Investment, Pass-Through, and Exchange Rates:

A Cross-Country Comparison

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ABSTRACT

Using detailed data from the United States, Canada, the United Kingdom, and Japan, we examine the implications of exchange rates for time series of sectoral investment. Both theoretically and empirically we show that investment responsiveness to exchange rates varies over time, positively in relation to sectoral reliance on export share and negatively with respect to the share of imported inputs in production. Important differences exist in investment endogeneity across high and low markup sectors, with investment in low markup sectors often significantly more responsive to exchange rates. Cross-country differences in investment response are only partially explained by industrial organization arguments.

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Running Head: Investment and Exchange Rates

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I. INTRODUCTION[1]

Despite the substantial movements in nominal and real exchange rates over the past decades, the implications of these movements for real economic activity remain an open question. Exchange rate can cause large shifts in relative unit labor costs and influence the prices of goods sold in domestic and foreign markets. If producers are not perfectly hedged against exchange rate movements, their short- and long-run profitability, overall levels of investment, and location of production facilities could depend on exchange rates. The main objective of the present paper is to provide a cross-country examination of the linkages between exchange rates and industry investment in plant and equipment.

Section II proceeds in this direction with a theoretical derivation of the exchange rate/ investment relationship under imperfectly competitive product markets. The framework utilized is a standard adjustment-cost model of investment[2] extended to account for export sales and the use of imported inputs in production, both of which introduce producer exposure to exchange rate movements. A firm's investment is an increasing function of its expected marginal profitability of capital. Exchange rate changes can affect this expected marginal profitability of capital, and, more generally, producer profits, by "passing-through" into home market prices, export market prices, and imported input prices. The importance of exchange rates for marginal profitability and investment is shown to explicitly depend on the firm's international orientation both through export markets and through the imported fraction of its productive inputs. Another explicit implication of the theory is

1 This paper is a substantially revised version of Campa and Goldberg (1995b) National Bureau of Economic Research Working Paper no. 5139.

2 Alternative approaches to modeling investment are surveyed in Chirinko (1993).

that industry competitive structure matters for investment responsiveness to exchange rates: highly competitive industries are expected to exhibit larger responsiveness to exchange rates, all else equal.

The rest of the paper tests the strength of the exchange rate / investment linkages using annual industry data from the United States, Canada, the United Kingdom, and Japan, for roughly the interval between 1970 to 1993. The estimating equations correlate the permanent component of exchange rate movements (derived using Beveridge-Nelson decompositions) with industry investment.[3] The magnitude of the implied investment response to exchange rates is permitted to vary over time with changes in the industry export share, import competition, and reliance on imported inputs into production.[4] We also control for the role of industry competitive structure in influencing the magnitude of investment response within countries and within individual industries across countries.

Our research broadens the growing literature that has sought both to untangle the mechanisms through which countries and industries cope with real exchange rate movements and to quantify the importance of exchange rates for real economic activity. There are a number of central themes around which this work is organized.

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3 The earlier working paper version of this paper (Campa and Goldberg 1995b) provides empirical results on the contribution of actual versus anticipated exchange rates movements to investment. This contrasts with the results reported herein, which represent the contribution to investment of the permanent component of exchange rate movements.

4 See Campa and Goldberg (1997) for a detailed presentation of industry external orientation in the United States, United Kingdom, Canada, and Japan. Campa and Goldberg (1995a) show the importance of exchange rates for real economic activity is understated if evolving exposure measures are excluded.

First, export price elasticities are emphasized in studies of pricing-to-market and pass-through of exchange rates.[5] This research has generated a set of stylized facts on the pass-through and pricing-to-market characteristics of countries and industries. On balance, foreign producers appear to adjust their profit margins to achieve stability of dollar prices on goods sold in the United States, while United States producers do not follow analogous export-pricing policies (Mann 1986; Knetter 1989). Local currency pricing-to-market is a strategy pursued by Japanese exporters, as evidenced by price differences between Japanese goods sold in Japan versus for export (Marston 1990). Yet, despite this body of evidence of country-specific tendencies in pricing, these results actually may be attributed to the composition of industries in each of these countries so that pricing-to-market and pass-through elasticities are better described as industry-specific rather than country-specific features (Knetter 1993).

Second, exchange rate movements lead to adjustments in the prices of goods produced and consumed domestically. In both the United States and Germany, the two documented channels for these effects are: (i) exposure to imported intermediate goods and (ii) price competition on goods competing with imported final products (Feinberg 1986, 1989). Although significant, these effects have been shown to be qualitatively quite small within the United States (Swagel 1995).

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5 Krugman (1987) and Baldwin and Krugman (1989) introduced the pricing-to-market terminology (i.e., destination-specific adjustment of markups in response to exchange rate changes). Dornbusch (1987) formally derived pass-through elasticities under alternative static models of imperfect competition. Froot and Klemperer (1989) stressed the role of dynamic considerations in current pass-through and pricing decisions, emphasizing that the objective of capturing future market share matters for the elasticity of current prices to transitory movements in exchange rates.

Third, there are differences across countries in producer willingness to absorb exchange rate shocks. Japanese producers are willing to adjust profit margins in response to shocks rather than adjust output and employment (Branson and Marston 1989). By contrast, producers in the United States are much more willing to undertake output and especially employment adjustments.[6] Such differences would, of course, be expected given the parallel empirical literature on differences across countries in responses to business cycle fluctuations.

Fourth, it has been difficult to establish strong empirical links between exchange rate movements and industry stock prices or excess returns. Part of the difficulty may be methodological: existing studies have used regression specifications that do not allow industry elasticities of response to exchange rates to vary with evolving industry external orientation. In this restricted testing context, excess industry returns are significantly correlated with exchange rates in less than half of the two-digit industries of the United States, Canada, and Japan (Bodnar and Gentry 1993). For both Canada and Japan, the derived elasticities of industry excess returns are significantly lower for nontraded industries and higher for industries that are export-intensive. For the United States, the derived elasticities of industry excess returns are positively correlated with raw materials input prices and industry foreign direct investment share.

The present paper continues our research agenda of unraveling the long-term implications of exchange rate movements. We build on our previous work which shows that, in the United States, real investments by two-digit manufacturing industries are significantly correlated with real exchange rate movements (Campa and Goldberg 1995a). To capture this relationship empirically it is important to control for evolving industry export shares and imported input shares into production. A single non-

6 Employment endogeneity to exchange rates is documented for United States manufacturing sectors by Branson and Love (1988).

interactive exchange rate term in investment regressions often misses or understates the importance of exchange rate effects. Moreover, all else equal, these exchange rate effects on investment are larger for U.S. low markup industries than for high-markup industries.[7]

The results of the present paper are broader and even more striking. First, we formally derive the exchange rate/ investment linkage in an imperfectly competitive market setting. Second, we extend the empirical analysis of the effects of exchange rate movements on investment to industries of the United States, Canada, Japan, and the United Kingdom, controlling by country for the evolution of the different channels of external orientation in these industries. Since these external orientation channels have grown over time, the magnitude of exchange rate implications also have evolved accordingly.

Our estimates provide further evidence that exchange rates have a more significant effect on low markup industries than on high markup industries. The sign and magnitude of the effects of a movement in the exchange rate varies by industry according to the industry's external orientation. The size of this effect appears to operate both through imported inputs and through export markets. According to our estimates, on average for low markup manufacturing industries in Japan and the United States a 10 percent home currency depreciation would result on a median change through our sample period of the order of –2 percent on investment. This effect on investment spending by low

7 Goldberg (1993) shows that studies of exchange rates and investment using aggregated macro-data underscore the impact and compositional effects. In cross-country studies, Campa (1993) and Goldberg and Kolstad (1995) consider the implications of exchange rate volatility for foreign direct investment. Campa finds that exchange rate volatility reduces foreign direct investment *levels*, especially in industries where sunk investments in physical and intangible assets are high. Goldberg and Kolstad find that exchange rate volatility increases the *share* of total production activity that producers locate overseas.

markup industries is more positive (negative) for industries with a larger net export (net imported input) orientation.

Controlling for differences across industries in trade orientation, the more significant effects of exchange rate changes in low markup industries may arise because producers in high markup industries are more able to absorb shocks to their overall profitability than are producers in low markup industries. Consequently, the link between permanent changes in exchange rates and producer profitability and investment is weaker in high markup industries.[8] As we show in our theoretical section, our empirical results and interpretation are fully consistent with the lessons of the theoretical and empirical literature on exchange-rate pass through.

II. INVESTMENT AND EXCHANGE RATES

Let a firm choose investment *I* to maximize the expected present value of the stream of future profits, *V*. Capital, the only quasi-fixed factor of production, is subject to a traditional capital accumulation equation and an increasing and convex cost of installing new capital. The maximized value of the firm at time *t* is given by

$$V_t(K_t, e_t) \;=\; \max_{\{I_t\}_{t=t}^{\infty}} E\left[\sum_{t=0}^{\infty} b^{t}\,[\Pi(K_{t+t}, e_{t+t}) - c(I_{t+t}) - I_{t+t}] \,|\, \Omega_t\right] \tag{1}$$

subject to

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

[8] In Bodnar and Gentry (1993), the sectors for which stock prices are relatively unresponsive to exchange rates generally fall within our classifications of high markup sectors.

where K_t is the beginning-of-period *t* capital stock, Π is the profit function, *b* is the discount rate, *d* is the depreciation rate of the capital stock, I_t is the investment expenditure in period *t*, *c* is the capital adjustment cost function, e_t is the period *t* exchange rate expressed in terms of domestic currency per unit of foreign currency, and $E[.|\Omega_t]$ is the expectations operator conditional on the time *t* information set Ω_t. For simplicity, it is assumed that the only source of uncertainty about the future is the exchange rate, over which the expectation operator applies.

The timing of the model is as follows. The firm observes the exchange rate at the beginning of the period. After observing the exchange rate, the firm chooses its variable inputs and output level for the period and observes the period's profits. Given profits this period and expected future profits, the firm chooses its investment level. The new capital resulting from this investment becomes productive at the beginning of next period, i.e. under the assumption of a one period time to build lag.

The first order condition for maximizing the value of the firm in Equation (1) subject to the constraint in Equation (2) is

$$E\left[V_t^k \middle| \Omega_t\right] = 1 + \frac{\partial c(I_t)}{\partial I_t} \quad \text{where}$$
$$V_t^k = \sum_{t=1}^{\infty} (b(1-d))^t \left[\frac{\partial \Pi(K_{t+t}, e_{t+t})}{\partial K_{t+t}}\right] \tag{3}$$

Equation (3) states that the firm should invest up to the point where the marginal cost of an additional unit of capital equals the expected present value of the stream of future profits generated by this additional unit. Following the standard treatment in the investment literature, we assume that the cost of adjustment function has the following quadratic form:

$$c(I_t) = \frac{g}{2}\left(I_t - m\right)^2 \tag{4}$$

where g and m are parameters. The first order condition (Equation (3)) becomes

$$I_t = m' + \frac{1}{g} E\left[V_t^k \middle| \Omega_t\right] = m' + \sum_{t=1}^{\infty} l^t E\left[\Pi_{t+t}^k \middle| \Omega_t\right] \tag{5}$$

where $m' = m - 1/g$ and $l = b(1-d)/g^{1/t}$, and we use Π_{t+t}^k as a notational shorthand for the marginal profitability of capital term in Equation (3). Therefore, Equation (5) states that investment levels are based on the expected future marginal profitability of capital. This marginal profitability of capital now needs to be specified.

As previously noted, at the beginning of each period the firm observes the exchange rate e_t and makes its choice of output sales in the foreign and domestic market, and of domestic and foreign variable input use, so as to maximize its per-period profits gross of investment costs. These producer profits for a firm are given by:

$$\begin{aligned} \Pi(K_t, e_t) \; &= \max_{q_t, q_t^*, L_t, L_t^*} p(q_t, e_t)\, q_t + e_t\, p^*(q_t^*, e_t)\, q_t^* - w_t L_t - e_t w_t^* L_t^* \\ & \quad subject \quad q_t + q_t^* = f(K_t, L_t, L_t^*) \end{aligned} \tag{6}$$

where L_t and L_t^* are the quantities of domestic and foreign variable inputs; q_t and q_t^* are the quantities supplied by the firm to the domestic and foreign market; w and w^* are the unit costs of the domestic and foreign input; $p(.)$ and $p^*(.)$ are the demands faced by the firm and $f(.)$ is a constant returns-to-scale production function. The firm produces output for both the domestic and export market using its beginning of period capital stock, and domestic and foreign variable inputs.

The domestic and foreign demand functions for the firm's product depend on both the respective quantities supplied by the firm to each market and on the exchange rate. The exchange rate directly influences prices because changes in exchange rates can alter the demand for the firm's products due to changes in the number of competitors and/or the quantities supplied by the competitors.[9] The exchange rate affects expected profitability through three channels: (i) export market revenues; (ii) imported input costs; and (iii) home market revenues. This third channel is intended to capture the possibility of import competition or the existence of wealth effects which potentially shift the demand schedule for domestically produced goods.

Solving the maximization problem in Equation (6) and differentiating the resulting gross profit function with respect to capital yields an expression for the marginal profitability of capital:[10]

$$\Pi_t^k \equiv \frac{¶\Pi_t}{¶K_t} = \frac{1}{K_t}\left(MKUP_t^{-1} p_t q_t + MKUP*_t^{-1} e_t p_t^* q_t^* - \left(w_t L_t + e_t w_t^* L_t^* \right)\right) \qquad (7)$$

where

$MKUP_t = 1/(1+h_t^{-1}) = p_t / MC_t$, and $MKUP_t^* = 1/(1+h_t*^{-1}) = e_t p_t * / MC_t$

h_t and h_t^* are price elasticities of demand in the domestic and foreign markets, and MC_t represents marginal cost.

To understand the effects of exchange rate movements on investment, we need to understand how exchange rates affect the marginal profitability of capital. To achieve this, assume that exchange rate changes are permanent and uncorrelated over time. Therefore, the current and past exchange rate information at time *t* provide all available information needed for calculating the response of V^k_t to exchange rate movements.

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9 The literature on pricing to market and exchange rate passthgrough all suggests that changes in exchange rates imply shifts in the demand curve faced by each individual firm in the market. See for instance Dornbusch (1987) or Knetter (1989, 1993). The demand curve could also shift due to a wealth effect from an exchange rate movement (Froot and Stein 1991).

10 See the appendix for the derivation of Equation (7).

Recall from Equation (5) that investment today depends on all future marginal profitabilities of capital. However, given that herein exchange rates are the only source of uncertainty and all exchange rate changes are assumed to be permanent, the expected marginal profitability in future periods is today's marginal profitability of capital, i.e. $E\left[\Pi_{t+\tau}^{k} \middle| \Omega_t\right] = \Pi_t^k$. Equation (5) becomes

$$I_t = m' + A\Pi_t^k = m' + \frac{A}{K_t}\left(MKUP_t^{-1}\, p_t\, q_t + MKUP_t^{*-1}\, e_t\, p_t^*\, q_t^* - (w_t\, L_t + e_t\, w_t^*\, L_t^*)\right) \qquad (8)$$

where $A = \dfrac{b}{g\left(1 - b(1-d)\right)}$.

Differentiating this function with respect to the exchange rate, collecting terms and multiplying and dividing by both e_t and total revenues, we get

$$\frac{\partial I_t}{\partial e_t} = \frac{A'_t}{AMKUP_t}\left[\left(h_{p,e} - h_{MKUP,e}\right)(1 - X_t) + \left(1 + h_{p^*,e} - h_{MKUP^*,e}\right)X_t - \left(1 + h_{w^*,e}\right)a_t\right]\frac{de_t}{e_t} \qquad (9)$$

where TR represents total revenues, $A'_t = A^*TR_t / K_t$ and $h_{p,e}$ and $h_{p^*,e}$ are exchange-rate pass-through elasticities in domestic and foreign markets; $h_{MKUP,e}$ and $h_{MKUP^*,e}$ are markup elasticities with respect to exchange rate changes; and $AMKUP$ is the average markup across domestic and foreign sales.[11] X_t represents the share of total revenues associated with foreign sales [(1-X_t) is the share associated with domestic sales], and a_t, the share of imported inputs in production costs, is multiplied by the elasticity of these input costs with respect to exchange rates, $\left(1 + h_{w^*,e}\right)$. We assume that b, g, and d are independent of exchange rate movements.

11 We will not be able to observe distinct markups for sales in domestic and foreign markets and therefore assume $MKUP_t = MKUP_t^* = AMKUP_t$ when deriving this final expression.

Equation (9) provides a very clean and general set of insights into both the channels through which exchange rates influence investment activity and the magnitudes of these channels. For each industry, the investment response to exchange rates, relative to the total sales of the industry, depends on the three main terms within the right-hand-side brackets.

First, exchange rates can affect investment by influencing the profitability of domestic sales. This effect depends on the response of home market prices and markups to exchange rate changes. The endogeneity of these prices, specifically discussed below, depends on the competitive structure of the home market.

Second, exchange rates affect directly the marginal profitability through the export revenues of the firm (a direct valuation effect). However, some of this effect may be offset by indirect effects attributed to local currency price adjustments and by an overall endogeneity of the markup on exported goods. The particular format of foreign currency price and markup endogeneity also will depend on the mode of competition in foreign markets for the specific industry and product.

The marginal profitability of capital and investment also are affected by changes in total production costs with respect to exchange rates. For example, imported input costs may rise with a depreciation of the domestic currency, resulting in a lower marginal profitability of capital. For a given effect of exchange rates on imported input prices, the larger the share of imported inputs into production, the greater the decline in marginal profitability. The degree of imported input price adjustment given exchange rate changes will be dependent on the industrial organization of the input markets.[12]

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[12] We implicitly treat total expenditure on domestically supplied inputs as insensitive to exchange rate movements. Our imported input series implicitly internalizes the elasticity of the domestic currency prices of these inputs with respect to exchange rates.

Finally, note that A_t' multiplies the right-hand-side of Equation (9) and scales the investment response to exchange rates. The overall response is smaller for industries or countries with high costs of capital stock adjustment *g*, or high rates of capital stock depreciation. The investment response increases when there is a high *b* and a low ratio of capital to revenues in the industry. [13]

The theoretical signs of the domestic and foreign market pass-through elasticities are crucial for evaluating the investment endogeneity with respect to exchange rates. The elasticities depend on the forms of competition within relevant markets and an interpretation of the applicable exchange rate process. Under our assumption of exchange rate changes being permanent and unanticipated, current price-setting depends only on current profits.

The three markets pertinent to the pass-through elasticities include the two markets for the final good being produced, which determine $h_{p,e} - h_{MKUP,e}$, and $h_{p^*,e} - h_{MKUP^*,e}$, and the market for the products used as the imported input, which determines $h_{ew^*,e} > 0$. Alternative models of industry competition yield distinct predictions on the magnitude of these elasticities (Dornbusch (1987). Under perfect competition, prices are taken as given and not affected by exchange rate changes.[14] Under Dixit- Stiglitz monopolistic competition, markups are constant and independent of exchange rate changes $h_{MKUP,e} = h_{MKUP^*,e} = 0$. If inputs into production are domestically supplied at exogenous domestic currency wages, domestic prices and quantities supplied by domestic producers are

13 Variations on the ex ante cost of capital account for more than half of the cyclical variation in the marginal profitability of capital (Abel and Blanchard 1986). An interest rate will be introduced into the empirical analysis.

14 This assumes that a subset of firms competing in the industry are not affected by the exchange rate shocks. It also implies that the law of one price need not hold, i.e. that there can be price discrimination across markets.

unchanged by a domestic currency depreciation, i.e. $\eta_{p,e} = 0$. The domestic currency price of exports also remains unchanged, so that the foreign currency price of this good falls to offset the domestic currency depreciation, i.e. $\eta_{p^*,e} = -1$ And quantities sold in foreign markets by domestic producers rise accordingly. [15] Under Cournot competition, markup ratios on exported goods rise when the domestic currency depreciates. The amount that markups increase in response to a domestic currency depreciation is negatively related to the degree of foreign competition in the export market and the proportion of imported inputs into production. A similar argument holds for the effect of exchange rates on prices of goods sold in domestic markets. The pass-through coefficient depends on the pricing behavior of foreign suppliers participating in this market and on the degree of local import competition.

III. EMPIRICAL IMPLEMENTATION AND DATA

We implement the investment model presented in Equation (8) and (9) with the following empirical specification:

$$\Delta I_t^i = b_0^i + \left(b_1 + b_2 c_{t-1}^i + b_3 a_{t-1}^i\right) AMKUP_{t-1}^{i\ -1} \cdot \Delta e_{t-1} + b_4 \Delta y_{t-1}^i + b_5 \Delta r_{t-1} + b_6 \Delta oil_{t-1} + m_t^i \quad (10)$$

where i indexes industries and Δ indicates log changes in the corresponding variables, with the exception of interest rates r_t, which enter as level changes. This equation shows that the exchange rate effects are interacted effects with the export and imported input shares of the industry. Investment also is a function of the cost of capital, r_t, the price of other inputs -- proxied by the real price of oil, oil_t,

15 If the monopolistic competitor supplies both domestic and foreign markets and faces variable marginal costs, the exchange-rate pass through elasticities will depend on the overall effects on marginal costs of total changes in the level of production for domestic and foreign markets (Marston 1990).

and real industry sales y_t^i, which is introduced to control for differences over time and across industries in sales and growth rates. We use first differences in the investment equation to control for the nonstationarity of the permanent component of the real exchange rate, e_t.

The model in the previous section shows that investment depends on expected future variables. These future variables need to be forecast at the time the decision to invest is made. Given the one-period time-to-build assumption, an investment decision that appears in the data at time *t* was made at time *t-1*, using the best forecast of expected future variables available at time t-1. Therefore, we use as explanatory variables for I_t only information available at time *t-1*.

In Equation (10), exchange rates are permitted to influence investment with constant elasticities (through b_1) or can vary over time with industry external exposure (i.e., with the industry export shares and the markup adjusted imported input shares). From Equation (9), we established that the coefficient on the non-interacted exchange rate term is a positive function of $h^i_{p,e} - h^i_{MKUP,e}$. The coefficients on the exchange rate interacted with export share (b_2) represent the sum of the valuation effects on exports and domestic sales, which is $1 + h^i_{p^*,e} - h^i_{MKUP^*,e} - h^i_{p,e} + h^i_{MKUP,e}$. Finally, the coefficients on imported input share (b_3) will be a positive function of $h_{ew^*,e}$.

Since the effects of exchange rates on investment are a function of the average markup of the industry, estimation of the investment regressions must account for the endogeneity of markups with respect to exchange rates.[16] Due to data issues implicit in the construction of the markup series, we

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16 Most of the focus of the recent literature on exchange-rate movements has been on the behavior of final prices under the assumption of constant marginal costs. Therefore, it implicitly focuses on the movement of markups. Dornbusch (1987) is a clear example of this. In our regressions, we use average rather than marginal markups. Our series represent an average of markups on domestic and foreign sales.

do not explicitly seek to study the behavior of markups. Instead, our main objective is to control for the comovements between markups and exchange rates, and their resulting effect on investment adjustments. We will use a 3SLS procedure to jointly estimate with the investment equation a second equation on the time change of industry markups as a function of changes in the exchange rate. This latter function controls for industry levels of export orientation (c_i), import competition (M_i), and imported inputs into production (a_i).[17]

The Data: We use data on industry investment and exposure to exchange rates in industries of the United States, Japan, Canada, and the United Kingdom. Three types of time-varying exposure to exchange rates are introduced for each industry of each country: exports relative to total domestic shipments, imports relative to total domestic consumption, and expenditures on imported inputs relative to total production costs. The first two series are straightforward. The third series, a measure of imported input share, is constructed using sectoral input-output data for each country combined with time series on industry import shares and labor costs.[18] The main strengths of the constructed series are that they explicitly utilize production and input-output tables for each country (and for numerous sample years) and combine this information with country data on industry imports, exports, total shipments, wage expenditures, and price-over-cost markups.

There are two main shortcomings of the imported input series. First, the data on industry import shares include both imports of final goods and of intermediate goods of the sector. We cannot determine whether the import share in overall consumption of a good is significantly different from the

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17 M_i is defined as the ratio of imports to domestic consumption.

18 Specific details regarding these series and the data for each country are provided in the appendix and in Campa and Goldberg (1997).

import share in intermediate input consumption. Second, we generally do not have meaningful or available annual input-output numbers and therefore must assume that the structure of production (i.e., the shares of particular industries in total production costs) is inflexible for time horizons of a number of years.

Countries differ tremendously in industry exposures and the evolution of these exposures. The United States has the dubious distinction of being the only country with many manufacturing industries that have at times evolved from net exporters to net reliance on imported inputs into production. Comparable results do not arise in the United Kingdom, Japan, and Canada when their respective currencies decline in value. Relative to the United States, industries in the United Kingdom have had much more stable patterns in net exposure, with net exporters generally remaining net exporters through the early 1990s. In Canada, many industries have increased their exports share more rapidly than their reliance on imported inputs into production throughout the 1970s and 1980s, leading to overall increases in net export shares. In Japan, there is no single tendency that can characterize net exposures across distinct industries.

Sectoral Markups: Our derivation of investment exposure to exchange rates yielded elasticities that depended on an average-cost and average-price based measure of price-over-cost markups. We follow the construction methodology of Domowitz, Hubbard and Petersen (1986), wherein the markup measures account for the behavior of the value of sales and changes in inventories:[19]

19 Instead of exclusively measuring output as, for example, in Hall (1988). This measure is subject to the usual criticisms (i.e., it does not adequately account for scale economies, capacity utilization, or overhead labor rates). Our *AMKUP* measure is equal to 1/(1-*MKUP*), where *MKUP* is the markup measure of Domowitz, Hubbard, and Peterson (1986). These measures are positive transformations of each other and are qualitatively similar. We also checked our markup estimates for the United States with those reported by Hall (1988), which provides estimates of

$$AMKUP = \frac{\text{value of sales} \ + \ \Delta\text{inventories}}{\text{payroll} + \text{cost of materials}} \tag{11}$$

which is identical to (value added +cost of materials)/(payroll + cost of materials).[20]

Within each country, we rank industries in order of low to high markup. These industry rankings are not identical across countries. Of course, this finding is expected based on principles of comparative advantage. The United States and Canada are most similar in their rankings of high to low markup industries (see Table 1). There is little correlation between the rankings of markups, loosely interpreted as industry profitability, between the United States or Canada and Japan. The ranking of average industry markups for the United Kingdom is most similar to the ranking observed for Japan. The low numbers arising in this comparison of markups across countries can be attributed to various forces. This can reflect stark differences in the relative profitability of production in different industries of different countries, differences in the fixed costs of production in industries across countries that are omitted from the markup construction, or differences in the country accounting procedures for data used in markup construction.

Computation of Permanent Exchange Rates: As derived in the previous section, investment responds to permanent changes in exchange rates. To decompose the real exchange rates into their

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price over marginal cost using an alternative methodology. A rank correlation between the two measures was positive (0.463) and highly significant.

20 We use source country data for this construction and do not view as appropriate direct cross-country comparisons of levels of markup series. Comparisons within a country of sectoral markup series are probably less problematic but still subject to well-known criticisms. Our main use of the markup series focuses on their rates of change within an industry in relation to exchange rate movements. For this application, we have far fewer misgivings about the series.

permanent and transitory components, we use the decomposition first suggested by Beveridge and Nelson (1981) and later employed to exchange rate data by Huizinga (1987), Campbell and Clarida (1987), Cumby and Huizinga (1990), and Clarida and Gali (1994), among others.

The Beveridge-Nelson procedure decomposes an I(1) time series into its transitory and permanent components. For the real exchange rate at time t, e_t, this is expressed as $e_t = e_t^{BN} + \hat{e}_t^{BN}$, where the permanent component is denoted by “^”. The transitory departure of the real exchange rate from its expected long-run equilibrium, e_t^{BN} , is given by:

$$e_t^{BN} = - E_t\left(\sum_{j=1}^{\infty} \Delta e_{t+j} \mid \Delta e_t , \Delta e_{t-1}, \ldots \right) \tag{12}$$

with the permanent component defined by:

$$\hat{e}_t^{BN} = e_t + E_t\left(\sum_{j=1}^{\infty} \Delta e_{t+j} \mid \Delta e_t , \Delta e_{t-1}, \ldots \right) \tag{13}$$

Beveridge and Nelson (1981) proved that the first of these components is a stationary process, while the second is a random walk.

We follow Beveridge and Nelson (1981) and Huizinga (1987) and model the exchange rate decomposition using lags of the real exchange rate.[21] In particular, we assume that the first differences of the quarterly (log) real exchange rate follow an AR(4) process, so that:

$$E_t\left(e_t^{BN}\right) = - E_t\left(\sum_{j=1}^{\infty} \Delta e_{t+j} \mid \Delta e_t , \Delta e_{t-1}, \Delta e_{t-2}, \Delta e_{t-3} \right) \tag{14}$$

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21 We also tried a multivariate system in which we also included three lags of the country’s quarterly inflation rate and GDP growth. The results of the decomposition were very similar, with an average correlation between the permanent components about 0.9. Given that these exchange rates are trade-weighted multilateral indices, we decided to report and utilize only the univariate decompositions.

The actual variance decomposition results suggest that the temporary component of exchange rate changes accounts for only a small proportion of the variance of the real exchange rate series (see Table 2).[22] The variance of the transitory component of the real exchange rate accounts for less than 25 percent of the total variability of the real exchange rates, with the exception of the United States where the ratio is considerably larger (at 40 percent). In our regression specifications, we use the estimated permanent exchange rates as the driving forces that determine investment.

IV. ESTIMATION RESULTS

In this section we present the results of regressions over investment data for manufacturing industries in the United States, Canada, Japan, and the United Kingdom. The investment series reflect the total amount of investment in plant and equipment within an industry within a country over the course of each year. The data do not identify the owner of the investment activity in domestic markets. Unless otherwise noted in the tables, we report results from a three-stage least-squares procedure of investment and markups. This procedure allows for the simultaneous determination of investment and of markups with respect to exchange rates. It also instruments interest rates to control for their possible endogeneity. We use as instruments the exchange rate changes and lagged values of interest rates.

The country regression results are provided in Tables 3 to 6. The first three rows of numbers in each of these tables represent the results for investment, followed by markup regressions in the next

22 Similar results are reported in Clarida and Galí (1994).

three rows of numbers.[23] In the investment regressions, the first three columns of variables show the coefficients and standard errors associated, respectively, with non-interacted exchange rates, and exchange rates interacted with evolving export and imported input shares. The coefficients on interest rates, oil prices, and sales growth also are reported. We do not report the coefficients on the industry dummies and industry trends included in the regressions. The reported Hausman test statistic indicates whether we actually needed to control for the possible endogeneity of markups. Rejection of the null, which occured in almost all of our regressions, shows that it is appropriate to use our 3SLS system. The F-test results, reported for investment and markup equations, test the null hypothesis that all exchange rate coefficients included in that equation are equal to zero.

For each country, the regressions are run using three different pooled time-series samples. In the first sample, time series data from all manufacturing industries in a country are constrained to have common regression coefficients. We also split the sample by their median markup since according to the model in the previous section the sensitivity of investment to exchange rates should be a function of industry specific variables such as the demand elasticity, and the pass-through elasticities of exchange rate changes in the output and input markets.[24] In the second sample, only the "high-markup industries" of a country are included. In the third, only the "low-markup industries" are included.

Each country has a distinct group of industries which fall under the heading of high versus low markup industries. To determine these industry groupings within a country, we compare an industry's

[23] 2SLS runs also were performed, wherein actual not instrumented markups were utilized. The results are qualitatively similar to the 3SLS results.

[24] Ideally one would like to allow the exchange rate coefficients to vary by industry. Given the limited length of our sample period, doing this would substantially reduce the degrees of freedom in such a specification.

average markup and the median average markup over all manufacturing industries *for that country*.[25] There is considerable overlap of industries within the high and low markup groups of countries, but the composition of these groups is not identical for any two countries. Thus, any comparisons of results across countries identify distinctions in behavior of industries classified relative to the country price-over-cost markup median. For this reason, we also run our regression systems for each country using a common grouping of industries based on the U.S. classification of high versus low markup industries. A discussion of these latter results concludes our section on empirical findings.

Preview of Country Results. The investment regressions consistently generate coefficients with the expected signs on the interacted export share terms (i.e., positive) and imported input share terms (i.e., negative), with the exception of Canada. The coefficients on the export share term also are usually significant. Thus, the more export-oriented is an industry, the greater the expansionary effect

25 We use this ordinal classification approach to abstract from country-specific biases in the data used in markup construction. Industries within the low-markup groupings are: United States -- primary metal products, fabricated metal products, transportation equipment, food and kindred products, textile mill products, apparel and mill products, lumber and wood products, furniture and fixtures, paper and allied products, petroleum and coal products, and leather and leather products; Japan -- primary metal products, electrical machinery, transportation equipment, textile mill products, lumber and wood products, paper and allied products, printing and publishing, and rubber and plastic products; United Kingdom -- primary metal products, fabricated metal products, nonelectrical machinery, electrical machinery, transportation equipment, textile mill products, paper and allied products, printing and publishing, rubber and plastic products, and leather and leather products; Canada -- primary metal products, fabricated metal products, transportation equipment, food and kindred products, textile mill products, lumber and wood products, furniture and fixtures, petroleum and coal products, and rubber and plastic products.

that a real depreciation has on investment.[26] Counteracting this export-orientation effect are the forces set in motion by imported input use: the more that an industry uses imported inputs into production, the more that production costs rise with a home currency depreciation and restrain investment. The balance of exchange rate effects on an industry depends both on the regression coefficients and on the size of the external orientation of an industry at different dates.

Important differences exist within and across countries in industry investment responsiveness to exchange rates. In the United States, Japan, and the United Kingdom, there are significant effects of exchange rates on investment in low markup industries -- but the group of exchange rate terms do not contribute significant explanatory power to investment regressions in high markup industries. Low-markup industries -- those industries that conceptually can be viewed as closer to perfect competition -- have larger responsiveness to exchange rates (all else equal).

The higher sensitivity of low markup industries is consistent with outcomes expected for terms in Equation (9) under models of imperfectly competitive markets. For example, under Cournot competition these results arise because $|h^{i}_{p^*,e}|$ for high markup exceeds $|h^{i}_{p^*,e}|$ for low markup industries. It is unlikely that the differences in the export share coefficients are due to differences in $h^{i}_{p,e}$ across high and low markup industries: regardless of the industry, domestic price elasticity with respect to exchange rates often is low or statistically insignificant.[27]

Since the exchange rate effects are particularly strong in the industries of the United States and Japan, for these two countries we also compute and discuss the economic importance of the effects of

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26 Our discussion uses as a focal point the effects of a domestic currency real depreciation on investment. Equal and opposite signed effects apply in the context of real appreciation implications.

27 See Feinberg (1989) and Swagel (1995) on evidence for the United States, and Goldberg and Knetter (1996) for an overview of existing evidence.

a currency depreciation on investment. The discussion focuses on the ranges of high and low-markup industry *investment rate* responses to changes in the exchange rate *depreciation rate*. The ranges are constructed using point estimates that we construct by using the estimated coefficients for high and low markup industries (reported in Tables 3 and 4), and specific industry data (on export share, imported input share, and markups) at distinct dates. In some industries an increase in the home currency depreciation rate stimulates investment, while in other industries an increase in this depreciation rate slows investment. For all practical purposes, this literal interpretation of the results -- in terms of changes in rates rather than in levels -- can be replaced by the more intuitive interpretation that we adopt in our continuing discussion of the empirics.

Results for the United States: For U.S. industries, the investment stimulus from a dollar depreciation significantly rises with industry export share (Table 3, column 2) and declines with imported input use (Table 3, column 3), although the significance of this latter term appears only for low markup industries. The non-interactive exchange rate terms are not statistically significant in any of the investment equations. F-tests indicate that the overall explanatory power of exchange rates for investment is most notable in the low-markup industries. Hausman tests indicate that the model specification, wherein we empirically allow for simultaneous endogeneity of investment and markups, is appropriate for the three industry groupings. The absolute size of each channel for exchange rate implications (through both export share and imported input share) is larger for the low markup industries than for the high markup industries.

As noted, cost shocks associated with reliance on imported inputs, captured by the interacted term $a^i \cdot \Delta\hat{e}$, were only statistically significant for investment in low markup industries. This could suggest that the prices of imported inputs into these sectors are sensitive to exchange rate movements

-- a result that contrasts with some assertions of complete local-currency-price stability on inputs into low markup sectors of United States industry.[28] The statistical insignificance of the imported inputs into high markup sectors is more consistent with stable prices on the imported inputs utilized by these sectors.

The implications of the differences in responses of investment in high and low markup industry groups are apparent when we combine industry data on markups, export share, and imported input share with the regression coefficients of that industry's affiliated grouping (high markup or low markup).[29] The weighted average of the effects on investment rates of a 10 percent rise in the dollar depreciation rate are: around -1 percent for U.S. high markup industries, and double (-2 percent) for low markup industries. The range of expected effects, however, varies widely by industry depending on the net external orientation of the industry. For low (high) markup industries this effect ranges from -12 percent for Petroleum & Coal Products (-6.9 percent for Printing & Publishing) in 1974 to 9.6 percent for Transportation Equipment (7.8 percent for Industrial Machinery and Equipment) in 1993.

Results for Japan: Table 4 shows that only low markup industries in Japan exhibit significant investment endogeneity with respect to exchange rate movements. As observed for the United States, (in low markup industries home currency depreciations stimulate investment in relation to an industry's

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28 An alternative possible explanation is that, given the high correlation between imports in the industry and imported inputs, this result reflects the effect of import competition.

29 For these specific industry results, industry-specific numbers on export share, imported input share, and markups are used in conjunction with the estimated regression coefficients to compute industry-specific elasticities of response to depreciation.

export exposure and depress investment in relation to imported input shares (although this last effect is statistically insignificant). The hypothesis that the coefficients on the exchange rate terms are jointly equal to zero is rejected for low markup industries while it cannot be rejected for high markup industries.

The point estimates of the interacted exchange rate coefficients are consistently smaller than those reported for the United States. Equation (9) suggests four distinct reasons for this different behavior: (*i*) lower b 's in Japan; (*ii*) higher Japanese d 's; (*iii*) higher Japanese g 's; and (*iv*) differences in domestic and foreign price elasticities with respect to exchange rates.

Anecdotal evidence suggests that lower Japanese b 's are an unlikely explanation for low Japanese investment responsiveness: Japanese producers are viewed as having a longer -- not shorter -- horizon on investment decisions. There also is no reason to expect capital in the same industry to depreciate at substantially different rates across countries.[30] The third explanation -- higher adjustment costs to changing the Japanese capital base -- seems more plausible as a contributing factor, but we cannot document the extent to which Japanese investment adjustment costs are higher than those in the United States.

The fourth reason for lower Japanese investment responsiveness is based on the set of elasticities multiplying export share in Equation (9): $1 + h^{i}_{p^*,e} - h^{i}_{MKUP^*,e} - h^{i}_{p,e} + h^{i}_{MKUP,e}$. The pricing-to-market literature suggests that $\left|h^{i}_{p^*,e}\right|$ is smaller for Japanese producers than for United States producers (e.g., Knetter 1989). $h^{i}_{p,e}$ is known to be quantitatively small and almost insignificant for the United States (Feinberg 1989; Swagel 1995), while Marston's (1990) analysis suggests a

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30 Cummins, Hassett, and Hubbard (1995) show that aggregate depreciation rates are similar for the United States and Japan.

relatively large $h^{i}_{p,e}$ for Japan.[31] Thus, this explanation is consistent with our results only if $|h^{i}_{p*,e}|$ for the United States is smaller than $h^{i}_{p,e}$ for Japan. Existing empirical studies do not resolve the issue of the relative size of these price elasticities with respect to exchange rates.

The implied range of industry investment effects of exchange rates for both high and low markup industries also are compounded by sharp differences across these groups in industry external orientation. Four of the five largest industries of the Japanese economy have export shares of 20 percent or more. Many other industries have very moderate export orientation, with export shares of less than 5 percent of shipments. Using 1992 data, for example, the shipments-weighted average of a 10 percent yen depreciation rate resulted in a median 3.3 percent *decrease* in the investment rate for low markup industries and a 0.9 percent *increase* for the high markup industries. The range of investment response across in low (high) markup industries goes from over -10 percent for Textile Products, Lumber & Wood Products, and Pulp, Paper & Paper Products (and -8 percent for Petroleum & Coal Products) throughout the sample period to an expansion of 6 percent for Transportation Equipment (8.3 percent in Instruments and Related Products).

<u>Results for the United Kingdom</u>: The effects of changes in the permanent component of exchange rates on investment are smaller in magnitude for industries in the United Kingdom (Table 5). Although the sign pattern on the coefficients on export share and imported input share are as expected (with the exception of the near zero coefficient on imported inputs in low markup industries), the imported input coefficients are never significantly different from zero. As was the case for the United

31 Using our notation, Marston presents evidence on $1+h^{i}_{p*,e}-h^{i}_{p,e}$. The overall size of this term ranged from approximately 1 to 0.5 and below. If $h^{i}_{p*,e}$ is near zero, then $h^{i}_{p,e}$ ranges from near zero to more than 0.5.

States and Japan, the null hypotheses of all exchange rate coefficients being equal to zero cannot be rejected for the sample of high markup industries. For low markup industries, none of the coefficients on the interacted exchange rate terms are statistically significant and the large negative point estimate of the coefficient on the non-interactive exchange rate term suggests that a home currency depreciation will most likely decrease investment in these industries. U.K. manufacturing industries have shown much more stable patterns of external exposure than industries in Japan and the United States. The lack of variability in these terms might explain the lower significance of the interacted exchange rate terms in the low markup industry regressions.

Results for Canada: Investment appears to have been the least responsive to exchange rate movements in Canadian manufacturing industries (Table 6). As the results indicate, the exchange rate terms were not jointly statistically significantly different from zero for either the high or low markup industry groupings. Also, the individual coefficients are almost always statistically insignificant, and no clear pattern exists in the sign of the coefficients.

The insignificance of investment rates to exchange rates can arise either because producer profits (and the marginal profitability of capital) are unresponsive to exchange rates, or because investment is unresponsive to changes in producer profitability. Our empirical model does not include a measure of profits so it is difficult to distinguish between these two alternatives. However, to the extent that industry markups are correlated with industry profitability, the regressions on the determinants of markups can provide some insight. The results for Canada and the United Kingdom (bottom panels of Tables 5 and 6) show the lack of significant response of industry markups to exchange rates in these countries, especially when compared to the results for Japan.

The lack of a statistically significant response of industry investment to exchange rate changes in Canada appears paradoxical given the size and high degree of external orientation of its manufacturing sectors. In order to check for the robustness of these results, we examined the possibility that the model might be misspecified. We reestimated our model in Equation (10) using three different definitions of the real exchange rate: 1) the log of the actual real exchange rate and anticipated changes in exchange rates based on interest rate differentials; 2) the deviations from trend of the log real exchange rate; and, 3) the one and two year cumulative deviations from trend of the log real exchange rate. In all cases, the results were qualitatively similar to the results reported above. Investments in Japanese and U.S. manufacturing industries were significantly responsive to exchange rate changes, especially in low markup industries, while for the United Kingdom and Canada there was no statistical significance of the response of investment to exchange rates.[32]

Comparison of Results across Countries and within Industries: The results presented in Tables 3 through 6 use high and low markup classifications based on the rankings of sectors within each country. This treatment means that different industries are contained within the high and low markup groups of each country. Differences in investment responses across countries may be due to cross-country distinctions in the industry composition of the groups.

To control for this possibility, we also tested whether our regression results for each country change when industries are pooled using the high versus low markup sector rankings of the United States. These new results (not reported here) are quite different from the results using own-country

[32] We also tested for the possibility that the more openness of the UK and Canadian economies might lead to a collinearity between exchange rates and interest rates. We dropped the interest rate terms, but the results did not significantly improve.

sector rankings. Using U.S. rankings, investment responsiveness to exchange rates is generally insignificant or qualitatively unimportant for countries other than the United States. This finding contrasts sharply with the country tables in which clear patterns of differences of adjustment across high and low markup sectors emerge for Japan and the United States. These results suggest that the markup rankings within countries are related to sectoral characteristics that impinge on investment elasticities with respect to exchange rates. Such characteristics could include industry concentration, relevant institutions for particular industries in a country, and the competition facing producers in their own markets.

V. SUMMARY AND CONCLUDING REMARKS

In this paper we have provided evidence on the effects that real exchange rate movements have on investment activity by manufacturing industries at the two-digit level of industrial aggregation in the United States, Japan, the United Kingdom, and Canada. The magnitude of these effects significantly evolves with the changing export and imported input orientation of producers. The importance of each of these exposure channels for the marginal profitability of capital, and implications of exchange rates depend on a set of pass-through and demand elasticities.

Specifically, the exposure of producer profitability and investment to exchange rates: (i) declines to the extent that exporters pass through exchange rate movements into the local currency prices of their exports; (ii) increases in relation to the price elasticity of foreign demand; (iii) increases in relation to the exchange rate elasticity of producer prices in domestic markets; (iv) declines in relation to the price elasticity of demand in domestic markets; and (v) declines (or becomes increasingly negative) to the extent that the producer relies on imported inputs into production and to the extent that exchange rate movements are passed through into the domestic currency price of these imported inputs. The sensitivity of investment to the expected marginal profitability of capital declines for industries with high rates of capital depreciation, high costs of capital stock adjustment, and low weight on future expected profits.

The empirical results provide some support to our basic model of investment, wherein the positive effects of a home currency depreciation on investment are increasing in an industry's export share and decreasing in its imported input share in the United States and Japan. Across countries, exchange rates tend to have weak or relatively insignificant effects on investment rates in high markup sectors. By contrast, in the United States, United Kingdom, and Japan, investment responsiveness to exchange rates is fairly strong in the low markup sectors. This plausible finding can be explained via lower sensitivity of international pass-through coefficients (i.e., smaller export pass-through coefficients) and price elasticities of demand among high markup sectors than among low markup sectors.

In both low and high markup sectors, the coefficients on the channels of exchange rate exposures are lower in Japan than in the United States. This result is consistent with the existence of higher pass-through elasticities within Japan. However, the results also are consistent with a view that investment activity in Japan is relatively unresponsive to short horizon patterns in producer profitability due to higher costs of adjusting the capital stock.

Viewed from an investment perspective, our research points to another force that contributes to the well-known volatility of investment. Since exchange rates move investment rates in the United States, volatile (but persistent) exchange rates thereby can contribute to the volatility of investment by U.S. manufacturing industries.

Future research could address the reasons for differences in investment response across industries and countries. In the present paper we emphasize distinct investment responses to changes in the marginal profitability of capital, where these changes are caused by exchange rates. However, the model suggests a limited set of additional explanations for these distinctions, including adjustment costs of the capital stock, capital depreciation rates, and rates of time preferences.

Other interesting and important institutional factors are likely to be country-specific. For example, local capital markets and industrial group activity may be important. Recent research argues that producer access to credit is not uniform across firms or across countries. In the United States, it is argued that differences exist among large and small firms in their means and ability to adjust to business cycles and monetary policy changes (Gertler and Gilchrist 1994).[33] Similarly, in Japan belonging to an industrial group can matter for the way in which a firm weather's economic cycles (Hoshi, Kashyap, and Scharfstein 1991). An important puzzle in this paper is the apparent lack of response to exchange rate changes of investment in the manufacturing industries of Canada. One could have expected more significant reponses given their higher degree of external orientation. In this context, a more detailed analysis of more country-specific factors driving investment in these economies should help understand this result.

33 Gertler and Gilchrist (1994) show that small firms in the United States may be excluded from credit markets when there are overall economic contractions. The firms therefore have reduced access to credit for hedging short-term fluctuations. Similar types of interactions between the banking sector and response to shocks may be present in Japan (Hoshi, Scharfstein, and Singleton 1990) and the United Kingdom (Stephen Bond, et al. 1995).

References

Abel, A. and O. Blanchard, "The Present Value of Profits and Cyclical Movements in Investment," *Econometrica* 54 (March 1986), pp. 249-73.

Baldwin, R., and P. Krugman, "The Persistent Trade Effects of Large Exchange Rate Shocks," *Quarterly Journal of Economics* 104, no. 4 (November 1989), pp. 635-54.

Beveridge, S. and C. Nelson, "A New Approach to the Decomposition of Economic Time Series Into Permanent and Transitory Components," *Journal of Monetary Economics*, 33, No.1 (1981), pp. 5-38.

Bodnar, G., and W. Gentry, "Exchange Rate Exposure and Industry Characteristics: Evidence from Canada, Japan, and the USA," *Journal of International Money and Finance* 12 (1993), pp. 29-45.

Bond, S., J. Elston, J. Mairesse, and B. Mulkay, "A Comparison of Empirical Investment Using Company Panel Data for France, Germany, Belgium, and the UK," manuscript, Nuffield College, Oxford, (1995).

Branson, W., and J. Love, "United States Manufacturing and the Real Exchange Rate," in R. Marston, ed., *Misalignment of Exchange Rates: Effects on Trade and Industry*, University of Chicago Press (1988).

Branson, W., and R. Marston, "Price and Output Adjustment in Japanese Manufacturing," National Bureau of Economic Research Working Paper no. 2878 (1989).

Campa, J., "Entry by Foreign Firms in the United States under Exchange Rate Uncertainty," *Review of Economics and Statistics* LXXV, no. 4 (November 1993), pp. 614-22.

Campa, J., and L. Goldberg, "Investment, Exchange Rates and External Exposure," *Journal of International Economics* 38 (May 1995a), pp. 297-320.

Campa, J., and L. Goldberg, “Investment, Pass-Through and Exchange Rates: A Cross-Country Comparison,” NBER Working Paper no. 5139 (1995b).

Campa, J., and L. Goldberg, “The Evolving External Orientation of Manufacturing: Evidence from Four Countries,” *Federal Reserve Bank of New York Economic Policy Review* (July 1997), pp. 53-81.

Campbell, J. and Clarida, R., "The Dollar and Real Interest Rates: An Empirical Investigation," *Carnegie-Rochester Conference Series on Public Policy*, 27, (1987), pp. 103-140.

Chirinko, R, “Business Fixed Investment Spending: Modeling Strategies, Empirical Results, and Policy Implications,” *Journal of Economic Literature* 31 (December 1993), pp. 1875-1911.

Clarida, R. and Gali, J., "Sources of real exchange rate fluctuations: How important are nominal shocks?," *Carnegie-Rochester Conference Series on Public Policy*, 41 (1994), pp. 1-56.

Cummins, J., K. Hassett, and R. G. Hubbard, “Tax Reforms and Investment: A Cross-Country Comparison,” NBER Working Paper no. 5232 (August 1995).

Domowitz, I., G. Hubbard, and B. Petersen, “Business Cycles and the Relationship between Concentration and Price-Cost Margins,” *Rand Journal of Economics* 17 (Spring 1986), pp. 1-17.

Dornbusch, R., “Exchange Rates and Prices,” *American Economic Review* 77 (March 1987), 93-106.

Feinberg, R., “The Interaction of Market Power and Exchange Rate Effects on German Domestic Prices,” *Journal of Industrial Economics* 35, (1986), pp. 61-70.

Feinberg, R., “The Effects of Foreign Exchange Movements on United States Domestic Prices,” *Review of Economics and Statistics* 71 (1989), pp. 505-11.

Frankel, J., and K. Froot., “Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations,” *American Economic Review* 77 (March 1989), pp. 133-53.

Froot, K., and P. Klemperer, "Exchange Rate Pass-Through When Market Share Matters," *American Economic Review* (September 1989),pp. 637-54.

Gertler, M., and S. Gilchrist, "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics* 109, no. 436 (1994), pp. 309-40.

Gilchrist, S., and C. Himmelberg, "Evidence on the Role of Cash Flow for Investment," *Journal of Monetary Economics* 36, no. 3 (December 1995).

Goldberg, L., "Exchange Rates and Investment in United States Industry," *Review of Economics and Statistics* LXXV, no. 4 (November 1993), pp. 575-88.

Goldberg, L., and C. Kolstad, "Foreign Direct Investment, Exchange Rate Variability, and Demand Uncertainty," *International Economic Review* 36, no.4 (November 1995).

Goldberg, P. and M. Knetter, "Goods Prices and Exchange Rates: What Have We Learned?" NBER Working Paper no. 5862 (1996).

Hall, R., "The Relation Between Price and Marginal Cost in U.S. Industry," *Journal of Political Economy* 96 (October 1988), pp. 921-47.

Hoshi, T., A. Kashyup, and D. Scharfstein, "Corporate Capital Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups," *Quarterly Journal of Economics* 106 (February 1991), pp. 33-60.

Hoshi, T., D. Scharfstein, and K. Singleton, "Japanese Corporate Investment and Bank of Japan Guidance of Commercial Bank Lending," In K. Singleton, ed., *Japanese Monetary Policy*. Cambridge, Mass: University of Chicago Press (1990).

Huizinga, J., "An Empirical Investigation of the Long Run Behavior of Real Exchange Rates," *Carnegie-Rochester Conference Series on Public Policy*, 27 (1987), pp. 149-215.

Ito, T., “Foreign Exchange Expectations: Micro Survey Data,” *American Economic Review* 80 (June 1990), pp. 434-49.

Knetter, M., Price Discrimination by U.S. and German Exporters. *American Economic Review* 79 (March 1989), pp. 198-210.

Knetter, M., “International Comparisons of Pricing-to-Market Behavior,” *American Economic Review* 83 (June 1993), pp. 473-86.

Krugman, P., “Pricing to Market When the Exchange Rate Changes,” In Arndtt Richardsson, ed., *Real-Financial Linkages among Open Economies*. Cambridge, MA: MIT Press (1987).

Mann, C., “Prices, Profit Margins, and Exchange Rates,” *Federal Reserve Bulletin* 72 (June 1986), pp. 366-79.

Mann, C., “Foreign Influences on U.S. Inflation: Further Investigation of Aggregate and Disaggregated Measures,” Memo, Board of Governors of the Federal Reserve System (1994).

Marston, R., “Pricing to Market in Japanese Manufacturing,” *Journal of International Economics* 29 (November 1990), pp. 217-36.

Rotemberg, J. and G. Saloner, “A Supergame-Theoretic Model of Price Wars During Booms,” *American Economic Review* 76 (June 1986), pp. 390-407.

Swagel, P., “Import Prices and the Competing Goods Effect,” Board of Governors of the Federal Reserve System, Discussion Paper no. 508 (April 1995).

Appendix

A. Derivation of the marginal profitability of capital

The first order conditions from the maximization problem in Equation (6) imply:

(a1) $(1+h_t^{-1})p(q_t,e_t) = (1+h_t^{*-1})e_t p^*(q_t^*,e_t)$;

(a2) $(p(q_t,e_t)(1+h_t^{-1}))\frac{df}{dL_t} = w_t$; and

(a3) $(p(q_t,e_t)(1+h_t^{-1}))\frac{df}{dL_t^*} = e_t w_t^*$,

Equation (a1) states that marginal revenue from the domestic market must equal marginal revenue from the foreign market and Equations (a2) and (a3) state respectively that the marginal cost of domestic and foreign variable inputs must equal the value of their marginal productivities. We have substituted into Equation (a3) the condition that the marginal revenues in the home and the foreign country are equal (from a1).

To obtain the marginal profitability of capital, we differentiate Equation (6) with respect to K_t:

(a4) $\frac{d\Pi_t(K_t)}{dK_t} = (1+h_t^{-1})p(q_t,e_t)\frac{df}{dK_t}$.

To solve for df/dK_t in Equation (a4), we substitute for w_t and $e_t w^*_t$ in average profits using Equations (a2) and (a3). Dividing the resulting equation by K_t yields:

(a5) $\frac{\Pi_t}{K_t} = \frac{p(q_t,e_t)q_t + p^*(q_t^*,e_t)q_t^*}{K_t} - (1+h_t^{-1})p(q_t,e_t)\left(\frac{L_t}{K_t}\frac{df}{dL_t} + \frac{L_t^*}{K_t}\frac{df}{dL_t^*}\right)$

For a constant returns to scale production function, Euler's theorem implies that

(a6) $\frac{df}{dK_t}K_t + \frac{df}{dL_t}L_t + \frac{df}{dL_t^*}L_t^* = q_t + q_t^*$.

Substituting Equation (a6) into (a5), we obtain (a7) $$\frac{\Pi_t}{K_t} = \frac{p(q_t, e_t)q_t + p^*(q_t^*, e_t)q_t^*}{K_t} - (1 + h_t^{-1})p(q_t, e_t)\left(\frac{q_t + q_t^*}{K_t} - \frac{df}{dK_t}\right)$$

Solving Equation (a7) for df/dK_t and substituting it into Equation (a4), the marginal profitability of capital is

(a8) $$\frac{d\Pi_t}{dK_t} = \frac{\Pi_t}{K_t} - \frac{p_t q_t + p_t^* q_t^*}{K_t} + (1 + h_t^{-1})\frac{p_t \cdot (q_t + q_t^*)}{K_t},$$

where we indexed by t the functions $p(.)$ and $p^*(.)$ and dropped their arguments for simplicity. Equation (a8) is transformed into Equation (7) in the text using the definitions for $MKUP_t$ and $MKUP_t^*$ and the fact that domestic and foreign marginal revenues are equal.

B. The Data

Japan

The data source is Japan Input-Output Tables Extended Chart by International Trade and Industry Statistics Association. Contains 1974-1990 data on annual input-output as well as exports, imports, wages and salaries, total production, material costs, value added, and total production, all nominal measured in millions of Japanese yen. a_t^i is the ratio of imported inputs purchased from agriculture, mining, raw materials, and manufacturing industries to total inputs purchased from these industries plus industry labor costs. The industry markups are computed as *AMKUP*= (Value of Production)/(cost of materials plus employee compensation). From *Japan Statistical Yearbook* by Statistics Bureau of the Prime Ministers Office are data on investments in equipment by industry. These data are survey data from all incorporated businesses with a capital subscription of 100 million yen or more and with its head or main office in Japan. Other data are from various issues of *International Financial Statistics*, including real effective exchange rates (relative unit labor costs, series reu) and interest rates on long term government bonds (series 61).

Canada

The *Input-Output Structure of the Canadian Economy* by Statistics Canada contains 1974 to 1990 data on exports, imports, employee compensation, total production, materials costs and value added, all reported in millions of Canadian dollars. a_t^i is the ratio of imported inputs purchased from agriculture, mining, raw materials, and manufacturing industries to total inputs purchased from these industries plus industry labor costs. The industry markups are computed as *AMKUP*= (Value of Production)/(cost of materials plus employee compensation). Data on investments are from CANSIM, a computer database organization sponsored by *Statistics Canada*. Data on investment for Tobacco Products is missing due to confidentiality. Other data are from various issues of *International Financial Statistics*, including real effective exchange rates (series reu) and interest rates on long term government bonds (series 61).

United Kingdom

Only one year of input-output data is used in our calculations, i.e., the *1990 Input-Output Balances for the United Kingdom* (1993) by Central Statistical Office of the United Kingdom. Annual data on total investment, investment in equipment and machinery, exports, imports, wages and salaries, employees' social security costs, total production, and value added are from *Industrial Structure Statistics* by the OECD. All data are in millions of British pounds. a_t^i includes in the numerator imported inputs purchased from manufacturing industries, assuming that in every year the ratio of imported inputs from industry *j* into industry's *i* production was the same as in 1990, i.e. $p_t^j q_{j,t}^i = p_{90}^j q_{j,90}^i \forall t$ and $VP_t^i = \sum_j p_{90}^j q_{j,90}^i$. The industry markups are computed as *AMKUP*= (Value of Production)/(value added minus employee compensation), where employee compensation=wages and salaries plus employee's social security. Other data are from various issues of *International Financial Statistics*, including real effective exchange rates (series reu), wholesale price index (series 63), and interest rates on long term government bonds (series 61).

United States

1972-1993 data. Only one year of input-output data is used in our calculations, i.e. 1982 Input-Output. Domestic investment is New Capital Expenditures by manufacturing industry. Source: Census of Manufactures, and Annual Survey of Manufactures from the Census Bureau. Industry sales data, along with export and import data, are from the US Department of Commerce. a_t^i includes in the numerator imported inputs purchased from manufacturing industries, assuming $p_t^j q_{j,t}^i = p_{82}^j q_{j,82}^i \forall t$, and $VP_t^i = \sum_j p_{82}^j q_{j,82}^i + w_t^i$ where w_t^i are wages and salaries in nominal dollars from the *National Income and Product Accounts*, deflated by the U.S. Producer Price index (1982=100) from the International Financial Statistics. The industry markups are computed as *AMKUP*= (Value Added plus Cost of Materials)/(Payroll plus cost of materials), with data from the Annual Survey of Manufactures from the Bureau of the Census. The exchange rate series is from the *International Financial Statistics* (series reu). In each period we use the real exchange rate in the fourth quarter of year t. 1985=100. The ten-year Treasury note comes from the U.S. Department of Commerce.

Table 1: Rank Correlation between Mean Industry Markups across Countries

	United States	Canada	United Kingdom	Japan
Canada	0.754	1.000		
U.K.	0.268	0.321	1.000	
Japan	0.214	0.018	0.514	1.000

Table 2 Variance of Exchange Rates Accounted by Temporary Shocks

Country	$var(e_t^{BN})/var(e_t)$
United States	0.403
United Kingdom	0.122
Japan	0.239
Canada	0.165

Table 3 Endogenous Investment & Markup: Within Country, Pooled across Industries. United States, 1972-1992

$$\Delta I_t^i = b^i + \left(b_0 + b_1 c_{t-1}^i + b_2 a_{t-1}^i\right) AMKUP_{t-1}^{i\ -1} \cdot \Delta\hat{e}_{t-1} + b_3 \Delta r_{t-1} + b_4 \Delta Oil_{t-1} + b_5 \Delta y_{t-1}^i + m_t^i$$

$$\Delta AMKUP_t^i = f^i + f_T^i \cdot trend^i + \left(f_0 + f_1 c_t^i + f_2 a_t^i + f_3 M_t^i\right) \cdot \Delta\hat{e}_t + f_4 \Delta y_t^i + V_t^i$$

INVESTMENT	β_0 : Δe_t	β_1: $\chi\Delta e_{t-1}$	β_2:$\alpha\Delta e_{t-1}$	β_3: Δr_{t-1}	β_4: ΔOil_{t-1}	β_5: Δy_{t-1}	adj.R^2	F-test	Hausman test
All Industries	-.337 .268	6.218** 3.469	-5.634 4.409	-.169* .073	.052* .024	.535* .093	.13	4.21*	3.85*
High Markup Industries	-1.108 .506	9.628** 5.655	-3.379 9.943	-.127 .112	.053 .039	.417* .163	.08	1.19	3.12*
Low Markup Industries	-.345 .347	17.196* 7.637	-14.467* 5.718	-.232* .092	.058** .030	.600* .108	.20	3.86*	3.96*
MARKUP	ϕ_0: $M\Delta e_t$	ϕ_1: $\chi\Delta e_t$	ϕ_2:$\alpha\Delta e_t$	ϕ_3:$M\ \Delta e_t$		ϕ_4: Δy_t	adj.R^2	F-test	
All Industries	.190* .091	-2.588* 1.043	2.232 1.365	.033 .432		.184* .040	.14	2.38	
High Markup Industries	-.095 .067	-.932 .711	3.902* 1.223	-.104 .374		.188* .031	.29	2.52	
Low Markup Industries	.456* .162	-6.178 3.938	2.096 2.787	-.071 .726		.180* .064	.15	2.37	

Each equation is corrected for first-order serial correlation and used instrumented interest rates. *, and ** indicate statistical significance at the 5 and 10 percent levels. Standard errors below parameter estimates. Permanent exchange rates are used in the regressions.

Table 4 Endogenous Investment & Markup: Within Country, Pooled across Industries. Japan, 1974-1990

$$\Delta I_t^i = b^i + \left(b_0 + b_1 c_{t-1}^i + b_2 a_{t-1}^i\right) AMKUP_{t-1}^{i\ -1} \cdot \Delta\hat{e}_{t-1} + b_3 \Delta r_{t-1} + b_4 \Delta Oil_{t-1} + b_5 \Delta y_{t-1}^i + m_t^i$$

$$\Delta AMKUP_t^i = f^i + f_T^i \cdot trend^i + \left(f_0 + f_1 c_t^i + f_2 a_t^i + f_3 M_t^i\right) \cdot \Delta\hat{e}_t + f_4 \Delta y_t^i + V_t^i$$

INVESTMENT	β_0 : Δe_{t-1}	β_1: $\chi\Delta e_{t-1}$	β_2: $\alpha\Delta e_{t-1}$	β_3: Δr_{t-1}	β_4: ΔOil_{t-1}	β_5: Δy_{t-1}	adj.R^2	F-test	Hausman test
All Industries	-.590 .511	5.305* 1.899	1.732 1.807	-.275 .227	.113* .045	.172 .124	.16	3.13*	2.97*
High Markup Industries	-.102 .662	3.961 2.687	-1.893 2.110	-.476 .303	.140* .060	.034 .325	.18	0.41	1.12
Low Markup Industries	-1.690** .852	8.259* 2.993	-.432 5.377	.198 .368	.053 .071	.629* .322	.18	2.98*	3.04*
MARKUP	ϕ_0: $M\Delta e_t$	ϕ_1: $\chi\Delta e_t$	ϕ_2: $\alpha\Delta e_t$	ϕ_3: $M\,\Delta e_t$		ϕ_4: Δy_t	adj.R^2	F-test	
All Industries	-.081* .030	.163 .166	-1.567* .165	.564* .221		-.053* .016	.54	44.46*	
High Markup Industries	-.062 .045	.354 .281	-1.255* .235	-1.080 .669		-.068* .022	.64	36.19*	
Low Markup Industries	-.132* .033	.381* .174	1.698** .749	-.739** .388		-.008 0.19	.27	5.51*	

Each equation is corrected for first-order serial correlation and used instrumented interest rates. *, and ** indicate statistical significance at the 1,5 and 10 percent levels. Standard errors below parameter estimates. Permanent exchange rates are used in the regressions.

Table 5 Endogenous Investment & Markup: Within Country, Pooled across Industries. United Kingdom, 1974-90

$$\Delta I_t^i = b^i + \left(b_0 + b_1 c_{t-1}^i + b_2 a_{t-1}^i\right) AMKUP_{t-1}^{i\ -1} \cdot \Delta\hat{e}_{t-1} + b_3 \Delta r_{t-1} + b_4 \Delta Oil_{t-1} + b_5 \Delta y_{t-1}^i + m_t^i$$
$$\Delta AMKUP_t^i = f^i + f_T^i \cdot trend^i + \left(f_0 + f_1 c_t^i + f_2 a_t^i + f_3 M_t^i\right) \cdot \Delta\hat{e}_t + f_4 \Delta y_t^i + V_t^i$$

INVESTMENT	β_0: Δe_{t-1}	β_1: $\chi\Delta e_{t-1}$	β_2: $\alpha\Delta e_{t-1}$	β_3: Δr_{t-1}	β_4: ΔOil_{t-1}	β_5: Δy_{t-1}	adj.R^2	F-test	Hausman test
All Industries	-1.965 1.449	5.639* 2.812	-7.478 8.096	-1.027* .112	.097* .026	.651* .105	.23	5.56*	4.12*
High Markup Industries	-.222 2.081	5.501** 3.241	-18.419 14.464	-.921* .169	.070** .038	.570* .133	.17	2.19	2.83*
Low Markup Industries	-4.355** 2.185	8.734 9.178	.138 12.071	-1.096* .156	.116* .036	.763* .170	.31	3.81*	3.49*
MARKUP	ϕ_0: $M\Delta e_t$	ϕ_1: $\chi\Delta e_t$	ϕ_2: $\alpha\Delta e_t$	ϕ_3: $M\,\Delta e_t$		ϕ_4: Δy_t	adj.R^2	F-test	
All Industries	.016 .014	-.054* .021	.052 .049	.017 .018		.025 .017	.12	2.84*	
High Markup Industries	.017 .026	-.067** .035	.104 .115	.023 .031		.025 .029	.12	1.71	
Low Markup Industries	.010 .010	-.028 .018	.091** .049	-.036 .026		.026** .014	.09	2.03	

Each equation is corrected for first-order serial correlation and used instrumented interest rates. * and ** indicate statistical significance at the 5 and 10 percent levels. Standard errors reported below parameter estimates. Permanent exchange rates are used in the regressions.

Table 6 Endogenous Investment & Markup: Within Country, Pooled across Industries. Canada, 1974-1991

$$\Delta I_t^i = b^i + \left(b_0 + b_1 c_{t-1}^i + b_2 a_{t-1}^i\right) AMKUP_{t-1}^{i\ -1} \cdot \Delta\hat{e}_{t-1} + b_3 \Delta r_{t-1} + b_4 \Delta Oil_{t-1} + b_5 \Delta y_{t-1}^i + m_t^i$$
$$\Delta AMKUP_t^i = f^i + f_T^i \cdot trend^i + \left(f_0 + f_1 c_t^i + f_2 a_t^i + f_3 M_t^i\right) \cdot \Delta\hat{e}_t + f_4 \Delta y_t^i + V_t^i$$

INVESTMENT	β_0 : Δe_{t-1}	β_1: $\chi\Delta e_{t-1}$	β_2: $\alpha\Delta e_{t-1}$	β_3: Δr_{t-1}	β_4: ΔOil_{t-1}	β_5: Δy_{t-1}	adj.R^2	F-test	Hausman test
All Industries	-2.483 2.918	-10.228 8.304	8.373 12.460	-.707** .193	.013 .054	.749* .174	.09	2.84*	2.97*
High Markup Industries	1.254 4.416	-28.047* 11.588	16.230 15.548	-.929* .303	.014 .084	.643* .241	.10	2.74	2.34
Low Markup Industries	-4.485 3.958	17.510 12.027	-16.533 22.548	-.532** .235	-.002 .067	.882* .254	.11	1.07	2.03
MARKUP	ϕ_0: $M\Delta e_t$	ϕ_1: $\chi\Delta e_t$	ϕ_2: $\alpha\Delta e_t$	ϕ_3: $M\,\Delta e_t$		ϕ_4: Δy_t	adj.R^2	F-test	
All Industries	.088 .069	.122 .208	-.319 .362	-.025 .128		.118 .020	.51	0.67	
High Markup Industries	.233* .063	-.027 .187	-.412 .246	-.162 .185		.093* .016	.33	3.60	
Low Markup Industries	.074 .126	.188 .388	-2.040 1.412	.410 .336		.148* .040	.54	.002	

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Each equation is corrected for first-order serial correlation and used instrumented interest rates. * and ** indicate statistical significance at the 5 and 10 percent levels. Standard errors below parameter estimates. Permanent exchange rates are used in the regressions.