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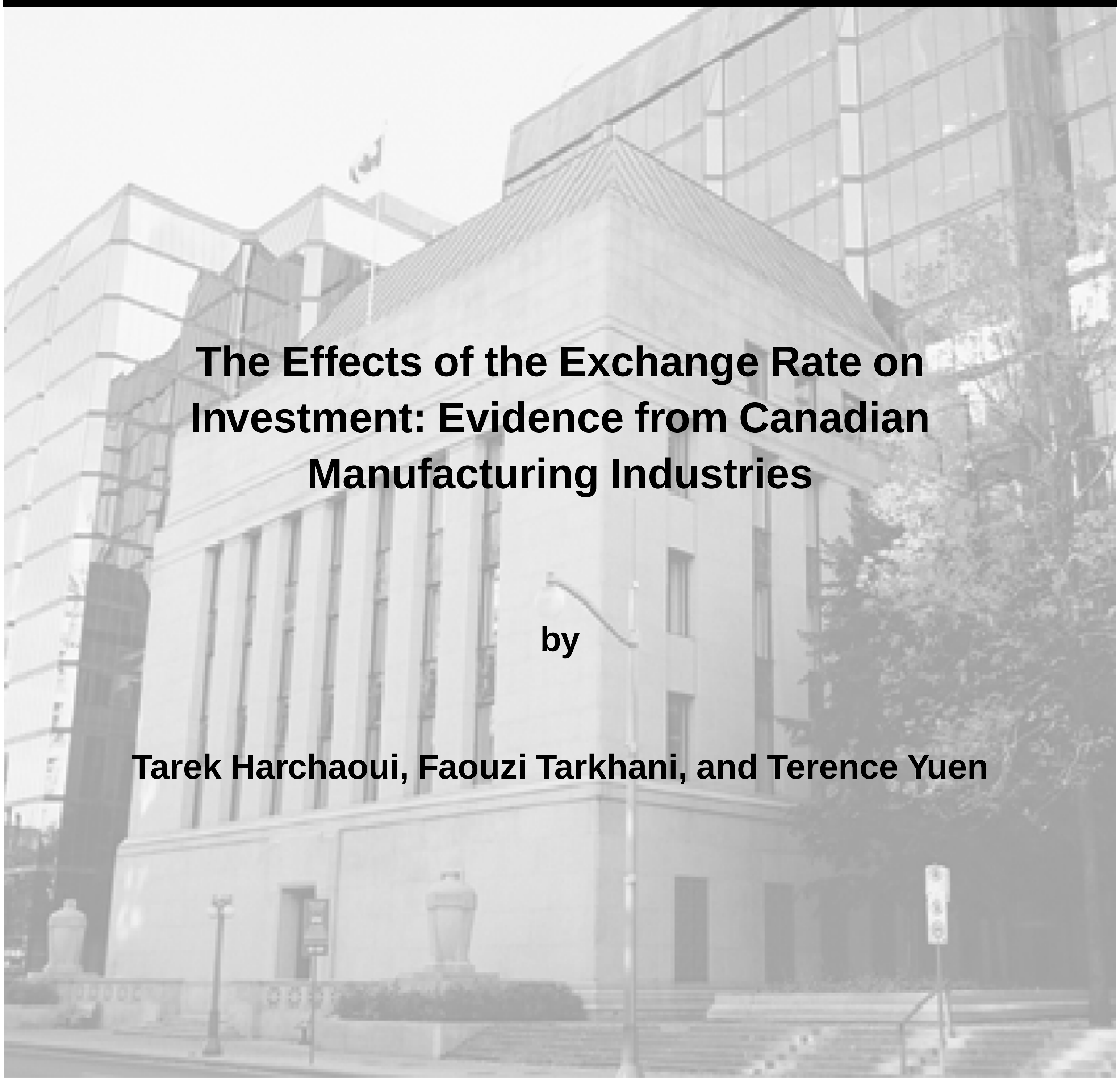

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Tarek Harchaoui,[1] Faouzi Tarkhani,[1] and Terence Yuen[2]

[1]Micro-Economic Analysis Division
Statistics Canada
Ottawa, Ontario, Canada K1A 0T6
tarek.harchaoui@statcan.ca
faouzi.tarkhani@statcan.ca

[2]Research Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
tyuen@bankofcanada.ca

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Abstract

Using industry-level data for 22 Canadian manufacturing industries, the authors examine the relationship between exchange rates and investment during the period 1981–97. Their empirical results show that the overall effect of exchange rates on total investment is statistically insignificant. Further investigation reveals the non-uniform investment response to exchange rate movements in three channels. First, it is important to distinguish between environments that have low and high exchange rate volatilities. Through changes in output demands, depreciations would have a positive effect on total investment when the exchange rate volatility is low. Yet, this stimulative effect becomes considerably smaller as the volatility increases. Second, these results for total investment are mainly due to movements in other machinery and equipment, and not to investment in information technology and structures. Third, investment in industries with low markup ratios are more likely to be affected by exchange rate movements.

JEL classification: F4, D24
Bank classification: Exchange rates; Domestic demand and components

Résumé

À l'aide de données sectorielles se rapportant à 22 branches industrielles canadiennes, les auteurs étudient le lien entre l'évolution du taux de change et l'investissement de 1981 à 1997. D'après leurs résultats empiriques, l'effet global des mouvements de change sur le volume total des investissements n'est pas significatif sur le plan statistique. Un examen plus approfondi révèle que l'investissement ne réagit pas de façon uniforme aux variations du taux de change. D'abord, il importe de distinguer les périodes où la volatilité de ce dernier est faible et celles où elle est élevée. Durant les périodes de faible volatilité, les dépréciations ont une incidence favorable sur l'investissement total en provoquant des modifications de la demande de produits. Toutefois, cette incidence diminue nettement avec l'augmentation de la volatilité. Deuxième constat : l'effet observé concerne essentiellement le segment autres machines et matériel, les investissements consacrés aux technologies de l'information et aux installations étant peu affectés. Troisièmement, dans les branches où les taux de marge sont bas, l'investissement tend à être plus sensible aux fluctuations du taux de change.

Classification JEL : F4, D24
Classification de la Banque : Taux de change; Demande intérieure et composantes

1. Introduction

Exchange rate movements have important implications for a wide range of economic variables. While a continuous effort has been made to improve our understanding of the exchange rate pass-through on prices (e.g., Taylor 2000) and profitability (e.g., Bodnar, Dumas, and Marston 2002), some recent studies have extended the analysis by examining the impact of exchange rate movements on the real economy. In particular, one research stream focuses on the relationship between exchange rate fluctuations and investment (e.g., Campa and Goldberg 1999). In theory, changes in the exchange rate have two opposite effects on investment. When the domestic currency depreciates, the marginal profit of investing an additional unit of capital is likely to increase, because there are higher revenues from both domestic and foreign sales. Yet, this positive effect is counterbalanced by the rising variable cost and the higher price for imported capital. Theoretical models provide no clear indication as to which effect is dominant. The overall effect of exchange rates on investment remains an empirical question.

Goldberg (1993) finds that a real depreciation (appreciation) of the U.S. dollar was likely to generate an expansion (reduction) in investment in the 1970s, but that the opposite pattern prevailed during the 1980s. Campa and Goldberg (1995) attribute this difference in investment response between the 1970s and 1980s to the decline in industry export exposure as U.S. firms progressively increased their reliance on imported inputs. Furthermore, their empirical findings show distinct investment patterns across industries with different price-over-cost markup ratios. They find that investment in high-markup industries with an oligopolistic market structure is less responsive to exchange rates.

Most of the empirical investigations in this area are based on data from U.S. manufacturing industries. The literature provides very limited evidence for other countries. A recent cross-country study by Campa and Goldberg (1999) compares the investment sensitivity in the United States, United Kingdom, Japan, and Canada for the period 1970–93. Surprisingly, given the high degree of openness of Canadian manufacturing industries, investment in Canada turns out to be the least responsive to exchange rate movements. The vector-autoregressive models in Lafrance and Tessier

(2001) also find an insignificant link between the Canadian real exchange rate and aggregate investment. The conclusions in these two studies pose a challenging question as to why investment in a small open economy like Canada's would be insulated from exchange rates.

We shed light on this puzzle by utilizing more disaggregated data at the industry level for the manufacturing sector, which enables us to explore four main issues regarding the non-uniformity of the exchange rate effects. First, we examine the different channels through which exchange rates affect total investment. An exchange rate depreciation (appreciation) stimulates (dampens) investment by enhancing demands in both the domestic and export markets, but it reduces (increases) investment because of the increasing cost of imported intermediate goods and the user cost of capital. Second, the variability of exchange rates can affect a firm's perception of whether the shocks are permanent or transitory. Therefore, the investment response to exchange rates may differ between a high- and low-volatility environment. Third, in addition to total investment, we compare the impact across three types of investment: information technology (IT), other machinery and equipment (M&E), and structures. Fourth, the sensitivity of investment to exchange rates may not be uniform across manufacturing industries. We check whether investment decisions in export-oriented firms with weak monopoly power are more responsive to currency fluctuations than those in firms with low export exposure and a strong ability to adjust their price-over-cost markup margins.

Our analytical framework provides the theoretical underpinning for the channels through which exchange rates affect investment. There is a widespread perception that a depreciation of the domestic currency will earn greater international competitiveness for domestic exporting firms. Rising shares in the domestic and international markets increase the firm's profitability which, in turn, leads to investment in a new plant and equipment. Hence, the larger the firm's export exposure, the more sensitive its investment in response to exchange rate fluctuations. Higher profitability also influences investment decisions either through the availability of the internal funds or the terms of credit (Gilchrist and Himmelberg 1995). Nevertheless, if domestic firms rely heavily on imported inputs in production, an exchange rate depreciation can have a negative impact on their investment decision: an increase in the variable cost of production and the user cost of capital reduces the marginal profit of investment. Moreover, our theoretical framework shows that investment in industries with weaker market power is more likely to be affected by exchange rate movements. A plausible explanation is that firms with stronger monopoly power have a greater ability to adjust their cost-price margin without altering their production and investment decisions, whereas adjustments in the low-markup industries are largely reflected in their profits.

Our empirical evidence is consistent with the earlier results in Campa and Goldberg (1999) and Lafrance and Tessier (2001). The overall effect of the exchange rate on total investment was statistically insignificant for the Canadian manufacturing sector between 1981 and 1997. In spite of this result, we find that depreciations (appreciations) tend to have a positive (negative) impact on investment when the exchange rate volatility is relatively low. This result highlights the importance of differentiating the investment response between a high and low exchange rate variability regime. Not only the level of the exchange rates but also the volatility matters for the firm's total investment decisions.

Analysis using disaggregated data reveals substantial differences across three types of capital: IT, other M&E, and structures. In a low-volatility regime, the exchange rate effects on total investment are mainly driven by the movements in other M&E, but not in investment in IT and structures. Furthermore, the sensitivity of other M&E investment to exchange rate movements is stronger in industries with low markup ratios.

The remainder of this paper is organized as follows. Section 2 outlines a theoretical framework for analyzing the main transmission channels of exchange rate variations to investment. Section 3 presents the data with some descriptive analysis. In section 4, we discuss the empirical specifications and the results. Section 5 offers some conclusions.

2. Theoretical Framework

2.1 The effects of the exchange rate on investment

We use a simple investment model in which both input and output prices are affected by the exchange rate. An industry-representative firm produces one output for the domestic (x) and foreign (x^*) market with two types of inputs: quasi-fixed capital (K)

and variable input (L). A certain portion of the factor inputs are imported. For simplicity, we assume that the ratios of the imported inputs, m_K and m_L, are determined by the firm's technology, which is constant over time.[1] In this framework, movements in exchange rates influence the firm's production decisions through changes in domestic and foreign sales, as well as the costs of imported inputs. The firm maximizes the expected present value of all future net cash flows. That is,

$$V_t = \max_{I_{t+\tau}, L_{t+\tau}} E_t \left[\sum_{\tau=0}^{\infty} \beta^{\tau} (\Psi_{t+\tau} - C(I_{t+\tau})) \right], \tag{1}$$

subject to

$$\Psi_t = p(x_t, e_t) x_t + e_t p^*(x_t^*, e_t) x_t^* - w(e_t) L_t, \tag{2a}$$

$$C(I_t) = g_t(e_t) I_t + \Phi(I_t), \tag{2b}$$

$$K_t = (1-\tau) K_{t-1} + I_t, \tag{2c}$$

$$x_t + x_t^* = F(K_t, L_t), \tag{2d}$$

where Ψ represents the total revenue from the domestic and foreign markets net of the total variable cost and $C(I)$ is the costs associated with the gross investment, I. The discount factor is $\beta = (1+r)^{-1}$, with r being the firm's nominal required rate of return, which is assumed to be constant over time. E_t is the expectation operator conditional on all the information available at time t. The exchange rate, e, is defined as the domestic currency per unit of foreign exchange. Assuming that the firm is not a price-taker in the product market, $p(\cdot)$ and $p^*(\cdot)$ denote the inverse demand functions in the domestic and foreign market, respectively. The average input prices for the variable input (w) and investment (g) are functions of the exchange rate, used to account for the corresponding

[1] The primary purpose of this theoretical framework is to illustrate the link between exchange rates and investment. With the simplified assumptions, the investment model has its limitations and it does not account for all related issues; for instance, the substitution between domestic and imported inputs, and the investment effects on the evolution of technology. Chirinko (1993) provides a general discussion on modelling business investment.

shares of imports. The total investment cost, $C(I)$, consists of the purchasing cost (gI) and the strictly convex adjustment cost (Φ). The capital stock at time t, K_t, is governed by the standard accumulation equation (2c), where τ is the depreciation rate of capital. The production function, $F(K, L)$, is homogeneous of degree one.

Solving the firm's maximization problem (1) yields the following optimal conditions[2]:

$$p\left(1+v^{-1}\right)=ep^{*}\left(1+v^{*-1}\right), \tag{3}$$

$$p\left(1+v^{-1}\right)F_L = w, \tag{4}$$

where v and v^{*} are the price elasticities of demand in the domestic and foreign markets, respectively. These first-order conditions provide interesting insights into the firm's decision process. Equation (3) states that output is allocated such that marginal revenues are the same in both domestic and foreign markets. For a given level of K, equation (4) ensures that the variable input is always adjusted such that the marginal revenue product of L equals its marginal cost, w. For the quasi-fixed capital, the optimal investment path satisfies

$$\sum_{\tau=0}^{\infty}(\beta(1-\tau))^{\tau} E_t\left(\frac{\partial\Psi\left(p_{t+\tau}, p^{*}_{t+\tau}, w_{t+\tau}, e_{t+\tau}\right)}{\partial K_{t+\tau}}\right)=\frac{\partial C(I_t)}{\partial I_t}=g_t+\frac{\partial\Phi}{\partial I}. \tag{5}$$

The expected per-period marginal benefits of investing an additional unit of capital are $E_t[\partial\Psi(\cdot)/\partial K]$. According to the optimal condition (5), the firm will invest up to the point when the present value of expected future marginal benefits of investment is equal to the marginal cost of investment, which includes the investment price and the marginal adjustment cost. Unlike the first-order condition (4) for the variable input, the quasi-fixed nature of capital requires that the investment decision at time t depend not only on the current but also the expected future gains.

To better illustrate the channels through which exchange rates affect investment, we further simplify the expectation of future price paths. Assuming that uncertainty in the

[2] To simplify the notation, all time indexes are dropped.

model is due exclusively to the exchange rate, and that the firm perceives variations in the currency as permanent shocks, the expected exchange rate in future periods is equal to today's exchange rate, $E_t(e_{t+\tau}) = e_t$. Thus, $E_t(\partial\Psi_{t+\tau}/\partial K_{t+\tau}) = \partial\Psi_t/\partial K_t$. Under these assumptions, equation (5) reduces to the expression that current investment depends only on current profits:

$$\frac{\partial\Psi(p_t, p_t^*, w_t, e_t)}{\partial K_t} = \beta(r+\tau)\left(g_t + \frac{\partial\Phi(I_t)}{\partial I_t}\right).^{3} \tag{5'}$$

Furthermore, differentiating equation (2a) with respect to K yields the following marginal benefit of investment:

$$\frac{\partial\Psi}{\partial K} = \left[p\left(1+\upsilon^{-1}\right)(1-\lambda) + ep^*\left(1+\upsilon^{*-1}\right)\lambda\right]F_K, \tag{6}$$

where λ is the share of exported output (i.e., $x^*/x+x^*$). The first and second terms inside the parentheses refer to the weighted average of the marginal revenue from domestic and export sales, respectively. The third term corresponds to the marginal product of capital. Equation (6) simply states that the marginal benefit of investing an additional unit of capital is the marginal revenue product of capital. Substituting (6) into (5'), the optimal investment path becomes

$$\left[p\left(1+\upsilon^{-1}\right)(1-\lambda) + ep^*\left(1+\upsilon^{*-1}\right)\lambda\right]F_K = \beta(r+\tau)\left(g + \frac{\partial\Phi}{\partial I}\right). \tag{7}$$

According to equation (7), the firm's investment decisions are determined by three main factors: the marginal revenue product of capital, the user cost of capital $((r+\tau)g)$, and the marginal adjustment cost of investment $(\partial\Phi/\partial I)$. In general, a rise in

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[3] It is interesting to look at the firm's long-run equilibrium when the net investment is completed such that the capital stock is maintained at the desired level, K^*. In other words, $K_t = K_{t-1} = K^*$ and $I = \tau K^*$. In the case when the marginal adjustment cost depends on the net investment, e.g., $\Phi(I) = a(I - \tau K)^2$, for $I = \tau K$, $\partial\Phi/\partial I = 0$. Equation (5) implies that, for $K = K^*$, $\partial\Psi(\cdot)/\partial K = (r+\tau)g$. This long-run condition is the familiar static equilibrium with no adjustment cost, which requires the firm to equate the marginal revenue product of capital to the user cost.

the marginal revenue product of capital will increase investment, whereas an increase in the user cost and the marginal adjustment cost will have the opposite effect. Let us consider in detail the different channels through which exchange rates affect these three factors. Following the literature, the adjustment cost of investment generally refers to the output loss associated with the installation and integration of new capital; for example, the costs of reorganization to incorporate new machinery, and on-the-job training of workers. These costs are internal to the firm and they are unlikely to be influenced by the exchange rate. Hence, our focus is on the transmission of exchange rate fluctuations to the marginal revenue product of capital and the user cost of capital.

2.1.1 Channel 1: Domestic and foreign demand

In a monopolistic market where domestic and imported products are differentiated, imports become relatively more expensive when the currency depreciates (Dornbusch 1987). This change in the relative price raises the demand for domestic goods. Export revenues also increase as a result of the direct valuation of the exchange rate depreciation. These correspond to an upward shift in the marginal revenue curves in the domestic and foreign markets, $p\left(1+\upsilon^{-1}\right)$ and $ep^{*}\left(1+\upsilon^{*-1}\right)$.[4] Thus, for a given K and L, both the marginal revenue product of capital and labour increase due to favourable demand conditions. Profit-maximizing firms respond by increasing K and L to produce more output.[5] We expect a depreciation to have a positive impact on investment as a result of stronger demand in both domestic and export markets.

2.1.2 Channel 2: Prices of imported variable inputs

If the pass-through on imports is greater than zero, for industries relying on imported variable inputs (i.e., $m_L > 0$), the variable input prices increase when the exchange rate depreciates. That is, $\partial w/\partial e > 0$. Also note that, for a given pass-through, the higher the ratio of m_L, the larger the increase in the variable input price as a result of a

[4] For detailed discussions on the effects of this shift on the industry's marginal revenue, see Appendix A.

[5] Note that the short-run expansion path is not a straight line, because of the adjustment cost of capital. As output increases, the ratio of K/L falls. This implies a decline in the marginal product of capital. For a homogeneous production function, the marginal product of capital depends only upon the K/L ratio; i.e., $F_K(K, L) = F_K(K/L)$.

depreciation. Intuitively, a rise in w has two opposing effects on investment. First, the marginal cost of producing an additional unit of output increases with the variable cost. As a result, both K and L diminish as firms lower their levels of output. Second, the negative output effect on investment is counterbalanced by the substitution effect. Keeping the price of capital constant with no pass-through, the partial effect is that variable inputs become relatively more expensive as the input-price ratio, w/g, rises. This change in the relative price enhances investment as a result of the substitution of capital for the variable input. Referring to equation (7), the negative output effect increases the marginal revenue, whereas the substitution effect of raising K/L would have a negative impact on the marginal product of capital (F_K). Therefore, the combined effect on the marginal revenue product of capital $(\partial\Psi/\partial K)$ is ambiguous, depending on the elasticity of the output demand. An increase in the variable input price caused by a depreciation can have a positive or a negative effect on investment. In a perfectly competitive market, the marginal revenue remains constant when output falls. A decline in F_K results in a decrease in $\partial\Psi/\partial K$. Conversely, if demand is highly inelastic, the decline in F_K can be offset by an increase in marginal revenue, in which case an increase in w may lead to an increase in $\partial\Psi/\partial K$.

2.1.3 Channel 3: Price of imported investment

Exchange rates have a direct impact on the user cost of capital through movements in the investment price, g.[6] As long as part of the investment is imported (i.e., $m_K > 0$) and the exchange rate pass-through on the imported capital is greater than zero, a depreciation leads to an increase in the price of investment. That is, $\partial g/\partial e > 0$. Similar to the imported variable price, the exchange rate effect on g increases with the share of imported investment (m_K). A rise in the user cost causes investment to diminish as firms reduce output and substitute the variable input for capital. Less output implies an upward movement along the demand curve, which raises the marginal revenue. Also, simultaneously, as the variable input is substituted for the relatively more expensive

[6] There can be a secondary link between exchange rates and the user cost of capital. The interest rate, as the instrument of monetary policy, may respond to exchange rate movements to shelter the real economy from their impact.

capital, the marginal product of capital increases as K/L rises. To maintain the optimal condition (7) in the case of higher user cost of capital, the output and substitution effects work together to decrease investment in order to increase the marginal revenue product of capital and reduce the marginal adjustment cost.

To summarize, exchange rates affect investment decisions via three channels: domestic and foreign demand, the prices of variable inputs, and the investment price. The first two channels affect the marginal benefit of investment, whereas the last channel influences the user cost of capital. Depending on the extent of the exchange rate pass-through, the shares of imported inputs, and demand elasticities, the net effect of the three channels on investment is unclear. In the case where all inputs are produced domestically, the only exchange rate effect is on domestic and foreign demand. Depreciation is likely to have a positive impact on investment as the marginal benefit of investment increases. In contrast, if the pass-through on the prices of imported inputs is high, firms that rely heavily on imported inputs would reduce their investment as the variable input price and the user cost of capital increases during periods of exchange rate depreciation. The theory provides no clear indication on the exchange rate's overall effect on investment. Determining the dominant effects remains an empirical question, which will be addressed in section 3.

2.2 Different investment sensitivity to exchange rates across industries

Despite the ambiguity of the overall exchange rate's effect on investment, our model is able to shed light on how investment sensitivity varies across industries. We focus on two main areas: the degree of pricing power and export exposure. The positive (negative) effect of a depreciation (appreciation) on investment increases with the industry's reliance on exports. Moreover, investment in highly competitive industries with low markup ratios is likely to be more responsive to exchange rate movements.

In general, export-oriented firms are more likely to be affected by exchange rate movements, because the direct valuation effect on export revenue is greater than the substitution effect in the domestic market. The empirical evidence in Campa and Goldberg (1999) supports this notion for the manufacturing industries in the United States and Japan. They find that the stimulative effect of a depreciation on investment rises with the industry's revenue share from exports and declines with its reliance on imported inputs.

The second industry feature is related to the degree of monopoly power that is commonly proxied by the price-over-cost markup ratio. Campa and Goldberg (1995 and 1999) show that the effects of the exchange rate on the firm's investment are inversely related to its markup ratios. Investment in highly competitive industries with low markup ratios is more responsive to exchange rate movements. Using data for the U.S. manufacturing sector, they find that a 10 per cent depreciation between 1970 and 1993 would result in an average reduction of investment by 2 per cent for the low-markup industries, but they find only half of the effect (-1%) for the high-markup industries.

In our analytical framework, firms maximize profits such that $p/MC = \left(1 + \upsilon^{-1}\right)^{-1}$. This implies that the markup ratio (*p/MC*) rises as υ becomes less negative. In other words, product demands in an oligopolistic market structure with high markup ratios are less elastic than those in a perfectly competitive market with zero markup. Even in the case when the exchange rate effects on the product demand are identical between the high- and low-markup industries, high-markup firms will dampen the exchange rate effect on profitability by adjusting their output prices and markups. In contrast, in highly competitive industries, firms have very limited pricing power and prices are set near to the marginal cost. The adjustments to exchange rates are largely reflected in changes in the firm's profits.[7] Therefore, the lower the industry markup ratio, the stronger the exchange rate effect on profits, and hence investment.

Note that our theoretical model is based on a neoclassical framework with no financial market in it. In the literature, there are other models that relate the firm's investment decisions to the financial situation. We are not able to explore that area, however, because our empirical analysis is conducted using industry-, not firm-level, data and very limited financial information is available at the industry level.

One notion is the possibility of hedging the exchange rate risk. Firms with a higher degree of monopoly power are less affected by exchange rates because their

[7] This is consistent with the findings in Allayannis and Ihrig (2001) and Bodnar, Dumas, and Marston (2002). Their theoretical models as well as the empirical evidence show that the responsiveness of the firm's profits to changes in exchange rates increases with the degree of competitiveness in the industry.

profits are typically hedged to a greater extent against the currency risk. The theoretical model in von Ungern-Sternberg and von Weizsacker (1990) demonstrates that the degree of optimal coverage, measured as the share of the firms' expected future profits, is greater in both Cournot and monopolistic competition than in perfect competition.[8] Using a sample of Standard and Poor's (S&P) 500 non-financial firms for 1993, Allayannis and Ofek (2001) document that firms heavily exposed to exchange rate risk through foreign sales are more likely to use currency derivatives for hedging. The negative relation between the optimal hedging and the degree of competitiveness in the industry would weaken the link between investment and exchange rates.

Fazzari, Hubbard, and Petersen (1988) and Gilchrist and Himmelberg (1995) argue that another way for firms with a higher degree of monopoly power to be less affected by exchange rate fluctuations relates to the positive relationship between cash flow and investment. A plausible explanation for this relationship is capital market imperfections due to information and incentive problems. In a perfect market, the availability of a firm's internal funds, conventionally proxied by cash flow, play an insignificant role in investment decisions. However, investment in financially constrained firms, which face a large wedge between internal and external funds, is excessively sensitive to cash flow.[9] To the extent that current profits display some co-movement with cash flow, and profits in low-markup industries are more sensitive to currency movements, we would expect the cash flow in low-markup industries, and hence investment, to be more responsive to exchange rates.

3. Data

Using annual data from the Canadian Productivity Accounts, we obtain investment information for 22 Canadian manufacturing industries[10] for the period 1981–

[8] See Hodrick (1989) for an insightful discussion on firms' decisions to hedge against foreign currency risk.

[9] Hubbard (1998) provides a detailed discussion of capital market imperfections and investment. His argument is challenged by Kaplan and Zingales (1998 and 2000), who assert that investment in less financially constrained firms is more sensitive to cash flow than those that are more financially constrained. They conclude that cash flow-investment sensitivities are not good measures of financial constraints.

[10] The manufacturing industries are grouped according to the 1980 Standard Industrial Classification. Each sector is identified in Table 1.

97. The data can be disaggregated into three different types of assets: IT, other M&E, and structures. Before we look at the investment patterns for individual industries, it is useful to examine the overall pattern for the manufacturing sector (Figure 1). It has been well-documented in the literature that investment and real output growth are strongly correlated at the aggregate level. Total investment in the manufacturing sector has shown positive growth for most of the years between 1981 and 1997, with an average annual rate of 4.4 per cent. The only significant decline in growth occurred during recessions in the early 1980s and 1990s. Differences across investment types are shown in Figure 2. It is obvious that fluctuations in total investment growth are mainly driven by investment in other M&E and structures, which account for the bulk of total investment. In contrast, IT investment, with an average annual growth of over 16 per cent for the period 1981–97, follows a somewhat different pattern over time, with relatively less variability.

We next examine investment patterns across industries. Table 1 reports the industry average annual growth rates by investment types. As shown in the last column, the growth rate of total investment ranged from -5 per cent in refined petroleum and coal products to 7.8 per cent in other manufacturing and transportation equipment. Divergent growth rates are also evident in other types of investment (columns 1 to 3). For example, investment in IT grew at an average annual rate of 8.9 per cent in textiles, and at the much faster rate of 25.3 per cent in plastic products. Furthermore, Figure 3 demonstrates that the investment patterns did not evolve identically across industries. While investment in the non-metallic mineral industries grew in cyclical patterns, similar to the aggregate picture, investment in the textile products industries grew at relatively steady rates. An important message from Table 1 and Figure 3 is that there are substantial variations in investment behaviour across industries.

For the key explanatory variable in our analysis, the exchange rate (e) is the real C-6 effective exchange rate computed by the Bank of Canada. It is an index of the weighted-average foreign exchange value of the Canadian dollar against foreign currencies of the major trading partners.[11] An increase in e is interpreted as a depreciation in the real value of the Canadian currency. Figure 4 compares the real C-6 and Canada-U.S. bilateral exchange rates between 1981 and 1997. It is not surprising that the two

[11] For details of the C-6 index, see Appendix B.

indexes are strongly correlated, because of the dominant U.S. trading weight in the C-6 calculation. Lafrance and St-Amant (1999) conclude that the difference between the two real exchange rate indexes is statistically insignificant.

Another interesting feature in Figure 4 is that movements of the real exchange rate between 1981 and 1997 can be broken down into three distinct periods. The Canadian dollar had been depreciating since the 1970s before the 14.3 per cent rebound between 1987 and 1991. The real exchange rate followed a sharp depreciation trend throughout the rest of the 1990s. As a result, the relative price between Canada and its major trading partners fell to the lowest level by the end of the sample period.

4. Empirical Estimation

The analytical framework developed in section 2 provides the theoretical motivation for the link between investment and exchange rates. To relax the restrictive assumption that all exchange rate shocks are permanent, we allow expectations at time t on future prices to depend on information available in the current year and the past two years.[12] The empirical implementation of the optimal condition (7) can be specified in the following log-linear investment equation:

$$\Delta I_{it} = \alpha + \theta \Delta K_{it-1} + \sum_{j=0}^{2} \kappa_j \Delta e_{t-j} + \sum_{j=0}^{2} \gamma_j \Delta uc_{it-j} + \sum_{j=0}^{2} \Theta_j \Delta w_{it-j}$$
$$+ \phi_0 \Delta C_t + \phi_0 \Delta US_t + \vartheta Y^{90} + v_{it}, \qquad (8)$$

where Δ indicates log changes of the variables; I_{it} represents the gross investment of industry i in year t; $K_{it\text{-}1}$ is the industry capital services in the previous year; e_t is the real C-6 exchange rate computed as units of domestic currency per unit of foreign currency; uc_{it} is the industry user cost of capital; w_{it} is a vector of variable input prices for energy, labour, material, and other services; C_t and US_t denote the Canadian aggregate consumption and the U.S. gross domestic product, respectively, to control for the aggregate demand conditions in the domestic and foreign markets, which are unrelated to

[12] The basic results reported in Tables 2 to 12 remain unchanged, with longer lag structures.

the exchange rates; and Y^{90} is a dummy variable[13] that allows the time trend (α) to differ in the post-1990 period. Appendix B provides detailed definitions of the variables.

All variables are first-differenced to eliminate the industry fixed effects that represent the industry-specific adjustment cost and depreciation rate. We also take into account the non-stationarity of the gross investment series and the real exchange rate.[14] We apply the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to each of the industry series used in our empirical analysis. None of the test values rejects the null hypothesis of a unit root at the 5 per cent confidence level. The unit root test for heterogeneous panels proposed by Im, Pesaran, and Shin (2003) provides the same result. We then run the tests on the first differences, and the result does not reject the unit root for any of them. The evidence thus suggests that all industry investment series are integrated of order one, I(1). To avoid the potential problem of a spurious panel regression,[15] we run our regressions using the first differences in logs of all the variables we employ.

Before turning to the empirical estimations, we use the theoretical model to guide us in interpreting the coefficients in equation (8). In particular, we focus on the coefficients that correspond to the three channels through which exchange rates affect investment decisions: domestic and foreign demand, the prices of variable inputs, and the investment price. First, it is important to note that the coefficient of the exchange rate (κ) represents only the demand channel.[16] We expect that $\kappa > 0$ because output demand from the domestic and foreign market is likely to increase as a result of a depreciation. Second, the investment price channel can be inferred from the parameter γ. An increase in the user cost of capital would have a negative impact on investment; i.e., $\gamma < 0$. The exchange rate effects on investment through the user-cost channel can be computed as γ

[13] $Y^{90} = 1$ for years after 1989, and 0 otherwise.

[14] In addition, other series, including aggregate consumption and U.S. gross domestic product, are also non-stationary.

[15] Another reason is that some data series (for example, variable input prices) are indexed.

[16] We do not include the current industry output as an explanatory variable, because exchange rates affect the industry output demands in the foreign and domestic markets. If current industry output is included, the exchange rate effects through the output demand channel would not be fully reflected in κ. In other words, κ is biased towards zero. Furthermore, adding lagged industry outputs as regressors does not change the main results in Tables 2 to 12.

multiplied by the exchange rate pass-through and the ratio of imported investment. Third, the variable price channel is captured in Θ. The theoretical model has no prediction regarding the sign of Θ. Depending on the elasticity of output demand and the substitutability between capital and the variable input, Θ can be positive or negative. Given the estimates of Θ, the exchange rate effect is further determined by the pass-through and the industry's reliance on imported variable inputs.

4.1 Total investment

Table 2 reports results for total investment. As a benchmark for comparison, we begin with the ordinary least squares (OLS) estimations in columns (1) and (2). Standard errors are corrected using the Beck and Katz (1995) procedure, which assumes heteroscedasticity across industries,[17] and that investment shocks are contemporaneously correlated across industries. That is, the error terms are assumed to have finite moments with Cov($\nu_{it}\ \nu_{jt}$) = σ_{ij}^2, for $i \neq j$, and Var(ν_{it}) = σ_{ii}^2.[18] A common solution to estimate this type of model is to use generalized least squares (GLS). As Beck and Katz (1995) point out, however, GLS is not feasible in this case, because the number of industries in our panel data is greater than the number of time periods.[19] Similar to White's (1980) heteroscedasticity-consistent estimator, the panel-corrected standard errors do not change the OLS estimates of the coefficients, but provide a robust covariance matrix.

One potential problem of OLS estimation relates to the inclusion of K_{t-1} as an explanatory variable in equation (8). Since K_{t-1} can be written as $(1-\tau)K_{t-2}+I_{t-1}$, first-

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[17] We perform the likelihood ratio test, and the null hypothesis of homoscedasticity is strongly rejected.

[18] In general, the covariance matrix of the disturbances of N industries with T time periods can be written as

$$\Omega = \Lambda \otimes I_T = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{12} & \sigma_{22} & & \\ \vdots & & \ddots & \\ \sigma_{122} & & & \sigma_{NN} \end{bmatrix} \otimes I_T,$$

where $\otimes$ is the Kronecker product, Λ is the N by N matrix of contemporaneous covariances, and I_T is a T-by-T identity matrix.

[19] For GLS estimators, we have to compute $\hat{\Omega}^{-1} = \hat{\Lambda}^{-1} \otimes I_T$ using the OLS residuals. Therefore, GLS requires that $\hat{\Lambda}$ be non-singular. If $T < N$, the rank of $\hat{\Lambda}$ is T and therefore $\hat{\Lambda}$ must be singular. In this case, GLS can still be estimated using the generalized inverse. Another concern is the finite sample properties of GLS. Asymptotic properties indicate that GLS is more efficient in large samples. Yet, for small samples, the Monte Carlo analysis by Beck and Katz (1995) finds that GLS typically produces downward bias in the standard errors.

differencing the data to remove the industry fixed effects and non-stationarity of the series would generate inconsistent estimates, because of the correlation between ΔK_{t-1} and Δv_{it-1}. This problem is similar to the fixed-effect estimator in a dynamic panel model with lagged dependent variables. To provide consistent estimates, two-stage least squares (2SLS) results using ΔK_{t-2} as an instrument for ΔK_{t-1} are reported in Table 2, columns (3) and (4). Furthermore, generalized method of moments (GMM) estimation following the Arellano and Bond (1991) procedure is reported in columns (5) and (6).[20] Lagged levels of K are used as instruments for ΔK_{t-1}.[21] In theory, Arellano-Bond GMM procedures are more efficient than the 2SLS estimator in large samples. The Monte Carlo study by Judson and Owen (1999), however, shows that in finite samples (e.g., $T = 20$ and $N < 100$), the difference in performance between these two estimators is very small. Robust standard errors are computed using White's (1980) procedure for both 2SLS and GMM estimates.

There are only minor differences across specifications in Table 2, columns (1) to (6). Estimates from OLS, 2SLS, and Arellano-Bond are very similar. Adding one more lag does not change the overall results. For the demand channel, all estimated coefficients of the current and lagged exchange rates are statistically insignificant. Moreover, the sum of these coefficients is not significantly different from zero in all cases. There is no evidence that a firm's investment decisions are affected by exchange rate movements through the demand channel. A direct interpretation is that exchange rates have no impact on output demands in the domestic and export markets and that, therefore, factor inputs including investment are insensitive to exchange rate variations. In other words, export prices in foreign currency fluctuate with the exchange rate such that the revenue from export sales remains relatively stable. This explanation is inconsistent with the empirical

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[20] The Sargan test of overidentifying restrictions suggests that the moment restrictions are valid. Also, the hypothesis that there is no second-order serial correlation in the first-differenced residuals cannot be rejected. See Arellano and Bond (1991) for details on the Sargan test and the test for serial correlation.

[21] In theory, any lagged level, log K_{it-j}, $j \geq 2$, is a valid instrument. The Arellano and Bond estimates reported in this paper use two lagged levels as instruments. The number of lags is restricted, because introducing a large number of lags leads to an "overfitting" problem, where the Arellano-Bond estimates tend to move towards the estimates from the within-groups OLS estimator. See Leung and Yuen (2005) for more details.

results in Yang (1998), who shows that most exporters to the United States would absorb exchange rate movements through their profit margins to keep their prices steady.

Another plausible explanation is that output demands are in fact influenced by the exchange rate, but that firms do not change their investment when they consider movements in the exchange rate to be mainly driven by temporary shocks. In this case, exchange rate fluctuations would be sheltered by adjustments in the variable inputs, but not the quasi-fixed investment. Especially when exchange rates are very volatile, it is difficult to distinguish between permanent and transitory shocks. Therefore, uncertainty tends to weaken the link between exchange rates and investment. The more volatile the exchange rates, the less responsive investment is to their movements. Without controlling the variability of the exchange rates, the coefficients of the current and lagged exchange rates in columns (1) to (4) may be biased towards zero.

To test this hypothesis, we need to compute the exchange rate variability. Since there is no consensus in the literature on the appropriate method of measuring exchange rate volatility, we examine three common measures of volatility that are constructed using the monthly nominal C-6 exchange rates: (i) the coefficient of the variation in the monthly level; (ii) the standard deviation of the monthly growth rates; and (iii) the conditional variance from a generalized autoregressive conditional heteroscedasticity (GARCH) (1,1) model.[22] Results are reported in Table 3. For ease of comparison, all measures are expressed in terms of the number of standard deviations from the sample mean. Therefore, a positive (negative) sign indicates that the exchange rate fluctuations are above (below) the average level. Although the magnitude may differ across volatility measures, Figure 5 shows that the evolution follows a similar pattern in all three series. Next, we divide exchange rate movements into two regimes: high and low volatility. Since there is no consensus on the most appropriate measure of exchange rate variability, our classification makes use of the information in all three of them. Formally, year t is considered to be in the high-variability regime only if the exchange rate variability at t is more than 0.5 standard deviations above the sample mean in at least two measures; otherwise, it is considered to be in the low-volatility regime. As shown in the last column

[22] More detailed discussions on various measures of the exchange rate volatility are provided in IMF (2004) and Siregar and Rajan (2002).

of Table 3, exchange rate movements in 1982, 1988, 1990, and 1992 to 1995 are in the high-volatility regime.

We modify equation (8) so that the exchange rate effect can vary between the high- and low-variability regimes[23]:

$$\Delta I_{it} = \alpha + \theta \Delta K_{it-1} + \sum_{j=0}^{2} \left(\kappa_j + o_j D_j^{\xi} \right) \Delta e_{t-j} + \cdots, \tag{9}$$

where the dummy variable D_j^{ξ} = 0 for the high- and low-volatility regimes. Hence, o_j distinguishes the difference in investment sensitivity between the two regimes. Note that the coefficient κ_j in equation (8) can be interpreted as the average output demand channel of the two variability regimes. In equation (9), κ_j corresponds to the exchange rate effect in the low-variability regime, whereas $\kappa_j + o_j$ represents the effect in the high-variability regime.

OLS, 2SLS, and Arellano-Bond estimates for equation (9) are reported in Table 4. Compared with the results in Table 2, there is a notable difference in the positive estimates of the current and lagged exchange rates (κ_j in equation (9)). The key finding is that the sum of the exchange rate coefficients is statistically significant and greater than zero; i.e., $\sum \kappa_j > 0$. This result is robust across estimation methods and lag lengths in columns (1) to (6). When the exchange rate volatility is close to or below the average level, depreciations (appreciations) tend to have a positive (negative) impact on total investment. A 1 per cent depreciation of the real exchange rate would raise the total investment by more than 1 per cent. This is consistent with the economic intuition that firms will adjust their investment patterns in response to output demands when they perceive the exchange rate movements to be permanent.

[23] An alternative approach is to decompose exchange rate movements into transitory and permanent components using some statistical procedures. Following the decomposition suggested by Beveridge and Nelson (1981), we try to model the quarterly C-6 real exchange rates. Similar to the results in other studies (e.g., Campa and Goldberg 1999), the variance of the transitory component accounts for only a very small portion of the actual movements. In particular, annual changes in the real exchange rate are remarkably close to the estimated permanent trend. Therefore, when we replicate the analysis using the permanent components of the exchange rate, the key results remain unchanged.

If exchange rate volatility has a dampening effect on the response of investment to changes in output demands, the coefficients of the interaction between the exchange rate and volatility dummy (o_j in equation (9)) should be negative. Consistent with intuition, our empirical results in Table 4 show that these estimates are mostly negative and statistically significant for time t and t-1. These results reject the null hypothesis that the investment response to exchange rates is identical between the high- and low-volatility regimes. The output channel effect is significantly smaller when the exchange rate variability is high. In this case, we would expect depreciations of the exchange rate to have a small positive effect on investment through the output channel. This implies that the sum of the coefficients on the exchange rates (Δe_{t-j}) and their interactions with the volatility dummy ($\Delta e_{t-j} \times D^{\xi}_{t-j}$) should be marginally positive or insignificantly different from zero. Yet, it is a bit puzzling that the results in Table 4 turn out to be all negative and significant, except in column (5); this means that investment will fall as a result of exchange rate depreciations when the exchange rate volatility is high.[24] This is probably due to the investment decline during the recession in the early 1990s and the continued softness in other M&E until 1995. Even with the control for aggregate demand, it is likely that part of the weakness in investment in the first half of the 1990s would be captured in the volatility dummy, because all years between 1990 and 1995, except 1991, are considered as the high-volatility regime. Nevertheless, an important message from Table 4 is that not just the level, but also the volatility, of exchange rates appears to play a crucial role in investment decisions.

Our discussion so far has focused on the output demand channel. As noted earlier, there are two other channels through which exchange rates affect investment. Regarding the user-cost channel, the sum of the coefficients on the user cost of capital in Tables 2 and 4 has the predicted negative sign in most cases. Only one of them (column (2) of Table 4), however, is statistically different from zero at the 5 per cent confidence level. It is not surprising that the elasticity of investment with respect to the user cost is close to zero in many empirical studies (Chirinko 1993 and 2002). One interpretation is that firms

[24] This result is even more problematic in the case of appreciations. Investment would rise when the currency appreciates in the high-volatility regime. We focus on the effects of depreciations, because exchange rate movements in the high-variability regime are predominantly depreciations in the early 1990s.

consider much of the variation in user cost as transitory shocks. Kiyotaki and West (1996) argue that this is the main reason why they find a much larger elasticity of capital with respect to output than with respect to user cost. Another reason is that the user-cost effect on investment varies substantially across its subcomponents. Schaller (2002) finds that the total capital stock is affected by its own price, but that the long-run elasticity with respect to the real interest rate and taxes is close to zero. We will discuss this matter in section 4.2 using the disaggregated data on three different types of investment. Arguably, the exchange rate directly affects the imported investment price, and hence the user cost of IT and other M&E, but not structures.

Another channel through which exchange rates affect investment is through changes in the price of imported variable inputs. Given that prices for energy, labour, and other services are mainly domestic and they are unlikely to be affected by exchange rate movements, we focus on the price of material inputs. As shown in Tables 2 and 4, the estimated coefficients of the material input price are all positive. The sum of the estimates of the current and lagged periods is between 0.4 and 0.5 in most cases, and a number of the sums are estimated with high precision. To compute the exchange rate effects on investment, we need to know the share of imported material inputs. Calculations based on the input-output tables indicate that the imported share of intermediate inputs in goods[25] for the manufacturing sector is around 0.45 in the 1990s. Hence, with the assumption of complete pass-through in the imported material price, a 1 per cent depreciation leads to a 0.45 per cent increase in the material input price. This, in turn, would raise the total investment by a maximum of 0.2 per cent. If any part of the imported material is priced to market, this estimate should be even lower.[26]

4.2 Investment in IT, other M&E, and structures

We next examine whether the patterns observed in Tables 2 and 4 apply uniformly to all types of investment. Equations (8) and (9) are re-estimated with the total

[25] Commodities 1 to 28 in the S-classification of the input-output tables are considered as intermediate inputs in goods.

[26] We are not able to investigate the exchange rate pass-through on imported input prices using our data, because Statistics Canada assumes the pass-through on imported input prices to be 100 per cent and there is no pricing-to-market. By construction, the price of imported inputs is calculated as the price in foreign currency multiplied by the bilateral exchange rate.

investment disaggregated into three types of investment: IT, other M&E, and structures. Results in Tables 5 to 10 reveal striking differences across investment types. We begin with the IT investment in Tables 5 and 6. Compared with total investment, a notable difference is that the exchange rate volatility does not seem to play an important role in IT investment. Although the estimates of the interaction term between the exchange rate and volatility dummy in Table 6 are positive, none of them is precisely estimated. From a statistical standpoint, we cannot reject the null hypothesis that there is no difference between the high- and low-variability regimes. Moreover, the sum of the coefficients of the exchange rate is not significantly different from zero in both Tables 5 and 6. This implies that changes in the exchange rate have no impact on IT investment through the output channel. Insignificant results are also found for the user cost and the material price channel. In sum, our findings show that IT investment does not respond to the exchange rate in any of the channels.

For other M&E investment, the results appear to be almost identical to those for total investment in Tables 2 and 4. In terms of the output demand channel, without controlling for the exchange rate regime, the sum of the coefficients of the exchange rates is insignificant in Table 7, except for in column (3). Results in Table 8 show that it is critical to distinguish the divergent patterns between the high- and low-variability regimes. The interaction term between the exchange rate and the volatility dummy is negative and precisely estimated for time *t* and *t*-1 in most cases, which means that the responsiveness of investment to the exchange rate is much lower in the high-volatility regime. When the currency depreciates, the sum of the coefficients of the exchange rates is greater than zero, which implies that other M&E investment is likely to rise only if the exchange rate volatility is low. Regarding the other two channels, none of the user-cost estimates is significant. Changes in the material input price due to exchange rate movements may have a small effect on other M&E investment.

Finally, results for investment in structures are similar to those for IT investment. The only significant results in Tables 9 and 10 are from the user cost. However, we expect the link between the exchange rate movements and the user cost of investment in structures to be relatively weak, because of the low direct pass-through on structure prices.

4.3 Differences across industries

To examine the variations in the sensitivity of investment across manufacturing industries, we focus on two dimensions: export orientation and monopoly power. The industry export orientation at year *t* is measured by the net trade exposure, defined as the ratio of exports to gross output minus the share of imported inputs in gross output plus the share of competing imports in the domestic market.[27] We calculate the average net trade exposure over the sample period for each industry. An industry is classified as high- (low-) export oriented if the average net trade exposure is above (below) the median. In other words, industries are equally divided between the high- and low-export groupings.

The degree of monopoly power is proxied by the price-over-cost markup ratio. Following the methodology of Roeger (1995),[28] we calculate the average markup ratios over the sample period for each industry. Industries are then equally divided into the high- and low-markup groups based on their average markup ratios. Table 11 arranges the classification of industries[29] into four subgroups: (i) high markup and high export (HH), (ii) high markup and low export (HL), (iii) low markup and high markup (LH), and (iv) low export and low markup (LL).

We re-estimate equation (9) by allowing the coefficients of the exchange rate (κ_j) and the volatility regime dummy (o_j) to vary across the four subgroups. 2SLS results[30] are reported in Table 12 for the total, other M&E, IT, and investment in structures. Columns denoted (LV) refer to the exchange rate impact through the output channel in the low-volatility regime $\left(\sum \kappa_j\right)$, and columns denoted (HV) refer to the output effects in the high-volatility regime $\left(\sum \kappa_j + o_j\right)$. The basic findings are the same as those reported in Tables 2 to 10. Changes in output demand due to exchange rate movements do not affect the investment decisions in IT and structures. Table 12 shows

[27] Details on the definition of each component are provided in Dion (1999–2000).

[28] Roeger shows that the difference between the primal- and dual-based measures of total-factor productivity is solely a function of the markup ratio if constant returns to scale and full-capacity utilization are assumed.

[29] The refined petroleum and coal products industry is dropped from this analysis because we are unable to construct the markup ratio, due to missing data.

[30] The specification includes two lags (i.e., j = 2) of exchange rates and input prices. The basic findings remain unchanged using Arellano-Bond GMM estimations.

that this conclusion applies to all four industry subgroups. None of the exchange rate estimates for these two types of investment is significant.

For total and other M&E investments in the high-variability regime, estimates in columns (HV) are negative and significant in most cases. Moreover, the magnitude is very similar across industry groups. We cannot reject the null hypothesis that they are the same in all four subgroups; i.e., HH=HL=LH=LL. In other words, when the exchange rate variability is high, the exchange rate impact on total and other M&E investment would be comparable across industries with different export-orientation and markup ratios.

In the low-volatility regime (LV), the exchange effects on total and other M&E investments are positive and significant only for the low-markup groups, LH and LL. In contrast, we cannot reject the null hypothesis that the estimates for both high-markup groups are jointly equal to zero; i.e., HH=HL=0. This is consistent with the theory that investment in industries with low market power is more sensitive to exchange rate movements. Within the low-markup industries, the exchange rate effects in the group exposed to high net trade (LH) appear to be larger than for the group exposed to low net trade (LL). However, we cannot reject the null hypothesis that the impact is the same in both groups; i.e., LH=LL. Thus, our results do not find strong evidence in support of a greater investment sensitivity to exchange rate movements in highly export-oriented industries.

5. Conclusions

Over the 1990s, as the Canadian exchange rate depreciated, there was considerable speculation among analysts that the depreciation would dampen investment because of the large degree of imports of M&E. Such a view relies heavily on one of the channels through which the exchange rate affects the user cost of capital. Depreciations are likely to contribute to lower investment by increasing the price of imported M&E and by lowering the relative cost of labour, and thereby substituting labour for capital. To present a more complete picture, we have to take the output channel into consideration. To the extent that the depreciation in the 1990s boosted external demand for outputs, this channel may have offset the negative impact from the rising cost of capital. The overall impact is not obvious a priori, because it depends on which of the channels prevails. Our empirical estimates show that the exchange rate effects on total investment in the Canadian manufacturing industries appear to have been minimal between 1981 and 1997. This conclusion is consistent with that of Campa and Goldberg (1999) and Lafrance and Tessier (2001). Moreover, the insignificant link between Canadian real exchange rates and investment is not explained by the possible opposing effects of the output and user-cost channels. Indeed, none of the channels shows a significant impact on investment behaviour at the industry level.

While this result is useful in assessing the average exchange rate effect on total investment, we have shown that not just the level, but also the volatility, of the exchange rate can play a crucial role in investment decisions. Total investment reacts differently to exchange rate shocks in low- and high-volatility environments. When the exchange rate variability is very high, firms may be uncertain about the persistence of exchange rate movements. As a result, the corresponding changes in the output demand and the price of imported investments are treated as transitory. Firms delay their adjustment process. This, in turn, weakens the link between investment and exchange rates. We have found empirical evidence in support of this view.

Changes in the exchange rate, however, are more likely to be treated as permanent shocks in the low-volatility case. In response to stronger output demands in both domestic and foreign markets, our estimated model predicts that a 1 per cent depreciation of the real exchange rate would raise total investment by more than 1 per cent when exchange rate volatility is low. Given that our estimated elasticity of investment with respect to the user cost is close to zero, the negative impact on total investment due to the rising imported investment price is very small. This implies that total investment would increase, since the output channel dominates. Arguably, the negative user-cost effect might be underestimated in the low-volatility case, because our estimates of the user-cost elasticity do not distinguish between permanent and transitory shocks. Studies based on micro-firm data find that the user-cost elasticity can be as high as one for permanent shocks. Even with the assumption that all exchange rate shocks are permanent in the low-volatility regime, and that there is complete pass-through to the price of the imported investment, a 1 per cent depreciation would lead to less than a 1 per cent increase in the user cost. This translates to less than a 1 per cent decline in total investment, which is still smaller than the positive effect from the output channel. Thus, the net effect on total investment would be marginally positive in this extreme case. Hence, depreciations do not cause a decline in total investment in the low-volatility regime.

In addition to exchange rate volatility, we have investigated the non-uniformity of the exchange rate effects in two other channels. First, we distinguished the exchange rate effects on three different types of investment using disaggregated data. Our results revealed divergent patterns among investment in IT, other M&E, and structures. All the key findings on total investment were mainly driven by the movements in other M&E (i.e., M&E excluding IT). Investment in IT and structures was not responsive to exchange rate movements in any of the channels. Second, we examined whether the sensitivity of investment to exchange rates varied across the manufacturing industries in two areas: export exposure and markup ratios. When exchange rate volatility is high, industries tend to react in a similar fashion in their investment decisions. In a low-volatility regime, the total and other M&E investments in low-markup industries are more responsive to exchange rate movements. Yet, there is no significant difference between the high- and low-export industries.

We have not aimed to provide a complete list of the potential asymmetric responses of investment to exchange rates. Asymmetry may arise in other areas that we have not explored. It is also worth noting that our results are limited by the nature of the dataset. The data pertain to a relatively short period between 1981 and 1997. This precludes us from examining some important issues, such as the IT investment boom in Canada in the second half of the 1990s. Furthermore, we conducted our analysis using industry-level data from the productivity database of Statistics Canada. It is possible that even at the industry level some information has been aggregated away. Moreover, firm-level data would allow us to examine other channels that may be important for investment, such as financial linkages. With the increasing availability of the firm-level data, other ways of modelling and testing firm's investment decisions should become possible. That is left for future research.

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Table 1. Means of Annual Investment Growth Rates in Manufacturing Industries by Types, 1981–97

	IT	Other M&E	Structure	Total
1. Food	0.184	0.030	0.027	0.041
2. Beverage	0.173	0.020	0.020	0.032
3. Tobacco products	0.208	0.036	0.039	0.056
4. Rubber products	0.166	0.009	-0.087	0.007
5. Plastic products	0.253	0.075	0.020	0.077
6. Leather products	0.096	-0.007	-0.081	-0.002
7. Primary textile	0.119	0.048	0.069	0.053
8. Textile products	0.089	0.061	0.054	0.061
9. Clothing	0.196	0.032	-0.031	0.041
10. Wood	0.159	0.067	0.047	0.065
11. Furniture and fixture	0.230	0.069	0.026	0.077
12. Paper and allied products	0.164	0.031	0.070	0.046
13. Printing and publishing	0.182	0.043	0.018	0.071
14. Primary metal	0.096	0.042	0.066	0.052
15. Fabricated metal products	0.152	0.058	0.016	0.057
16. Machinery (except electrical)	0.165	0.040	-0.029	0.040
17. Transportation equipment	0.163	0.070	0.091	0.078
18. Electrical and electronic products	0.219	0.030	0.044	0.066
19. Non-metallic mineral products	0.099	0.010	-0.006	0.014
20. Refined petroleum and coal products	0.092	-0.047	-0.063	-0.050
21. Chemical and chemical products	0.156	-0.004	0.016	0.013
22. Other manufacturing	0.179	0.058	0.054	0.078

Table 2. The Effects of Exchange Rates on Total Investment, 1981–97

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	-0.2060	0.0380	-0.3215	-0.0566	-0.2336	0.1667
	(0.268)	(0.295)	(0.318)	(0.351)	(0.328)	(0.274)
Δe_{t-1}	0.2399	-0.4454	-0.0338	-0.3104	0.1593	-0.5932
	(0.241)	(0.381)	(0.266)	(0.428)	(0.293)	(0.645)
Δe_{t-2}		0.4400		0.4429		0.5642
		(0.397)		(0.426)		(0.626)
$\sum \Delta e_{t-j}$	0.0338	0.0326	-0.3552	0.0759	-0.0743	0.1377
	(0.273)	(0.353)	(0.352)	(0.472)	(0.458)	(0.528)
Δuc_t	-0.0683*	-0.1142**	-0.0520	-0.0711	-0.1074**	-0.1553
	(0.041)	(0.051)	(0.050)	(0.057)	(0.052)	(0.094)
Δuc_{t-1}	-0.0460	-0.1199*	-0.0386	-0.0633	-0.0045	-0.1021
	(0.044)	(0.063)	(0.054)	(0.063)	(0.044)	(0.066)
Δuc_{t-2}		-0.0677		-0.0105		-0.0567
		(0.050)		(0.056)		(0.073)
$\sum \Delta uc_{t-j}$	-0.1143*	-0.3019**	-0.0906	-0.1448	-0.1119	-0.3142
	(0.068)	(0.135)	(0.082)	(0.138)	(0.080)	(0.221)
Δw_t^m	0.1909	0.1230	0.0752	0.0828	0.1904*	0.0956
	(0.194)	(0.195)	(0.125)	(0.116)	(0.100)	(0.120)
Δw_{t-1}^m	0.2242	0.2069	0.2421**	0.2047	0.2437*	0.2440
	(0.190)	(0.192)	(0.111)	(0.142)	(0.138)	(0.179)
Δw_{t-2}^m		0.1605		0.3253**		0.1922
		(0.204)		(0.159)		(0.197)
$\sum \Delta w_{t-j}^m$	0.4151	0.4904	0.3174**	0.6218**	0.4340**	0.5318*
	(0.279)	(0.347)	(0.162)	(0.232)	(0.154)	(0.296)

Notes: Standard errors are in parentheses. Panel-corrected standard errors for OLS estimates assume that disturbances are heteroscedastic and contemporaneously correlated across industries. Standard errors in 2SLS are corrected using White's (1980) procedure. All other explanatory variables are specified in equation (8). $N = 308$, except in column (1), where $N = 330$.

* (**) Significant at the 10 (5) per cent confidence level.

Table 3. Measures of Volatility of Nominal C-6 Exchange Rate, 1981–97

Year	Percentage change of annual level[1]	Coefficient of variation of monthly level[2]	Standard deviation of monthly growth rates[2]	GARCH (1,1)[2]	Volatility regime[3]
1981	-0.87	-0.81377	-1.27685	-1.33105	Low
1982	-1.33	0.158801	1.278888	0.72354	High
1983	-2.396	-1.60868	-1.96799	-1.44364	Low
1984	4.1365	0.133328	-0.08409	-0.47069	Low
1985	4.9874	1.267762	-0.06336	-0.07817	Low
1986	5.5356	-1.23109	-0.98374	-1.00013	Low
1987	-3.905	-0.78157	0.517631	0.23599	Low
1988	-7.481	1.340967	1.101304	1.954785	High
1989	-5.789	-0.41281	-1.504	-0.61579	Low
1990	0.3338	-0.57422	1.274779	1.161185	High
1991	-0.864	-0.32459	-0.39724	-1.1799	Low
1992	7.1753	1.980801	-0.22039	0.907435	High
1993	7.0386	1.18266	0.689916	0.410561	High
1994	7.2075	0.51506	0.809002	0.630918	High
1995	1.4897	0.298468	1.035454	1.045659	High
1996	-1.319	-0.92141	-0.30898	-0.95535	Low
1997	0.8605	-0.20972	0.099656	0.004663	Low

1. A positive (negative) sign represents an exchange rate depreciation (appreciation).

2. All three volatility measures are expressed in terms of the number of standard deviations away from the sample mean between 1991 and 1997. A positive (negative) sign represents that the volatility is above (below) the sample mean.

3. Exchange rate movements are considered to be in the high-volatility regime if the fluctuations are more than 0.5 standard deviation above the sample mean in at least two volatility measures.

Table 4. The Effects of Exchange Rates on Total Investment, 1981–97
High- vs. Low-Volatility Regime

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	0.2069	0.6320	0.2202	0.5786	0.1667	0.9468
	(0.392)	(0.410)	(0.453)	(0.485)	(0.633)	(0.588)
Δe_{t-1}	0.8643**	0.6327	1.0398**	0.8461	0.9410**	0.8044
	(0.360)	(0.423)	(0.437)	(0.533)	(0.395)	(0.489)
Δe_{t-2}		0.4111		0.4716		0.2812
		(0.471)		(0.581)		(0.810)
$\sum \Delta e_{t-j}$	1.0712**	1.6758**	1.2600**	1.8962**	1.1077*	2.0324**
	(0.493)	(0.551)	(0.628)	(0.744)	(0.600)	(0.678)
$\Delta e_t \times D_t^{\xi}$	-0.9008	-1.2713**	-1.2223**	-1.4170**	-1.0448	-1.7393**
	(0.565)	(0.518)	(0.619)	(0.634)	(0.682)	(0.750)
$\Delta e_{t-1} \times D_{t-1}^{\xi}$	-1.002*	-2.1315**	-1.8439**	-2.2585**	-1.1652*	-2.6503**
	(0.532)	(0.683)	(0.598)	(0.816)	(0.649)	(0.883)
$\Delta e_{t-2} \times D_{t-2}^{\xi}$		0.1438		0.0096		0.3471
		(0.450)		(0.499)		(0.571)
$\sum \left(\Delta e_{t-j} + \Delta e_{t-j} \times D_{t-j}^{\xi}\right)$	-0.8312*	-1.5832**	-1.8062**	-1.7697**	-1.1023	-2.0101**
	(0.472)	(0.694)	(0.563)	(0.815)	(0.685)	(0.785)
Δuc_t	-0.0474	-0.1049**	-0.0200	-0.0587	-0.0566	-0.1244
	(0.040)	(0.051)	(0.054)	(0.059)	(0.056)	(0.090)
Δuc_{t-1}	-0.0536	-0.1541**	-0.0591	-0.1006	-0.0407	-0.1543**
	(0.043)	(0.063)	(0.058)	(0.068)	(0.041)	(0.075)
Δuc_{t-2}		-0.1329**		-0.0833		-0.1661*
		(0.056)		(0.066)		(0.089)
$\sum \Delta uc_{t-j}$	-0.1010	-0.3919**	-0.0790	-0.2426	-0.0972	-0.4448*
	(0.067)	(0.140)	(0.087)	(0.149)	(0.087)	(0.236)
Δw_t^m	0.2179	0.1489	0.1148	0.1096	0.1947	0.1529
	(0.196)	(0.186)	(0.133)	(0.123)	(0.111)	(0.128)
Δw_{t-1}^m	0.2333	0.1733	0.2613**	0.1732	0.2403*	0.1601
	(0.189)	(0.183)	(0.113)	(0.131)	(0.129)	(0.185)
Δw_{t-2}^m		0.1328		0.2984*		0.1217
		(0.195)		(0.154)		(0.196)
$\sum \Delta w_{t-j}^m$	0.4512	0.4550	0.3760**	0.5812**	0.4350**	0.4348
	(0.280)	(0.330)	(0.171)	(0.224)	(0.181)	(0.321)

Notes: Standard errors are in parentheses. Panel-corrected standard errors for OLS estimates assume that disturbances are heteroscedastic and contemporaneously correlated across industries. Standard errors in 2SLS are corrected using White's (1980) procedure. All other explanatory variables are specified in equation (9). N = 308, except in column (1), where N = 330. * (**) Significant at the 10 (5) per cent confidence level.

Table 5. The Effects of Exchange Rates on IT Investment, 1981–97

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	0.6116**	0.7952**	0.8217**	0.7910*	0.5922**	0.7995**
	(0.266)	(0.217)	(0.319)	(0.418)	(0.193)	(0.387)
Δe_{t-1}	-0.3054	0.1314	-0.4380	0.1627	-0.3037	0.1467
	(0.281)	(0.302)	(0.282)	(0.410)	(0.364)	(0.428)
Δe_{t-2}		-1.0998**		-1.1503**		-0.9965*
		(0.376)		(0.552)		(0.552)
$\sum \Delta e_{t-j}$	0.3062	-0.1732	0.3837	-0.1967	0.2886	-0.0503
	(0.263)	(0.331)	(0.331)	(0.624)	(0.347)	(0.628)
Δuc_t	-0.1408	-0.2585**	-0.1222	-0.2270	-0.0664	-0.2106
	(0.117)	(0.132)	(0.161)	(0.175)	(0.129)	(0.186)
Δuc_{t-1}	0.1462	0.0268	-0.1035	-0.0122	0.1275	-0.3493
	(0.101)	(0.140)	(0.149)	(0.169)	(0.112)	(0.200)
Δuc_{t-2}		-0.0570		-0.0749		-0.1188
		(0.080)		(0.092)		(0.096)
$\sum \Delta uc_{t-j}$	0.0054	-0.2886	-0.2257	-0.3142*	0.0612	-0.3643
	(0.152)	(0.204)	(0.158)	(0.186)	(0.177)	(0.215)
Δw_t^m	0.1602	0.2124	0.1599	0.1742	0.2084	0.1149
	(0.179)	(0.170)	(0.143)	(0.145)	(0.250)	(0.215)
Δw_{t-1}^m	-0.1617	0.0062	-0.1039	-0.0257	-0.1303	-0.0666
	(0.173)	(0.174)	(0.195)	(0.202)	(0.197)	(0.168)
Δw_{t-2}^m		-0.0767		-0.0890		-0.0623
		(0.182)		(0.130)		(0.153)

Notes: See notes to Table 2.

Table 6. The Effects of Exchange Rates on IT Investment, 1981–97
High- vs. Low-Volatility Regime

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	0.4963	0.6141	0.5742	0.4471	0.3505	0.5204
	(0.419)	(0.475)	(0.462)	(0.616)	(0.498)	(0.491)
Δe_{t-1}	-0.7010	0.4125	-0.7399	0.4839	-0.4162	0.9407
	(0.431)	(0.486)	(0.463)	(0.617)	(0.534)	(0.769)
Δe_{t-2}		-0.6574		-0.6037		-0.3913
		(0.538)		(0.667)		(0.701)
$\sum \Delta e_{t-j}$	-0.2047	0.3692	-0.1657	0.3273	-0.0657	1.0698
	(0.567)	(0.668)	(0.639)	(0.858)	(0.799)	(0.800)
$\Delta e_t \times D_t^{\xi}$	0.2803	0.0510	0.4894	0.3337	0.5345	0.3018
	(0.629)	(0.604)	(0.741)	(0.740)	(0.912)	(0.929)
$\Delta e_{t-1} \times D_{t-1}^{\xi}$	0.6909	-0.4772	0.4900	-0.6374	0.0721	-1.4387
	(0.624)	(0.738)	(0.636)	(0.934)	(0.794)	(1.144)
$\Delta e_{t-2} \times D_{t-2}^{\xi}$		-0.7716		-0.8631		-1.0879
		(0.565)		(0.783)		(0.728)
$\sum \left(\Delta e_{t-j} + \Delta e_{t-j} \times D_{t-j}^{\xi}\right)$	0.7665	-0.8286	0.8137	-0.8396	0.5409	-1.1550
	(0.494)	(0.613)	(0.626)	(1.111)	(0.819)	(1.256)
Δuc_t	-0.1697	-0.2174	-0.1556	-0.1830	-0.0882	-0.1111
	(0.121)	(0.135)	(0.172)	(0.181)	(0.127)	(0.169)
Δuc_{t-1}	0.1517	0.0371	-0.0876	-0.0010	0.1368	-0.0106
	(0.099)	(0.140)	(0.150)	(0.172)	(0.104)	(0.202)
Δuc_{t-2}		-0.0987		-0.1274		-0.2079
		(0.091)		(0.115)		(0.128)
$\sum \Delta uc_{t-j}$	-0.0179	-0.2790	-0.2432	-0.3114*	0.0485	-0.3296
	(0.153)	(0.205)	(0.165)	(0.187)	(0.180)	(0.205)
Δw_t^m	0.1266	0.2303	0.1260	0.1855	0.1783	0.1270
	(0.183)	(0.178)	(0.140)	(0.147)	(0.289)	(0.260)
Δw_{t-1}^m	-0.1653	0.0361	-0.1140	-0.0019	-0.1180	-0.0224
	(0.173)	(0.178)	(0.196)	(0.201)	(0.200)	(0.177)
Δw_{t-2}^m		-0.1018		-0.1263		-0.1717
		(0.193)		(0.152)		(0.218)

Notes: See notes to Table 4.

Table 7. The Effects of Exchange Rates on Other M&E Investment, 1981–97

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	-0.0513	0.3082	-0.5895*	-0.0836	-0.2688	0.1847
	(0.273)	(0.273)	(0.347)	(0.369)	(0.298)	(0.192)
Δe_{t-1}	0.1330	-0.0377	-0.0463	0.0116	0.0083	-0.0824
	(0.241)	(0.296)	(0.291)	(0.413)	(0.424)	(0.388)
Δe_{t-2}		0.1680		0.1109		0.1271
		(0.388)		(0.513)		(0.567)
$\sum \Delta e_{t-j}$	0.0817	0.4385	-0.6358*	0.0389	-0.2605	0.2294
	(0.242)	(0.288)	(0.353)	(0.498)	(0.458)	(0.698)
Δuc_t	-0.1042	-0.1475*	-0.0661	-0.0500	-0.1467	-0.1142
	(0.076)	(0.086)	(0.104)	(0.110)	(0.104)	(0.189)
Δuc_{t-1}	0.0629	-0.0168	0.0185	0.0595	0.1105	0.0719
	(0.081)	(0.099)	(0.096)	(0.123)	(0.102)	(0.200)
Δuc_{t-2}		0.0124		0.1349		0.0874
		(0.083)		(0.104)		(0.171)
$\sum \Delta uc_{t-j}$	-0.0413	-0.1519	-0.0475	0.1445	-0.0362	0.0451
	(0.112)	(0.197)	(0.151)	(0.261)	(0.172)	(0.542)
Δw_t^m	0.1207	0.1113	0.1503	0.1900	0.1658	0.1632*
	(0.190)	(0.193)	(0.118)	(0.136)	(0.097)	(0.094)
Δw_{t-1}^m	0.1282	0.1525	0.2485	0.2555	0.2478	0.2340
	(0.179)	(0.196)	(0.153)	(0.177)	(0.206)	(0.233)
Δw_{t-2}^m		0.0476		0.2623		0.1913
		(0.206)		(0.237)		(0.200)

Notes: See notes to Table 2.

Table 8. The Effects of Exchange Rates on Other M&E Investment, 1981–97
High- vs. Low-Volatility Regime

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	0.4089	0.8179*	0.0835	0.4147	0.1409	0.7074
	(0.364)	(0.429)	(0.444)	(0.513)	(0.492)	(0.584)
Δe_{t-1}	0.7865**	1.0539**	0.9447**	1.3445**	0.9995**	1.5098**
	(0.296)	(0.388)	(0.416)	(0.621)	(0.404)	(0.666
Δe_{t-2}		-0.0273		0.2305		-0.2140
		(0.537)		(0.660)		(0.655)
$\sum \Delta e_{t-j}$	1.1953**	1.8445**	1.0282*	1.9897**	1.1404**	2.0031**
	(0.439)	(0.516)	(0.613)	(0.803)	(0.577)	(0.935)
$\Delta e_t \times D_t^{\xi}$	-1.0281*	-1.0861	-1.4408*	-1.3813*	-1.347**	-1.5868*
	(0.575)	(0.573)	(0.784)	(0.796)	(0.648)	(0.821)
$\Delta e_{t-1} \times D_{t-1}^{\xi}$	-1.1077**	-1.9490	-1.6980**	-2.334**	-1.603**	-2.541**
	(0.436)	(0.692)	(0.617)	(0.895)	(0.655)	(0.973)
$\Delta e_{t-2} \times D_{t-2}^{\xi}$		0.3113		-0.2166		0.0018
		(0.476)		(0.561)		(0.774)
$\sum \left(\Delta e_{t-j} + \Delta e_{t-j} \times D_{t-j}^{\xi}\right)$	-0.9405**	-0.8794	-2.1106**	-1.942**	-1.810**	-2.123**
	(0.409)	(0.576)	(0.680)	(0.892)	(0.690)	(0.927)
Δuc_t	-0.0376	-0.1116	0.0280	0.0018	0.0246	0.0073
	(0.078)	(0.093)	(0.124)	(0.129)	(0.110)	(0.220)
Δuc_{t-1}	0.0727	0.0113	0.0347	0.0561	0.0785	0.1077
	(0.073)	(0.106)	(0.097)	(0.126)	(0.098)	(0.186)
Δuc_{t-2}		-0.0939		-0.0158		-0.0919
		(0.095)		(0.122)		(0.200)
$\sum \Delta uc_{t-j}$	0.0351	-0.1943	0.0627	0.0421	0.1031	0.0230
	(0.105)	(0.217)	(0.164)	(0.278)	(0.190)	(0.575)
Δw_t^m	0.1728	0.1792	0.2271*	0.2711*	0.2773*	0.2984*
	(0.196)	(0.194)	(0.127)	(0.133)	(0.136)	(0.120)
Δw_{t-1}^m	0.1265	0.1274	0.2414	0.2483	0.2148	0.2369
	(0.176)	(0.194)	(0.156)	(0.174)	(0.193)	(0.233)
Δw_{t-2}^m		-0.0238		0.1673		0.0732
		(0.206)		(0.228)		(0.191)

Notes: See notes to Table 4.

Table 9. The Effects of Exchange Rates on Structure Investment, 1981–97

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	-0.2469	-0.1099	-0.0670	-0.0511	0.1596	0.1337
	(0.358)	(0.341)	(0.479)	(0.528)	(0.581)	(0.576)
Δe_{t-1}	0.7153**	-0.6104	0.2056	-0.5382	0.6041	-0.7662
	(0.351)	(0.490)	(0.496)	(0.728)	(0.353)	(0.671)
Δe_{t-2}		0.4495		0.5521		0.2540
		(0.453)		(0.810)		(0.690)
$\sum \Delta e_{t-j}$	0.4684	-0.2708	0.1386	-0.0372	0.7637	-0.3785
	(0.413)	(0.564)	(0.532)	(0.847)	(0.584)	(1.061)
Δuc_t	-0.0843**	-0.1299**	-0.0743	-0.0963	-0.0742	-0.1418*
	(0.038)	(0.044)	(0.050)	(0.062)	(0.049)	(0.074)
Δuc_{t-1}	-0.0620	-0.1541**	-0.0512	-0.1091	-0.0486	-0.1653**
	(0.039)	(0.051)	(0.059)	(0.072)	(0.059)	(0.076)
Δuc_{t-2}		-0.0777*		-0.0336		-0.1033
		(0.044)		(0.061)		(0.068)
$\sum \Delta uc_{t-j}$	-0.1463**	-0.3617**	-0.1256*	-0.2390	-0.1229	-0.4104**
	(0.060)	(0.111)	(0.076)	(0.155)	(0.096)	(0.201)
Δw_t^m	0.3008	0.1504	-0.0145	-0.0701	0.3248**	0.1704
	(0.249)	(0.248)	(0.257)	(0.211)	(0.158)	(0.154)
Δw_{t-1}^m	0.3778	0.3430	0.3523*	0.2849	0.2658	0.3474
	(0.235)	(0.244)	(0.195)	(0.218)	(0.182)	(0.272)
Δw_{t-2}^m		0.2092		0.4765*		-0.1130
		(0.243)		(0.250)		(0.290)

Notes: See notes to Table 2.

Table 10. The Effects of Exchange Rates on Structure Investment, 1981–97
High- vs. Low-Volatility Regime

	OLS		2SLS		GMM	
	(1)	(2)	(3)	(4)	(5)	(6)
Δe_t	-0.1505	0.4757	0.1277	0.5708	0.3897	0.9411
	(0.583)	(0.572)	(0.780)	(0.828)	(0.930)	(0.978)
Δe_{t-1}	0.9103	-0.2621	1.379*	0.0570	0.5756	-0.1527
	(0.565)	(0.616)	(0.811)	(0.899)	(0.653)	(0.812)
Δe_{t-2}		-0.0754		0.0263		-0.2699
		(0.545)		(1.087)		(0.993)
$\sum \Delta e_{t-j}$	0.7598	0.1382	1.5062	0.6542	0.9653	0.5185
	(0.786)	(0.828)	(1.108)	(1.538)	(1.144)	(1.347)
$\Delta e_t \times D_t^{\xi}$	-0.2121	-0.8551	-0.5358	-0.9179	-0.4618	-1.6375
	(0.818)	(0.722)	(0.109)	(1.104)	(1.137)	(1.118)
$\Delta e_{t-1} \times D_{t-1}^{\xi}$	-0.3378	-0.6168	-2.2899*	-1.1817	0.1587	-1.3020
	(0.816)	(0.991)	(1.226)	(1.569)	(1.009)	(1.249)
$\Delta e_{t-2} \times D_{t-2}^{\xi}$		0.8833		0.9449		0.8501
		(0.606)		(0.937)		(0.975)
$\sum (\Delta e_{t-j} + \Delta e_{t-j} \times D_{t-j}^{\xi})$	0.2099	-0.4503	-1.3194	-0.5005	0.6623	-1.5709
	(0.680)	(1.050	(1.035)	(1.359)	(1.108)	(1.597)
Δuc_t	-0.0822**	-0.1323**	-0.0645	-0.1006	-0.0719	-0.1469*
	(0.038)	(0.045)	(0.055)	(0.062)	(0.056)	(0.076)
Δuc_{t-1}	-0.0639	-0.1605**	-0.0673	-0.1222	-0.0538	-0.2019**
	(0.040)	(0.053)	(0.062)	(0.075)	(0.054)	(0.081)
Δuc_{t-2}		-0.0856		-0.0493		-0.1515*
		(0.052)		(0.071)		(0.084)
$\sum \Delta uc_{t-j}$	-0.1461**	-0.3784**	-0.1319*	-0.272*	-0.1257	-0.5003**
	(0.061)	(0.119)	(0.077)	(0.165)	(0.103)	(0.220)
Δw_t^m	0.3118	0.1684	0.0061	-0.0425	0.3147**	0.2136
	(0.251)	(0.244)	(0.265)	(0.209)	(0.160)	(0.164)
Δw_{t-1}^m	0.3817	0.3171	0.3686	0.2535	0.2681	0.2766
	(0.234)	(0.243)	(0.200)	(0.215)	(0.190)	(0.296)
Δw_{t-2}^m		0.2077		0.4520*		-0.1206
		(0.246)		(0.249)		(0.297)

Notes: See notes to Table 4.

Table 11. Classification of Industries

Average net trade exposure		Average markup ratios: High	Average markup ratios: Low
	High	(HH) Primary textile Wood Paper and allied products Machinery (except electrical) Chemical and chemical products	(LH) Leather products Primary metal Transportation equipment Electrical and electronic products Other manufacturing
	Low	(HL) Beverage Tobacco products Plastic products Printing and publishing Non-metallic mineral products	(LL) Food Rubber products Textile products Clothing Furniture and fixture Fabricated metal

Table 12. The Effects of Exchange Rates on Investment: Variations across Groups, 1981–97

	Total		IT		Other M&E		Structures	
	(LV)	(HV)	(LV)	(HV)	(LV)	(HV)	(LV)	(HV)
HH	1.0680	-1.2098	1.0792	-1.7924	0.7976	-0.8975	-1.3279	0.2864
	(0.817)	(0.718)	(1.145)	(1.881)	(1.017)	(0.887)	(1.644)	(1.314)
HL	0.5911	-1.7744	-0.4622	-0.1645	1.0509	-1.8113	-0.6789	-1.2934
	(1.151)	(0.765)	(1.251)	(1.003)	(0.993)	(0.815)	(2.466)	(1.564)
LH	2.5078**	-1.4804	0.1751	-1.3920	3.0071**	-1.2975	3.3045	0.8830
	(0.827)	(0.788)	(1.443)	(1.085)	(0.871)	(0.899)	(2.147)	(1.592)
LL	1.7519**	-2.0413	1.6495	-0.7318	2.0722**	-1.1915	1.7138	-1.7156
	(0.735)	(0.743)	(1.098)	(0.914)	(0.839)	(0.858)	(1.434)	(1.536)
HH=HL=0	$\chi^2(2)=1.77$				$\chi^2(2)=1.51$			
LH=LL	$\chi^2(1)=0.67$				$\chi^2(1)=0.83$			
HH=HL=LH=LL		$\chi^2(3)=1.73$				$\chi^2(3)=1.54$		

Notes: 2SLS estimates with standard errors corrected using White's (1980) procedure. All other explanatory variables are specified in equation (9). HV reports the sum of the coefficients of the exchange rates (i.e., $\sum \kappa_j$ in the high-volatility regime); LV reports the sum of the coefficients of the exchange rate and the interaction terms with volatility dummy $\sum \kappa_j + o_j$ in the low-volatility regime. Standard errors are in parentheses. HH: High-markup and high-export industries; HL: High-markup and low-export industries; LH: Low-markup and high-export industries; LL: Low-markup and low-export industries. * (**) Significant at the 10 (5) per cent confidence level.

Figure 1. Total Investment Growth in Manufacturing Sector, 1982–97

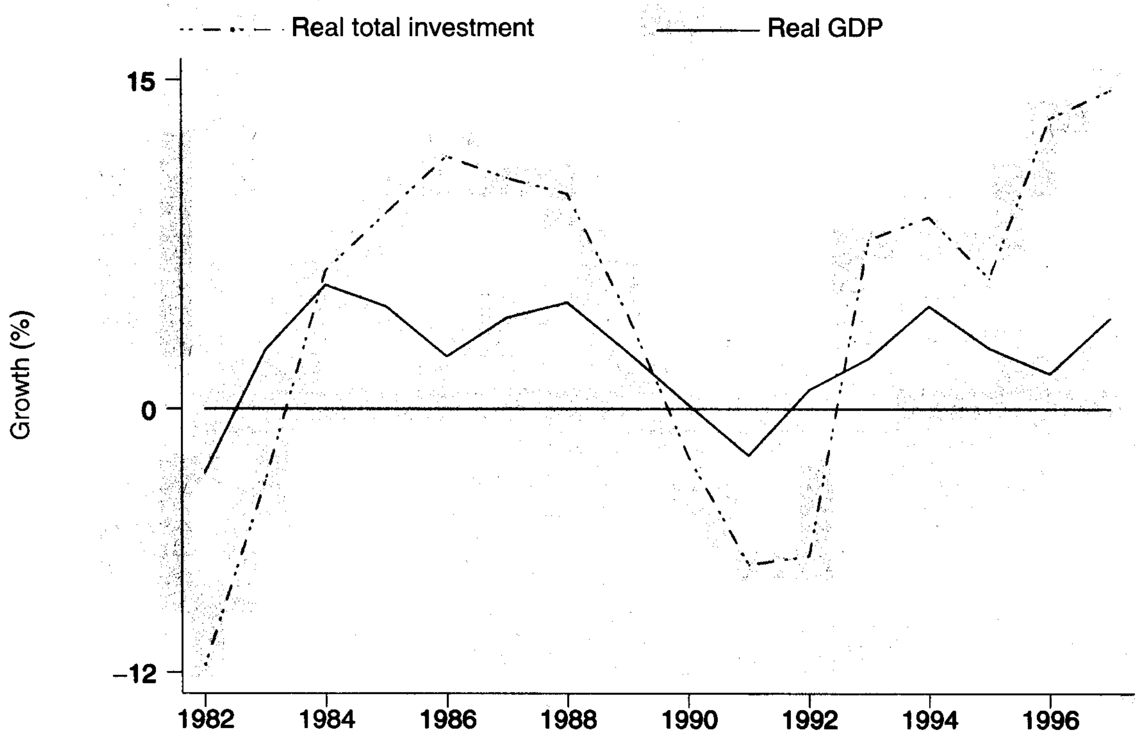

Figure 2. Real Investment Growth in Manufacturing Sector by Types, 1982–97

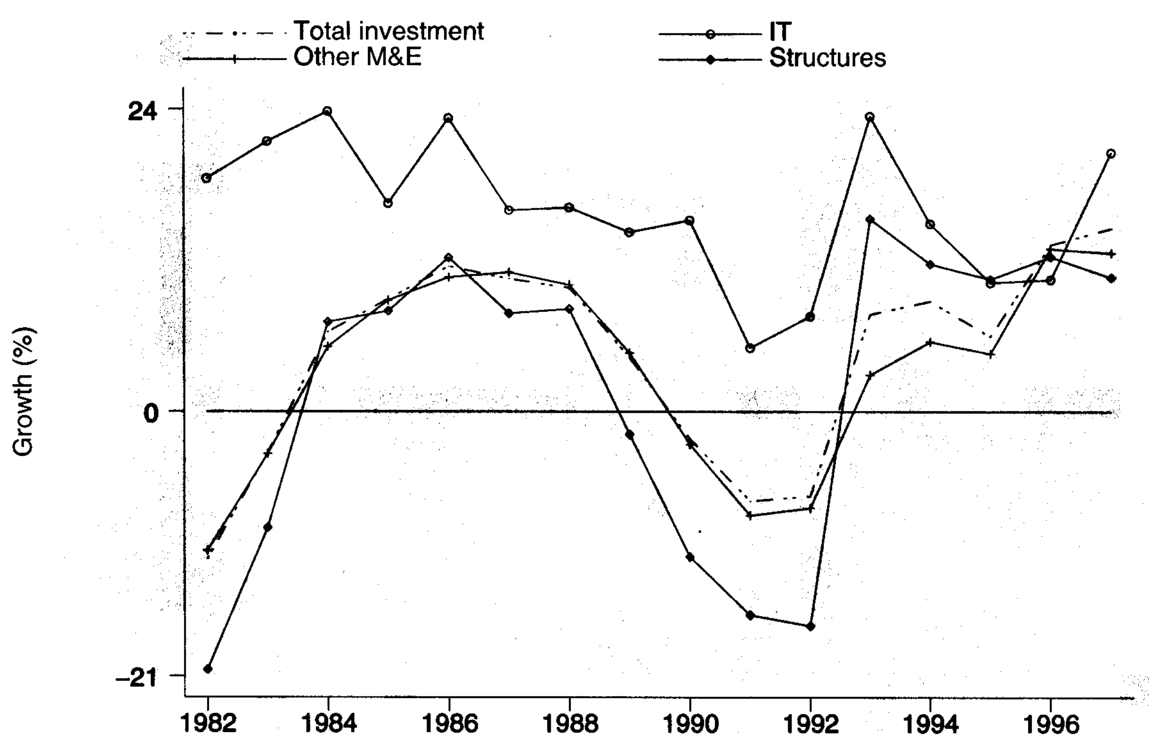

Figure 3. Real Investment Growth in Manufacturing Industries by Types, 1982–97

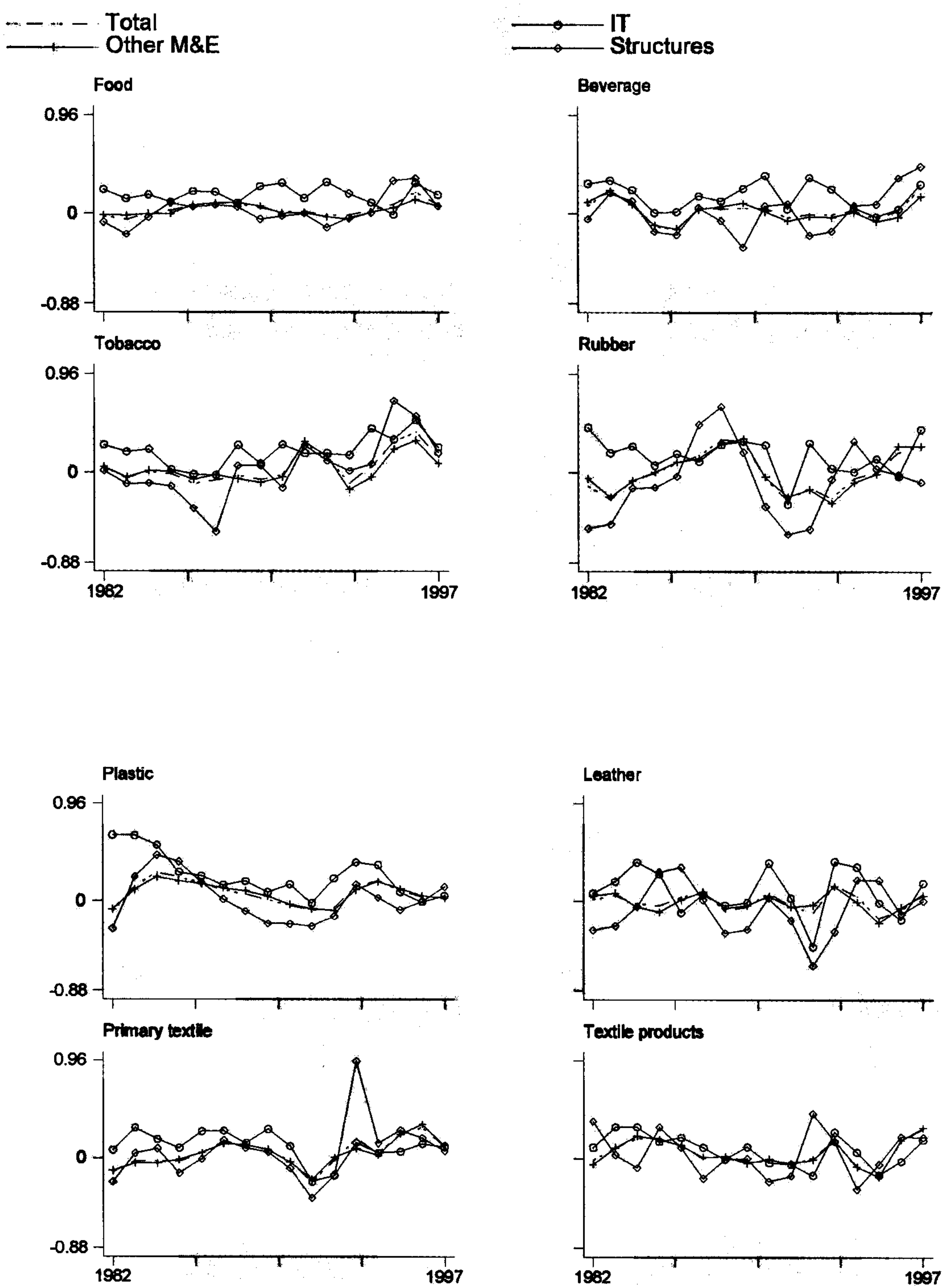

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Figure 3. Investment Growth in Manufacturing Industries by Types, 1982–97
(cont'd)

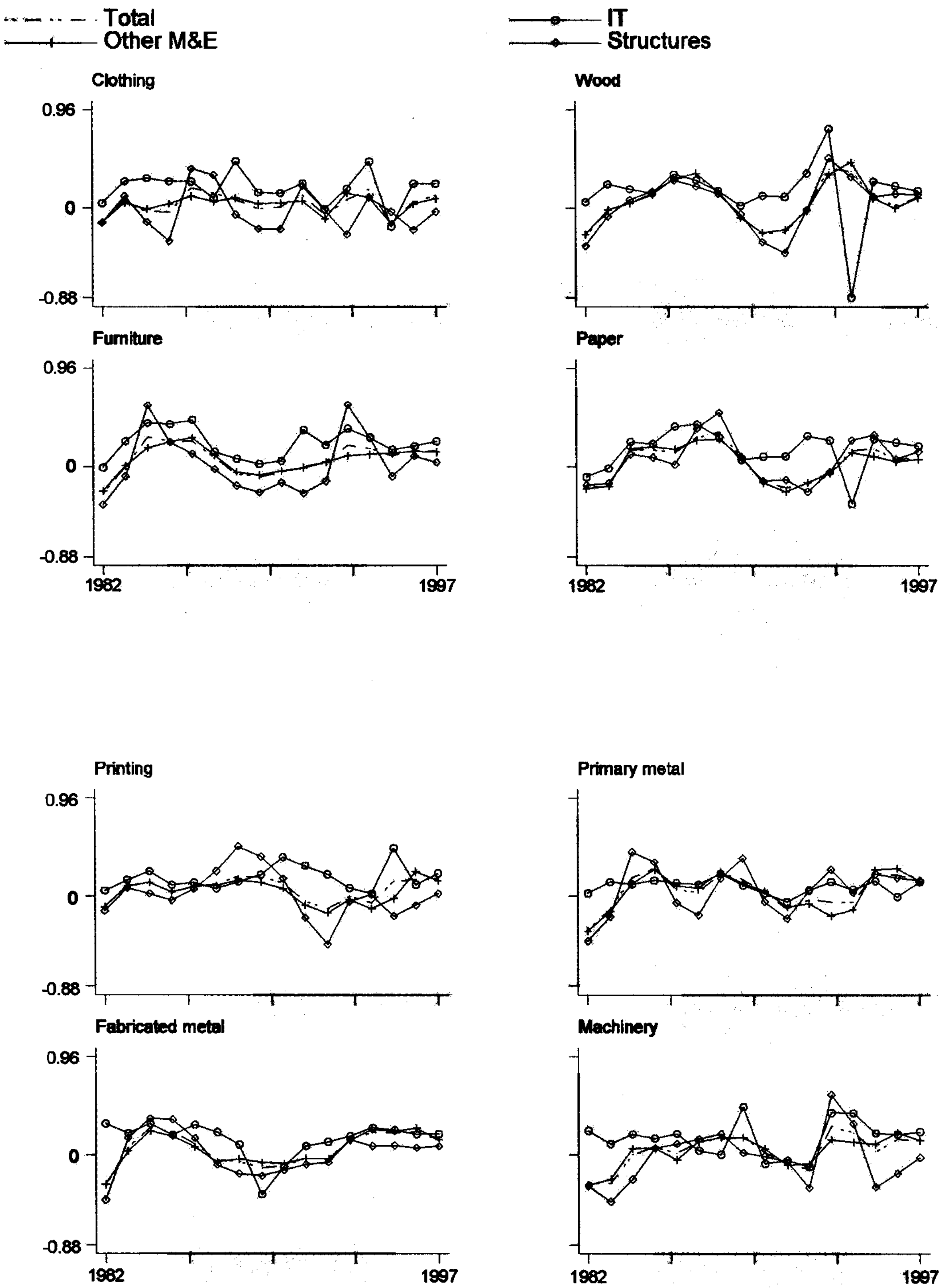

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Figure 3. Investment Growth in Manufacturing Industries by Types, 1982–97
(concluded)

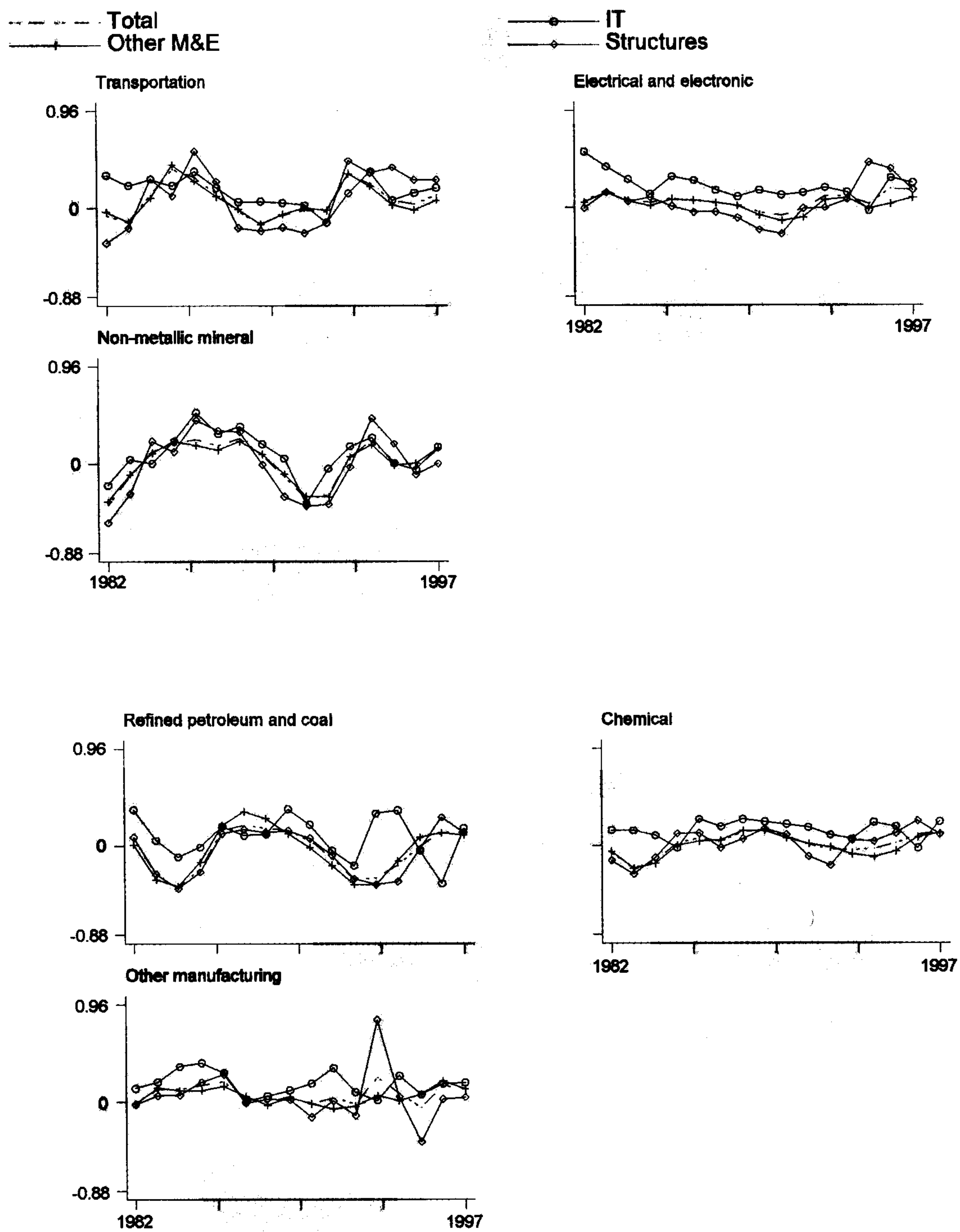


Figure 4. Canadian Real Exchange Rates, 1981–97

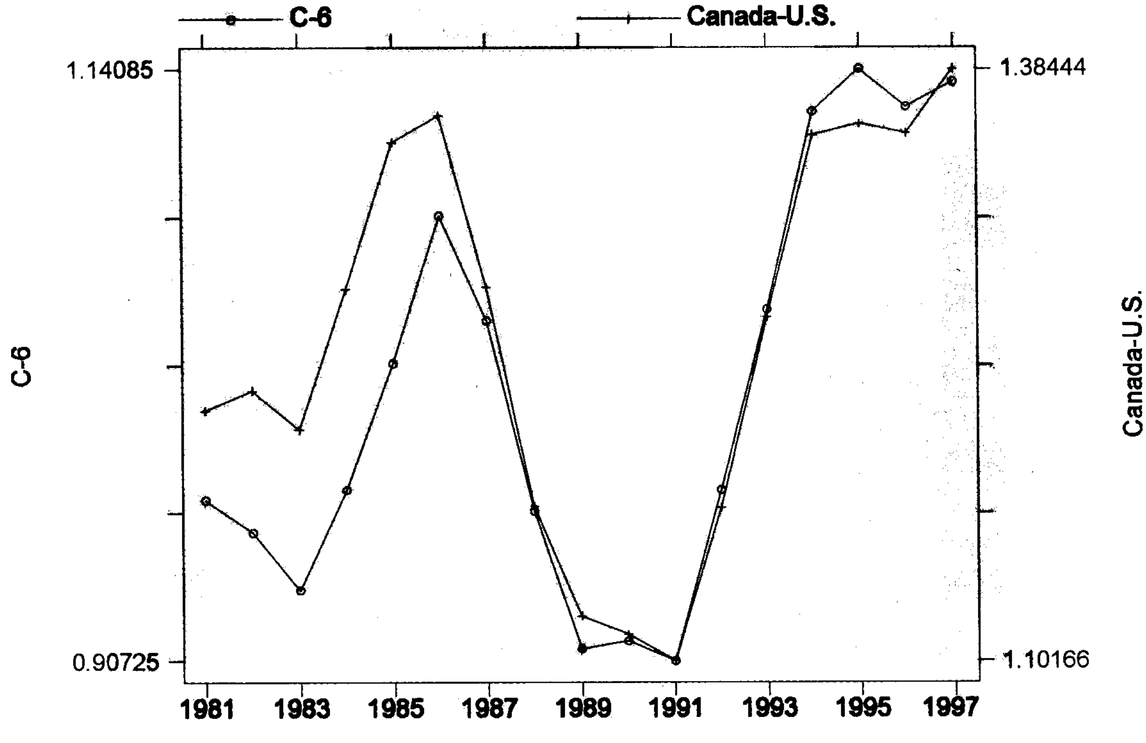
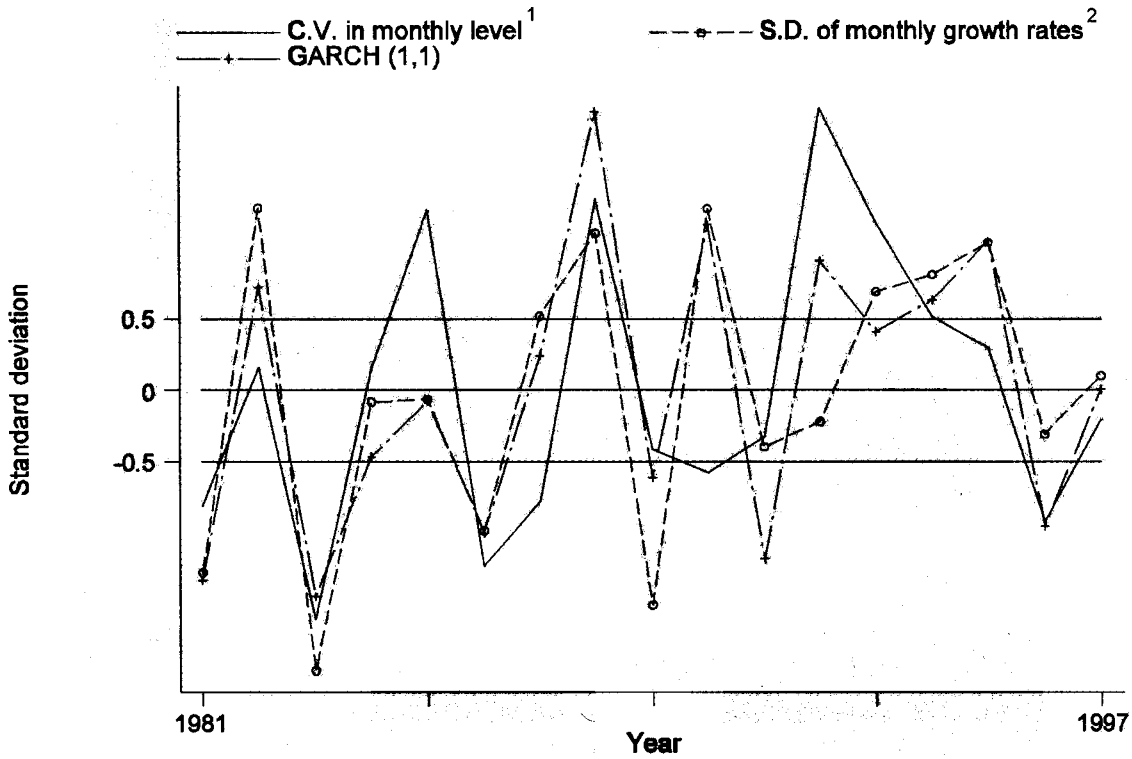


Figure 5. Nominal C-6 Exchange Rates Volatility, 1981–97



1. C.V. = coefficient of the variation
2. S.D. = standard deviation

Appendix A: The Effect of Exchange Rates on Marginal Benefits of Investment

As noted in the first-order conditions (3) and (4), for a given K, L, x and x^* are optimally chosen to maximize a firm's profit, depending on the domestic and foreign demand conditions, p and p^*, and the price of the variable inputs, w. Thus, the marginal benefit of investment can be expressed in the general form

$$\partial\Psi/\partial K = h(K, p(e), ep^*(e), w(e)). \tag{A1}$$

Equation (A1) summarizes the key channels through which exchange rates affect the marginal revenue product of capital. It is clear that p, p^*, and w are functions of the exchange rate. Let us look at the corresponding changes in each of these components in the case of a depreciation of the exchange rate; i.e., e increases. While the following discussion refers to a depreciation, all considerations are simply reversed in the case of an appreciation. On the domestic side, as imports become relatively more expensive in the domestic market, substitution between imported and domestic goods raises the inverse demand, p. That is, the exchange rate pass-through elasticity in domestic demand ($\psi_{p,e}$) is positive. The elasticity of the marginal revenue with respect to the exchange rate is:

$$\frac{\partial p\left(1+\upsilon^{-1}\right)}{\partial e}\frac{e}{p\left(1+\upsilon^{-1}\right)} = \psi_{p,e} + \varsigma_{1+\upsilon^{-1},e}, \tag{A2}$$

where $\varsigma_{1+\upsilon^{-1},e} = \frac{\partial\left(1+\upsilon^{-1}\right)}{\partial e}\frac{e}{\left(1+\upsilon^{-1}\right)}$. Since $\psi_{p,e} > 0$, equation (A1) states that, unless the domestic demand becomes less elastic such that $\varsigma_{1+\upsilon^{-1},e} < -\psi_{p,e}$, the marginal revenue from domestic sales will increase as a result of the depreciation. Moreover, for a given level of K, an increase in the marginal revenue causes the firm to produce more output, $x + x^*$, by raising L. For a homogeneous production function, this higher level of L translates to an increase in the marginal product of capital as K/L decreases. Hence, an increase (decrease) in the marginal revenue as a result of a depreciation has a positive (negative) effect on investment.

On the foreign side, the primary effect is the direct valuation of the exchange rate on the export price. A 1 per cent depreciation translates to a 1 per cent increase in the marginal revenue due to the rise in export prices expressed in terms of the domestic currency. The firm may then lower the foreign currency price of exports to capture a larger share of the foreign market. In a monopolistic market, foreign firms will respond by reducing their prices. This, in turn, will generate some downward pressure on the inverse demand, p^*. The exchange rate pass-through elasticity in foreign demand ($\psi_{p^*,e}$) is negative. In terms of the exchange rate elasticity in the marginal revenue of exports,

$$\frac{\partial ep^*\left(1+\upsilon^{*-1}\right)}{\partial e}\frac{e}{ep^*\left(1+\upsilon^{*-1}\right)}=1+\left(\psi_{p^*,e}+\varsigma_{1+\upsilon^{*-1},e}\right), \quad \text{(A3)}$$

where $\varsigma_{1+\upsilon^{*-1},e}=\frac{\partial\left(1+\upsilon^{*-1}\right)}{\partial e}\frac{e}{\left(1+\upsilon^{*-1}\right)}$. In equation (A2), if the direct valuation effect dominates (i.e., $\psi_{p^*,e}+\varsigma_{\mu^*,e}>-1$), the marginal revenue from foreign sales will increase when the currency depreciates. Clarida (1997) finds that the effect of a depreciation on export revenue is unambiguously positive regardless of the market structure. Similar to the domestic market, a rise in marginal revenue from export sales also stimulates investment.

Appendix B: Data Definitions

B1 Real Exchange Rate

The nominal exchange rates are published as the C-6 exchange rate in the *Bank of Canada Banking and Financial Statistics*. It is an index constructed as the weighted average of the bilateral exchange rates between Canada and the other C-6 countries: the United States, EMU countries, Japan, the United Kingdom, Switzerland, and Sweden. The weights are derived from Canadian merchandise trade flows between 1994 and 1996. The nominal C-6 index has been based on 1992 (i.e., C-6 = 100 in 1992), and it is calculated using the following formula:

$$\text{C-6} = 100 \times \frac{\left(US^{0.8584}\right)\left(EMU^{0.0594}\right)\left(Jap^{0.0527}\right)\left(UK^{0.0217}\right)\left(Swit^{0.0043}\right)\left(Swed^{0.0035}\right)}{1.046294}, \qquad \text{(B1)}$$

where each bilateral exchange rate is computed as units of the Canadian dollar per units of foreign currency; e.g., *US* = $Canadian/$U.S. Note that currencies from each EMU country are used before 1999. To obtain the real C-6 exchange rates, the nominal C-6 index is multiplied by the ratio of the GDP deflators between Canada and the weighted average of the C-6 countries. Lafrance and St-Amant (1999) discuss in detail the effects of using different weighting system and price indexes in calculating the real exchange rate index for Canada.

B2 Investment

Investment data cover 22 non-residential assets and 4 residential assets. The assets are then classified into three broad asset classes: IT, other M&E, and structures (see Table B1). The objective is not only to distinguish long-lived structures from short-lived equipment, but also to distinguish among various types of equipment within asset classes. The estimates of total real investment are based on a chained Fisher index.

B3 User Cost of Capital

Taking taxes into consideration, the user cost of capital, uc_{iat}, may be expressed as follows for capital asset type a in industry i at period t (Christensen and Jorgenson 1969):

$$uc_{iat} = q_{iat-1}\left\{\left(\frac{1-v_{it}z_{iat}-k_{iat}}{1-v_{it}}\right)\left[r_t+\tau_{ia}-\frac{\left(q^{*}_{iat}-q_{iat-1}\right)}{q_{iat-1}}\right]+\omega_{it}\right\}, \tag{B2}$$

where q is the price of capital, a, and r is the interest payment if a loan is taken out to acquire the asset. Alternatively, r can be interpreted as the opportunity cost of employing capital elsewhere than in production. τ is the cost of depreciation or the loss in value of the machine as it ages. The loss in value reflects the physical decay or loss of efficiency of the asset, and also the fact that its expected service life has declined by one period. ω is the effective rate of property taxes (nominal valued taxes assessed on the real stocks of land and structures), and $\left(\frac{1-vz-k}{1-v}\right)$ is the effective rate of taxation on capital income, where v is the corporate income tax rate, z is the present value of depreciation deductions for tax purposes on a dollar's investment in capital type a over the lifetime of the investment, and k is the rate of the investment tax credit; $\frac{\left(q^{*}_{iat}-q_{iat-1}\right)}{q_{iat-1}}$ is the expected capital gain.

Table B1. Classification of Total Capital by Asset Classes

1. Information Technology (IT)
    - Computers & Office Equipment
    - Communications Equipment
    - Software—Own Account
    - Software—Pre-Packaged
    - Software—Custom Design
2. Other Machinery and Equipment (M&E)
    - Office Furniture, Furnishing
    - Household and Services Machinery and Equipment
    - Electrical Industrial Machinery and Equipment
    - Non-Electrical Industrial Machinery and Equipment
    - Industrial Containers
    - Conveyors & Industrial Trucks
    - Automobiles & Buses
    - Trucks (Excluding Industrial Trucks) & Trailers
    - Locomotives, Ships & Boats, & Major Replacement Parts
    - Aircraft, Aircraft Engines, & Other Major Replacement Parts
    - Other Equipment
3. Structures
    - Non-Residential Building Construction
    - Road, Highway, & Airport Runway Construction
    - Gas & Oil Facility Construction
    - Electric Power, Dams, & Irrigation Construction
    - Railway & Telecommunications Construction
    - Other Engineering Construction
    - Cottages
    - Mobiles
    - Multiples
    - Singles

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