{\partial K_{i,2}}{\partial e_1} = 0 \tag{18}$$

Thus, the investment function of a tradable firm looks like that on Panel D of Figure 1, where we allow for a massive appreciation to cause a tradable firm's bankruptcy. Assuming that the only difference among tradable firms is their level of domestic debt L_i, there is also in this case a critical level $L(e_1)$, a function of the real exchange rate, beyond which tradable firms are constrained. Now, however, when a real *appreciation* occurs, the fraction of unconstrained firms is reduced and therefore $\frac{dL(e_1)}{de_1} > 0$. Letting $F(L)$ be the cumulative distribution of tradable firms with domestic debt less than L, and $f(L)$ be the density distribution function, we obtain the aggregate investment function for tradable firms, I_t^T:

$$I_t^T = \int_{-\infty}^{L(e_1)} K_2^U (r) \, dF (L) + \int_{L(e_1)}^{\infty} K_2^R (r, e_2; L_i^*, L_i) \, dF (L) \tag{19}$$

and the first derivative of investment with respect to e_1

$$\frac{\partial I_t^T}{\partial e_1} = \int_{L^*(e_1)}^{\infty} \frac{\partial K_2^R (r, e_2; L_i^*, L_i)}{\partial e_1} dF (L) + \left(K_2^U - K_2^R\right) f (L (e_1)) \frac{dL (e_1)}{de_1} > 0 \tag{20}$$

which is positive given that both terms in (20) are positive.

If we now calculate aggregate investment $I_t = I_t^T + I_t^{NT}$ as a function of the real exchange rate, we may obtain a function such as that in Figure 2, which can be linearized around e' and e'' to obtain a linear aggregate investment function with a kink of the form in equation (1).[5] Notice that λ may be negative or positive: the negative balance-sheet effect for small depreciations in the nontradable sector may not be enough to compensate the competitiveness plus positive balance-sheet effects in the tradable sector. This does not affect our main result that, when the depreciation is large there will appear a stronger negative effect, so that $\rho < 0$ for sure. In other words, the first section of I_t may be increasing or decreasing on the real exchange rate ($\lambda > 0$ or $\lambda < 0$, respectively) but eventually, for a large enough e, the function will be decreasing or, at least, flatter because of $\rho < 0$ (flat I_t^T combined with decreasing I_t^{NT}).

[FIGURE 2 HERE]

The coefficient ρ measures the magnitude of this "large depreciation" balance-sheet effect. From the model it can be seen that this magnitude depends:

- Positively on the degree of currency mismatch (liability dollarization) of the economy. In fact, both λ and ρ are functions of the level of liability dollarization: the negative balance-sheet in nontradables is more intense the larger L_i^* is -regardless of L_i- and the positive balance-sheet effect in tradables is less intense the larger L_i^* compared to L_i.

[5] The specific shape of I_t –whether it has an upward sloping part or a downward sloping part– depends on both $H(L^*)$ and $F(L)$. The main point here is that the slope for large values of the real exchange rate is lower than that for small values, which implies that $\rho < 0$.

- Negatively on the proportion of tradables in the composition of output.

- Positively on the level of indebtedness of the country's firms, denoted here by the distributions $H(L^*)$ and $F(L)$.

- Positively on the extent of the financial friction, here denoted by θ. This friction, in turn, depends on factors such as the country's legal framework -the extent to which repayment of credit contracts can be enforced- and the strength of the banking sector: banks with stronger balance-sheets or with less currency mismatch in their balance sheets will tend to lend more.

3 Conclusion

Our results are relevant to extend the empirical literature on the effects of depreciations for emerging markets, which present both high degrees of dollarization and large exchange rate swings (Bigio and Salas, 2006; Goujon, 2006; Leiderman et al., 2006; Ca'Zorzi et al., 2007). We have shown that in a small open economy with currency mismatch (liability dollarization) the presence of a simple financial friction not only generates a traditional balance-sheet effect of a real depreciation, but also a possible "large depreciation" effect. This effect may lead to a kink in the investment/real exchange rate function so that it becomes downward sloping or, at least, its positive slope is significantly reduced. The result suggests that contractionary balance-sheet effects could be empirically noteworthy only in the presence of large enough depreciations.

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Figure 1

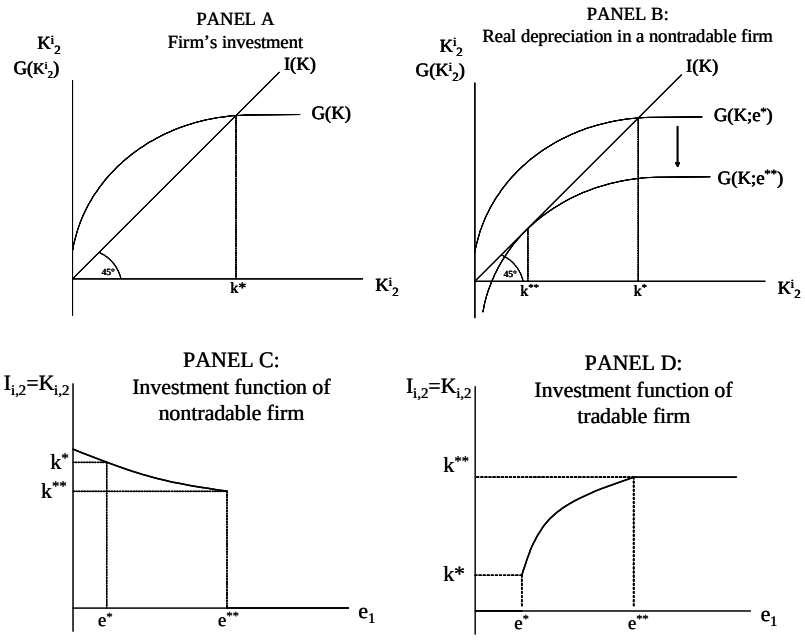

Figure 1:

Figure 2:
Linearized aggregate investment function

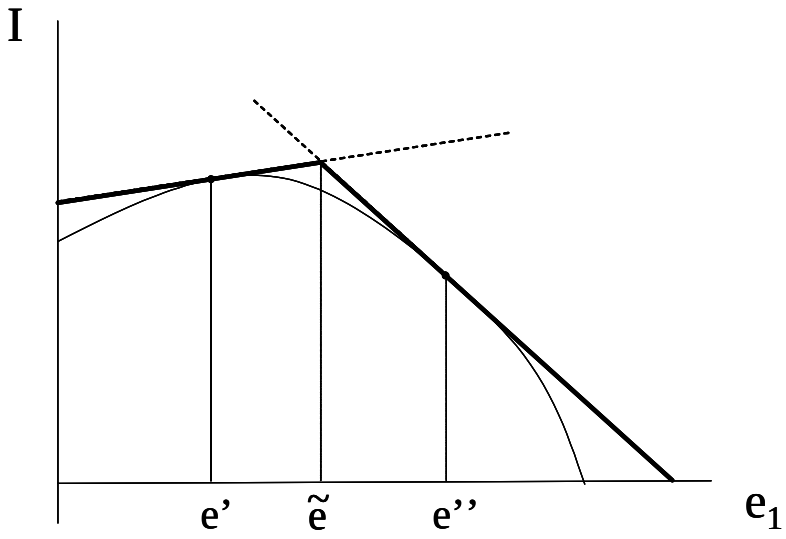

Figure 2: