The Effect of the Exchange Rates on Investment in Mexican Manufacturing Industry

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ABSTRACT

This paper, considering revenue and cost exposure channels, investigates the effects of exchange rate behaviour on fixed capital investment in Mexican manufacturing sector over 1994-2002. We find that i) currency depreciation has a positive (negative) effect on fixed investment through the export (import) channel; ii) exchange rate volatility impacts mostly export oriented sectors; iii) the sensitivity of investment to exchange rate movements is stronger in non-durable goods sectors and industries with low mark-up ratios.

JEL Classification: E22

Key Words: Exchange rate volatility, investment, external exposure, market structure

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1 Introduction

A large body of empirical research has been devoted to understanding the implications of exchange rate movements on economic activity. This literature suggests that a change in the value of the currency may affect the real economy through different channels. A real depreciation, for example, is expected to have expansionary effects by increasing the operating profits in the export sector but to lead to a contraction in the import sector due to opposing reasons (see Nucci and Pozzolo, 2001). Contrarily, large currency depreciations may deteriorate the firm's net worth through the 'balance-sheet-effect', as the dollar-denominated debt burden of firms increases (see Carranza *et al*., 2003; Aguiar, 2004; Patrap and Urrutia, 2004).

Beside the level impact of exchange rate, it has long been acknowledged that exchange rate uncertainty affects firms' real activities.[1] Several empirical studies have shown a negative relation between exchange rate volatility and investment. In particular, Goldberg (1993) and Campa and Goldberg (1995) using a sample of US manufacturing sectors conclude that exchange rate variability has a depressing effect on investment. Darby *et al*. (1999) find that although exchange rate uncertainty has a significant and negative impact on investment, this effect depends on the particular industry involved. Serven (2002) points out that the negative impact of real exchange rate uncertainty on investment is significantly larger in economies that were highly open and in those with less developed financial systems. More recently, Harchaoui *et al.* (2005) show that depreciations had a positive (negative) effect on total investment when the exchange rate volatility is low (high), and Fuentes (2006) provides empirical evidence for Chile on the negative relationship between exchange rate volatility and investment under irreversibility.

This paper investigates the linkages between the level and the volatility of the exchange rate and firms' capital investment behaviour in Mexico using annual manufacturing sectoral data for the period 1994-2002.[2] In our investigation we consider if the market structure, external exposure measures and product specific

[1] There are several competing theories on the impact of uncertainty on private investment. Several models emphasize a positive impact of uncertainty on investment; see Hartman (1972) and Abel (1983). Recent research, following Dixit and Pindyck (1994), highlight a negative relationship between uncertainty and investment. See Carruth *et al*. (2000) for a survey of this literature.

[2] The Mexican peso was floated in 1994. Also, structural changes that were implemented in the Mexican economy lead her to the North American Free Trade Agreement (NAFTA) in 1994. These changes transformed Mexico's economy by creating an outward looking and an export oriented economy (see Messmacher, 2002).

differences affect the relationship between investment and exchange rate movements. We show that exchange rate depreciation has a positive (negative) effect on investment through the export (import) channel. We also find that exchange rate volatility impacts mostly export oriented sectors. Finally, we present evidence that the sensitivity of investment to exchange rate movements is stronger in non-durable goods sectors and industries with low mark-up ratios.

The rest of the paper is organised as follows. Section 2 introduces the empirical specification and describes the data. Section 3 discusses the empirical results and section 4 concludes.

2 Empirical Specification and Data

2.1 The Model

We use a variant of Campa and Goldberg (1995, 1999) model to understand the impact of exchange rate movements on sectoral investment in Mexico. Our analysis utilizes the industry structure and the external exposure of the firms. The model takes the following form:

$$\frac{I_t^i}{I_{t-1}^i} = \beta_0^i + \beta_1 \frac{s_t^i}{s_{t-1}^i} + (\beta_2 + \beta_3 \cdot ext_t^i)\frac{rer_{t-1}}{rer_{t-2}} + (\beta_4 + \beta_5 \cdot ext_t^i)\frac{vol_{t-1}}{vol_{t-2}} + \beta_6 \frac{ir_t}{ir_{t-1}} + \lambda_i + \varepsilon_t^i \quad (1)$$

where I_t^i represents gross domestic investment in manufacturing sector *i*; s_t^i represents sector sales; rer_t is the real exchange rate defined as pesos per US dollar; vol_t stands for volatility of the exchange rate and; ir_t is the annual interest rate. The level and the volatility of exchange rate are allowed to enter into the model in conjunction with external exposure, ext_t^i, which may have changed significantly over time. Any such differential effects can be detected through the significance of β_3 and β_5. Furthermore, we introduce once lagged level and volatility of the exchange rate as it has been widely accepted in the literature that movements in exchange rates takes up to a year to affect the firm's behaviour (see, for instance, Baum *et al*., 2004). This strategy is also useful to avoid potential bias that may be induced by their possible correlation with current investment (see Campa and Golberg, 1995).

We estimate the models taking into account industry-specific fixed effects, λ_i and instrument the interest rate.[3] This is mainly due to the fact that current interest rate affects overall manufacturing sector capital investment behaviour as well as sector specific capital investment. Hence, interest rate may be correlated with the error term ε_t^i. The reported standard errors are corrected for heteroskedasticity following White (1980).

2.2 Data

This study uses a balanced annual panel dataset which provides consistent information on investment, sales, and price index on Mexican manufacturing industries over the period 1994-2002. Most of the data are obtained from the Annual Industry Survey (AIS) conducted by the National Institute of Statistics, Geography and Computational Science (INEGI) and the Central Bank of Mexico. The survey covers on average 6,224 firms grouped into 205 three-digit level manufacturing sectors. The AIS is used as an input for the Industrial Census and annual GDP calculations and the firms in the dataset accounts for almost 80 percent of the value added in manufacturing. All variables are reported in real pesos where the base year is set to 2003 and the producer price index is used as the deflator. Details of the data and sources are given in Appendix A. We use the three-digit sectoral data since INEGI does not provide the firm-level data information. In the following sub-sections, we define the measures of external exposure, market power and exchange rate uncertainty.

2.2.1 External Exposure Measures

Movements in exchange rates can notably influence the performance of domestic manufacturing industries. However, the firm's response generally depends on a variety of factors such as the reliance on imported inputs and the share of foreign sales in total sales. Using information on imported inputs and foreign sales reported in the AIS, we compute two external exposure measures (*ext*). The export share denoted by *Xm* is calculated as the ratio of exports to total revenues and the imported-input share in a manufacturing sector is approximated by the ratio of imported to total inputs (*Mm*). Industries with high export shares are likely to have total revenues that are more sensitive to movements in the exchange rate than producers with low export

[3] We experimented with instrumenting sales and exchange rates. These results, which available from the authors, are very similar to those reported.

shares. Similarly, a manufacturer that relies greatly on imported inputs will possibly be more exposed to exchange rate movements through costs than a producer that relies mostly on domestic inputs (see Campa and Goldberg, 1997).

Table 1: External exposure by manufacturing sectors

	1994		2002		1994-2002*	
	Export-share	Imported--input share	Export-share	Imported--input share	Export-share	Imported--input share
Manufacturing non-durables						
1. Food, Beverages and Tobacco	0.0398	0.1105	0.0617	0.1093	0.0623	0.1214
2. Textile, Apparel and Leather Industries	0.0644	0.1403	0.1655	0.2210	0.1590	0.1762
3. Lumber and Wood Products. Including Furniture	0.1238	0.1412	0.1291	0.1186	0.1846	0.0875
4. Paper and Allied Products, Printing and Publishing	0.0204	0.2139	0.0354	0.2559	0.0344	0.2253
5. Chemicals, Petroleum, Coal, Rubber and Plastic Products	0.1350	0.2397	0.1544	0.3058	0.1711	0.2799
Manufacturing durables						
6. Non-Metallic Mineral Products, except Petroleum and Coal Products	0.0759	0.0562	0.1099	0.0706	0.1227	0.0749
7. Basic Metal Industries	0.1591	0.1307	0.2184	0.1758	0.2272	0.1572
8. Metal Products, Machinery and Equipment. Including Surgical and Precision Instruments	0.3544	0.4841	0.6053	0.4838	0.5661	0.5246
9. Other Manufacturing Industries	0.1118	0.2910	0.2373	0.2387	0.2218	0.3106
Total Manufacturing	0.1612	0.2547	0.2861	0.3015	0.2747	0.3030

(*) Mean values over the period 1994-2002

Table 1 presents summary information for the external exposure measures, grouped into 9-manufacturing industries and divided by durable *versus* non-durable manufacturing goods.[4] On average, the industries that generally depend on exports are metal products, machinery and equipment, basic metal industries, lumber and wood products and non-metallic mineral products. The industries that rely mostly on imported-inputs are other manufacturing industries followed by a group of non-durable sectors, including chemicals, petroleum and plastic products, paper and allied products and textiles and leather industries. Manufacturing non-durable goods, as a group, have more reliance on imported-inputs as compared with manufacturing durable goods. Hence, this group of industries are expected to experience higher sensitivity to movements in the exchange rate through the cost side of its balance sheet.

4 The breakdown of manufacturing sectors into durables and non-durables goods is based on earlier work by Campa and Golberg (1995).

2.2.2 Measuring Market Power

In our analysis, we explore the role of the competitive structure of the industry in determining the impact of exchange rates on investment. To measure the degree of the sector-specific market power, following Domowitz *et al*. (1986), we construct a time varying measure of profits margins:

$$markup = \frac{Value\ added - Payroll}{Value\ added + Cost\ of\ materials} \tag{2}$$

Table 2: Industry mark-up ratios

	1994	1997	2000	2002	1994-2002*	Coef. of variation
Manufacturing non-durables						
1. Food, Beverages and Tobacco	0.2768	0.2712	0.2894	0.2941	0.2824	0.0284
2. Textile, Apparel and Leather Industries	0.1478	0.2071	0.1922	0.1829	0.1912	0.1077
3. Lumber and Wood Products. Including Furniture	0.1529	0.1850	0.1632	0.1532	0.1691	0.0884
4. Paper and Allied Products, Printing and Publishing	0.2446	0.2595	0.2586	0.2419	0.2568	0.0370
5. Chemicals, Petroleum, Coal, Rubber and Plastic Products	0.2454	0.2724	0.2580	0.2870	0.2699	0.0444
Manufacturing durables						
6. Non-Metallic Mineral Products, except Petroleum and Coal Products	0.3874	0.4113	0.4515	0.4268	0.4183	0.0532
7. Basic Metal Industries	0.2096	0.2481	0.2332	0.1982	0.2294	0.0906
8. Metal Products, Machinery and Equipment. Including Surgical and Precision Instruments	0.2129	0.2258	0.2090	0.2817	0.2269	0.1020
9. Other Manufacturing Industries	0.2022	0.2413	0.2803	0.2435	0.2481	0.1059

(*) Mean values over the period 1994-2002

Table 2 presents summary information for a subset of years on our sector specific annual mark-up ratios. We observe variability across time and across manufacturing industry. In particular, our results show relatively higher variability of the mark-up ratios in manufacturing durables and higher values can generally be observed at the end of our sample for all industries. For example, the non-metallic mineral products' industry had a mark-up of 0.3874 in 1994, 0.4113 in 1997 and 0.4268 in 2002.[5] The mark-up ratio is most variable for textile, apparel and leather industries, other manufacturing industries and metal products, machinery and equipment.

[5] Mark-up value of 0.387 implies that the industry sets the retail price at approximately 38.7% above its marginal cost.

2.2.3 Measuring Exchange Rate Volatility

Researchers have proposed a number of ways to generate a proxy for exchange rate volatility. As Baum *et al*. (2004) point out the choice of a particular specification to generate a proxy for uncertainty may have a considerable impact on the empirical findings. A common approach is to use either a moving average standard deviation or the coefficient of variation of the past monthly exchange rates as a measure of exchange rate volatility (see Campa, 1993; Campa and Goldberg, 1995; Amuedo and Pozo, 2001 and Harchaoui *et al*., 2005). However, such a measure gives rise to substantial serial correlation in the summary measure. In this study, we use GARCH methodology to proxy for exchange rate volatility.

To compute a proxy for real exchange rate uncertainty, we use monthly data over the 1988 to 2002 period and estimate an ARCH specification for the first differenced real exchange rate series. We find out that the mean equation (Δx_t) exhibits an AR(2) process and the conditional variance (h_t) is best described as an ARCH (1). The results from these estimations along with the diagnostics are provided in Appendix B.[6]

3 Empirical Results

In what follows below we present empirical results regarding the role of exchange rate movements on firms' capital investment behaviour. In our analysis, we consider the role of external exposure measures, product type and the market structure in that relationship. All regressions incorporate fixed effects and we use lagged interest rate as instruments.

3.1.1 Investment and the Role of Exposure Measures

Table 3 presents results obtained for equation (1) using instrumental variables with fixed effects, where we instrument the interest rate up to two lags.[7] The first column contains no interacted terms whereas the remaining columns do. Those interactions in the model basically capture the potential impact of the level and the volatility of the exchange rate on firm's capital investment behaviour through the firm's degree of external exposure (i.e. import *versus* export orientation of the firm).

[6] Note that we use 12-month averages of the estimated conditional variances as a proxy for uncertainty.
[7] Summary statistics of the main variables used in the regression analysis are presented in Appendix C.

Column 1 provides estimates of the standard model where we exclude the level and the volatility interactions with the external exposure measure. In line with earlier findings reported in the literature, we find that investment is always positively and significantly correlated with sales as captured by the coefficient β_1. Furthermore, currency depreciations are associated with reductions in investment (β_2 coefficient) and volatility has a positive impact on our dependent variable (β_4 coefficient), yet neither coefficient is significant. Similar to the findings reported by Campa and Golberg (1995) for US, the interest rate has a positive and significant impact on investment.[8] Finally, the Sargan test statistic of overidentifying restrictions suggests that the instrument set is valid.

Table 3: Investment and the role of exposure measures

	Non-ext (1)	***Xm*** (2)	***Mm*** (3)
sales (β_1)	1.091*	1.105*	1.100*
	0.255	0.255	0.256
rer (β_2)	-1.516	-1.672	-1.544
	1.065	1.071	1.091
*rer*ext* (β_3)	---	3.214*	-0.643
		1.406	1.736
vol (β_4)	0.195	0.391*	0.122
	0.159	0.186	0.193
*vol*ext* (β_5)	---	-1.910*	0.692
		0.922	0.989
irate (β_6)	0.166*	0.165*	0.165*
	0.071	0.071	0.071
Overidentification test (p-value)	0.666	0.580	0.704

No. of observations: 1,095

Robust standard errors are reported beneath parameter estimates

* Significant at the 5% level

** Significant at the 10% level

Next, we introduce the interaction terms into the model; measures of external exposure, ext_t^i, interacted with the level and the volatility of the exchange rate. The results from the estimated coefficients on the interacted terms uncover different and

[8] Neoclassical models of investment support the general conclusion that changes in sales have a dominant role on investment while that of the user cost plays a minor role (see Chirinko, 1993). Taylor (1999) also attempts to explain the weak link between interest rates and investment by considering the effects of different costs of various types of finance available to the firm or the presence of irreversibility and uncertainty.

significant responses across manufacturing sectors. This finding justifies our approach and reveals the importance of using information on firms' external orientation in understanding their investment behaviour.

Column 2 reports results on the export oriented sectors, whereas column 3 concentrates on that of the import orientated sectors.[9] From column 2 we see that the coefficients associated with the interaction terms, β_3 and β_5, are significant. The interaction term β_3 is significant and positive revealing that currency depreciation will have a positive impact on the investment behaviour of the firm through the revenue channel. It seems that depreciation inducing higher exports and higher firm revenue promote more investment, as the literature has widely documented. Interestingly, volatility on its own, β_4, has a significant positive effect on investment as some early neoclassical models emphasise.[10] Contrarily, the interaction between uncertainty and export exposure measure coefficient, β_5, takes a negative sign implying that as uncertainty increases, investment of an export oriented firm will be hampered. This may be explained by the option theory that delaying an investment project may give more accurate view of market conditions. Hence, exchange rate volatility, creating an uncertain economic environment, causes export oriented manufacturing sectors to postpone their capital investments.[11] In column 3, results reveal that neither the level nor the volatility measures have any effect on the investment behaviour of the import oriented firm. Only changes in sales and interest rates seem to affect such firms. Perhaps, the managers of these firms mainly concentrate on the internal market and as long as sales are on the rise they pursue on investing in new capital stock, and employ imported intermediate goods to satisfy the internal demand despite the behaviour of exchange rates.

3.1.2 Investment and the Role of Durable vs. Non-Durable Goods

We split the sample into two categories based on product durability while considering the degree of firm's external exposure. This split reveals additional findings as

[9] To consider the possible influence of the market structure under the manufacturing sector operates, we redefine our external measures as: $ext^{i}_{t^*}\delta$, where δ = (1-markup) ; δ=1 describes a perfectly competitive market and δ=0 denotes a monopolistic industry. See Campa and Golberg, 1995 and Nucci and Pozzolo, 2001 for further discussion.

[10] Hartman (1972) and Abel (1983) show that if one assumes perfect competition and constant returns to scale as well as symmetric adjustment costs, an increase in uncertainty may raise the value of a marginal unit of capital and hence the incentive to invest.

[11] Dixit and Pindyck (1994) highlight the importance of the timing of investment decisions and argue that irreversibility may lead to the postponement of capital investment decisions.

depicted in Table 4. Columns 1 and 2 present the estimates for the durable goods sector and columns 3 and 4 lay our results for the non-durables sector. For durables goods sector it turns out that variations in the exchange rate (β_4 and β_5) do not have any significant impact on capital investment at all. Contrarily, both the level and the volatility of exchange rate movements have significant effects on capital investment behaviour for non-durable firms (last two columns in Table 4). The level effect of exchange rate (β_2) is negative for both import and export oriented firms. Perhaps, due to the non-durable nature of the product, the investment behaviour of an export oriented firm is negatively affected as the firm looses revenue after devaluation and reduces its investment. Likewise, an import oriented firm reduces its capital investments for it gets costlier to run the business after currency devaluation. The interaction term (β_3) is positive and significant for the export oriented firm, but it is insignificant for the import oriented firm. Hence, the total impact of devaluation on capital investment of an export oriented firm seems to be positive, while it is negative for the import oriented firm.

Table 4: Investment and the role product durability

	Manufacturing ***durables***		Manufacturing ***non-durables***	
	Xm	Mm	Xm	Mm
	(1)	(2)	(3)	(4)
sales (β_1)	0.815*	0.796*	1.590*	1.605*
	0.370	0.365	0.374	0.371
rer (β_2)	-0.259	0.035	-2.399**	-2.374**
	1.771	1.809	1.337	1.354
*rer*ext* (β_3)	1.686	-2.302	3.912**	0.009
	1.981	2.653	2.272	2.392
vol (β_4)	-0.136	-0.452	0.689*	0.448**
	0.338	0.339	0.223	0.235
*vol*ext* (β_5)	-0.429	1.934	-3.156*	0.018
	1.466	1.530	1.364	1.419
irate (β_6)	-0.004	-0.001	0.286*	0.289*
	0.120	0.120	0.086	0.087
Overidentification test (p-value)	0.865	0.963	0.602	0.696

No. of observations: 451 (high markup sectors); 644 (low markup sectors)

Robust standard errors are reported beneath parameter estimates

* Significant at the 5% level

** Significant at the 10% level

When we concentrate on the effects of exchange rate volatility on capital investment behaviour, it seems that the export oriented firm is negatively effected

from volatility; while the own effect of volatility is positive and significant, the interaction term (β_5) is negative and significant. The opposing effects of volatility on investment can be explained by the larger reliance from these manufacturing industries on imported inputs into production as our earlier analysis about the external exposure from manufacturing sectors suggest.[12] In contrast, for the import oriented firm, volatility has an overall positive effect on investment. As we mentioned before, import oriented firms possibly compete with domestic producers and they increase their capital investments to satisfy the internal demand as long as there is a strong sales record.

3.1.3 Investment and the Role of Market Structure

Next we explore the role of the market structure on the effects of exchange rate movements on firms' capital investment. To do so, we split the sample by the mean mark-up value into 'high' and 'low' mark-up manufacturing sectors. The aim is to investigate empirically the role of market power in determining the relationship between firm's capital investment behaviour and the movements in exchange rate. The results in Table 5 reveal differences on the effects of exchange rates movements on capital investment when the market structure is considered. Columns 1 and 2 show the results for high mark-up sectors and the last two columns from Table 5 present the estimates in low mark-up sectors. In the case of high mark-up firms, the level of exchange rate (β_2) is not relevant in determining the capital investment behaviour of a firm regardless of the orientation of the firm. However, we see that exchange rate volatility affects the investment behaviour of the export oriented firms negatively; the own effect (β_4) is small and positive and the interaction term (β_5) is negative and large.

Contrarily, in column 3 we observe that the export oriented low mark-up firm's capital investment behaviour is more responsive to changes in the exchange rate and its volatility as both interaction terms are significant. Here, depreciation encourages investment through the revenue channel (β_3) and volatility has a negative effect (β_5). The imported input channel, see column 4, does not give us significant

[12] Empirical studies focusing on developing countries have found a negative relation between real exchange rate volatility and exports. See Caballero and Corbo (1991), Serven (2002) and Grier and Smallwood (2007) among others.

results. Overall, these results suggest that low mark-up industries with high export shares are subjected more to the exchange rate effects in capital investment.[13]

Table 5: Investment and the role of market structure

	High Markup *sectors*		***Low Markup*** *sectors*	
	Xm	Mm	Xm	Mm
	(1)	(2)	(3)	(4)
sales (β_1)	0.322	0.395	1.548*	1.459*
	0.400	0.404	0.353	0.354
rer (β_2)	-1.691	-1.429	-1.050	-1.084
	1.623	1.653	1.531	1.559
*rer*ext* (β_3)	2.006	-2.142	4.664*	1.872
	2.609	2.739	1.781	2.392
vol (β_4)	0.539**	0.203	0.360	0.101
	0.285	0.299	0.259	0.266
*vol*ext* (β_5)	-2.441**	0.748	-2.186**	0.108
	1.462	1.510	1.240	1.356
irate (β_6)	0.179	0.179	0.178**	0.167**
	0.116	0.116	0.917	0.093
Overidentification test (p-value)	0.632	0.786	0.837	0.867

No. of observations: 451 (high markup sectors); 644 (low markup sectors)

Robust standard errors are reported beneath parameter estimates

* Significant at the 5% level

** Significant at the 10% level

3.2 External Exposures, Market Structure and Industry Group

Given our findings so far, we finally investigate the role of mark-up as well as product specification, i.e. durable *vs.* nondurable while considering the orientation (import or export) of the industry. Table 6 depicts these results. On the whole, the sign and significance of all coefficients are similar to those results we have provided earlier. In almost all cases, sales growth induces higher investment. Depreciation on its own significantly reduces capital investment (β_2 <0) of non-durables sectors only. Otherwise, its effects are insignificant. We observe that volatility has a positive impact (β_5 >0) on capital investment of non-durables sector on its own at the 5% significance level. However, when we consider the interactions between the exchange rate and the firm exposure measure, we find that export oriented sectors significantly increase their capital investment (β_3 >0) when the domestic currency depreciates. In

[13] Campa and Golberg (1995, 1999), Nucci and Pozzolo (2001) and more recently Harchahoui *et al*. (2005) have found similar results in which the effect of the real exchange rate on investment is stronger for industries or firms with low price-cost margin than for firms with high mark-up.

the case of import oriented sectors, they significantly reduce their capital investment (β_4 <0) when the domestic currency depreciates. We also find that volatility in conjunction with the measure of external orientation tend to significantly reduce investment of export oriented sectors (β_6 <0) and to increase that of import oriented sectors (β_7 >0).

Table 6: Investment models using both export and imported-input exposures

	Full sample (1)	High Markup (2)	Low Markup (3)	Durables (4)	Non Durables (5)
sales (β_1)	1.129*	0.391	1.542*	0.852*	1.599*
	0.255	0.404	0.353	0.371	0.375
rer (β_2)	-1.675	-1.457	-1.468	-0.163	-2.408**
	1.096	1.656	1.565	1.828	1.362
*rer*Xm* (β_3)	3.956*	3.114	5.232*	3.210	4.029**
	1.468	2.695	2.862	2.189	2.288
*rer*Mm* (β_4)	-2.028	-4.296	1.054	-3.617	-0.725
	1.835	2.886	2.513	2.960	2.409
vol (β_5)	0.271	0.353	0.308	-0.311	0.637*
	0.200	0.308	0.276	0.357	0.249
*vol*Xm* (β_6)	-2.740*	-3.593*	-2.722*	-2.125	-3.300*
	1.039	1.644	1.388	1.795	1.396
*vol*Mm* (β_7)	1.918**	2.666	0.069	3.069**	0.717
	1.119	1.715	1.519	1.888	1.449
irate (β_8)	0.164*	0.178	0.167**	-0.002	0.285*
	0.071	0.116	0.092	0.120	0.087
Overidentification test (p-value)	0.652	0.766	0.964	0.992	0.609
Wald test of joint significance (p-value)	0.000	0.250	0.000	0.062	0.000
No. of observations	1095	451	644	453	642

Robust standard errors are reported beneath parameter estimates

* Significant at the 5% level

** Significant at the 10% level

4. Conclusions

This paper investigates the effects of the level and the volatility of exchange rate on capital investment using a sample of manufacturing sector data obtained from Mexico over the period 1994-2002. Our results emphasize the role of firm's external exposure, the market structure and product characteristics in that relationship. We find that depreciation affects capital investment positively through the export channel and depresses expected profits if there is a high reliance on imported inputs. When we turn our attention to exchange rate volatility, we find that volatility has a negative effect on

investment for firms that are export oriented. We also show that exchange rate volatility has a stimulating effect on firm's investment through the import channel. Furthermore, our results imply that firms that operate in low mark-up industries and that produce non-durable products tend to be more sensitive to both the level and volatility of exchange rates.

It may be useful to note some limitations and possible extensions associated with the current study. Currently, there is only a handful of studies that investigate the capital investment behaviour of firms using sector specific data. Hence, it would be useful to investigate the linkages between sectoral investment and exchange rate movements using data from other countries. We also think that firm level analysis might yield further interesting insights. For instance, it would be quite fruitful to study the role of financial frictions along with exchange rate movements in determining the capital investment behaviour of firms implementing a similar model we present here.

Appendix A

Table A1. Description of data

Variable	Description	Source
Gross Investment	The sum of gross fixed investment and variations in inventories. Gross Fixed Investment is defined as purchases minus sales of used and new assets plus improvements on existing assets plus capital produced for own use.	INEGI: www.inegi.gob.mx
Total Sales	Annual sales per industry or sector level. The survey provides information on foreign and national sales.	INEGI: www.inegi.gob.mx
Total Inputs	Total inputs per industry or sector. The survey provides information on imported inputs into production.	INEGI: www.inegi.gob.mx
Real Exchange Rate	The real exchange rate index measures the value of the peso against more than one hundred trading partners of Mexico. A rise in the index indicates a real depreciation of the domestic currency.	Banco de México: www.banxico.org.mx
Volatility	We compute a proxy for real exchange rate uncertainty using monthly data and GARCH models. See Appendix B for details.	Banco de México: www.banxico.org.mx
Interest Rate	The annual interest rate (Treasury Bill – CETES).	Banco de México: www.banxico.org.mx
Price Index	The producer price index measured at the end of the corresponding year is used as deflator.	Banco de México: www.banxico.org.mx

All variables considered are in terms of 2003 prices. Only sectors with positive values for investment are considered in our sample.

Appendix B

Table B1. Exchange rate volatility
ARCH model*

$$\Delta x_t = \underset{(0.003)}{-0.003} + \underset{(0.076)}{1.356}\,\Delta x_{t-1} - \underset{(0.073)}{0.395}\,\Delta x_{t-2} + e_t$$

$$h_t = \underset{(0.000)}{0.001} + \underset{(0.224)}{0.556}\,e_{t-1}^2$$

Statistics for the Standardised Residuals
Q^2-statistic(6) = 2.74
Skewness = 0.33
Kurtosis = 6.50
ARCH-LM(6) = 0.44 (0.84)
N=180

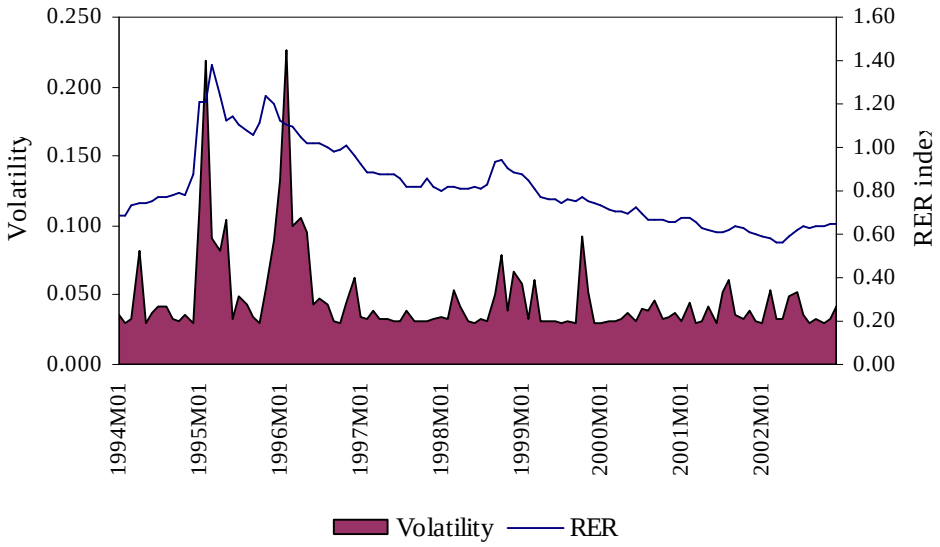
(*) Bollerslev - Wooldrige robust standard errors are in parenthesis except in the ARCH-LM test where the 'p' value is reported.

The estimated model for the change in the log of the real exchange rate is:

$$\Delta x_t = \beta_0 + \beta_1 \Delta x_{t-1} + \beta_2 \Delta x_{t-2} + e_t$$

where, $e_t \,|\, I_{t-1} \sim N(0,h_t)$ and $h_t = \alpha_0 + \alpha_1 e_{t-1}^2$ denotes the conditional variance. The results for the ARCH (1) specification show a mean reverting variance process. The value of the ARCH parameter (α_1=0.556) indicates some persistence of volatility shocks. Diagnostic statistics show that the variance equation has been correctly specified. Specifically, Q-statistics and the Lagrange Multiplier (LM) test ensure no remaining ARCH effects.

Figure B1. Real exchange rate and volatility in Mexico: 1994-2002



Appendix C

Table C1: Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Investment rate*	1.3520	1.5765	0.0021	19.4510
Interest rate	1.1729	0.8968	0.3706	3.2542
Sales rate	1.0098	0.1835	0.2899	2.5884
Exchange rate	0.9916	0.2139	0.8338	1.5440

(*)Establishments with zero or negative values were eliminated from the sample. In addition, sectors that reported values for the investment rate within 5 standard deviations from the sample mean were discarded.

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