# INVESTMENT AND EXPOSURE TO EXCHANGE RATE CHANGES IN COLOMBIA

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## Abstract

We assemble a large data base of Colombian medium & large firms covering the 1997-2008 period and study different channels through which real exchange rate (RER) changes affect firm investment and profits. With regard to investment, (i) there are adjustment costs, presumably related to capital market imperfections; (ii) investment increases with liquidity as firms face restricted access to external financing; (iii) RER changes have no direct effect on investment, even after controlling for the effects of each sector; (iv) we find no evidence of a differential effect of RER changes on investment depending on exposure to foreign debt. This might be because few firms carry foreign debt or because those that do avoid currency mismatches through "natural" hedging or use financial instruments to hedge exchange rate risk. Other estimations show that firms with higher *total* debt invest more after a devaluation; i.e. *probably* any negative effect in terms of net worth declining with a devaluation is offset by the positive effect on present and future income. This hypothesis is supported by our analysis of the currency composition of debt. Firms that export more are more likely to carry foreign debt, and the foreign debt they carry is larger. This points to "natural matching" between foreign currency revenue and liabilities. Finally, changes in the RER have no effect on bank performance (i.e. on NPLs), beyond the indirect effects that stem from RER changes affecting firm profits. This result is probably driven by regulation that restricts the exposure of banks to exchange rate risk. In summary, Colombian firms and banks benefit from RER devaluations and are negatively affected by RER appreciations. These findings, coupled with the fact that the preference of the central bank has been to allow the exchange rate to float more freely when it is bound to weaken than when it is bound to strengthen, has lessened any need by firms to use financial derivatives to hedge exchange rate risk.

JEL classification: E22, F31

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## I. Introduction

In a world of floating exchange rates, exchange rate volatility might affect firm profitability and investment. Firms involved in international trade (i.e. because they import and/or export) or that have financial linkages to the outside world (i.e. because they hold foreign assets and/or liabilities) are generally influenced directly by changes in exchange rates. Furthermore, even if direct real or financial links to the outside world are not significant, a firms' profitability might be affected by exchange rate movements if it happens to operate in an import-competing sector. On the other hand, and probably more interestingly, the performance of a firm with strong links to the rest of the world to a great extent might be isolated from the effects of exchange rate movements if its foreign currency operations happen to be either "naturally" or financially hedged. In the first case, for example, a firm indebted in foreign currency might also happen to be a net exporter, in which case a devaluation might have no significant effect on its overall performance. In the second case, a firm that does not trade internationally but does hold foreign currency debt might not be adversely affected by a devaluation if its foreign currency liabilities are appropriately hedged through the use of financial instruments such as derivatives. All these competing forces imply that the effect of exchange rate movements on firm performance is an issue to be addressed empirically.

A meaningful case study of the impact of exchange rate changes on firm performance requires fulfilling several conditions. First, it must be in reference to a country that *de facto*, and not just *de jure*, operates within a reasonably flexible exchange rate regime[2]. Second, the economy in question must be reasonably open both commercially as well as financially. Third, the empirical analysis is data intensive, requiring access to a comprehensive firm-level database, one that allows for a clear identification of the currency composition of the income statements and the balance sheet. Colombia satisfies these three conditions. A case study on Colombia is interesting along another dimension, having to do with the fact that the country has had a long tradition of a very conservative approach both towards foreign currency exposure in the financial sector and towards the use of sophisticated financial instruments to hedge risk. Banks are not allowed to offer

[2] Even though the exchange rate in Colombia has not been consistently more volatile than in countries like Mexico, Brazil and Chile and even the euro, volatility has increased since 2005 and is higher in periods of devaluation (Arbeláez and Steiner, 2009).

foreign currency denominated deposits and face significant restrictions regarding their foreign currency exposure.[3] This has contributed to the underdevelopment of hedging instruments.[4] Although Colombia´s derivatives market is very much dominated by the use of forward foreign exchange transactions, hedging exchange rate risk is still uncommon and, as a result, firms, banks and the government are, in principle, subjected to significant risk on account, among others, of exchange rate volatility.

A possible consequence of not having a developed market for exchange rate risk hedging is that firms whose income stream is in dollars and its costs are mostly in pesos (i.e. a typical net exporting firm, such as one in the cut-flower sector) become very vulnerable during episodes of strengthening of the local currency. More importantly, firms might borrow in foreign currency, and that borrowing might not be "naturally" matched by an income stream in foreign currency. Under those circumstances, a devaluation of the local currency might have very negative consequences over firm performance, including on its profits and its investment. Although the case in favor of policies to promote the development of hedging instruments is stronger in the absence of "natural hedging", such development is relevant even in the presence of natural hedges. After all, while the data might show that firms that borrow in foreign currency also generate income in foreign currency, it might well be the case that had there been adequate financial instruments for exchange rate risk hedging, firms that do no export could have expanded their activities through loans from abroad had they been able to adequately shift to a third party the exchange rate risk involved.

An important body of literature has emerged trying to determine the effects of exchange rate movements on firm performance, taking into consideration the fact that while a devaluation might enhance the competitiveness of exporting and import-competing local firms (the competitiveness effect), it should negatively affect performance of firms holding foreign currency denominated liabilities (the so-called balance sheet effect). Studies that investigate the role of balance-sheet effects intensified following the sharp

[3] See Appendix 2.

[4] Colombia has a rather underdeveloped derivatives market, even when compared to other Latin American countries. While in June 2009 the Brazilian and Mexican derivates market traded US$1,179 billon and US$252 billion, respectively, the Colombian market traded just over US$1.5 billion. Furthermore, the use of credit derivates is almost non-existent due in part to the lack of a short-term reference data index, which has hampered the assessment of derivate instruments. A Reference Bank Index (IBR) was not established until March, 2008 (García and Ong, 2005).

exchange rate devaluations during the Asian and the Brazilian crises[5]. This literature, nonetheless, produced mixed results, and the overall effect remains an empirical issue. For example, Prasetyantoko (2007) finds that in Indonesia listed companies holding dollar debt significantly reduces their investment following exchange rate depreciations; therefore the corporate balance sheet channel exacerbated and prolonged the effects of the crisis. Something similar is found in Turkey (Kesriyeli, *et al*., 2005) where firms only partially match the currency composition of their debt with their income streams, making them highly vulnerable to real exchange rate devaluation shocks.

Contrary to these results, for a sample of firms of five Latin American countries for the period 1990-1999, Bleakley and Cowan (2008) find that firms holding dollar debt do not invest less after currency devaluations. This arises from the fact that they match the currency composition of income and liabilities, and that the positive competitiveness effect prevails. However, results are quite different when considering studies for individual Latin American countries and there is strong evidence that some are highly affected in a negative manner by currency devaluations. For the case of Mexico, Aguilar (2005) concludes that firms holding short-term dollar debt were heavily affected after the 1994 peso crisis. In the same direction, Carranza *et al.* (2003) find evidence for the Peruvian economy that, due to the high degree of liability dollarization and currency mismatch combined with a relatively small and poorly diversified exporting sector, the balance sheet effect prevails following a devaluation. For the Brazilian case, Bonomo *et al.* (2003) conclude that more dollar-indebted firms tend to invest less after a devaluation. Similarly, Janot *et al.* (2008) argue that firms with currency mismatches between 2001 and 2003 decreased their investment rates after the crisis, including those concentrated on exports.

As opposed to these results, Chilean firms seem to benefit from devaluations. Benavente *et al.* (2003) identify a positive impact on investment of a devaluation for firms with dollar denominated debt - although the absolute value is very small – and suggest that firm size and export orientation are relevant variables in explaining the size of losses due to exchange rate changes. However, according to Cowan *et al.* (2005), the balance sheet effect becomes significant after controlling for differences in the currency composition of assets, income and net derivative positions. Interestingly the authors find that not only is

[5] A complete survey of the literature is presented in Galindo *et al*. (2003).

there currency matching between income and debt (natural hedging); in addition, Chilean firms actively use derivatives to reduce risks associated with exchange rate exposure.

Evidence up to date for the case of Colombia is mixed. A negative effect from a RER devaluation over investment (as a percentage of assets) for 1995-2001 was identified by Echeverry *et al*. (2003), using a panel of firms in which firms not reporting for four consecutive years were excluded. The opposite result was reported in Arbeláez and Echavarría (2003), using as explanatory variable investment in relation to the capital stock and using an unbalanced panel excluding only outliers, for the 1994-2002 period.

In this paper we assemble a large data base of Colombian firms covering the 1997-2008 period and study the different channels through which exchange rate movements might affect firm performance, particularly profits and investment. The paper is organized as follows. Following this brief introduction, in the second section we summarize the theoretical model on the determinants of investment. In the third section we present the empirical strategy and describe the data base. In the fourth section we report the econometric findings regarding the effects of changes in the real exchange rate over firm investment and profits. We also undertake an econometric exercise in order to evaluate the determinants of the currency composition of debt. In section five we focus on the financial sector, providing an econometric assessment of the effects of changes in the real exchange rate on the evolution of bank non-performing loans. Finally, in the last section we summarize the main findings and policy implications.

## II. From the theoretical to the empirical model

We rely on two theoretical approximations, which are jointly dealt with in the empirical analysis. The first consists of an equation in which investment is derived from the maximization of the market value of a firm, explicitly taking into consideration financial restrictions associated with existing leverage. The second model goes a step further by considering the transmission channels by which changes in the real exchange rate might affect the optimal level of investment.

A profit-maximizing firm will have a rate of investment $\left(\frac{I}{K}\right)$ that is a function of financial variables and other determinants, as in equation (1), where $I_{it}$ is firm´s $i$ gross investment in period $t$, $K_{it}$ the capital stock, $Y_{it}$ the firm´s output (i.e. sales), $D_{it}$ leverage (i.e. the level of indebtedness), $Liq_{it}$ a measure of liquidity (i.e.. liquid assets minus liquid

liabilities)[6]. Under this specification, the rate of investment is a function of its lagged value, a consequence of imperfections in the capital market that make adjustment costly and therefore not instantaneous. The coefficient for output is expected to be positive ($\beta_2 > 0$); a firm´s good performance fosters it to undertake additional investments (i.e. investment increases with the marginal product of capital). *A priori* the coefficient accompanying leverage can be positive or negative ($\beta_3 \lessgtr 0$). A positive coefficient suggests that debt incurred in previous periods sends a signal of firm strength to financial markets. This is the reasoning behind Harris *et al* (1994) for the positive coefficient they obtain in their analysis of firms and conglomerates in Indonesia. Most studies have found a negative coefficient, suggesting that highly leveraged firms find it more difficult to access new sources of financing[7]. Finally, in a setting in which there are liquidity restrictions, the coefficient for lagged liquidity should be positive ($\beta_4 > 0$); there are adjustment costs and the firm requires own resources to finance its purchase of capital goods.

$$\frac{I_{it}}{K_{it-1}} = \beta_1 \frac{I_{it-1}}{K_{it-2}} + \beta_2 \frac{Y_{it-1}}{K_{it-1}} + \beta_3 \frac{D_{it-1}}{K_{it-1}} + \beta_4 \frac{Liq_{it-1}}{K_{it-2}} + \eta_{it} \qquad (1)$$

The second model, based on Beakley & Cowan (2008), captures a competitiveness and a balance sheet effect associated with changes in the RER. A profit maximizing firm chooses its optimal capital stock subject to a financial restriction --the level of debt that can be carried by the firm decreases with its net worth, and net worth varies with changes in the exchange rate in the case of firms having foreign currency assets and/or liabilities. Profit maximization determines a demand function for capital goods that depends on a competitiveness and a balance sheet effect, as in (2). The former is associated with the fact that a devaluation enhances the demand for locally produced goods, while the latter depends on the firm´s financing structure, with net worth of a firm indebted in foreign currency declining as a result of a devaluation. The net effect of a devaluation over

[6] Also, $\eta_{it} = \varepsilon_{it} + \alpha_i + \delta_t$ with $\varepsilon_{it}$ an idiosyncratic error term, $\alpha_i$ the firm´s non-observable heterogeneous effects and $\delta_t$ the time fixed effects. This framework is base on Whited (1992) and Hubbard *et al*. (1995), where the first-order conditions for a maximizing firm determine a Euler equation relating investment $\left(\frac{I}{K}\right)$ to financial variables and other determinants (Delgado, 2004 and De Brun *et al*., 2003). The specification in (1) follows Gilchrist and Himmelberg (1998) and assumes a quadratic cost function as in Love (2003).

[7] A negative relationshio between investment and leverage is reported by Gallego and Loayza (2000) for the case of Chile, Devereux and Schiantarelli (1989) for the U.K., Jaramillo, Schiantarelli and Weiss (1996) for Ecuador and Harris, Schiantarelli and Siregar (1994) in the case of small firms in Indonesia.

investment is ambiguous; it depends on the amount of foreign currency debt, on the sensitivity of the risk premium to changes in leverage and on the effects of the RER on current/future profits. If a firm´s foreign currency debt is aligned with its possibility of generating foreign currency revenue, it is feasible that it will be these firms whose investment will be more positively sensitive to a real devaluation. Following Beakley & Cowan (2008), we obtain a reduced form equation for investment which can be estimated:

$$\frac{I_{it}}{K_{it-1}} = \gamma\left(\frac{D^*_{it-1}}{K_{it-2}} \times \Delta e_t\right) + \varphi_1 \frac{D^*_{it-1}}{K_{it-2}} + \varphi_2 \Delta e_t + \eta_{it} \qquad (2)$$

Where $I_{it}$ is firm´s $i$ gross investment at time $t$, $K_{it}$ the capital stock, $D^*_{it}$ foreign currency debt, $\Delta e_t$ the percentage change in the RER (where an increase stands for a depreciation)[8]. The key explanatory variable in our analysis is the interaction between the lagged values of foreign debt and changes in the RER. This interaction accounts for the differential effect of a devaluation on firms with distinct levels of foreign currency debt. The sign of the coefficient of this term is ambiguous and depends on the extent to which firms match their foreign currency revenue with their foreign currency liabilities. The sign of $\gamma$ determines whether or not the (negative) balance sheet effect on firms with foreign currency liabilities stemming from a devaluation is compensated by a (positive) competitiveness effect.

## III. Empirical framework

Equations (1) and (2) can be considered jointly without altering the model underpinning each of them. Following Beakley & Cowan´s theoretical framework, the effect of total debt in (1) can be decomposed so as to obtain a joint specification of the following form:

$$\frac{I_{it}}{K_{it-1}} = \beta_1 \frac{I_{it-1}}{K_{it-2}} + \beta_2 \frac{Y_{it-1}}{K_{it-1}} + \beta_3 \frac{Liq_{it-1}}{K_{it-2}} + \beta_4 \frac{D_{it-1}}{K_{it-1}} + \gamma\left(\frac{D^*_{it-1}}{K_{it-2}} \times \Delta e_t\right) + \varphi_1 \frac{D^*_{it-1}}{K_{it-2}} + \varphi_2 \Delta e_t + \eta_{it} \qquad (3)$$

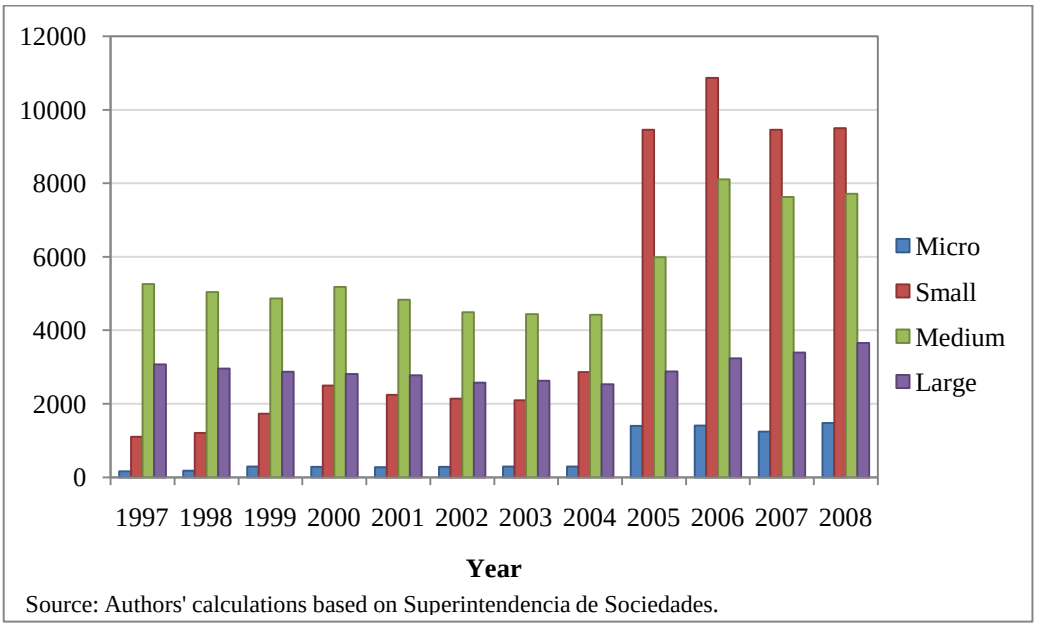
[8] Also, $\eta_{it} = \varepsilon_{it} + \alpha_i + \delta_t$ with $\varepsilon_{it}$ an idiosyncratic error term, $\alpha_i$ the firm´s non-observable heterogeneous effects and $\delta_t$ time fixed effects.

This joint specification captures the direct effect on investment of credit restrictions associated with leverage ($D_i$) and of financing with own resources ($Liq_i$) as well as the indirect effects that arise from the impact of exchange rate changes on the value of a firm´s foreign debt ($D_i^* \times \Delta e$).

## 1. The data base

Our original date base consists of a panel averaging 13.800 firms per year during 1997-2008, with information from the balance sheet and income statements that these firms have provided to the Superintendencia de Sociedades (SS in what follows). Figure 1 shows the evolution over time, by size, of the number of firms that reported to the SS.

**Figure 1. Number of Firms**




Source: Authors' calculations based on Superintendencia de Sociedades.

**As a result of changes in reporting requirements, the number of micro & small firms reporting to the SS increased significantly after 2005. Prior to 2004 only medium & large firms had to report their financial statements to the SS and, as a result, most that did were medium or large. In 2005 it was decided that size was not the only factor determining whether or not firms should report; as a result, many micro & small firms started to report. With the purpose of having a balanced, representative and consistent sample across time and in order to avoid selection bias problems[9], our analysis is based on those firms that throughout our sample period were under SS vigilance (i.e. medium & large firms). It is relevant to note that micro & small firms held no foreign debt and undertook, on average during 1997-2008, only 2% of overall investment (Table 1). In**

Table 2 we report the yearly evolution of the number of medium & large firms within our sample.

[9] If we were to include the micro & small firms that report after 2005, this would bias the 1997-2004 sample because firms that did not report during that period did not do so not because they did not exist, but rather because they faced a low ex ante probability of having to report –in contrast to a much higher probability after 2005. Only medium & large firms faced the same probability of having to report before and after 2004.

**Table 1. Investment and Foreign Debt, 1997-2008**

| | Average share | |
|---|---|---|
| **Size** | Investment | Foreign Debt |
| Large | 86% | 94% |
| Medium | 12% | 6% |
| Small | 20% | 0% |
| Micro | 0% | 0% |

Source: Authors' calculations based on SS.

**Table 2: Number of Firms in Our Sample**

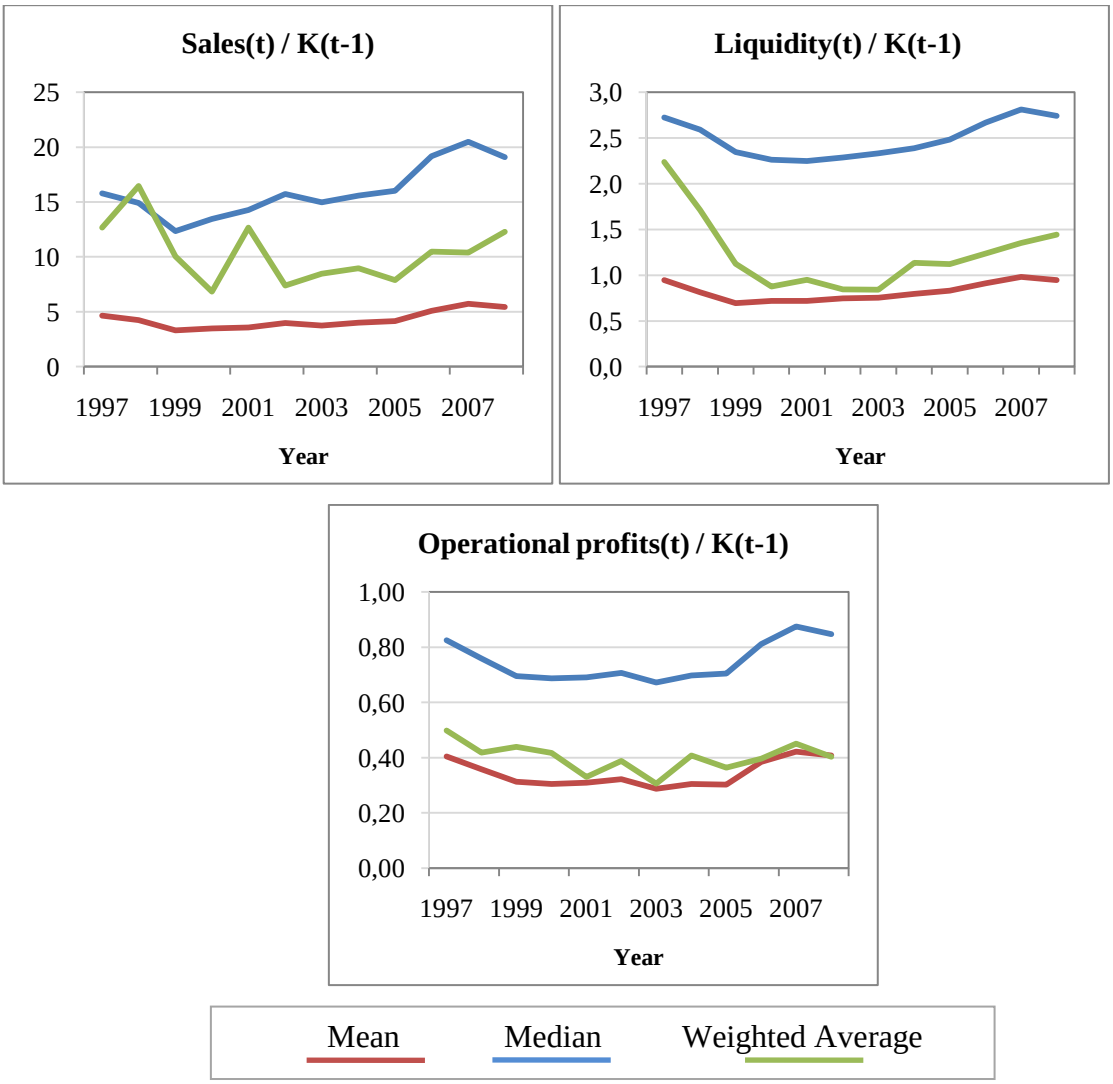
| Year | Medium | Large | Total |
|---|---|---|---|
| 1997 | 5.260 | 3.071 | 8.331 |
| 1998 | 5.043 | 2.956 | 7.999 |
| 1999 | 4.863 | 2.868 | 7.731 |
| 2000 | 5.176 | 2.814 | 7.990 |
| 2001 | 4.833 | 2.780 | 7.613 |
| 2002 | 4.496 | 2.575 | 7.071 |
| 2003 | 4.439 | 2.626 | 7.065 |
| 2004 | 4.421 | 2.531 | 6.952 |
| 2005 | 5.987 | 2.882 | 8.869 |
| 2006 | 8.108 | 3.236 | 11.344 |
| 2007 | 7.630 | 3.398 | 11.028 |
| 2008 | 7.713 | 3.656 | 11.369 |
| **Total** | 78.660 | 41.376 | 120.036 |

Source: Authors' calculations based on SS.

Figure 2 reports the mean, median and weighted mean[10] of some key variables used in our econometric exercises. They are all expressed as a proportion of the capital stock at the beginning of the period. Sales correspond to total operational income; liquidity is the difference between current assets and liabilities (Arbeláez and Echavarría, 2002). Profits are proxied by operational profits. The consistently large difference between mean and median is a sign of the asymmetry in the empirical distribution of each variable. Weighted averages provide a time series for each variable that more closely resembles what one should expect given the known evolution of some of these variables at the aggregate level.

[10] Variables are weighted by assets.

**Figure 2. Sales, Liquidity and Profits**



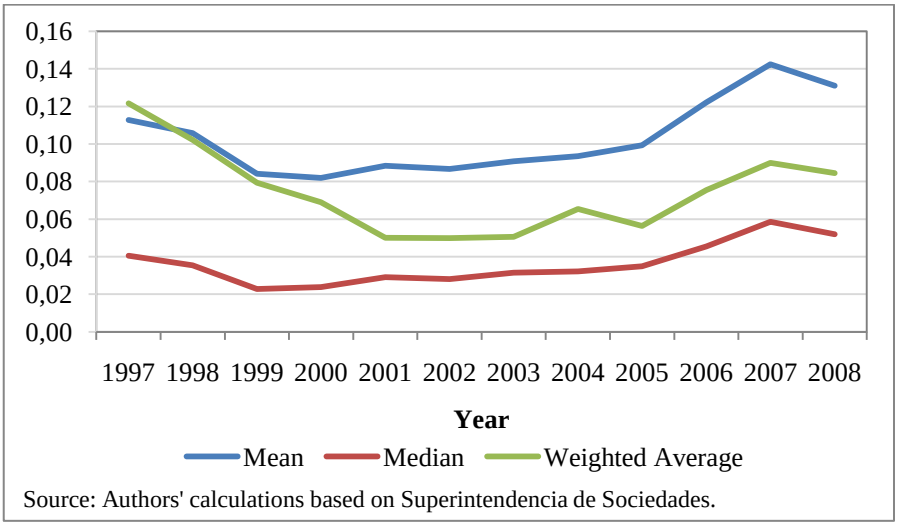

Source: Authors' calculations based on SS. Note: Weights based on total assets.

Some variables critical to our analysis –particularly, capital goods and financial obligations– are available only in the annexes to the financial statements. Unfortunately, only around 90% of firms report these annexes. As a result, the number of firms considered in our estimations declines as the number of variables of interest increases[11]. Investment is defined as purchases of machinery and equipment (including office, transportation & communication and computing equipment)[12]. The capital stock is the final book value of machinery and equipment. Foreign debt is the domestic currency value of financial debt

[11] Table A1 in the Appendix provides information on the percentage of firms that report both financial statements and annexes every year.
[12] Information obtained from Annex 9 – Property, plant and equipment.

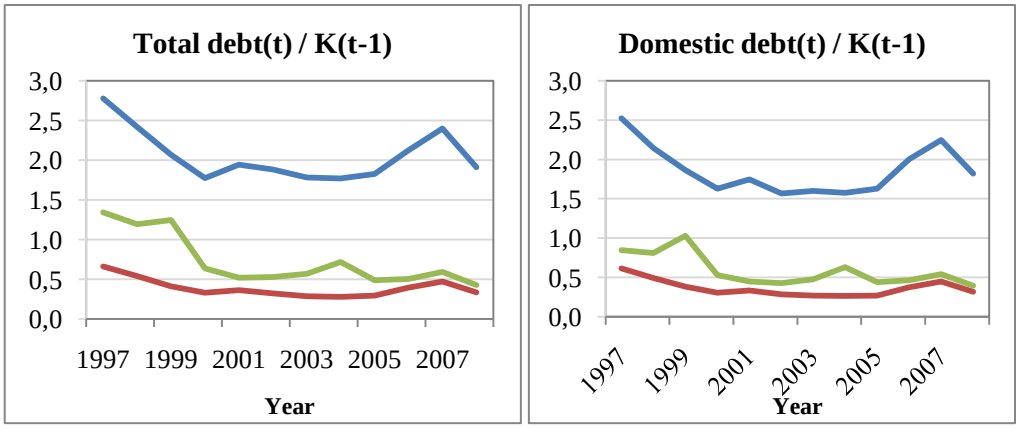
contracted in foreign currency[13]. Total debt includes all short term and long term financial obligations. Figure 3 and Figure 4 show the evolution of the mean, median and weighted average of these variables, expressed in relation to the capital stock. It is important to note that the median for foreign currency debt is always zero –i.e. more than 50% of medium & large firms have no foreign debt. On average only 10% of large firms have any foreign debt, a percentage that falls to 2 in the case of medium-sized firms[14].

**Figure 3. Investment(t)/K(t-1)**

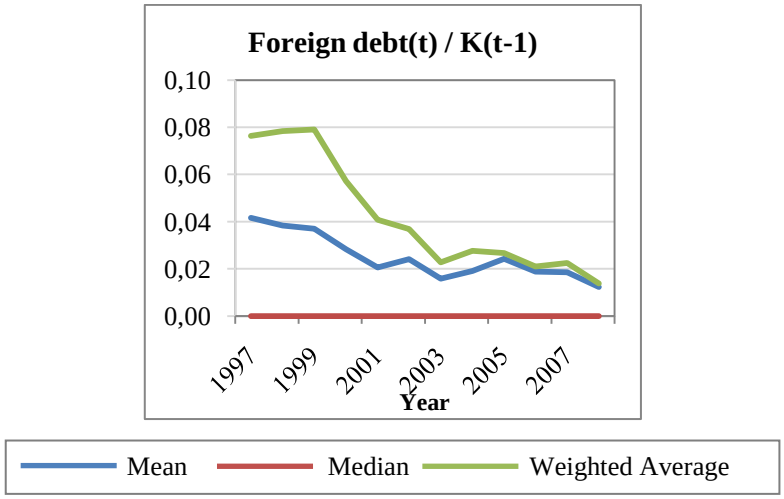



Source: Authors' calculations based on Superintendencia de Sociedades.

**Figure 4: Indebtedness**



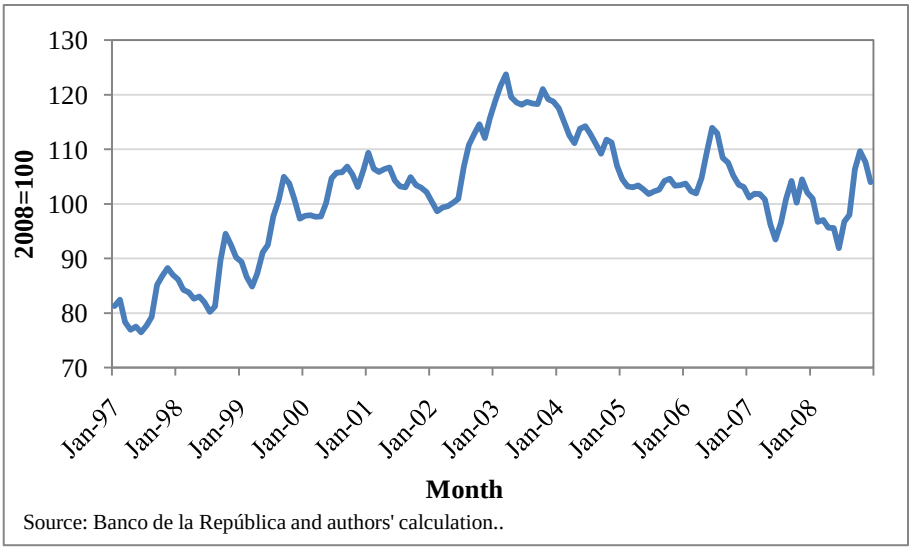

[13] Does not include suppliers credit denominated in foreign currency. Because banks in Colombia cannot make loans in foreign currency, the value of foreign currency denominated debt matches the value of foreign debt. Thus, hereafter we will use both terms interchangeably.
[14] See Table A2 for a detailed description.




Source: Authors' calculations based on SS. Note: Weights based on total assets.

The real exchange rate is the RER index provided by Banco de la República, which is computed as a weighted average of bilateral real exchange rates (Figure 5). The real exchange rate devaluation is estimated as the percentage change in the RER. [15]

**Figure 5: Real Exchange Rate Index (RER)**




Source: Banco de la República and authors' calculation..

[15] The weights are monthly, and are calculated as a 12 month moving average of the sum of exports – excluding coffee, oil, coal, nickel, emeralds and gold-- and imports for Colombia´s 20 main trading partners. Both domestic and foreign producer prices are used as deflators –with the exceptions of Ecuador, Panama and France, in which consumer prices (CPI) are used. In exercises not reported but available with the authors we use different specifications for the real exchange rate, including one using the CPI as deflator. Results are robust to different RER definitions.

We have excluded outliers for all variables. This was done year by year for each variable, expressed as a proportion of the capital stock. Since for all variables the median is consistently smaller than the mean (figures 2 to 4), the empirical distribution in each case has a positive bias. On account of this, and in order to avoid selection bias that might lead to biased estimators, we exclude the lower 1% and the upper 5% of observations. Table 3 reports some descriptive statistics, once outliers have been excluded.

**Table 3. Descriptive Statistics**

| | Statistics | | | | |
|---|---|---|---|---|---|
| Variable | Mean | Standard deviation | Min | Max | Median |
| I/K | 0,11 | 0,18 | 0,00 | 1,03 | 0,04 |
| Sales/K | 17,71 | 41,46 | 0,00 | 460,82 | 4,62 |
| Exports/K | 0,61 | 3,66 | 0,00 | 83,95 | 0,00 |
| Imports/K | 1,09 | 5,30 | 0,00 | 94,42 | 0,00 |
| Total Debt/K | 2,37 | 7,24 | 0,00 | 92,92 | 0,43 |
| Domestic Debt/K | 2,15 | 6,40 | 0,00 | 81,16 | 0,39 |
| Foreign Debt/K | 0,03 | 0,19 | 0,00 | 3,07 | 0,00 |
| Liquidity/K | 2,67 | 4,75 | -1,62 | 29,53 | 0,88 |
| Operational profits/K | 0,80 | 1,07 | 0,00 | 5,82 | 0,37 |

Source: Authors' calculations based on SS.

## 2. Estimation strategy

We use a *Generalized Method of Moments* (GMM), designed to provide consistent estimators in panel data when there is non-observable time-invariant heterogeneity (fixed effects), simultaneous determination of some exogenous variables and the endogenous variable, or reverse causality and inertia of the endogenous variable, which may generate autocorrelation[16]. When we estimate (3) we must deal with these three problems: there are non-observable firm level variables that do not change in time, for example the city where it operates; some independent variable such as sales or debt, might be jointly determined

[16] These problems imply that OLS lead to inconsistent estimators, biased towards large coefficients. Bond (2002) shows that estimations under fixed effects produce estimators that are biased downwards. On account of this, some authors report both estimators, as an upper and a lower bound of the consistent estimator.

with investment, so we must control for joint endogeneity of explanatory variables; a significant effect from lagged investment might generate autocorrelation problems.[17]

Notwithstanding its appeal, this methodology is not problem-free. Arellano and Bover (1995) and Blundell and Bond (1998) show that lagged variables are weak instruments for variables in first differences when the number of years in the panel is small (i.e. $T \leq 10$) and there exists persistence in investment (i.e. $\beta_1 \approx 1$) or high values for the relation $\frac{\text{var}(\alpha_i)}{\text{var}(\varepsilon_{it})}$. These authors argue in favor of a system composed of an equation in levels and another in first differences, a GMM-system. In order to instrument the variables in the equation in differences, lagged values of the variables in levels are once again used, while lags of the differences are used to instrument the variables in levels[18]. Finally, the GMM-system estimation is undertaken using a two-step estimator, which is robust and efficient in the context of any pattern of heteroscedasticity or autocorrelation[19].

## IV. General results

### 1. Investment

Table 4 reports estimations of equations (1) and (3), in each case considering both time and firm fixed effects. Column (1) shows the estimated coefficients for equation (1). The main conclusions derived from this specification are:

i. Lagged investment has a positive and significant effect on current investment; i.e. there are adjustment costs, presumably related to capital market imperfections.

[17] The GMM-differences estimation methodology first advanced by Holtz-Eakin *et al* (1988) and further developed by Arellano and Bond (1991) uses first differences to remove firm fixed effects. In order to deal with endogeneity, this methodology uses lags of the variables in levels as instruments for their first differences, thereby avoiding the strict exogeneity assumption. The weak exogeneity assumption, which implies that future innovations in investment do not affect previous realizations of the independent variables, can be verified with the tests described below. In general, variables such as the real exchange rate and the dummy variables can be considered to be strictly exogenous.

[18] The GMM-system estimator will be consistent only if the instruments are valid –i.e. if they satisfy the restrictions imposed by the additional moments condition, for which a Sargan test is used. Since this test is not robust when there are several instruments or in the presence of heteroscedasticity and autocorrelation, we also report Hansen´s *J* statistic. Likewise, we can test for serial autocorrelation of innovations $\varepsilon_{it}$ by verifying that there is first-order serial correlation in the differences and no second-order correlation.

[19] However, since this estimator can produce downward-biased standard errors when the number of instruments is large, in all of our estimations standard errors are computed using the correction for small samples proposed by Windmeijer (2000).

ii. Liquidity, a proxy for cash flow, is a positive and significant determinant of investment. This is indicative of firms restricted access to external financing.

iii. Additional support for these restrictions comes from the negative (and significant) effect of firm debt on investment.

iv. Sales also have a positive and significant effect on investment.

v. It is important to note that the above effects, both in significance and in magnitude, are robust to the different specifications.

Column (2) controls for the direct effect of changes in the real exchange rate (where a positive change stands for a devaluation). Changes in the RER have no significant effect on investment, even after controlling for the effects of each sector (more on this below, in Table 7). Column (3) is similar to (2), with foreign debt replacing total debt. In (3) neither lagged foreign debt nor RER changes affect investment.

What happens if we control for the differential effect that a real devaluation can have on investment, depending on a firm´s exposure to foreign debt? In column (4) we include the interaction term$(D_i^* \times \Delta e)$. We find no evidence of such a differential effect. Finally, in column (5) we control for domestic debt and, once again, we find no effect on investment from changes in foreign debt or in the RER or from the interaction term.

**Table 4: Investment regressions (1997-2008)**

Dynamic panel-data estimation, two-step system GMM

Dependent variable: I/K(t)

| **Variables** | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| I/K(t-1) | 0.091*** | 0.091*** | 0.093*** | 0.093*** | 0.085*** |
| | (0.014) | (0.014) | (0.013) | (0.013) | (0.014) |
| I/K(t-2) | 0.031*** | 0.031*** | 0.036*** | 0.036*** | 0.023** |
| | (0.009) | (0.009) | (0.008) | (0.008) | (0.010) |
| Y(t-1) | 0.001*** | 0.001*** | 0.001*** | 0.001*** | 0.001* |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Liq(t-1) | 0.005** | 0.005** | 0.005*** | 0.005*** | 0.006** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| Total Debt(t-1) | -0.005*** | -0.005*** | | | |
| | (0.002) | (0.002) | | | |
| ΔRER(t) | | 0.367 | 0.376 | 0.377 | 0.379 |
| | | (0.284) | (0.271) | (0.271) | (0.288) |
| Foreign Debt(t-1) | | | 0.007 | 0.007 | 0.015 |
| | | | (0.011) | (0.012) | (0.015) |
| Domestic Debt(t-1) | | | | | -0.003* |
| | | | | | (0.002) |
| Foreign Debt(t-1)*ΔRER(t) | | | | 0.024 | 0.027 |
| | | | | (0.214) | (0.242) |
| Constant | 0.080*** | 0.093*** | 0.085*** | 0.085*** | 0.097*** |
| | (0.006) | (0.009) | (0.009) | (0.009) | (0.010) |
| Time Effects | Yes | Yes | Yes | Yes | Yes |
| Number of firms | 8121 | 8121 | 8648 | 8648 | 8083 |
| Wald Test ($\chi^2$) | 591.317 | 591.317 | 659.545 | 660.483 | 534.982 |
| Prob > $\chi^2$ | 0 | 0 | 0 | 0 | 0 |
| Observation per firm: | | | | | |
| Min | 1 | 1 | 1 | 1 | 1 |
| Max | 10 | 10 | 10 | 10 | 10 |
| Average | 4.5 | 4.5 | 4.8 | 4.8 | 4.5 |
| Number of instruments | 142 | 142 | 142 | 142 | 100 |
| Hansen | 107.7 | 107.7 | 156.6 | 156.5 | 82.70 |
| Hansen (p-values) | 0.892 | 0.892 | 0.0384 | 0.0338 | 0.488 |
| Arellano-Bond AR(1) | -24.14 | -24.14 | -26.21 | -26.21 | -24.31 |
| AR(1) p-values | 0 | 0 | 0 | 0 | 0 |
| Arellano-Bond AR(2) | 0.641 | 0.641 | 0.289 | 0.295 | 0.821 |
| AR(2) p-values | 0.522 | 0.522 | 0.773 | 0.768 | 0.411 |

Standard errors robust to heteroskedasticity and arbitrary pattems of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

Lags *t-1*, *t-2*, *t-3* and *t-4* included as instruments for GMM difference equations. Equation (5) includes only *t-1*, *t-2* lags as instrumets.

In summary, we identified a negative and significant effect of total debt on investment (col. 1). When we disaggregate total debt into its domestic and foreign components (col. 5), we find that all the effect stems from its local currency component. This is probably due to the

fact that while foreign debt is an important component of total debt for those firms carrying foreign debt[20], only 7% of all medium & large firms carry any foreign currency debt at all.

From a strictly econometric viewpoint, finding no significant effect for the interaction between foreign debt and RER changes might be a consequence of the fact that the number of firms carrying any foreign debt at all is very small in relation to the number of firms for which the dependent variable (investment) is available and/or that those firms that do carry foreign debt are prudent in avoiding significant balance sheet mismatches, either through "natural" hedging or through the use of financial instruments for hedging exchange rate risk. In order to verify this hypothesis, in Table 5 we report two regressions in which we introduce the interaction between *total* debt and changes in the RER[21].

In column (2) we include the liquidity variable (cash flow) in order to assess the existence of financial constraints. The positive and significant sign confirms that firms face financial constraints when investing, something to be expected in imperfect credit markets with information asymmetries. Moreover, the negative sign of the total debt coefficient also suggests that firms have hit the leverage ceiling. These findings are in line with other Colombian studies, including Arbeláez & Echavarría (2002) and Delgado (2004).

In the estimation reported in column (2) we include an interaction term between *total* debt and changes in RER in order to control for the fact that very few firms in the sample have foreign debt (as shown in Table A2). The fact that the level of foreign debt (as a proportion of capital) declined over the sample period has been at the expense of a slight increase in domestic debt (as illustrated in Figure 4). The estimation supports the following conclusions: (i) once again the main determinants of the Euler equation have their expected (and significant) sign; (ii) both the direct and the interacted effect of foreign debt continue to be non-significant; (iii) importantly, there exists a positive differential effect of a devaluation depending on a firm´s total debt. The sign of the interaction term $(D_i^{Total} \times \Delta e)$ implies that firms with higher *total* debt report higher investment following a devaluation[22]. This probably implies that any negative effect in terms of net worth declining as a result of a devaluation is more than compensated by the positive effect of a

[20] On average, 48% in large and 53% in medium-sized firms.

[21] While total debt is available for all firms, evidently the effects of RER changes are only relevant for those firms for which a part of its debt is denominated in foreign currency.

[22] The estimated coefficient for the interaction term $(D_i^{Total} \times \Delta e)$ implies that a firm having a total debt level that surpasses the mean level by one standard deviation will, ceteris paribus, invest 6% following a 10% real depreciation.

devaluation on present and future income[23]. As we will see below, the analysis regarding the currency composition of debt indicates that exporting firms are more likely to carry foreign debt and the foreign debt they carry is larger. This points to "natural matching" between foreign currency revenue and liabilities. Of course, the effects of an appreciation work in much the same way. In particular, any positive balance sheet effect arising from an appreciation is more than compensated by its negative competitiveness effect. Evidently, the existence of some sort of natural hedge does not imply that firm performance is *neutral* to changes in the exchange rate. While one would not recommend hedging away the benefits stemming from a currency depreciation, it would obviously make sense to hedge the risks arising from an appreciation. Under a floating exchange rate regime, it is of course not possible to cherry pick, and firms should in principle hedge always. Unfortunately, there is evidence for the case of Colombia that exchange rate flexibility has been asymmetric, with the central bank much more willing to let the peso freely float when it is on a weakening trend than when the trend is towards its strengthening[24]. The case can be made that these revealed asymmetric preferences from the central bank have also deterred the use of hedging instruments. After all, the central bank leans against the wind in times of pressures towards the strengthening of the peso –strengthening that would hurt firm investment and profitability—but allows the currency to freely float when pressures arte towards a weakening of the currency. This implicit insurance provided by the central bank appears to compete with explicit insurance instruments provided by the private sector.

[23] As we report below, a devaluation does indeed have a positive and significant effect on profits.
[24] See for example Kamil (2008) and Arbeláez and Steiner (2009).

## Table 5: Investment Regressions Controlling for Total Debt

Dynamic panel-data estimation, two-step system GMM, 1997-2008

| Dependent variable: I/K(t) | | |
|---|---|---|
| **Variables** | (1) | (2) |
| I/K(t-1) | 0.099*** | 0.082*** |
| | (0.014) | (0.014) |
| I/K(t-2) | 0.027*** | 0.023** |
| | (0.009) | (0.010) |
| Y(t-1) | 0.001** | 0.001** |
| | (0.000) | (0.000) |
| Liq(t-1) | | 0.006** |
| | | (0.002) |
| Total Debt(t-1) | -0.001 | -0.003* |
| | (0.001) | (0.002) |
| Total Debt(t-1)*ΔRER(t) | 0.016* | 0.044*** |
| | (0.009) | (0.016) |
| ΔRER(t) | 0.411 | 0.335 |
| | (0.281) | (0.287) |
| Foreign Debt(t-1) | 0.012 | 0.019 |
| | (0.013) | (0.015) |
| Foreign Debt(t-1)*ΔRER(t) | 0.005 | 0.010 |
| | (0.184) | (0.241) |
| Constant | 0.107*** | 0.095*** |
| | (0.009) | (0.010) |
| Time Effects | Yes | Yes |
| Number of firms | 8489 | 8084 |
| Wald test ($\chi^2$) | 565.7 | 542.1 |
| Prob > $\chi^2$ | 0 | 0 |
| Observation per firm: | | |
| Min | 1 | 1 |
| Max | 10 | 10 |
| Average | 4.5 | 4.5 |
| Number of instruments | 100 | 100 |
| Hansen | 80.32 | 77.78 |
| Hansen (p-values) | 0.563 | 0.611 |
| Arellano-Bond AR(1) | -25.47 | -24.37 |
| AR(1) p-values | 0.000 | 0.000 |
| Arellano-Bond AR(2) | 0.362 | 0.801 |
| AR(2) p-values | 0.717 | 0.423 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.
*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

Lags *t-1*, *t-2* included as instruments for GMM difference equations.

## 2. Robustness check

In this section we control for omitted factors that are potentially relevant in determining a firm´s investment decisions. First, we control for each firm´s exports and imports, and verify that our previous findings continue to hold. To account for this possibility, we control for (lagged) exports and imports as well as for the interaction of each of them with changes in the RER. Results are reported in Table 6. In column (1) we include domestic debt, in column (2) total debt. Interestingly, in both cases sales cease to be a significant determinant of investment. This is due to the fact that total operational income of exporting firms is highly correlated with income generated abroad (i.e. exports). Also, neither exports nor imports have a significant effect on investment[25].

In Table 7 we control for possible differentiated effects according to the sector to which the firm belongs (at the ISIC 1-digit level). Results show that the findings reported in tables 4 and 5 are robust to the inclusion of sectoral differences in the reaction of investment to changes in the RER. In particular, we once again observe that, after controlling for all relevant variables, a RER devaluation has a positive differential effect on firms having higher levels of total debt. On the other hand, it is possible that a firm might invest more following a devaluation not because the firm itself directly sees its competitiveness enhanced (i.e. its exports), but rather because it belongs to an import-competing sector that is likely to see its domestic sales expand as a result of a devaluation acting as a deterrent of its foreign competitors. In order to assess this possible channel of influence, we interact changes in the RER with a sector dummy to account for the sector to which the firm belongs[26]. The results reported in Table 7 suggest that firms in two sectors –mining & quarrying and transport, storage and communications— do enhance their investment as a result of a RER devaluation.

Finally, we control for firm size with a *dummy* variable in which, following the SS, a firm is considered medium or large according to the value of its assets. Results are reported in Table 8. Columns (1) to (3) include the size dummy variable and, alternatively, domestic and total debt. On average, medium-sized firms invest less (as a proportion of

[25] Table A3 in the Appendix reports the distribution of exporting and importing firms in the sample. We ran regressions controlling for years and sectors and same results were obtained.

[26] In order to avoid perfect multicolinearity among the $ISIC \times \Delta e$ interactions, we exclude the interaction for the aggregate sector denominated *other sectors*. Therefore, the coefficient of $\Delta e$ captures the effect on the other sectors.

their capital stock) than large firms. We once again find no direct effect on investment of changes in the RER, and a positive differential effect on investment of RER changes depending on the total level of debt. In order to determine whether this differential effect is affected by firm size, in column (4) we include the interaction term ($D_i^{\text{Total}} \times \Delta e \times \text{Size}$). The lack of significance of this term suggests that the effect of the interaction term ($D_i^{\text{Total}} \times \Delta e$) is the same for medium and for large firms.

## Table 6: Investment Regressions Controlling for Imports and Exports

Dynamic panel-data estimation, two-step system GMM, 1997-2008

| Dependent variable: I/K(t) | | |
|---|---|---|
| **Variables** | (1) | (2) |
| I/K(t-1) | 0.083*** | 0.083*** |
| | (0.015) | (0.015) |
| I/K(t-2) | 0.022** | 0.023** |
| | (0.010) | (0.010) |
| Y(t-1) | 0.000 | 0.000 |
| | (0.000) | (0.000) |
| Liq(t-1) | 0.005** | 0.005** |
| | (0.002) | (0.002) |
| Total Debt(t-1) | | -0.002 |
| | | (0.002) |
| Total Debt(t-1)*ΔRER(t) | | 0.031* |
| | | (0.016) |
| ΔRER(t) | 0.382 | 0.351 |
| | (0.289) | (0.289) |
| Foreign Debt(t-1) | 0.012 | 0.015 |
| | (0.015) | (0.015) |
| Foreign Debt(t-1)*ΔRER(t) | -0.071 | -0.070 |
| | (0.239) | (0.238) |
| Domestic Debt(t-1) | -0.002 | |
| | (0.002) | |
| Export(t-1) | 0.002 | 0.002 |
| | (0.002) | (0.002) |
| Export(t-1)*ΔRER(t) | -0.010 | -0.012 |
| | (0.017) | (0.018) |
| Imports(t-1) | -0.001 | -0.001 |
| | (0.001) | (0.001) |
| Imports(t-1)*ΔRER(t) | 0.012 | 0.009 |
| | (0.016) | (0.016) |
| Constant | 0.102*** | 0.101*** |
| | (0.010) | (0.010) |
| Time Effects | Yes | Yes |
| Number of firms | 8026 | 8027 |
| Wald Test ($\chi^2$) | 524.607 | 527.344 |
| Prob > $\chi^2$ | 0.000 | 0.000 |
| Number of instruments | 136 | 136 |
| Hansen (p-values) | 0.297 | 0.308 |
| AR(1) p-values | 0.000 | 0.000 |
| AR(2) p-values | 0.604 | 0.629 |

Standard errors robust to heteroskedasticity and arbitrary pattems of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.
** denotes significance at the 99% level, ** at the 95%, * at the 90%.
Lags *t-1*, *t-2* included as instruments for GMM difference equations.

## Table 7: Investment Regressions Controlling for Sectors

Dynamic panel-data estimation, two-step system GMM, 1997-2008

| Dependent variable: I/K(t)<br>**Variables** | (1) |
|---|---|
| I/K(t-1) | 0.082*** |
| | (0.014) |
| I/K(t-2) | 0.023** |
| | (0.010) |
| Y(t-1) | 0.001** |
| | (0.000) |
| Liq(t-1) | 0.006** |
| | (0.002) |
| Total Debt(t-1) | -0.003* |
| | (0.002) |
| Total Debt(t-1)*ΔRER(t) | 0.046*** |
| | (0.016) |
| ΔRER(t) | 0.284 |
| | (0.296) |
| Foreign Debt(t-1) | 0.018 |
| | (0.015) |
| Foreign Debt(t-1)*ΔRER(t) | -0.004 |
| | (0.240) |
| Constant | 0.093*** |
| | (0.009) |
| ISIC(A) - Agriculture, hunting and forestry | 0.007* |
| | (0.004) |
| ISIC(C) - Mining and quarrying | 0.045*** |
| | (0.010) |
| ISIC(D) - Manufacturing | -0.001 |
| | (0.003) |
| ISIC(E) - Electricity, gas and water supply | -0.017 |
| | (0.022) |
| ISIC(F) - Construction | -0.008 |
| | (0.007) |
| ISIC(G) - Wholesale and retail trade | 0.006 |
| | (0.008) |
| ISIC(I) - Transport, storage and communications | 0.030*** |
| | (0.006) |
| ISIC(J) - Financial intermediation | -0.025*** |
| | (0.007) |
| ISIC(A)*ΔRER(t) | -0.008 |
| | (0.117) |
| ISIC(C)*ΔRER(t) | 0.032 |
| | (0.263) |
| ISIC(D)*ΔRER(t) | 0.087 |
| | (0.090) |
| ISIC(E)*ΔRER(t) | -1.354 |
| | (0.828) |
| ISIC(F)*ΔRER(t) | -0.093 |
| | (0.132) |
| ISIC(G)*ΔRER(t) | 0.054 |
| | (0.101) |
| ISIC(I)*ΔRER(t) | 0.310* |
| | (0.181) |
| ISIC(J)*ΔRER(t) | -0.036 |
| | (0.204) |
| Time Effects | Yes |

| **Table 7. (*Continued*)** | | |
|---|---|---|
| Number of firms | | 8084 |
| Wald Test ($\chi^2$) | | 851 |
| Prob > $\chi^2$ | | 0.000 |
| Observation per firm: | | |
| | Min | 1 |
| | Max | 10 |
| | Average | 4.5 |
| Number of instruments | | 78.59 |
| Hansen | | 0.586 |
| Hansen (p-values) | | -24.41 |
| Arellano-Bond AR(1) | | 0.000 |
| AR(1) p-values | | 0.775 |
| Arellano-Bond AR(2) | | 0.438 |
| AR(2) p-values | | |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction. *** denotes significance at the 99% level, ** at the 95%, * at the 90%.

Lags *t-1*, *t-2* included as instruments for GMM difference equations.

## Table 8: Investment Regressions Controlling for Firm Size

Dynamic panel-data estimation, two-step system GMM, 1997-2008

| Dependent variable. I/K(t) | | | | |
|---|---|---|---|---|
| **Variables** | (1) | (2) | (3) | (4) |
| I/K(t-1) | 0.087*** | 0.084*** | 0.084*** | 0.085*** |
| | (0.014) | (0.014) | (0.014) | (0.014) |
| I/K(t-2) | 0.024** | 0.024** | 0.024** | 0.024** |
| | (0.010) | (0.010) | (0.010) | (0.010) |
| Y(t-1) | 0.001* | 0.001** | 0.001** | 0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Liq(t-1) | 0.006** | 0.006** | 0.006** | 0.006** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Total debt(t-1) | | -0.003* | -0.003* | -0.004* |
| | | (0.002) | (0.002) | (0.002) |
| ΔRER(t) | 0.350 | 0.307 | 0.307 | 0.328 |
| | (0.288) | (0.287) | (0.287) | (0.288) |
| Foreign Debt(t-1) | 0.015 | 0.019 | 0.019 | 0.019 |
| | (0.015) | (0.015) | (0.015) | (0.015) |
| Domestic Debt(t-1) | -0.004* | | 0.045*** | 0.094 |
| | (0.002) | | (0.016) | (0.066) |
| Foreign Debt(t-1)*ΔRER(t) | 0.033 | 0.015 | 0.015 | -0.018 |
| | (0.242) | (0.240) | (0.240) | (0.242) |
| Total Debt(t-1)*ΔRER(t) | | 0.045*** | 0.045*** | 0.094 |
| | | (0.016) | (0.016) | (0.066) |
| Total Debt*ΔRER(t)*Size | | | | -0.095 |
| | | | | (0.120) |
| size(medium) | -0.016*** | -0.017*** | 0.104*** | 0.106*** |
| | (0.002) | (0.002) | (0.010) | (0.010) |
| Constant | 0.107*** | 0.104*** | -0.017*** | -0.018*** |
| | (0.010) | (0.010) | (0.002) | (0.003) |
| Time Effects | Yes | Yes | Yes | Yes |
| Number of firms | 8083 | 8084 | 8084 | 8084 |
| Wald test ($\chi^2$) | 590.9 | 599.6 | 599.6 | 594.4 |
| Prob > $\chi^2$ | 0 | 0 | 0 | 0 |
| Observation per firm: | | | | |
| Min | 1 | 1 | 1 | 1 |
| Max | 10 | 10 | 10 | 10 |
| Average | 4.499 | 4.499 | 4.499 | 4.499 |
| Number of instruments | 101 | 101 | 101 | 101 |
| Hansen | 83.83 | 78.34 | 78.34 | 78.16 |
| Hansen (p-values) | 0.454 | 0.594 | 0.594 | 0.569 |
| Arellano-Bond AR(1) | -24.30 | -24.37 | -24.37 | -24.38 |
| AR(1) p-values | 0.000 | 0.000 | 0.000 | 0.000 |
| Arellano-Bond AR(2) | 0.873 | 0.861 | 0.861 | 0.870 |
| AR(2) p-values | 0.383 | 0.389 | 0.389 | 0.384 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.
*** denotes significance at the 99% level, ** at the 95%, * at the 90%.
Lags *t-1*, *t-2* included as instruments for GMM difference equations.

## 3. Profits

The fact that a devaluation has a positive indirect effect on investment that depends on a firm´s total level of debt implies that the *competitiveness effect* more than compensates for any negative *balance sheet effect* associated with a decline in net worth of firms indebted in foreign currency. That being the case, a RER devaluation should have a positive and significant effect on profits. In Table 9 we report estimates of the Beakley & Cowan model, using as dependent variable operational profits (as a proportion of the capital stock at the beginning of the period). We find that (i) a RER devaluation has a positive and significant effect on profits, an effect that is symmetric in the case of a RER appreciation, bearing in mind that the central bank has revealed a preference for intervention in the foreign exchange market when the currency is experiencing pressures towards appreciation; (ii) total debt has a negative and significant effect; (iii) the interaction of changes in the RER with debt (external and total) is not significant.

In order to check if the level of profits of firms in different sectors may affect the previous results, in the first column of Table 10 we control for sector fixed effects. The main results continue to hold. It is possible that a firm that does not export and is indebted in foreign currency might benefit from a RER devaluation if it happens to actively compete with imports. To account for this differential effect of a devaluation among sectors, in the second column of Table 10 we interact changes in the RER with a sector dummy variable[27]. Results show that the average positive effect of a devaluation on firm´s profits is to a great extent determined by the gains received by firms in mining (the $\Delta RER(t)$ coefficient for firms in this sector becomes 2.846 + 2.045 = 4.891) and wholesale & retail trade (2.045 + 1.095 = 3.14). On the other hand, construction benefits less from devaluations.

[27] So as to avoid perfect multicolinearity, we exclude the aggregate sector denominated *other sectors.*

## Table 9: Profits Regressions

| Dynamic panel-data estimation, two-step system GMM, 1997-2008 | | |
|---|---|---|
| Dependent variable: Profits/K | | |
| **Variables** | (1) | (3) |
| Profits/K(t-1) | 0.272** | 0.274** |
| | (0.112) | (0.115) |
| Total Debt(t-1) | -0.067*** | -0.063* |
| | (0.024) | (0.033) |
| ΔRER(t) | 2.643** | 2.477* |
| | (1.176) | (1.291) |
| Foreign Debt(t-1) | 0.391* | 0.368 |
| | (0.222) | (0.229) |
| Foreign Debt(t-1)*ΔRER(t) | -0.026 | -0.363 |
| | (4.198) | (4.167) |
| Total Debt(t-1)*ΔRER(t) | | 0.143 |
| | | (0.427) |
| Constant | 0.754*** | 0.747*** |
| | (0.073) | (0.080) |
| Time Effects | Yes | Yes |
| Number of firms | 8255 | 8255 |
| Wald Test chi2 | 292.507 | 297.273 |
| Prob > chi2 | 0 | 0 |
| Observation per firm: | | |
| Min | 1 | 1 |
| Max | 11 | 11 |
| Average | 3.750 | 3.750 |
| Number of instruments | 86 | 86 |
| Hansen | 64.54 | 64.03 |
| Hansen (p-values) | 0.692 | 0.678 |
| Arellano-Bond AR(1) | -4.442 | -4.327 |
| AR(1) p-values | 0.000 | 0.000 |
| Arellano-Bond AR(2) | 0.248 | 0.265 |
| AR(2) p-values | 0.804 | 0.791 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

Lags *t-4*, *t-8* included as instruments for GMM difference equations.

**Table 10: Profits Regressions Controlling for Sector**

Dynamic panel-data estimation, two-step system GMM, 1997-2008

| Dependent variable: Profits/K | |
|---|---|
| **Variables** | (1) |
| Profits/K(t-1) | 0.224* |
| | (0.122) |
| Total Debt(t-1) | -0.060** |
| | (0.025) |
| ΔRER(t) | 2.405* |
| | (1.244) |
| Foreign Debt(t-1) | 0.365 |
| | (0.365) |
| Foreign Debt(t-1)*ΔRER(t) | -1.117 |
| | (3.994) |
| Constant | 0.663*** |
| | (0.068) |
| ISIC(A) - Agriculture, hunting and forestry | -0.091** |
| | (0.036) |
| ISIC(C) - Mining and quarrying | 0.140* |
| | (0.081)) |
| ISIC(D) - Manufacturing | -0.080*** |
| | (0.024) |
| ISIC(E) - Electricity, gas and water supply | 0.066 |
| | (0.207) |
| ISIC(F) - Construction | 0.143*** |
| | (0.046) |
| ISIC(G) - Wholesale and retail trade | 0.453*** |
| | (0.060) |
| ISIC(I) - Transport, storage and communications | 0.013 |
| | (0.043) |
| ISIC(J) - Financial intermediation | 0.507*** |
| | (0.082) |
| ISIC(A)*ΔRER(t) | 0.020 |
| | (0.483) |
| ISIC(C)*ΔRER(t) | 2.846* |
| | (1.563) |
| ISIC(D)*ΔRER(t) | 0.239 |
| | (0.376) |
| ISIC(E)*ΔRER(t) | -4.134 |
| | (5.831) |
| ISIC(F)*ΔRER(t) | -1.777** |
| | (0.808) |
| ISIC(G)*ΔRER(t) | 1.095** |
| | (0.505) |
| ISIC(I)*ΔRER(t) | 1.203 |
| | (0.906) |
| ISIC(J)*ΔRER(t) | -1.767 |
| | (1.906) |
| Time Effects | Yes |

| **Table 10. (*Continued*)** | | |
|---|---|---|
| Number of firms | | 8255 |
| Wald Test ($\chi^2$) | | 1373 |
| Prob > $\chi^2$ | | 0.000 |
| Observation per firm: | | |
| | Min | 1 |
| | Max | 11 |
| | Average | 3.8 |
| Number of instruments | | 102 |
| Hansen | | 65.20 |
| Hansen (p-values) | | 0.672 |
| Arellano-Bond AR(1) | | -3.783 |
| AR(1) p-values | | 0.000 |
| Arellano-Bond AR(2) | | -0.210 |
| AR(2) p-values | | 0.833 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses. Standard errors were computed using Windmeijer finite-sample correction.
*** denotes significance at the 99% level, ** at the 95%, * at the 90%.
Lags *t-1*, *t-2* included as instruments for GMM difference equations.

In order to make better sense of these results, in Table 11 we report some interesting descriptive statistics of our database at the sector level. Some important features that emerge include the following:

i. In relation to total sales, the largest sectors in our sample is manufacturing (41.7% of total sales), followed by wholesale & retail trade (31.8%), construction (5.2%), agriculture (4.7%), transport & communications (4.1%), mining (3.2%) and financial intermediation (1.5%).

ii. In agriculture, debt in foreign currency is low (only 0.9% of total debt within the sector), although the few firms that hold foreign currency debt (5% of firms) hold 54% of their debt in foreign currency. Furthermore, exports constitute around 19% of sales and the indicator $(X - M)/(X + M) = 13.6\%$ shows that the sector is a net exporter[28], explaining the positive competitiveness effect from devaluations.

iii. Foreign currency debt in the manufacturing sector is high both at the level of the sector (representing 10% of total debt) and at the level of the firm (47% of total debt of firms holding some foreign currency debt). The econometric evidence,

[28] The indicator $(X - M)/(X + M)$ captures the share of net exports in total trade volume. A negative value indicates that the sector is net importer and values close to 1 that sector is net exporter. Calculations were based on information at SIIC level taken from National Accounts.

however, shows that following a devaluation the negative effect on profits from the "balance sheet effect" is more than compensated by the positive effect stemming from the high penetration of exports (11.4% of total sales) and the enhancement of competitiveness with regard to imports (as this sector is a net importer with $(X - M)/(X + M) = -26.1\%$). Additionally, this is the sector in which derivatives are more widely used as a way to hedge exchange rate risk (Figure 6).

iv. The wholesale & retail trade sector, notwithstanding its own level of exports, benefits from a devaluation. Two factors can explain this result: (i) a devaluation can reduce smuggling (high in this sector) and (ii) since a devaluation has a positive impact on most other sectors), there is a spillover effect that benefits the wholesale & retail trade sector. It should also be pointed out that among non-financial sectors, wholesale & retail trade is second only to manufacturing in the use of forward operations (in term of number of contracts) to hedge exchange rate risk (Figure 6).

v. The construction sector is characterized by having low levels of foreign debt and exports, but imports construction materials. This explains why the sector is relatively less benefitted from devaluations.

vi. Notwithstanding the importance of foreign currency denominated debt in the transport sector, we find no significant evidence of exchange rate fluctuations negatively affecting firms operating in this sector. It is possible that these findings are influenced by firms in this sector using hedging instruments[29].

vii. Finally, although financial institutions are relatively heavily indebted in foreign currency compared to other sectors, they benefit from devaluations. On the one hand, the financial sector is an active user of hedging derivatives; on the other hand, financial institutions they benefit from the positive impact of devaluations in other economic activities (spillover effects). In section V we explore the possible relationship between bank performance (as proxied by the evolution of non-performing loans) and real exchange rate volatility.

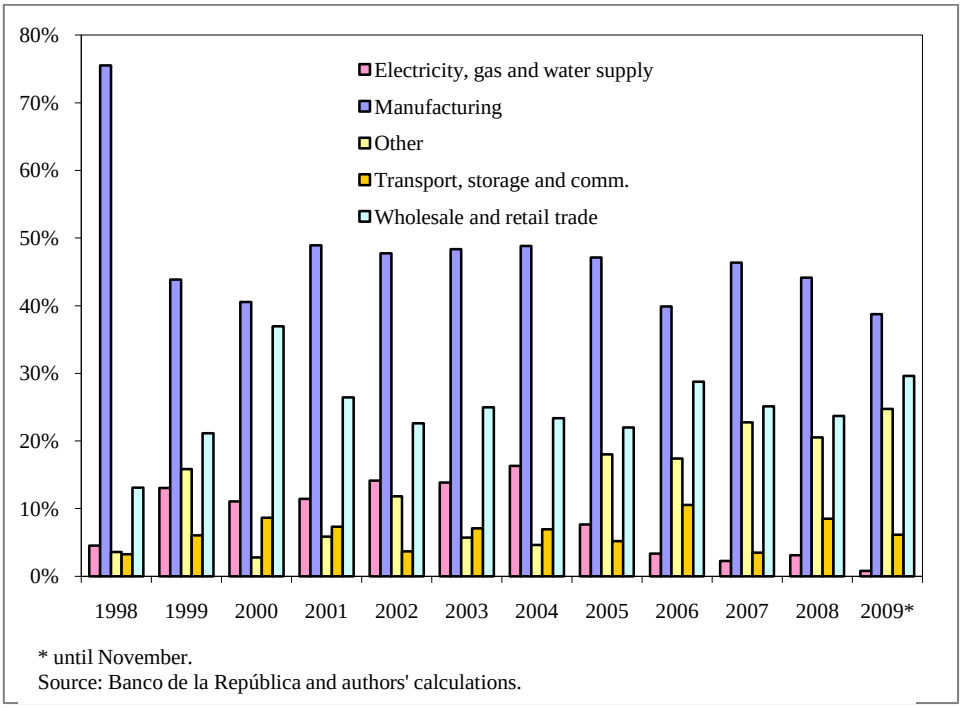
[29] The sector trades 6.5% of the total amount of forwards traded by the real sector.

## Table 11: Descriptive Statistics by Economic Sector

| | Size | | | Foreign Debt | | | | Trade | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ISIC Sector | Sales of each sector/Sales of all sectors | Percentage of firms on each sector | Average number of firms | Foreign debt /Total debt by sectors | Foreign debt /Total debt by firms | Foreign debt /Total debt by firms with positive foreign debt | Number of firms with foreign debt | Exports/Total sales by sector | Imports/Total purchases by sector | (X-M) /(X+M) |
| ISIC(A) - Agriculture, hunting and forestry | 4,7% | 8,9% | 630 | 0,9% | 3,4% | 54,0% | 29 | 19,2% | 15,3% | 13,6% |
| ISIC(C) - Mining and quarrying | 3,2% | 2,0% | 144 | 0,8% | 4,4% | 64,7% | 5 | 1,9% | 31,3% | 95,0% |
| ISIC(D) - Manufacturing | 41,7% | 28,5% | 1992 | 10,1% | 3,6% | 47,0% | 113 | 11,4% | 52,8% | -26,1% |
| ISIC(E) - Electricity, gas and water supply | 0,1% | 0,2% | 12 | 0,1% | 13,6% | 79,0% | 2 | 2,7% | 27,0% | - |
| ISIC(F) - Construction | 5,2% | 8,7% | 613 | 1,1% | 2,4% | 54,3% | 18 | 1,7% | 11,7% | - |
| ISIC(G) - Wholesale and retail trade | 31,8% | 25,7% | 1840 | 4,3% | 2,5% | 54,9% | 64 | 3,2% | 33,8% | - |
| ISIC(I) - Transport, storage and communications | 4,1% | 4,2% | 290 | 3,1% | 5,7% | 69,4% | 15 | 2,3% | 39,0% | - |
| ISIC(J) - Financial intermediation | 1,5% | 5,4% | 375 | 1,0% | 6,2% | 68,5% | 13 | 1,9% | 15,2% | - |
| Rest of sectors | 1,1% | 2,4% | 168 | 0,3% | 2,2% | 57,0% | 4 | 6,5% | 18,2% | - |

Source: Authors' calculations based on SS and National Accounts (DANE).

**Figure 6: Distribution of Turnover of Corporate Forward Contracts by Sector**




* until November.
Source: Banco de la República and authors' calculations.

## 4. Currency composition of debt

The results just reported suggest that firms more heavily indebted in foreign currency are the same ones that, following a devaluation, benefit (in the form of higher profits) from a "competitiveness effect". In order to verify whether this is indeed the case, we run two different specifications in order to study the determinants of the currency composition of debt. We are particularly interested in determining whether the preponderance of foreign currency denominated debt is related to firm size and to whether the firm is an exporter or an importer. In the first column of Table 12 we report the results of a *Tobit* regression[30] where the dependent variable is the ratio of foreign currency denominated debt to total debt $\left({}^{D^*}/_{D^{\text{Total}}}\right)$. In column 2 we report results from a *Probit* regression in which the dependent variable is a dummy equal to 1 if ${}^{D^*}/_{D^{\text{Total}}} > 0$ and equal to 0 otherwise.

[30] In initial specifications we used fixed effects. However, given the large number of firms with no foreign currency debt, we obtained very poor results. To deal with this issue, we considered a Tobit regression with data censured at the left of ${}^{D^*}/_{D^{\text{Total}}} = 0$. In another specification we used fixed effects with the dependent variable truncated at ${}^{D^*}/_{D^{\text{Total}}} = 0$, This specification, however, leads to biased and inconsistent estimators.

Results show that foreign currency indebtedness is positively related to firm size; medium sized firms have a lower probability of carrying foreign currency debt than do larger firms. Likewise, firms with a higher proportion of exports as a percentage of total sales not only are more likely to carry foreign currency debt, the average size of foreign debt (as a proportion of total debt) that they carry is also larger. As a result, the higher local currency revenue from exports following a devaluation could counterbalance any negative "balance sheet" effect. *Mutatis mutandis*, the same result holds for importing firms. We also find that the level of sales is also positively correlated with both the probability of carrying foreign currency debt and with the level of foreign currency debt itself. This implies that firms with higher levels of foreign currency debt are also those which derive more income from its productive activity, enhancing the possibility that, following a devaluation, the "competitiveness effect" compensate any negative "balance sheet effect".

Finally, Table 12 also shows that the sectors with higher levels of foreign currency debt and higher probability of having foreign currency debt are public utilities, transportation and financial intermediation. On the other hand, firms in the manufacturing and wholesale & retail sales sectors have an intermediate level of foreign currency debt as well as intermediate probability of carrying foreign currency debt.

Summarizing, our results point to a natural matching between foreign currency revenue and foreign currency denominated liabilities in the case of large firms that export and sell more and belong to a more tradable sector.

**Table 12: Determinants of the Currency Composition of Debt (1997-2008)**

| Dependent variable: D*/D | (1) | (2) |
|---|---|---|
| **Variables** | Tobit | Probit |
| Exporting firm | 0.199*** | 0.433*** |
| | (0.028) | (0.061) |
| Importing firm | 0.065*** | 0.153*** |
| | (0.021) | (0.044) |
| Size (medium) | -0.396*** | -0.879*** |
| | (0.025) | (0.052) |
| Log (sales) | 0.042*** | 0.107*** |
| | (0.009) | (0.019) |
| Constant | -2.197*** | -4.669*** |
| | (0.153) | (0.322) |
| ISIC(A) - Agriculture, hunting and forestry | 0.166*** | 0.329*** |
| | (0.060) | (0.121) |
| ISIC(C) - Mining and quarrying | 0.157 | 0.204 |
| | (0.108) | (0.224) |
| ISIC(D) - Manufacturing | 0.148*** | 0.310*** |
| | (0.048) | (0.096) |
| ISIC(E) - Electricity, gas and water supply | 0.898*** | 1.675*** |
| | (0.229) | (0.478) |
| ISIC(F) - Construction | -0.087 | -0.147 |
| | (0.060) | (0.124) |
| ISIC(G) - Wholesale and retail trade | 0.042 | 0.088 |
| | (0.048) | (0.097) |
| ISIC(I) - Transport, storage and communications | 0.282*** | 0.552*** |
| | (0.071) | (0.144) |
| ISIC(J) - Financial intermediation | 0.192*** | 0.426*** |
| | (0.071) | (0.151) |
| Time Effects | Yes | Yes |
| Number of uncensored observations | 3267 | - |
| Number of left-censored observations | 53023 | - |
| Number of firms | 13145 | 13145 |
| Wald test chi2 | 654.9 | 789.8 |
| Prob > chi2 | 0.000 | 0.000 |

Asymptotic Standard errors in parentheses.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

Note: A firm is defines as exporting if the ratio Exports/Sales>=0.2, in the same way, a firm is said to be importing if the ratio Imports/Purchases>=0.2.

Note: Categorical dependent variable is 1 if Foreign Debt>0 and zero otherwise.

## V. Exposure of the banking system to exchange rate volatility

In this section we explore whether changes in the RER have direct effects on banks' performance through non-performing loans (NPLs). Following Barajas *et al* (2000) and Boudriga *et al* (2009), we model NPLs as a function of both bank specific and macroeconomic variables. The former determinants are intended to capture differences between banks in terms of ownership structure, credit and provision policies and the level of regulatory capital, among others; the latter allow us to control for the impact of the business environment. Within the set of macroeconomic factors, we expect lagged real GDP growth to negatively impact NPLs, and anticipate a positive relationship between the rate of unemployment and NPLs. Finally, we include real exchange rate changes in order to capture for any *direct effect* of exchange rate volatility on bank performance. Since bank deposits and loans are both denominated in local currency, and bank regulation is strict in terms of foreign exchange exposure (see Central Bank Regulation in Annex 2) we do not expect a direct impact of RER changes on NPLs, but rather an indirect effect occurring through firms' profits, and captured either in GDP growth or in the rate of unemployment.

### 1. Bank-specific determinants

- *Real credit growth* as a proxy of bank credit policy. Since a rapid growth of loans could be achieved by lending to lower credit quality borrowers, this could lead, through adverse selection problems, to an increase of NPLs. Nevertheless, banks with higher credit growth rates may be concentrated on credit activities, having high experience in controlling borrowers' solvency. Thus, the impact on NPLs can be either positive or negative. Also, the effect of credit growth on NPLs can be different throughout the business cycle. For example, in periods of high economic growth, higher rates of growth of credit might be considered "good news" while in economic downturns high rates of growth of credit might well be considered "bad news". We construct a dummy variable (taking the value of 1 in quarters where GDP growth is below average) and interact it with the rate of growth of credit.
- *Loan loss provisions* are hypothesized to be a factor associated with expected loan portfolio deterioration of loan portfolio. Banks anticipating high levels of loan

portfolio deterioration should create higher provisions in order to decrease earnings volatility and reinforce medium term bank solvency (Boudriga *et al.*, 2009). We use as explanatory variable the lagged value of general loan loss provisions as a percentage of total loans.

- The *Capital Adequacy Ratio (CAR)* is an indicator used to control for excessive risk taking by banks and to prevent insolvency. On the one hand, banks with a CAR below the regulatory minimum are exposed to a high risk of insolvency due to an excess of risk weighted assets. On the other hand, banks with higher CAR than the minimum required might be encouraged to undertake more risky activities, leading to riskier credit portfolios. Therefore, the relationship between NPLs and CAR can be either positive or negative. In the estimations we include observed CAR minus the minimum required capital, which for Colombian banks is 9%.
- *Profitability of banks* could influence their risk taking behavior. Banks with strong performance are less compelled to make risky credit offers. Likewise, banks with low profitability are expected to be more willing to offer risky credits in order to improve returns. We use Return on Assets (ROA) as a proxy of bank performance.
- *Bank Size* could be correlated with enhanced experience in dealing with bad borrowers, thereby implying a negative association with NPLs. However, large banks that have large credit portfolios may also face a higher probability of having greater bad loans, especially in the presence of adverse selection problems. Size is proxied through the logarithm of total assets.
- *Income diversification* is expected to reduce risk as it makes it possible to compensate loan losses with gains from non-interest sources of revenue. For banks with well-diversified revenue sources, where non-interest revenues are important, NPLs should be lower than for less (poorly) diversified banks (Boudriga *et al.*, 2009). As a measure of diversification we calculate a Herfindahl Index (IH) which is equal to the sum of squares of interest income and other non-interest sources of revenues (financial revenues and capital gains) as a share of total bank income[31].

[31] We consider nine sources of income: interest income, income from valuation, dividends and sale of investments, profits from operations in the money market, profits from operations with derivatives, financial services, foreign exchange and other leasing operations.

- *Average lending interest rate* is expected to be positively linked to loan quality, since higher interest rates may lead to further payment defaults. We construct lending interest rate as interest received over performing loans.
- *Foreign ownership* is presumably negatively related to NPLs since international expertise of foreign banks is expected to improve the supply and the quality of financial services[32]. On the other hand, it is possible that foreign banks may end up being differentially affected by the domestic problems of adverse selection.
- Finally, *state owned* banks could have more incentives to fund riskier projects in favor of small & micro firms under the development mandate of governments. This reduces their credit recovery capacity when compared to privately owned banks.

## 2. Database

Our empirical analysis is based on quarterly balance sheet and financial statements data for a sample of 13 commercial banks over the period 2000-2009, reported to the Financial Superintendency. The sample of banks represent 95% of total bank assets in 2009. Out of the 13 banks, 8 are domestically owned and one, Banco Agrario, is state-owned. Throughout the period of analysis several mergers and acquisitions took place. In order to deal with them, we mimicked the different mergers and acquisitions back to the beginning of the period[33]. Table 13 describes the full sample of banks, acquisitions (mergers) and ownership.

[32] Barajas *et al.* (2000) report a negative relation between NPLs and foreign ownership for a sample of 32 Colombian banks over the period 1985-1998 on semi-annual data.
[33] If bank´s X and Y merged in 2005 to create bank Z, we combine the financial statements of X and Y since 2000.

**Table 13: Banking System**

| Bank | Acquisition | Date of acquisition | Ownership |
|---|---|---|---|
| Banco de Bogotá | Megabanco | June - 2006 | Domestic |
| Banco Popular | - | - | Domestic |
| Banco Santander | - | - | Foreign |
| Bancolombia | Corfinsura, Conavi | July - 2005 | Domestic |
| Citibank | - | - | Foreign |
| Banco GNB Sudameris | Banco Tequendama | June - 2005 | Foreign |
| BBVA | Banco Granahorrar | may-06 | Foreign |
| Helm Bank | Banco de Crédito | August - 2009 | Foreign (since 2009-08) |
| Banco de Occidente | - | - | Domestic |
| Banco Caja Social | Banco Colmena | June - 2005 | Domestic |
| Davivienda | Bancafé | September - 2007 | Domestic |
| AV Villas | Corp. ahorro vivienda Ahorramas | January - 2000 | Domestic |
| Banco Agrario | - | - | Domestic |

Source: Prepared by authors.

## 3. Methodology

We estimate panel data regressions on NPLs. We tested for random effects and fixed effects estimations (i.e. Hausman test) and concluded that fixed effects pooled regression would lead to greater efficiency. Standard errors of the estimated coefficients are adjusted for heteroskedasticity and arbitrary patterns of autocorrelation within individuals. Our estimated equation can be summarized as:

$$NPLs_{i,t} = \varphi_0 + \Phi\mathcal{B}_{i,t} + \Theta\mathcal{M}_t + \eta_{it}$$

where $\mathcal{B}$ is a vector of bank-specific determinants, $\mathcal{M}$ is a vector of macroeconomic variables and $\eta_{it} = \varepsilon_{it} + \alpha_i$ with $\varepsilon_{it}$ is an idiosyncratic error term and $\alpha_i$ are banks non-observable heterogeneous fixed effects.

## 4. Descriptive Statistics

The summary of descriptive statistics for bank-specific variables used in the empirical analysis is presented in Table 14. We note that NPLs vary significantly within banks, with

Banco Agrario (state-owned) having the largest portfolio of bad loans. A similar pattern is observed for banks' performance (ROA). Regarding capital adequacy ratio, all banks are on average near the minimum required (9%). Loan loss provisions over total loans range from 0.6 to 0.8, less than 1% in all cases. Finally, the Herfndahl Index is on average very high (0.63), indicating that banks in the sample are highly concentrated on credit activities.

**Table 14: Average of Bank Specific Determinants (%)**

| Bank | NPLs | Loan Loss Provisions | ROA | CAR | Market Share | Herfindahl Index |
|---|---|---|---|---|---|---|
| Bogotá | 3.14 | 0.67 | 2.33 | 11.43 | 13.25 | 0.57 |
| Popular | 5.05 | 0.70 | 1.78 | 11.41 | 5.34 | 0.57 |
| Santander | 2.13 | 0.71 | 0.70 | 14.18 | 3.55 | 0.65 |
| Bancolombia | 4.55 | 0.69 | 2.32 | 13.40 | 21.69 | 0.60 |
| Citibank | 3.01 | 0.83 | 2.37 | 14.20 | 3.81 | 0.59 |
| Sudameris | 3.53 | 0.77 | 0.06 | 10.75 | 2.59 | 0.62 |
| BBVA | 8.71 | 0.81 | 1.01 | 12.12 | 12.19 | 0.76 |
| Helm bank | 1.98 | 0.66 | 1.84 | 12.65 | 2.47 | 0.94 |
| Occidente | 3.59 | 0.67 | 2.50 | 10.71 | 6.38 | 0.54 |
| Caja Social BCSC | 12.11 | 0.72 | 1.10 | 11.44 | 4.79 | 0.60 |
| Davivienda | 8.71 | 0.73 | 2.08 | 14.83 | 13.72 | 0.55 |
| AV Villas | 6.27 | 0.73 | 2.49 | 13.57 | 6.28 | 0.59 |
| Agrario | 14.27 | 0.67 | 1.01 | 14.15 | 3.94 | 0.56 |
| Total | 5.93 | 0.72 | 1.66 | 12.68 | 7.69 | 0.63 |

Source: Authors' calculations based on Superintendencia Financiera.

With respect to the ownership structure, foreign banks appear to have loan portfolios of better quality (see Table 15) and higher loan loss provisions, but they are less profitable and more concentrated on credit activities.

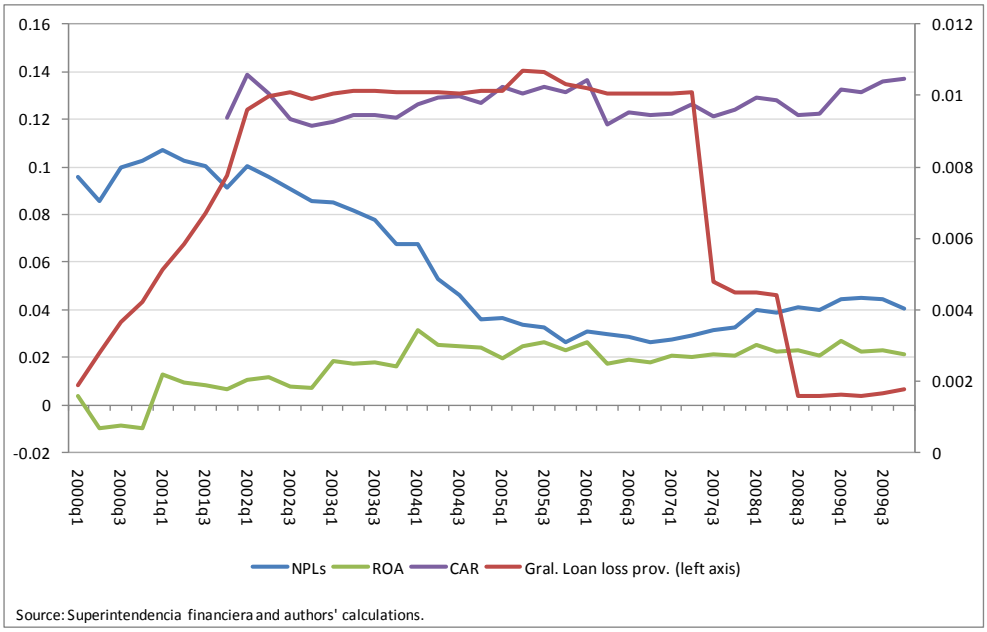
**Table 15: Average of Bank Specific Determinants by Ownership (%)**

| Ownership | NPLs | Loan Loss Provisions | ROA | CAR | Market Share | Herfindahl Index |
|---|---|---|---|---|---|---|
| Domestic | 6.63 | 0.70 | 1.94 | 12.61 | 8.65 | 0.61 |
| Foreign | 4.35 | 0.78 | 1.03 | 12.82 | 5.53 | 0.66 |
| Total | 5.93 | 0.72 | 1.66 | 12.68 | 7.69 | 0.63 |

Source: Authors' calculations based on Superintendencia Financiera.

Finally, Figure 7 shows the average evolution of bank specific variables[34] and Figure 8 illustrates real GDP growth and the unemployment rate.

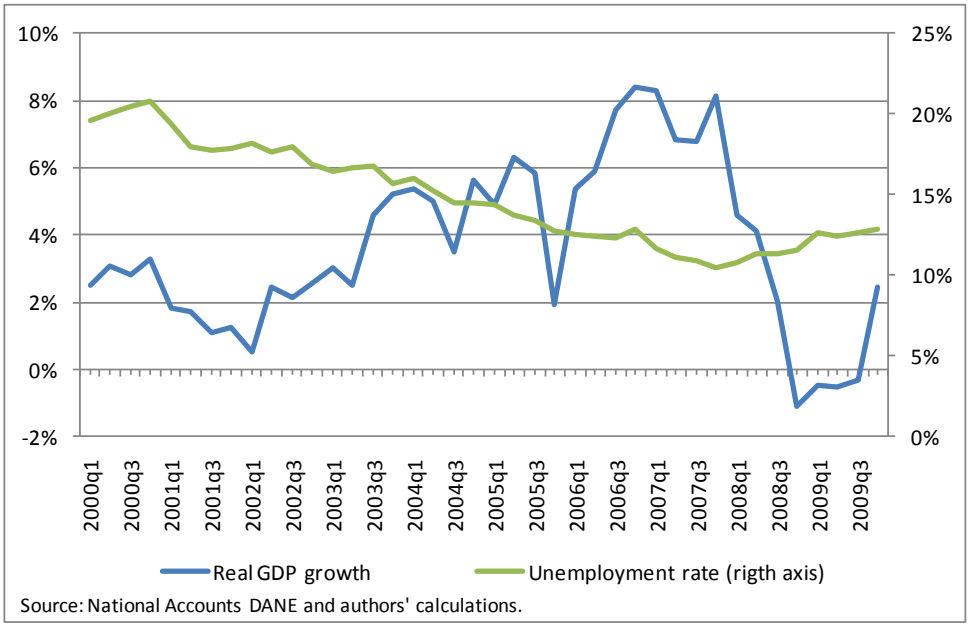
**Figure 7: Bank Specific Indicators**




Source: Superintendencia financiera and authors' calculations.

[34] Means were calculated as non-weighted averages.

**Figure 8: Macroeconomic Factors**




## 5. Results

We first run a basic model (i.e. without explicitly including changes in the RER) incorporating bank-specific variables, controlling for macroeconomic conditions. Results are presented in Table 16. We find that banks' credit growth is negatively related to NPLs, which suggests that more dynamic banks in credit activities have higher experience in controlling borrowers' solvency. As expected, loan loss provisions have a positive impact on NPLs, indicating that banks use provisions as a tool to anticipate potential loan default risks. The coefficient of ROA is negative and statistically significant, which supports the hypothesis that better performance reduces NPLs. The diversification of banks' internal activities -measured through the Herfindahl index - and lending interest rates do not seem to be linked to banks' credit quality. The first result is explained by the fact that banks are mainly concentrated on credit activities, as shown in Table 14. Regarding lending interest rate, this finding is contrary to previous results, which report a positive impact on NPLs (Barajas *et al.*, 2000). It is important to bear in mind that this paper was in reference to the 1985-1999 period, and that in 1998 Colombia experienced a major financial crisis. It could very well be the case that the practice of "gambling for resurrection" –i.e. when things go bad, banks lend to riskier borrowers at higher rates of interest—very much ceased to exist following the very negative experience of the late 1990s.

The coefficient of CAR-9% is statistically significant and negative, which confirms our prediction that the Capital Adequacy Ratio is a good tool for reducing bank credit risk, as posited in the Basel Agreement. Concerning bank ownership structure, results indicate that state-owned banks tend to have higher levels of NPLs. In the case of foreign banks results are not robust, since when controlling for GDP growth we find a negative impact on NPLs but a positive one when controlling for unemployment.

In order to assess the impact of RER devaluations on loan quality of banks, we re-run the baseline model, including changes in the real exchange rate as an explanatory variable. Results are reported in Table 17. The findings show that real devaluations (revaluations) do not have an independent significant impact on NPLs. That is to say, any effect of changes in RER over NPLs is indirect, and related to the influence of RER changes on GDP growth and/or unemployment. Finally, we interact credit growth with a dummy variable related to the business cycle, in order to capture possible differential effects of credit growth on NPLs. We find no differentiated effect in times of moderate growth; therefore, previous findings remain unaltered (see Table 18).

**Table 16: Basic NPLs regression**

| VARIABLES | (1) NPL | (2) NPL |
|---|---|---|
| Average lending interest rate | -0.255 | 0.338 |
| | (0.286) | (0.256) |
| Loan loss provisions(t-1) | 1.357* | 2.480*** |
| | (0.820) | (0.581) |
| ROA | -1.109*** | -0.612*** |
| | (0.244) | (0.185) |
| CAR-9% | -0.126 | -0.197** |
| | (0.078) | (0.084) |
| Size (log(assets)) | -0.009 | 0.082*** |
| | (0.006) | (0.010) |
| Quarterly real credit growth | -0.168*** | -0.104*** |
| | (0.033) | (0.028) |
| Herfindahl Index | 0.000 | -0.001 |
| | (0.001) | (0.001) |
| Annual real GDP growth(t-1) | -0.386*** | |
| | (0.075) | |
| Unemployment rate | | 1.688*** |
| | | (0.156) |
| State | 0.022*** | 0.093*** |
| | (0.006) | (0.009) |
| Foreign | -0.036*** | 0.118*** |
| | (0.009) | (0.018) |
| Constant | 0.234** | -1.567*** |
| | (0.110) | (0.195) |
| Observations | 427 | 427 |
| R-squared | 0.609 | 0.710 |
| F | 21.43 | 32.62 |
| Prob F | 0.000 | 0.000 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

**Table 17: NPLs regression with RER**

| VARIABLES | (1) NPL | (2) NPL |
|---|---|---|
| Average lending interest rate | -0.268 | 0.328 |
| | (0.288) | (0.258) |
| Loan loss provisions(t-1) | 1.232 | 2.443*** |
| | (0.841) | (0.583) |
| ROA | -1.093*** | -0.604*** |
| | (0.245) | (0.185) |
| CAR-9% | -0.118 | -0.192** |
| | (0.078) | (0.084) |
| Size (log(assets)) | -0.010 | 0.081*** |
| | (0.006) | (0.010) |
| Quarterly real credit growth | -0.174*** | -0.108*** |
| | (0.033) | (0.029) |
| Herfindahl Index | 0.000 | -0.001* |
| | (0.001) | (0.001) |
| Annual real GDP growth(t-1) | -0.369*** | |
| | (0.077) | |
| Unemployment rate | | 1.677*** |
| | | (0.156) |
| State | 0.022*** | 0.092*** |
| | (0.006) | (0.009) |
| Foreign | -0.036*** | 0.118*** |
| | (0.009) | (0.018) |
| ΔRER | 0.025 | 0.016 |
| | (0.026) | (0.021) |
| Constant | 0.244** | -1.554*** |
| | (0.112) | (0.195) |
| Observations | 427 | 427 |
| R-squared | 0.610 | 0.711 |
| F | 20.63 | 31.21 |
| Prob F | 0.000 | 0.000 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

**Table 18: NPLs regression controlling for credit growth in "bad times"**

| VARIABLES | (1) NPL | (2) NPL |
|---|---|---|
| Average lending interest rate | -0.259 | 0.339 |
| | (0.289) | (0.261) |
| Loan loss provisions(t-1) | 1.158 | 2.345*** |
| | (0.860) | (0.596) |
| ROA | -1.086*** | -0.596*** |
| | (0.244) | (0.184) |
| CAR-9% | -0.121 | -0.195** |
| | (0.079) | (0.085) |
| Size (log(assets)) | -0.010 | 0.080*** |
| | (0.006) | (0.010) |
| Quarterly real credit growth | -0.158*** | -0.089*** |
| | (0.034) | (0.027) |
| (Credit growth) x (Bad times) | -0.044 | -0.050 |
| | (0.057) | (0.054) |
| Herfindahl Index | 0.000 | -0.001* |
| | (0.001) | (0.001) |
| Annual real GDP growth(t-1) | -0.373*** | |
| | (0.078) | |
| Unemployment rate | | 1.681*** |
| | | (0.156) |
| State | 0.022*** | 0.092*** |
| | (0.006) | (0.009) |
| Foreign | -0.037*** | 0.117*** |
| | (0.009) | (0.017) |
| ΔRER | 0.025 | 0.016 |
| | (0.026) | (0.021) |
| Constant | 0.252** | -1.547*** |
| | (0.114) | (0.195) |
| Observations | 427 | 427 |
| R-squared | 0.611 | 0.711 |
| F | 19.91 | 30.45 |
| Prob F | 0.000 | 0.000 |

Standard errors robust to heteroskedasticity and arbitrary patterns of autocorrelation within individuals in parentheses.

*** denotes significance at the 99% level, ** at the 95%, * at the 90%.

## VI. Conclusions

Colombia has a floating exchange rate regime and is reasonably open commercially and financially. It provides an interesting case study for examining the effects of exchange rate changes on firm performance, including on investment and profitability. In general, one would expect a depreciation to enhance the competitiveness of local firms --either because they are net exporters or because they operate in an import-competing sector-- while at the same time producing a negative "balance sheet effect" if they carry foreign currency denominated debt. Of course, the performance of a firm with strong links to the outside world might be isolated to a great extent from exchange rate movements if its foreign currency operations are either "naturally" (i.e. a firm indebted in foreign currency might also be a net exporter) or financially hedged. These competing forces imply that the effect of exchange rate movements on firm performance is an issue to be addressed empirically.

A case study on Colombia is interesting because that country has a long tradition of a conservative approach towards foreign currency exposure in the financial sector and the use of sophisticated financial instruments to hedge risk. Banks are not allowed to offer foreign currency denominated deposits and face significant restrictions regarding foreign currency exposure. This has contributed to the underdevelopment of hedging instruments. Hedging exchange rate risk is still uncommon; as a result, firms, banks and the government are, in principle, subjected to significant risk on account of exchange rate volatility.

We assemble a large data base of medium & large firms covering the 1997-2008 period and study different channels through which exchange rate movements affect firm performance, particularly investment and profits. On average, our sample has 10.000 firms every year, 2/3 of them medium sized. We use a GMM-system methodology that provides consistent estimators in panel data with non-observable time-invariant heterogeneity, simultaneous determination of some exogenous variables and the endogenous variable, or reverse causality and inertia of the endogenous variable.

With regard to the determinants of investment, we find that: (i) there are adjustment costs, presumably related to capital market imperfections; (ii) liquidity, a proxy for cash flow, is a positive determinant of investment, and this is indicative of firms facing restricted access to external financing, a result further supported by the fact that we also identify a negative effect of debt on investment; (iii) sales have a positive effect on investment; (iv) changes in the real exchange rate (RER) have no direct effect on

investment; (v) on average, medium-sized firms invest less (as a proportion of their capital stock) than large firms; (vi) we find no evidence of a differential effect of RER changes on investment depending on a firm´s exposure to foreign debt.

Finding no significant effect for the interaction between foreign debt and RER changes might be due to the fact that the number of firms carrying any foreign debt is very small and/or because those firms that do carry foreign debt avoid currency mismatches, either through "natural" hedging or through the use of financial instruments for hedging exchange rate risk. Indeed, while foreign debt is an important component of total debt for those firms carrying foreign debt, only 7% of medium & large firms carry any foreign currency debt at all. In order to deal with this limitation, we run regressions in which we interact *total* debt and changes in the RER. These estimations suggest that firms with higher debt invest more following a devaluation. This probably implies that any negative effect in terms of net worth declining with a devaluation is more than offset by the positive effect it has on present and future income, hypothesis that is tested in the analysis of the currency composition of debt. While the effects of an appreciation work in much the same way (i.e. negatively affecting investment), there is evidence that exchange rate flexibility in Colombia has been asymmetric, with the central bank more willing to let the peso freely float when it is on a weakening trend than when the trend is towards its strengthening.

These estimations were complemented by regressions in which the dependent variable was the level of profits. We found evidence that a RER devaluation has a positive and significant effect on profits. When controlling for the sector in which the firm operates, the average positive effect of a devaluation is to a great extent determined by gains received by firms in mining and wholesale & retail trade. While it is evident that total debt has a negative and significant effect on profits, the interaction of changes in the RER with debt (external and total) is not significant.

We then proceed to study the determinants of the currency composition of debt. We find evidence that foreign currency indebtedness is related to firm size and that firms with a higher proportion of exports as a percentage of total sales not only are more likely to carry foreign currency debt, the average size of the foreign debt (as a proportion of total debt) they carry is also larger. As a result, the higher local currency revenue from exports following a devaluation offsets any negative "balance sheet" effect. We also find that sales are positively correlated with both the probability of carrying foreign currency debt and with the level of foreign currency debt. This implies that firms with higher levels of foreign

currency debt are also those which derive more of their income from its productive activity, enhancing the possibility that, following a devaluation, the "competitiveness effect" compensate any negative "balance sheet effect". These results point to a "natural matching" between foreign currency revenue and foreign currency liabilities.

Finally, we undertook an exercise to determine whether changes in the RER have an effect on bank performance (proxied by NPLs), beyond the indirect effects that stem from the fact that RER changes do affect firm performance. We model NPLs as a function of both bank specific and macroeconomic variables. The empirical analysis is based on quarterly balance sheet and financial statements data for a sample of 13 commercial banks over the period 2000-2009 The sample represents 95% of total bank assets in 2009. In the sample, 8 banks are domestically owned, one is state-owned. We find support for the following conclusions: (i) NPLs decline with GDP growth and increase with unemployment; (ii) credit growth is negatively related to NPLs, which suggests that more dynamic banks in credit activities have more experience in controlling borrowers' solvency; (iii) loan loss provisions have a positive impact on NPLs, indicating that banks use provisions as a tool to anticipate potential loan default risks; (iv) profitability (proxied by return on assets) reduces NPLs, suggesting that profits allow for a more conservative approach to credit; (v) NPLs are also negatively related to solvency (proxied by the risk-weighted capital to asset ratio); (vi) NPLs are not influenced by how diversified a bank´s income sources are and, surprisingly, are also unrelated to lending interest rates; (vii) the state-owned bank has higher NPLs, but results are not robust in the case of foreign-owned banks; (viii) importantly, RER changes do not have an independent impact on NPLs. That is to say, any effect of changes in RER over NPLs is indirect, and related to the influence of RER changes on GDP growth and/or unemployment. Presumably, this result is driven by regulation that severely restricts the exposure of banks to exchange rate risk.

In summary, Colombian firms and banks benefit from RER devaluations and are negatively affected by RER appreciations. This seems to be associated with the fact that most firms do not carry much foreign currency denominated debt and that those that do tend to be "naturally hedged". These findings, coupled with the fact that the revealed preference of the central bank has been to allow the exchange rate to float more freely when it is bound to weaken than when it is bound to strengthen, has lessened any need by firms to actively engage in using financial derivatives to hedge exchange rate risk.

**Appendix 1**

**Table A1. Firms with Information on Balance Sheet and Relevant Annexes**

| Year | Annex 09 - Capital goods | Annex 15 - Movements in Foreign Currency | Annex 10 - Financial Obligations |
|---|---|---|---|
| 1997 | 91% | 100% | 89% |
| 1998 | 91% | 100% | 88% |
| 1999 | 90% | 100% | 86% |
| 2000 | 89% | 100% | 84% |
| 2001 | 58% | 64% | 55% |
| 2002 | 90% | 100% | 84% |
| 2003 | 88% | 100% | 82% |
| 2004 | 92% | 100% | 86% |
| 2005 | 92% | 99% | 85% |
| 2006 | 91% | 96% | 84% |
| 2007 | 94% | 72% | 88% |
| 2008 | 91% | 100% | 67% |

Source: Authors' calculations base on SS. Calculations include firms of all sizes.

**Table A2. Percentage of Firms Indebted in Foreign Currency**

| Year | Large | Medium | Small | Micro |
|---|---|---|---|---|
| 1997 | 14% | 4% | 1% | 0% |
| 1998 | 14% | 4% | 1% | 0% |
| 1999 | 12% | 3% | 1% | 0% |
| 2000 | 10% | 3% | 0% | 0% |
| 2001 | 10% | 2% | 0% | 0% |
| 2002 | 9% | 2% | 0% | 0% |
| 2003 | 8% | 2% | 0% | 0% |
| 2004 | 9% | 2% | 0% | 0% |
| 2005 | 10% | 3% | 0% | 0% |
| 2006 | 9% | 2% | 0% | 0% |
| 2007 | 9% | 2% | 1% | 0% |
| 2008 | 7% | 2% | 0% | 0% |

Source: Authors' calculations based on SS.

**Table A3. Exporting and Importing Firms**

| | Export | Import |
|---|---|---|
| Yes | 25.1% | 32.8% |
| No | 74.9% | 67.3% |
| Total | 100% | 100% |

Source: Authors' calculations based on SS.

**Appendix 2. Limits imposed by the central bank that hamper the development of the foreign exchange market (Central Bank External Resolution no. 4, 2007)**

- **Own position (Posición Propia, PP):** IMC´s own position (PP) is defined as the difference between all (on-balance, off-balance, realized or contingent) foreign currency denominated assets and liabilities, including those that can be settled in Colombian pesos35. The three (3) day simple average of PP cannot exceed 20% of technical net worth expressed in USD. The 3 day average can be negative, as long as it does not exceed 5% of the USD equivalent of technical net worth.
- **Cash position (Posición Propia de Contado, PPC):** IMC´s cash position (PPC**)** is defined as the difference between all liquid foreign currency denominated assets and liabilities36. The three (3) day simple average for PPC cannot exceed 50% of technical net worth expressed in USD. This average *cannot be negative*.
- **Gross leveraging position (Posición Bruta de Apalancamiento, PBA):** IMC´s gross leveraging position (PBA) is defined as the sum of: i) all foreign currency denominated assets and liabilities in fixed-term and future contracts; ii) all foreign currency denominated cash operations due in 1 or 2 business days; y iii) the foreign currency exposure associated with contingent assets and liabilities acquired in the negotiation of options and other exchange rate derivatives. In other words, the PBA is the sum of an IMC´s foreign currency derivative contracts and contingencies, regardless of whether they generate a right or an obligation. The three (3) day simple average for the PBA may not exceed 550% of the IMC´s technical net worth. The purpose of regulation regarding the PBA is to "reduce the possibility of systemic risk and counter-party risk in some financial intermediaries that have open positions in foreign currency that far exceed their net worth"[37].

Arbeláez and Steiner (2009) provide evidence that limits on IMC´s cash position (PPC) are particularly restrictive in shallow markets such as the Colombian, where discrepancies between demand and supply force firms to cover their open positions in the spot market.

[35] Assets include investments in financial assets, investment in subsidiaries, foreign currency loans, foreign currency liquidity and purchase *Forwards.* Liabilities include liabilities abroad and sale *Forwards*.
[36] Assets include investments in negotiable securities, foreign currency loans and foreign currency liquidity. Liabilities include liabilities abroad.
[37] See *Reportes del Emisor*, July 2007.

The lower limit on the PPC, establishing that it cannot be negative, is especially restrictive, promotes off-shore transactions and generates over costs that distort the pricing of derivatives. Furthermore, the effects are asymmetrical among institutions, and are particularly strong for IMC´s with small net worth and with less capability of accessing the off-shore market. The gross leveraging position(PBA) is also biding for entities with low net worth. Cayazzo *et al*, (2007) highlight the fact that these restrictions enhance volatility and make the forwards market less liquid. On the other hand, Asobancaria (2007) argues that instead of preventing speculative activities, the PPC shifted *forward* peso-dollar operations from the local market to the *off –shore* market, widening the gap between buying and selling quotations and limiting IMC´s ability to provide exchange rate coverage to firms involved in international trade.

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