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Exchange rates and investment good prices: A cross-industry comparison

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Abstract

This paper presents estimates of the impact of exchange rate movements on the industry-level price of investment goods using a panel of OECD countries. An exchange rate depreciation (appreciation) causes a significant rise (fall) in the prices of the investment goods used by most industries, but the magnitude of this effect differs greatly across sectors. A currency depreciation causes a stronger increase in the price of investment goods used by industries that produce high-technology products and employ a larger proportion of imported capital. Hence, movements in the exchange rate may affect the level and distribution of investment across sectors.

JEL classification: F3; F4; E22

Keywords: Exchange rate; Investment; Prices; Pass-through

1. Introduction

Empirical evidence suggests that investment has important consequences for growth and productivity. De Long and Summers (1991) show that investment in machinery and equipment is associated with faster growth while Jones (1994) finds a negative relationship between economic growth and the relative price of machinery. A related strand of research shows that countries with a higher share of imported machinery experience higher growth (Mazumdar, 2001).

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This may be because imports of machinery facilitate the international transmission of technical innovations or lead to increased export competitiveness (Coe et al., 1997; Xu and Wang, 1999; Mody and Yilmaz, 2002). It is not uncommon for governments to encourage investment through tax breaks and other incentive programs. Although exchange rate policy is not typically considered to be an investment incentive program, currency valuation changes can affect the profitability of investment by, for example, altering the prices of imported investment goods.

Given the large exchange rate movements experienced by many countries,[1] if exchange rate changes have a significant impact on investment good prices and, thereby, on investment and capital imports, they may ultimately affect productivity and growth. This study estimates the magnitude of the impact of exchange rate movements on the prices of the investment goods used by individual sectors and sub-sectors of manufacturing and non-manufacturing industries.[2] The use of disaggregated data allows sector-level effects to be identified and gives a broader perspective on the impact of the exchange rate on investment good prices than would an analysis that employs aggregate data or data for manufacturing only.[3] As the data set consists of a panel of OECD countries, more observations are available for each sector than would be available in a single-country study. In addition, as noted by Frankel and Rose (1996), the use of a panel makes it possible to take advantage of the cross-country variation in exchange rates.

The results described below indicate that movements in the exchange rate have a significant effect on the price of investment goods at the aggregate level as well as in many individual sectors, but the magnitude of this effect differs widely across sectors. Unsurprisingly, the exchange rate has the smallest impact on the prices of the investment goods used by sectors in which a relatively large proportion of capital is typically in the form of non-traded building structures – industries such as restaurants, hotels, real estate services and social and personal services. The sectors that exhibit the greatest impact of exchange rate changes on investment good prices generally employ a large proportion of capital in the form of machinery and equipment, a form of capital that tends to be tradable. Industries of this type include manufacturing, transport and communications. A key implication of these results is that monetary and fiscal policies that alter the exchange rate may affect both the level of investment and the sectoral distribution of investment, and could act as a (perhaps unintended) industrial strategy.

To our knowledge, the impact of the exchange rate on the prices of investment goods has not been examined previously. A related literature examines the impact of exchange rate movements on import good prices or the aggregate price level, but does not explicitly examine the prices of investment goods.[4] Another strand of the literature investigates the impact of exchange rate movements on investment and productivity growth. Using data for individual countries, Campa and Goldberg (1999) and Nucci and Pozzolo (2001), for example, find that exchange rate changes have a significant effect on the growth rate of investment in manufacturing.[5] The results reported in Campa and Goldberg (1999) imply that a 10% currency depreciation leads to a 1–2% decline in US investment. Given the relatively small size of their sample,

[1] For example, relative to the US dollar, the average annual percentage change (in absolute value) of OECD country currencies was 10.5% from 1981 to 2001. See the OECD *Bilateral Trade Database*.

[2] Data limitations preclude a sector-level analysis of the prices of *imported* investment goods only.

[3] Although manufacturing is generally a large contributor to GDP, it still accounts for less than a third of non-government GDP in each of the countries included in the data set employed here. See the OECD's *National Accounts*.

[4] See Mann (1986), Feenstra (1989), Knetter (1989), Marston (1990), Feenstra et al. (1996), Swift (2001), Takagi and Yoshida (2001), Campa and Goldberg (2002), Gagnon and Ihrig (2001), and Uctum (2003).

[5] Also, see Goldberg (1993), Campa and Goldberg (1995) and Bell and Campa (1997).

however, they cannot determine whether the impact of exchange rate changes on investment differs across sub-sectors of manufacturing (other than that it differs between sectors with "high" and "low" markups).[6] Using firm-level data on commodity producing firms, Forbes (2002) shows that firms with higher capital/labour ratios exhibit slower growth in capital investment following a currency *depreciation*, while Fung (2003) finds that a large currency *appreciation* leads to higher productivity in Taiwanese manufacturing firms. Studies by Strauss (1999) and Harris (2001) indicate that exchange rate movements have a significant impact on productivity in OECD countries, but their analyses do not make it possible to disentangle the conflicting channels through which the exchange rate may affect productivity.

This study investigates just one of the many channels through which currency movements may affect investment and the economy. There are, of course, other channels and these have been examined in the theoretical macroeconomics literature by Lizondo and Montiel (1989), Gylfason and Schmid (1983), Rebelo and Végh (1996), Kouri (1979) and Risager (1987). For example, by increasing the demand for domestic goods, a currency depreciation can raise the revenues and profits of domestic exporting firms and, thereby, induce an increase in economic activity and investment.[7] On the other hand, a depreciation may have a contractionary impact on output if it causes a rise in the price of investment goods and this, in turn, causes a decline in investment, the size of the capital stock and firm productivity (Porter, 1990; Martin and Porter, 2001).[8] While this paper focuses on only one channel through which the exchange rate may affect the economy – the impact on the price of investment goods – a better understanding of this particular channel is an important component to a more complete understanding of the effects of currency valuation changes.

The findings presented in this study are also relevant to the issue of the effectiveness of flexible exchange rates in macroeconomic adjustment. Numerous studies have found a weak or insignificant pass-through effect from the exchange rate to the aggregate price level.[9] Obstfeld (2002, p. 1) argues that the low response of prices to exchange rate changes observed in many empirical studies would "appear to call for a radical rethinking of conventional views on the role of exchange rates in international adjustment". The results described below show that, consistent with these studies, a 1% currency depreciation leads to a relatively small 0.12% rise in the price of investment goods at the economy-wide level. However, there is substantial industry-level

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[6] In their studies of the impact of the exchange rate on investment, Campa and Goldberg (1995, 1999) and Nucci and Pozzolo (2001) utilize a cross-industry panel for individual countries rather than a cross-country panel as used here. Their approach employs less data on exchange rate changes than does a cross-country panel (since it utilizes data for a single country only) and restricts the parameter estimates to be constant across sectors.

[7] There are also channels whereby a currency depreciation can have a negative effect on aggregate demand. For example, a depreciation may generate income redistribution from groups with a low marginal propensity to save to groups with a high marginal propensity to save (Diaz-Alejandro, 1965; Krugman and Taylor, 1978), or may lead to inflation that reduces the real value of nominal assets (a real balance effect). Empirical studies have found both a positive and a negative impact of exchange rate changes on *aggregate* investment and/or output in LDCs (see Edwards, 1986, 1989; Morley, 1992; Upadhyaya, 1999; Kamin and Rogers, 2000).

[8] In the Canadian context, Martin and Porter (2001, p. 9) state "While some laud the lower Canadian dollar as enhancing competitiveness by decreasing the relative prices of our exports, the true effect is exactly the opposite. A low Canadian dollar dulls the incentive for upgrading and competing on any basis other than lower price. In addition, in the Canadian context, the low dollar makes investment in upgrading more expensive. Approximately 70% of Canada's installed machinery and equipment is imported. Consequently, the low dollar during the 1990s made machinery and equipment imports dramatically more expensive, which is likely to have contributed to a fall in the growth rate of capital stock per worker, thus making labour productivity growth still more difficult to achieve".

[9] See the literature reviews in Rogoff (1996) and Goldberg and Knetter (1997).

variation, as in some industries there is no statistically significant effect at all, while in others the impact is approximately three times the magnitude of the aggregate effect.[10] This suggests that the exchange rate may, in fact, be a vehicle for relative price adjustment and resource allocation.

The plan of the paper is as follows. The next section outlines the empirical framework, while Section 3 describes the data and provides a discussion of several estimation issues. Section 4 presents aggregate and sector-level estimates of the impact of exchange rate movements on investment good prices, while Section 5 provides a brief conclusion.

2. The empirical specification

The price of the investment goods used by a firm in industry i in country m varies with the domestic currency price of imported investment goods, the price of tradable domestically produced investment goods, and the price of non-tradable domestic investment goods. This is consistent with the observation that investment involves expenditures on both non-traded capital, such as building structures, and tradable capital, such as machinery.[11] Following Feenstra (1989), Marston (1990), Knetter (1989) and Goldberg and Knetter (1997), the price of each tradable investment good is taken to be a function of the marginal cost of production denominated in the currency of the importing country. As a result, the estimating equation that describes a change in the price of the investment goods used in industry i, $\Delta \mathrm{PI}_{imt}$, for a panel of M countries (m) over T time periods (t) can be written:

$$\Delta \mathrm{PI}_{imt} = \alpha_{i0} + \alpha_{i1}\left(\Delta e_{mt} + \Delta c_t^{\mathrm{f}}\right) + \alpha_{i2}\Delta \mathrm{PI}_{mt}^{\mathrm{N}} + \alpha_{i3}\Delta c_{mt} + \sum_{t=1}^{T-1}\beta_{it}D_t + \sum_{m=1}^{M-1}\gamma_{im}D_m + v_{imt}, \quad (1)$$

where Δx_t denotes the percentage change in variable x from time period $t-1$ to t.[12] In Eq. (1), $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$ captures the change in the domestic currency marginal cost of imported investment goods, where Δe_{mt} denotes the percentage change in the exchange rate, defined as the country m (the importer) currency price of one unit of the foreign (exporter's) currency, and Δc_t^{f} denotes the percentage change in the exporter's marginal cost of investment good production (denominated in the exporter's currency). The variable Δc_{mt} represents the percentage change in the marginal cost of tradable investment good production in country m, and $\Delta \mathrm{PI}_{mt}^{\mathrm{N}}$ is the percentage change in the price of non-tradable investment goods in county m.[13] While the values of the marginal cost and price explanatory variables are the same across industries,

[10] Obstfeld (2002) also finds considerable heterogeneity among industrial categories in the response of import prices to exchange rate changes.

[11] As a rough indication of the relative importance of tradable and non-tradable investment goods, note that *Producer's Durable Goods*, a large proportion of which is likely to be tradable, comprised approximately half (48.3%) of all gross fixed capital formation in the US in 1995. Of this, 77% was *Machinery and Equipment*, while the remainder was *Transport Equipment*. These values are similar to those for other OECD countries (see OECD *National Accounts, Volume II Detailed Tables*, Table 4 for each country).

[12] This specification follows other studies where variables are expressed in rate of change or log change form. See, for example, Marston (1990) or Campa and Goldberg (2002).

[13] Feenstra (1989) and Marston (1990) propose models in which exporting firm markups affect imported goods prices, and these markups may vary with demand factors such as domestic income and the general price level. When the change in income (measured as real GDP) and the price level (measured as the GDP deflator) were included in the estimating equation, these variables were generally insignificant and their inclusion had only a small effect on the magnitude of the exchange rate parameter estimates.

since industries employ different proportions of imported investment goods (due to industry-specific technology, for example), the impact of these cost and price variables on the price of investment goods may differ across industries (and, thus, the parameters are indexed by i).

The dummy variables D_t and D_m denote year- and country-specific fixed effects, respectively, while v_{imt} is a mean zero random error. The country fixed effects account for factors (such as institutional differences) that are constant over time, but that differ across countries. The time period fixed effects represent events that are common to all countries in a particular year (such as a change in the world price of oil or a shock to world demand).

3. The data

Investment price indices, PI_{imt}, are constructed for each industry, as well as for an industry aggregate, using current and constant dollar data on gross fixed capital formation from the OECD's *National Accounts, Volume II, Detailed Tables*. Data availability restricted the sample to 12 OECD countries − Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Italy, The Netherlands, Norway, Sweden, and the United Kingdom. The investment data are disaggregated into nine major sectors, and the data for several of these nine sectors, such as *Manufacturing*, are further disaggregated into sub-sectors. In total, investment price indices can be constructed for 22 sectors − nine major sectors and 13 sub-sectors, as well as for the aggregate *Total industries*, the total of all industries except for producers of government and non-profit private services.[14]

The data are annual and span the period from 1971 through 1997.[15] However, data for all 22 sectors are not available for this entire period, nor are data available for all sectors for all countries or, when available, for the same time period for all countries. As a result, the sample employed for each sector is unbalanced, and the particular years and countries included differ across sectors. Use of an unbalanced sample made considerably more observations available than would have been the case if a balanced sample had been employed. The average number of observations available for each of the 22 sectors and sub-sectors is 199.6, although for each of the nine major sectors there are, on average, 229.1 observations. The average number of observations per country is 20.1 for the nine major sectors and 19.6 for all 22 sectors and sub-sectors. Appendix A provides information on the number of observations and countries used to estimate the investment price equation for each sector, the exact sample periods employed for each industry and country, as well as descriptive statistics. Appendix B provides definitions and detailed sources for all the data employed.

In order to estimate the investment price equation, Eq. (1), empirical counterparts to the explanatory variables in this equation must be specified. For all the countries in the sample, either the US or Germany was the largest supplier of machinery and equipment imports.[16] These two countries were the first and second largest source of machinery and equipment for five countries, and either the first and second or the first and third largest source for 10 of the 12 countries. No other country played a comparable role as a source of machinery and equipment

[14] In order to ensure the availability of a large number of observations, it was decided a priori to use data only for those sectors for which data were available for at least eight countries. On average, data on 10.2 countries were available for each of the 22 sectors, with data available for 11.4 countries, on average, for the nine major sectors.

[15] The sample ends in 1997 because of a change in the OECD's data collection methodology in that year.

[16] See the US dollar value of *Machinery and equipment* imports, by country, from the OECD's *Bilateral Trade Database* for 1993 (the approximate midpoint of the sample period).

imports for the 12 countries in the sample. For these reasons, the exchange rate–marginal cost variable $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$ is proxied by a trade weighted average of US and German data.[17]

Since the largest component of firm costs is typically wage costs, the percentage change in the marginal cost of foreign investment good production, Δc_t^{f}, is represented by the percentage change in the manufacturing wage in the foreign country (a weighted average of the US and Germany).[18] Similarly, the percentage change in the marginal cost of domestically produced investment goods, Δc_{mt}, is represented by the rate of change in the domestic manufacturing wage. The percentage change in the price of non-traded investment goods, $\Delta \mathrm{PI}_{mt}^{\mathrm{N}}$, is proxied by the percentage change in the price index of domestic non-residential construction.

4. Empirical results

Table 1 reports aggregate and industry-level estimates of the investment price equation, Eq. (1). The coefficient estimates associated with the change in the exchange rate are significantly different from zero in 17 of 22 sectors as well as in the aggregate of all industries (*Total industries*) and are positive, as expected (when significantly different from zero). These results imply that a currency depreciation (appreciation) leads to a statistically significant increase (decrease) in the prices of the investment goods used by most sectors even after controlling for domestic cost effects and country and time period fixed effects. The coefficient estimates for the other explanatory variables are consistent with expectations – the estimated coefficients associated with the price of non-traded investment goods and the domestic marginal cost variable are positive in all cases. As will be discussed more fully in the next sub-section, the estimates appear to be robust, are not rejected by several specification tests, and explain a large proportion of the variation in the price of investment goods.

The exchange rate coefficient estimates reported in Table 1 are quite diverse in terms of magnitude. For example, the estimated exchange rate coefficients for the *Transport, storage and communications* industry (0.3151) and *Manufacturing* (0.2922) are two and a half times as great as the *Total industries* coefficient (0.1225). The first column of Table 2 presents the predicted impact on the price of investment goods of a 10% depreciation (using the estimates of Table 1), with the industries ordered according to the magnitude of the exchange rate effect, from largest to smallest. Of the nine major industries, movements in the exchange rate have the largest effect on the price of investment goods in the *Transport, storage and communication* sector. A 10% depreciation of the domestic currency leads to a predicted rise in the price of investment goods purchased by this sector of 3.15%. Statistically significant coefficient estimates in the range of 3% are relatively large, given that many studies find little or no impact of exchange rate changes on aggregate prices, while studies that examine only *import* good prices find that a 10% currency depreciation typically leads to a 3–8% price rise.[19] Since the values in Table 2 give the impact of an exchange rate change on the price of *all* the investment

[17] Since data for the US and Germany are used to construct the variable $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$, these two countries cannot be included in the panel of countries for which the investment price equation is estimated.

[18] To investigate the robustness of the results, the percentage change in the foreign currency price of the investment goods used in sector *i* of the foreign country was also used as a proxy for the change in foreign marginal cost, Δc_t^{f}. The use of this alternative proxy had almost no impact on the results. This is, perhaps, not surprising given that much of the variation in the variable $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$ is due to changes in the exchange rate.

[19] See Mann (1986), Marston (1990), Feenstra (1989), and Campa and Goldberg (2002), as well as the literature reviewed in Goldberg and Knetter (1997).

Table 1
Estimates of the industry-level investment price equation

		Explanatory variables			$\bar{R}^2$	AR1 test[a]	Reset test[b]	Test of parameter constancy[c]
		$\Delta e + \Delta c^{f}$	ΔPI^{N}	Δc				
	Total industries	0.1225* (3.69)	0.5037* (11.65)	0.1619* (3.28)	0.928	0.12	0.48	40.04 (11)[e]
1	*Agriculture, hunting forestry and fishing*	0.2178* (3.82)	0.4026* (4.40)	0.1483 (1.62)	0.771	0.95	0.95	13.98 (11)
2	*Mining and quarrying*	0.2619* (3.03)	0.4268* (3.11)	0.1538 (1.20)	0.676	0.01	1.63	2.91 (9)
3	*Manufacturing*	0.2922* (6.30)	0.3097* (5.71)	0.1385 (1.95)	0.848	0.35	2.53[d]	11.75 (11)
3.1	Food, beverages and tobacco	0.2207* (4.31)	0.3262* (4.58)	0.2567* (2.93)	0.819	0.36	2.57[d]	12.98 (9)
3.2	Textile, wearing apparel and leather industries	0.3431* (3.93)	0.2040* (2.12)	0.3497* (2.89)	0.706	0.07	2.20[d]	5.72 (9)
3.3	Wood, and wood products, including furniture	0.2657* (4.01)	0.2813* (3.09)	0.2128 (1.43)	0.712	1.81	0.05	2.32 (7)
3.4	Paper and paper products, printing and publishing	0.1474 (1.07)	0.2748 (1.58)	0.0310 (0.07)	0.164	2.52[d]	2.46[d]	8.32 (8)
3.5	Chemicals and chemical petroleum coal, rubber and plastic products	0.2551* (3.51)	0.3100* (3.44)	0.1021 (0.62)	0.683	0.79	1.19	9.21 (8)
3.6	Non-metallic mineral products except products of petroleum and coal	0.2472* (3.10)	0.0775 (0.34)	0.4442 (1.95)	0.536	0.64	2.54[d]	7.69 (8)
3.7	Basic metal industries	0.3346* (4.96)	0.3131* (3.13)	0.1749 (1.31)	0.750	0.18	2.25[d]	13.05 (9)
3.8	Fabricated metal products, machinery and equipment	0.2714* (5.88)	0.2757* (4.33)	0.2061* (2.53)	0.844	0.06	2.47[d]	7.89 (9)
4	*Electricity, gas and water*	0.2020* (3.57)	0.4857* (3.69)	0.1158 (0.93)	0.824	1.59	0.99	16.32 (11)
5	*Construction*	0.1859* (3.38)	0.2884* (3.42)	0.2212* (2.03)	0.716	0.41	2.79[e]	9.92 (10)
6	*Wholesale and retail trade, restaurants and hotels*	0.2005* (4.58)	0.5159* (6.95)	0.1595 (1.94)	0.698	0.06	1.89	20.56 (10)[d]
6.1	Wholesale and retail trade	0.2349* (4.59)	0.4795* (5.23)	0.1579 (1.61)	0.670	0.02	1.86	14.86 (9)
6.2	Restaurants and hotels	0.1231 (1.57)	0.5765* (5.65)	0.1131 (1.03)	0.549	0.69	1.46	9.34 (7)
7	*Transport, storage and communication*	0.3151* (2.37)	0.3850* (4.20)	0.2089 (0.59)	0.337	0.46	1.51	13.00 (11)
7.1	Transport and storage	0.3542* (3.03)	0.1948 (1.55)	0.3827* (2.80)	0.654	0.39	0.51	4.99 (9)
7.2	Communication	0.2935* (4.90)	0.3901* (3.42)	0.2402* (2.20)	0.744	0.52	1.80	8.81 (9)

(*continued on next page*)

Table 1 (*continued*)

		Explanatory variables			$\bar{R}^2$	AR1 test[a]	Reset test[b]	Test of parameter constancy[c]
		$\Delta e + \Delta c^f$	ΔPI^N	Δc				
8	*Finance, insurance, real estate and business services*	0.0242 (0.49)	0.6726* (8.35)	0.1277 (1.79)	0.842	0.18	0.06	36.75 (11)[e]
8.1	Real estate and business services	−0.0345 (0.53)	0.6630* (7.16)	0.1204 (1.38)	0.781	2.16[d]	0.05	22.19 (8)[e]
9	*Community, social and personal services*	0.1253 (1.89)	0.5697* (4.57)	0.0997 (1.01)	0.531	1.33	0.15	10.33 (10)

Dependent variable: percentage change in industry i investment price index (ΔPI_i). The 23 estimated equations also included a constant, country dummy variables and year dummy variables.

The number in brackets under each coefficient estimate is the absolute value of the t-statistic. All t-statistics, test statistics and standard errors were calculated using a variance–covariance matrix that has been corrected for heteroscedasticity of unknown form using method HC_3 of Davidson and MacKinnon (1993, 554). This divides the vector of squared residuals in the usual White heteroscedasticity correction by $(1\text{-}h)^2$ where h is a vector of the diagonal elements of $X(X'X)^{-1}X'$ and X is the matrix of data on the explanatory variables. MacKinnon and White (1985) provide Monte Carlo evidence comparing different types of heteroscedasticity corrections.

*The estimated coefficient is significant using a 95% confidence level.

[a] *AR1 Test* – A t-test of the significance of the estimated lagged residual in a regression of the residuals on the lagged residuals and the explanatory variables. See Davidson and MacKinnon (1993, 358). The null hypothesis is no serial correlation.

[b] *Reset Test* – A t-test of the significance of the squared predicted value when it is included as an explanatory variable in the estimating equation. The null hypothesis is no model misspecification.

[c] *Test for exchange rate parameter constancy* – A Wald test that the coefficient on the exchange rate variable $(\Delta e + \Delta c^f)$ is not significantly different across the countries in the sample. Distributed as a χ^2 statistic with degrees of freedom given in brackets. The null hypothesis is parameter constancy.

[d] Cannot reject the null hypothesis at 99%, but reject at 95%.

[e] Reject the null hypothesis at 99%.

goods used by an industry, the impact on the price of *imported* investment goods is likely to be larger.

One explanation for the greater sensitivity of investment good prices to exchange rate changes in some industries rather than others is that these industries are relatively large users of tradable capital. As a general indication of which industries are larger users of tradable capital, column two of Table 2 presents data on investment good imports as a share of investment by sector for The Netherlands, a country that appears to be representative of the other countries in the sample in terms of investment good imports. The two major sectors with the largest estimated exchange rate pass-through, *Transport, storage and communication* and *Manufacturing*, have the largest and third largest proportions of imported investment goods, 51.0 and 47.7%, respectively.[20] Across all sectors, the simple correlation coefficient between the estimated exchange rate pass-through coefficients and the share of capital that is imported is 0.87. Hence, the relatively large estimated coefficients associated with the exchange rate in these sectors

[20] There exists only spotty data on imports of investment goods by industry across countries and over time. The *OECD Input–Output Database*, the source for column two of Table 2, includes only a small number of years of data for a subset of the countries in our sample (France, Italy, the Netherlands, and the UK). The industries *Transport, storage and communication* and *Manufacturing* are ranked within the top four users of imported capital (of the nine major sectors) in all these countries (using the most recent year of data available). Thus, the Netherlands data appear to be representative.

Table 2
Impact of a 10% depreciation on the price of investment goods used by each sector

	Model of Table 1	Percent of investment goods imported[a]	Currency valuation effects − Table 3
Transport and storage	3.54* (1)	52.3	3.74* (2)
Textile, wearing apparel and leather industries	3.43* (2)	48.0	3.79* (1)
Basic metal industries	3.35* (3)	49.5	3.24* (3)
Transport, storage and communication	*3.15** (4)	*51.0*	*2.81** (8)
Communication	2.94* (5)	46.6	3.14* (4)
Manufacturing	*2.92** (6)	*47.7*	*3.08** (5)
Fabricated metal products, machinery and equipment	2.71* (7)	47.4	2.84* (7)
Wood, and wood products, including furniture	2.66* (8)	41.6	2.86* (6)
Mining and quarrying	*2.62** (9)	*44.9*	*2.57** (12)
Chemicals and chemical petroleum, coal, rubber and plastic products	2.55* (10)	48.5	2.71* (9)
Non-metallic mineral products except products of petroleum and coal	2.47* (11)	47.3	2.69* (10)
Wholesale and retail trade	2.35* (12)	42.8	2.57* (11)
Food, beverages and tobacco	2.21* (13)	45.9	2.56* (13)
Agriculture, hunting, forestry and fishing	*2.18** (14)	*34.6*	*2.16** (16)
Electricity, gas and water	*2.02** (15)	*39.3*	*2.13** (17)
Wholesale and retail trade, restaurants and hotels	*2.01** (16)	*41.4*	*2.23** (14)
Construction	*1.86** (17)	*50.3*	*2.19** (15)
Paper and paper products, printing and publishing	1.47 (18)	48.6	1.69 (18)
Community, social and personal services	*1.25* (19)	*29.0*	*1.54** (20)
Total Industries	*1.23** (20)	*28.9*	*1.45** (21)
Restaurants and hotels	1.23 (21)	28.3	1.57* (19)
Finance, insurance, real estate and business services	*0.24* (22)	*2.3*	*0.64* (22)
Real estate and business services	−0.35 (23)	1.5	0.21 (23)

Major industries and *Total industries* are indicated in italics. Sectors are ordered from largest to smallest effect using the Table 1 column one results. The rankings, by size of impact for each column, are given in brackets.
* The underlying coefficient is significant at the 95% confidence level.
[a] Imports of investment goods as a share of total investment for the Netherlands Source: *OECD Input–Output Database*, 1986.

could, at least partly, be the result of these sectors being relatively large users of imported capital.

Within *manufacturing*, the exchange rate generally has a somewhat larger impact on the prices of the investment goods in sectors that are identified by the OECD as producers of "high-technology" or "medium-high-technology" products.[21] This may be because these sectors use more machinery and equipment, particularly specialized machinery, and this type of machinery is more likely to be tradable. In two of these industries, *fabricated metal products, machinery and equipment* and *chemicals and chemical petroleum, coal, rubber and plastic products*, a 1% currency depreciation is predicted to cause an increase in the investment good price of 0.2714 and 0.2551%, respectively. In contrast, in the "low-technology" *paper and paper products,*

[21] According to the OECD's classification, all products classified as "High-technology" and "Medium-high-technology" are produced in the sectors *Fabricated metal products, machinery and equipment* or *Chemicals and chemical petroleum, coal, rubber and plastic products*. See Table 1 of Hatzichronoglou (1997).

printing and publishing manufacturing industry, the estimated exchange rate coefficient is small and insignificantly different from zero.

In the industries that primarily produce services, exchange rate changes have a relatively small effect on the price of investment goods. For two of these industries, *Finance, insurance, real estate and business services* and *Community, social and personal services*, the impact of exchange rate changes on the price of investment goods is insignificantly different from zero. As well, exchange rate changes have an insignificant impact on the price of investment goods used by the sub-sector *Restaurants and hotels.* The small impact of the exchange rate on the price of investment goods used by service industries is not unexpected since a large share of investment in these sectors takes the form of non-tradable structures. Column two of Table 2 shows that *Finance, insurance, real estate and business services* and *Community, social and personal services* have the lowest share of capital imports of the nine major sectors (2.3 and 29.0%, respectively).[22] The relatively large weights of these two sectors in total investment (34.1 and 9.8%, respectively) may explain why the estimated exchange rate parameter for *Total industries* is fairly small (0.1225).

The magnitudes of the estimates presented above suggest that currency valuation changes may have an important impact on investment and output. Table 2 shows that a 10% currency depreciation leads to a 2.5–3.5% rise in the prices of the investment goods used by many sectors. To put this result in perspective, Jones (1994) finds that a decrease in the relative price of machinery caused by a 10% tax credit raises the annual growth rate of output in the US by 0.1–0.2 percentage points. Since our findings suggest the industries most strongly affected by a currency movement tend to produce relatively more high-technology products and their goods are used as inputs by other sectors, the impact on output could be larger.

4.1. Tests of specification and robustness

As shown in Table 1, the model explains a large proportion of the variation in the changes in the industry-level investment price indices and the model is not rejected in most cases by a Reset test or a test for serial correlation. For most sectors, it is also not possible to reject the restriction that the parameter associated with the exchange rate variable $(\Delta e_{mt} + \Delta c_t^{\rm f})$ is the same across countries.[23] Further, a test of the restriction that Δe_{mt} and $\Delta c_t^{\rm f}$ have the same impact on investment good prices, implied by the use of the sum $(\Delta e_{mt} + \Delta c_t^{\rm f})$, is not rejected at 95% for any sector. Finally, since $(\Delta e_{mt} + \Delta c_t^{\rm f})$ is a weighted average of data for Germany and the US, a test was conducted of the hypothesis that the data for these two countries have the same impact on the price of investment goods. This hypothesis could not be rejected at the 95% confidence level in all but one sector, and in all sectors at 99%.

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[22] As would be expected, the industries that are shown in column two of Table 2 to employ less imported capital tend to exhibit a relatively large and significant response of investment good prices to changes in the price of *non-traded* investment goods, PI^N, as well as a small response to exchange rate changes. For example, of the nine major sectors, *Community, social and personal services* and *Finance, insurance, real estate and business services* have the largest coefficients in Table 1 associated with changes in the price of non-traded investment goods.

[23] As a further test of the robustness and stability of the coefficient estimates, Eq. (1) was re-estimated for each sector with each country sequentially removed from the sample. This process yielded 237 estimates of the coefficient associated with the exchange rate variable, $(\Delta e_{mt} + \Delta c_t^{\rm f})$. The estimates of this coefficient were less than one standard error from the corresponding coefficients reported in Table 1 in 230 of 237 cases, and in the remaining seven cases the estimates differed by less than two standard errors.

Tests of the dynamic properties of the model show that there is no role for lagged variables.[24] Given the data are annual, this result is consistent with the results of previous studies that examine how exchange rate changes affect import prices. For example, Marston (1990) finds adjustment generally takes 1–3 months, while Campa and Goldberg (2002) and Goldfajn and Werlang (2000) find that complete adjustment takes place in four quarters.

To assess the robustness of the results, several alternative specifications of the estimating equation were considered. Using a procedure similar to Goldfajn and Werlang (2000) and Goldfajn and Gupta (2003), we test whether the impact of exchange rate changes on prices is larger the more undervalued is a currency. We generalize the model to allow the effect of the exchange rate on investment good prices to differ between periods of exchange rate undervaluation and overvaluation through the interaction of the exchange rate variable $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$ with a misalignment variable, V, defined as the ratio of the exchange rate to the purchasing power parity exchange rate.

Table 3 reports estimates that incorporate the exchange rate variable interacted with the misalignment variable, $V(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$, but exclude the non-interactive exchange rate variable $(\Delta e_{mt} + \Delta c_t^{\mathrm{f}})$ since the latter is almost always insignificant once the interaction term is included. With this specification, the interaction variable is significant in 19 sectors as well as in *total industries*. The positive coefficient on this variable implies that a rise in the exchange rate (a domestic currency depreciation) is passed on into the domestic price of investment goods to a greater extent the more undervalued is a currency (consistent with the findings of Goldfajn and Werlang, 2000 and Goldfajn and Gupta, 2003).

The estimates of the coefficients associated with the exchange rate misalignment interaction variable given in Table 3 are not directly comparable to the estimated exchange rate coefficients of Table 1 because, in the model of Table 3, the exchange rate effect depends on V which varies across observations. To facilitate a comparison, the third column of Table 2 reports simulations of the impact on the price of investment goods of a 10% depreciation using the coefficient estimates from Table 3. As is clear from comparing the pass-through estimates presented in columns one and three of Table 2, while the exchange rate misalignment interaction variable is statistically significant, the specification of Table 3 causes only a modest alteration in the impact of a change in the exchange rate on the prices of investment goods. As well, the simple correlation coefficients between the simulated effects for the two models, and the rankings of these effects, are both above 0.97. Hence, when interpreting the pass-through coefficients, the amount of misalignment does not matter.[25]

A number of studies have suggested that the extent to which changes in the exchange rate are passed on to domestic prices may vary with country or time varying factors.[26] With respect to country factors, some have argued that changes in exchange rates may have a larger impact on prices in countries that are more import dependent, or in smaller countries that may be more reliant on capital imports. Neither of these factors are found to be important. With respect to

[24] When the investment price equation is re-estimated with a lagged dependent variable, in 20 of 23 cases the lagged dependent variable is insignificant using a 95% confidence level (while it is insignificant in all but one sector at 99%). If the lagged values of all the explanatory variables are added to the estimating equation, these lagged variables are not jointly significant in any industry at the 99% confidence level (and are significant at 95% in only two cases).

[25] Further, when the exchange rate variable was split between periods of appreciation and depreciation, the estimated coefficients for the two periods were insignificantly different.

[26] The estimates of the remaining more general specifications of the model are not reported to conserve space, but are available from the authors.

Table 3
Estimates of the industry-level investment price equation with a currency valuation effect

		Explanatory Variables			$\bar{R}^2$	AR1 test[a]	Reset test[b]	Test of parameter constancy[c]
		$V(\Delta e + \Delta c^f)$	ΔPI^N	Δc				
	Total Industries	0.1132* (4.97)	0.4903* (12.04)	0.1581* (3.38)	0.932	0.29	0.33	43.01 (11)[e]
1	*Agriculture, hunting, forestry and fishing*	0.1689* (3.37)	0.3840* (4.29)	0.1438 (1.57)	0.772	1.02	0.74	10.57 (11)
2	*Mining and quarrying*	0.2115* (3.14)	0.4027* (3.02)	0.1698 (1.35)	0.673	0.05	1.71	3.33 (9)
3	*Manufacturing*	0.2404* (7.68)	0.2823* (5.50)	0.1328 (1.86)	0.858	0.51	1.95	9.30 (11)
3.1	Food, beverages and tobacco	0.2078* (5.48)	0.3155* (4.51)	0.2238* (2.50)	0.834	0.08	2.06[d]	11.41 (9)
3.2	Textile, wearing apparel and leather industries	0.3067* (4.51)	0.1861 (1.94)	0.3044* (2.43)	0.728	0.15	1.10	6.13 (9)
3.3	Wood, and wood products, including furniture	0.2547* (3.84)	0.2860* (3.14)	0.2041 (1.36)	0.711	1.99[d]	0.03	4.72 (7)
3.4	Paper and paper products, printing and publishing	0.1434 (1.36)	0.2675 (1.55)	0.0420 (0.10)	0.167	2.53[d]	2.38[d]	6.58 (8)
3.5	Chemicals and chemical petroleum coal, rubber and plastic products	0.2375* (3.38)	0.3091* (3.45)	0.0994 (0.59)	0.681	0.82	1.17	9.12 (8)
3.6	Non-metallic mineral products except products of petroleum and coal	0.2130* (3.89)	0.0625 (0.27)	0.3983 (1.74)	0.543	0.76	1.93	6.32 (8)
3.7	Basic metal industries	0.2637* (4.58)	0.2893* (2.81)	0.1422 (1.00)	0.750	0.38	1.56	19.37 (9)[d]
3.8	Fabricated metal products, machinery and equipment	0.2308* (6.11)	0.2602* (4.00)	0.1730* (2.04)	0.852	0.11	1.45	8.02 (9)
4	*Electricity, gas and water*	0.1688* (3.11)	0.4645* (3.39)	0.1084 (0.85)	0.828	1.52	0.87	16.43 (11)
5	*Construction*	0.1776* (4.17)	0.2800* (3.25)	0.1965 (1.70)	0.724	0.17	1.96[d]	7.27 (10)
6	*Wholesale and retail trade, restaurants and hotels*	0.1811* (5.60)	0.5082* (6.78)	0.1357 (1.58)	0.704	0.05	1.56	18.32 (10)[d]
6.1	Wholesale and retail trade	0.2083* (5.66)	0.4682* (5.07)	0.1255 (1.20)	0.678	0.03	1.44	12.16 (9)
6.2	Restaurants and hotels	0.1252* (2.34)	0.5768* (5.75)	0.0857 (0.77)	0.553	0.68	1.38	7.84 (7)
7	*Transport, storage and communication*	0.2194* (2.83)	0.3625* (3.87)	0.2028 (0.58)	0.333	0.45	1.38	17.14 (11)
7.1	Transport and storage	0.2836* (2.98)	0.1602 (1.26)	0.3580* (2.69)	0.663	0.41	0.93	4.82 (9)
7.2	Communication	0.2381* (5.38)	0.3607* (3.08)	0.2199* (2.04)	0.752	0.36	1.41	7.74 (9)
8	*Finance, insurance, real estate and business services*	0.0499 (1.50)	0.6656* (8.27)	0.1259 (1.81)	0.844	0.16	0.04	32.65 (11)[e]

Table 3 (*continued*)

		Explanatory Variables			$\bar{R}^2$	AR1 test[a]	Reset test[b]	Test of parameter constancy[c]
		$V(\Delta e + \Delta c^f)$	ΔPI^N	Δc				
8.1	Real estate and business services	0.0166 (0.33)	0.6591* (7.16)	0.1296 (1.51)	0.781	2.13[d]	0.09	20.13 (8)[e]
9	*Community, social and personal services*	0.1238* (2.26)	0.5542* (4.50)	0.1130 (1.16)	0.535	1.38	0.30	8.88 (10)

See notes to Table 1.

dating issues, Taylor (2000) suggests that the speed at which exchange rate changes are passed through into prices may have declined as the level of inflation fell in the mid-1980s. Gagnon and Ihrig (2001) and Campa and Goldberg (2002) empirically find some evidence of a decline in pass-through in the 1990s for consumer prices and import prices; however, we do not find similar support for investment good prices.

Campa and Goldberg (2002) find that the volatility of the exchange rate affects the rate at which firms pass exchange rate changes through into prices. However, volatility (measured, following Campa and Goldberg, 1995 as the quarterly standard deviation of the percentage change in the exchange rate for the previous three years) does not appear to be important here.

5. Concluding comments

The estimates reported above indicate that, for the *Total industries* aggregate and in 17 of the 22 sectors and sub-sectors examined, a currency depreciation leads to a significant rise in the price of investment goods even after controlling for movements in non-traded investment good prices, foreign and domestic production cost factors, country fixed effects and time period fixed effects. These estimates are not rejected by several specification tests and are robust to several generalizations of the model. The estimated magnitude of the impact of the exchange rate on the price of investment goods differs significantly across industries. To the extent that monetary and fiscal policies alter the exchange rate, such policies will affect the price of investment goods in some industries more than in others. This may affect the level and distribution of investment across sectors and, ultimately, may affect output and productivity growth.

Several generalizations of the model provide little evidence that the effect of exchange rate movements on the price of investment goods is asymmetric, dependent on country size or openness, different between periods of higher and lower inflation, or sensitive to the volatility of the exchange rate. There is some evidence, however, that the domestic price of investment goods is more responsive to exchange rate changes the more undervalued is the currency on a purchasing power parity basis. However, the simulated impact on investment good prices of a change in the exchange rate is quite similar whether or not this effect is taken into account.

The results of the analysis undertaken here indicate that movements in the exchange rate have a larger impact on the prices of the investment goods purchased by industries that import more capital, are less service-oriented and produce more high-technology products. As well, some of the industries that are most strongly affected by exchange rate movements, such as *Transport, storage and communication* and *Manufacturing*, produce goods and services that are used as inputs by other industries. This, in addition to the typically larger impact on high-technology sectors, suggests that a currency depreciation that raises the price of imported machinery and equipment may have negative repercussions for future economic growth.

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Appendix A. Descriptive statistics and sample periods for each industry and country

A1. Investment goods price: sample periods and descriptive statistics[27]

Total industries: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1995; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1996; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 254. Mean: 0.0717. Min.: −0.0356. Max.: 0.2932. SD: 0.0598.

1. *Agriculture, hunting, forestry and fishing*: Austria: 1977–1996; Belgium: 1976–1997; Denmark: 1971–1995; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1996; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 256. Mean: 0.0702. Min.: −0.0729. Max.: 0.2856. SD: 0.0627.
2. *Mining and quarrying*: Austria: 1977–1994; Denmark: 1971–1995; Finland: 1971–1996; France: 1971–1992; Greece: 1971–1992; Ireland: 1987–1997; Netherlands: 1986–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1993–1996. Nobs: 171. Mean: 0.0726. Min.: −0.0370. Max.: 0.3892. SD: 0.0667.
3. *Manufacturing*: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1995; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1986–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 244. Mean: 0.0691. Min.: −0.0297. Max.: 0.3228. SD: 0.0595.
   - 3.1. *Food, beverages and tobacco*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 194. Mean: 0.0618. Min.: −0.0293 Max.: 0.3281. SD: 0.0530.

[27] Note: The following abbreviations have been used. Nobs: number of observations. Mean, Min., Max., SD indicate the mean value, minimum value, maximum value and the standard deviation, respectively, of the percentage change in the *Investment Goods Price* (PI_i) for the indicated industry sample. For the *Other Variables*, since the exchange rate and price data are the same for all industries in each country, and so vary only due to the different sample periods used for each industry, the mean, minimum value and maximum value are reported for only the aggregate *Total industries* sample.

3.2. *Textile, wearing apparel and leather industries*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1987, 1990–1996; France: 1971–1997; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 192. Mean: 0.0614. Min.: −0.0437. Max.: 0.2792. SD: 0.0547.

3.3. *Wood, and wood products, including furniture*: Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1979–1992. Nobs: 136. Mean: 0.0543. Min.: −0.0378. Max.: 0.1871. SD: 0.0433.

3.4. *Paper and paper products, printing and publishing*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 170. Mean: 0.0593. Min.: −0.2645. Max.: 0.3897. SD: 0.0760.

3.5. *Chemicals and chemical petroleum, coal, rubber and plastic products*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1979–1993. Nobs: 159. Mean: 0.0476. Min.: −0.0309. Max.: 0.1853. SD: 0.0410.

3.6. *Non-metallic mineral products except products of petroleum and coal*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1987–1994; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 174. Mean: 0.0632. Min.: −0.1451. Max.: 0.3825. SD: 0.0620.

3.7. *Basic metal industries*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1987–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1991. Nobs: 188. Mean: 0.0614. Min.: −0.0319. Max.: 0.3653. SD: 0.0601.

3.8. *Fabricated metal products, machinery and equipment*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 194. Mean: 0.0587. Min.: −0.0297. Max.: 0.3249. SD: 0.0545.

4. *Electricity, gas and water*: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1995; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1993–1996. Nobs: 221. Mean: 0.0700. Min.: −0.0257. Max.: 0.3275. SD: 0.0653.

5. *Construction*: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1995; Finland: 1971–1992; France: 1971–1997; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1986–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 217. Mean: 0.0642. Min.: −0.0389. Max.: 0.2789. SD: 0.0568.

6. *Wholesale and retail trade, restaurants and hotels*: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1971–1996; France: 1971–1997; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 227. Mean: 0.0620. Min.: −0.0336. Max.: 0.4227. SD: 0.0611.

6.1. *Wholesale and retail trade*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1987–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1990, 1993–1996. Nobs: 192. Mean: 0.0645. Min.: −0.0305. Max.: 0.4227. SD: 0.0609.

6.2. *Restaurants and hotels*: Belgium: 1976–1997; Finland: 1976–1996; France: 1971–1997; Italy: 1971–1994; Netherlands: 1987–1994; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1990, 1993–1996. Nobs: 159. Mean: 0.0680. Min.: −0.0379. Max.: 0.6142. SD: 0.0747.

7. *Transport, storage and communication*: Austria: 1977–1994; Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 249. Mean: 0.0735. Min.: −0.3695. Max.: 0.7947. SD: 0.0940.

7.1. *Transport and storage*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1987–1994; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 197. Mean: 0.0764. Min.: −0.1236. Max.: 0.3311. SD: 0.0725.

7.2. *Communication*: Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1996; Italy: 1971–1994; Netherlands: 1987–1994; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 196. Mean: 0.0705. Min.: −0.1311. Max.: 0.3040. SD: 0.0730.

8. *Finance, insurance, real estate and business services*: Austria: 1977–1995; Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Italy: 1971–1994; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 250. Mean: 0.0742. Min.: −0.1356. Max.: 0.2925. SD: 0.0692.

8.1. *Real estate and business services*: Denmark: 1971–1992; Finland: 1976–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1990, 1993–1996. Nobs: 178. Mean: 0.0763. Min.: −0.1401. Max.: 0.2899. SD: 0.0706.

9. *Community, social and personal services*: Austria: 1977–1996; Belgium: 1976–1997; Denmark: 1971–1992; Finland: 1971–1996; France: 1971–1997; Greece: 1971–1992; Ireland: 1987–1997; Netherlands: 1978–1995; Norway: 1979–1997; Sweden: 1981–1994; United Kingdom: 1971–1996. Nobs: 227. Mean: 0.0589. Min.: −0.4224. Max.: 0.2746. SD: 0.0738.

A2. Other variables: descriptive statistics

Rate of change in the exchange rate (Δe): Nobs: 254. Mean: 0.0359. Min.: −0.0886. Max.: 0.3122. SD: 0.0654.

Rate of change in the exchange rate—depreciations: Nobs: 176. Mean: 0.0616. Min.: 0.0005. Max.: 0.3122. SD: 0.0617.

Rate of change in the exchange rate—appreciations: Nobs: 78. Mean: −0.0222. Min.: −0.0886. Max.: −0.0202. SD: 0.0219.

$(\Delta e + \Delta c^{\mathrm{f}})$: Nobs: 254. Mean: 0.0875. Min.: −0.0543. Max.: 0.3457. SD: 0.0715.

ΔPI^N: Nobs: 254. Mean: 0.0756. Min.: −0.0866. Max.: 0.3133. SD: 0.0727.
Δc: Nobs: 254. Mean: 0.0914. Min.: 0.0117. Max.: 0.3349. SD: 0.0652.

Appendix B. Data sources

Δc = *percentage change in the marginal cost of producing domestic tradable investment goods*: Proxied by the percentage change in the manufacturing wage. Source: OECD, *Historical Statistics*, cd-rom, except for Denmark, 1971, 1974; Finland, 1978; Greece, 1976; and the UK, 1976; for which the source is the IMF *International Financial Statistics, Yearbook*, 1978.
$\left(\Delta e + \Delta c^f\right)$ = *percentage change of the exchange rate-marginal cost variable*: Specifically: $(\Delta e_{mt} + \Delta c_t^{\rm f}) \equiv \delta_m^{\rm US}\left(\Delta e_m^{\rm US} + \Delta c^{\rm US}\right) + \delta_m^{\rm G}\left(\Delta e_m^{\rm G} + \Delta c^{\rm G}\right)$. Here $\Delta e_m^{\rm US}$ and $\Delta e_m^{\rm G}$ are the percentage changes in the yearly average country m currency price of one US dollar and one German mark, respectively. (Therefore, $\Delta e_{mt}^{\rm US} \equiv (e_{mt}^{\rm US} - e_{m,t-1}^{\rm US})/e_{m,t-1}^{\rm US}$.) Source: OECD *STAN Database* 1998 except for the data for 1969 (required to construct the lagged change) which is from the IMF *International Financial Statistics, Yearbook*, 1978, and except for the data for Ireland. The nominal exchange rate for Ireland is from the IMF *International Financial Statistics* cd-rom (series 178..RH.Z). The variables $\Delta c^{\rm US}$ and $\Delta c^{\rm G}$ represent the percentage change in the marginal cost of imported investment goods from the US and Germany, respectively. This variable is proxied by the percentage change in the US and German manufacturing wage. Source: OECD, *Historical Statistics*, cd-rom. (As an alternative proxy, the change in marginal cost was measured as the weighted average of the percentage change in the price of investment goods used in sector i in Germany and the US. This price was calculated by taking the ratio of nominal to constant dollar gross fixed capital formation (gfcf) in sector i in the US and Germany. Data for current and constant dollar gfcf are from Table 3 of the OECD *National Accounts, Volume II*, cd-rom.). The weight $\delta_m^{\rm US}\left(\delta_m^{\rm G}\right)$ is the average share of imports of machinery and transport equipment, measured in US dollars, by country m from the US (West Germany) relative to the total of these imports from the US and West Germany for the years 1975, 1980, 1985 and 1990. For 1975, 1980 and 1985 the shares were obtained from *Trade by Commodities*, OECD, and for 1990 *Commodity Trade Statistics*, United Nations. (Data at five-year intervals were used because data for all countries and all years were not readily available.)[28]
ΔPI_i = *percentage change in the price of investment goods used by sector i*: The price index is calculated by taking the ratio of nominal to constant dollar gross fixed capital formation (gfcf) in sector *i*. Source: Data for current and constant dollar gfcf are from Table 3 of the OECD *National Accounts, Volume II, Detailed Tables*, cd-rom.
ΔPI^N = *percentage change in the price of non-traded investment goods*: Proxied by the price index for non-residential construction. Source: OECD, *Historical Statistics*, cd-rom.

[28] As an alternative, the trade weights for 1970 (from the OECD, *Trade by Commodities*) were employed. With these trade weights (not reported) the estimated coefficients on the variable $\left(\Delta e + \Delta c^{\rm f}\right)$ were almost the same as the results reported in Table 1, and were always within one standard error of the original estimates. Only one of the exchange rate parameters change from being significant at the 5% level to being significant at the 10% level. All the conclusions of the AR1 and Reset tests are the same (although in two cases, the Reset test rejects at 99% rather than 95%), and the $\bar{R}^2$ is close to the initial estimate. In all cases, the significance of the other estimated coefficients does not change.

A3. Additional data (used to test the robustness of the estimates)

Measure of import dependence: The ratio of nominal imports to nominal GDP from Table 1 of the OECD *National Accounts, Volume II, Detailed Tables* cd-rom.

Measure of currency valuation (V): Measured as $V \equiv \delta_m^{US}\left(e_m^{US}/e_m^{US,PPP}\right) + \delta_m^{G}\left(e_m^{G}/e_m^{G,PPP}\right)$, where $e_m^{US,PPP}$ and $e_m^{G,PPP}$ are the purchasing power parity exchange rates of country m relative to the US and Germany, respectively. Source: See above for exchange rates and trade weights. For the PPP exchange rates, the OECD *STAN Database* 1998 except for the data for Ireland, which was downloaded from the OECD web site ‘‘PPPs for GDP – Historical Series’’ on 23 May 2002 in Euros and then converted to Irish pounds using the official Euro conversion rate.

Country size: The ratio of a country's population to the population of the US. Source: The population data are from the IMF *IFS* cd-rom.

Standard deviation of the exchange rate: The standard deviation of the quarterly percentage change in the exchange rate over the three years prior to the current year. Source: The quarterly nominal exchange rate data (market rate period averages) used to create this variable are from the IMF's *IFS* cd-rom.

Percentage change in the aggregate price level: Represented by the percentage change in the GDP price index. Source: The GDP price index is calculated as the ratio of current to constant dollar GDP from Table 1 of the OECD *National Accounts, Volume II Detailed Tables* cd-rom.

Percentage change in aggregate output: Represented by the percentage change in constant dollar GDP. Source: Table 1 of OECD *National Accounts, Volume II, Detailed Tables*, cd-rom.

References

Bell, G.K., Campa, J.M., 1997. Irreversible investments and volatile markets: a study of the chemical processing industry. Review of Economics and Statistics 79 (1), 79–87.

Campa, J.M., Goldberg, L.S., 1995. Investment, exchange rates and external exposure. Journal of International Economics 38 (3–4), 297–320.

Campa, J.M., Goldberg, L.S., 1999. Investment, pass-through, and exchange rates: a cross-country comparison. International Economic Review 40 (2), 287–314.

Campa, J.M., Goldberg, L.S., 2002. Exchange rate pass-through into import prices: a macro or micro phenomenon? NBER working paper 8934.

Coe, D.T., Helpman, E., Hoffmaister, A.W., 1997. North-south R&D spillovers. Economic Journal 107 (440), 134–149.

Davidson, R., MacKinnon, J.G., 1993. Estimation and Inference in Econometrics. Oxford University Press, New York, NY.

De Long, J.B., Summers, L.H., 1991. Equipment investment and economic growth. Quarterly Journal of Economics 106 (2), 445–502.

Diaz-Alejandro, C., 1965. Exchange–Rate Devaluation in a Semi-Industrialized Country: The Experience of Argentina, 1955–1961. MIT Press, Cambridge, MA.

Edwards, S., 1986. Are devaluations contractionary? Review of Economics and Statistics 68 (3), 501–508.

Edwards, S., 1989. Real Exchange Rates, Devaluation, and Adjustment: Exchange Rate Policy in Developing Countries. MIT Press, Cambridge, MA.

Feenstra, R.C., 1989. Symmetric pass-through of tariffs and exchange rates under imperfect competition: an empirical test. Journal of International Economics 27 (1–2), 25–45.

Feenstra, R.C., Gagnon, J.E., Knetter, M.M., 1996. Market share and exchange rate pass-through in world automobile trade. Journal of International Economics 40 (1–2), 187–207.

Forbes, K.J., 2002. Cheap labor meets costly capital: the impact of devaluations on commodity firms. NBER working paper 9053.

Frankel, J.A., Rose, A.K., 1996. A panel project on purchasing power parity: mean reversion within and between countries. Journal of International Economics 40 (3–4), 209–224.
Fung, L., 2003. Large real exchange rate movements, firm dynamics, and productivity growth. Working paper, Department of Economics, University of Alberta, Edmonton, Alberta, Canada.
Gagnon, J.E., Ihrig, J., 2001. Monetary policy and exchange rate pass-through. International finance discussion paper number 704, Board of Governors of the Federal Reserve System, Washington, DC.
Goldberg, L.S., 1993. Exchange rates and investment in United States industry. The Review of Economics and Statistics 75 (4), 575–588.
Goldberg, P.K., Knetter, M.M., 1997. Goods prices and exchange rates: what have we learned? Journal of Economic Literature 35 (3), 1243–1272.
Goldfajn, I., Gupta, P., 2003. Does monetary policy stabilize the exchange rate following a currency crisis? IMF Staff Papers 50 (1), 90–114.
Goldfajn, I., Werlang, S.R.C., 2000. The pass-through from depreciation to inflation: a panel study. PUC-Rio discussion paper no. 423, Departamento de Economia, Pontificia Universidade Catolica.
Gylfason, T., Schmid, M., 1983. Does devaluation cause stagflation? Canadian Journal of Economics 16 (4), 641–654.
Harris, R.G., 2001. Is there a case for exchange rate induced productivity changes? Working paper no. 164, Canadian Institute for Advanced Research, Toronto, Canada.
Hatzichronoglou, T., 1997. Revision of the high-technology sector and product classification. STI working paper 1997/2, Organisation for Economic Co-operation and Development, Paris.
Jones, C.I., 1994. Economic growth and the relative price of capital. Journal of Monetary Economics 34 (3), 359–382.
Kamin, S., Rogers, J.H., 2000. Output and the real exchange rate in developing countries: an application to Mexico. Journal of Development Economics 61 (1), 85–109.
Knetter, M.M., 1989. Price discrimination by U.S. and German exporters. American Economic Review 79 (1), 198–210.
Kouri, P., 1979. Profitability and growth in a small open economy. In: Lindbeck, A. (Ed.), Inflation and Employment in Open Economies. North-Holland, Amsterdam, pp. 129–142.
Krugman, P., Taylor, L., 1978. Contractionary effects of devaluation. Journal of International Economics 8 (3), 445–456.
Lizondo, J.S., Montiel, P.J., 1989. Contactionary devaluation in developing countries. IMF Staff Papers 36, 182–227.
MacKinnon, J.G., White, H., 1985. Some heteroscedasticity consistent covariance matrix estimators with improved finite sample properties. Journal of Econometrics 29, 305–325.
Mann, C.L., 1986. Prices, profit margins and exchange rates. Federal Reserve Bulletin 72, 366–379.
Marston, R.C., 1990. Pricing to market in Japanese manufacturing. Journal of International Economics 29 (3–4), 217–236.
Martin, R.L., Porter, M.E., 2001. Canadian Competitiveness: a Decade After the Crossroads. University of Toronto, Toronto, Ontario, Canada.
Mazumdar, J., 2001. Imported machinery and growth in LDCs. Journal of Development Economics 65 (1), 209–224.
Mody, A., Yilmaz, K., 2002. Imported machinery for export competitiveness. The World Bank Economic Review 16 (1), 23–48.
Morley, S.A., 1992. On the effect of devaluation during stabilization programs in LDCs. Review of Economics and Statistics 74 (1), 21–27.
Nucci, F., Pozzolo, A.F., 2001. Investment and the exchange rate: an analysis with firm-level panel data. European Economic Review 45 (2), 259–283.
Obstfeld, M., 2002. Exchange rates and adjustment: perspectives from the new open economy macroeconomics. University of California, Berkeley, CIDER WP 125.
Porter, M.E., 1990. The Competitive Advantage of Nations. Free Press, New York, NY.
Rebelo, S., Végh, C., 1996. Exchange-rate-based stabilizations: theory and evidence. In: Bernanke, B.S., Rotemberg, J.J. (Eds.), NBER Macroeconomics Annual 1995. MIT Press, Cambridge, MA, pp. 125–174.
Risager, O., 1987. The effects of currency depreciation in a model with capital formation. European Economic Review 31 (2), 399–406.
Rogoff, K., 1996. The purchasing power parity puzzle. Journal of Economic Literature 34 (2), 647–668.
Strauss, J., 1999. Productivity differentials, the relative price of non-tradables and real exchange rates. Journal of International Money and Finance 18 (3), 383–409.
Swift, R., 2001. Exchange rates and commodity prices: the case of Australian metal exports. Applied Economics 33 (6), 745–753.

Takagi, S., Yoshida, Y., 2001. Exchange rate movements and tradable goods prices in East Asia: an analysis based on Japanese customs data, 1988–99. IMF Staff Papers 48 (2), 266–289.

Taylor, J.B., 2000. Low inflation, pass-through, and the pricing power of firms. European Economic Review 44 (7), 1389–1408.

Uctum, M., 2003. Pricing to market: the Japanese experience with a falling yen and the Asian crisis. Review of International Economics 11 (2), 360–378.

Upadhyaya, K.P., 1999. Currency devaluation, aggregate output, and the long run: an empirical study. Economics Letters 64 (2), 197–202.

Xu, B., Wang, J., 1999. Capital goods trade and R&D spillovers in the OECD. Canadian Journal of Economics 32 (5), 1258–1274.