

**Measuring the Effects of Exchange Rate Changes on Investment  
in Australian Manufacturing Industry**

*Robyn Swift\**

Economics and Business Statistics  
Department of Accounting, Finance and Economics  
Griffith University  
Nathan Campus  
Brisbane Qld 4111  
Australia

Ph: (+61 7) 3735 7765

Fax: (+61 7) 3735 3719

E-mail: [r.swift@griffith.edu.au](mailto:r.swift@griffith.edu.au)

\*This research is part of a project supported by a Griffith University Research Development Grant (GURD)

# **Measuring the Effects of Exchange Rate Changes on Investment in Australian Manufacturing Industry**

## **Abstract**

This paper uses an empirical framework derived from an optimising adjustment-cost model of investment to examine the relationship between exchange rates and investment in Australian manufacturing industry between 1988 and 2001. The results show that the response of investment to exchange rate changes varies with the external exposure of industry, positively with export share of sales and negatively with the share of imported inputs into production. Industry competitive structure, represented by markup of price over cost, interacts with external exposure so that lower levels of markup increase the responsiveness of investment to exchange rate changes. For Australian manufacturing industry, a 10% real appreciation of the Australian dollar (AUD) leads to an average 8.0% decrease in total investment through the export share channel over the period, and an average 3.8% increase in total investment through the imported input share channel, with most of the response occurring through investment in Equipment, Plant and Machinery.

## **1. Introduction**

There have been substantial changes in the value of the Australian dollar (AUD) over the last decade but we still have little detailed information about the implications of these movements for Australian industry. There is now a considerable international literature on the factors that influence the initial stage of the adjustment process, the change in relative prices that follows an exchange rate change, usually referred to as exchange rate pass-through.<sup>1</sup> However, fewer studies have extended this analysis to investigate the longer-term

---

<sup>1</sup> See Goldberg and Knetter (1997) for a comprehensive review of the literature on exchange rate pass-through and related issues.

effects of exchange rates on investment and employment, and only for a limited number of countries (for example, Campa and Goldberg 1995, 1999; Nucci and Pozzolo 2001). This paper uses quarterly data from 1988 to 2001 to estimate the size and determinants of the effects of exchange rate changes on investment in Australian manufacturing industry.

The optimal level of investment for a firm is an increasing function of the current and expected value of future profits. Exchange rate changes influence profits not only through changes in the prices of domestically produced goods sold in export markets but also through changes in the prices of imported goods used as inputs to production and in the prices of imports that compete with domestically produced goods. A firm with a larger share of sales in export markets, for example, would be expected to reduce investment in response to an appreciation of the domestic currency. Conversely, a firm that is highly dependent on the use of imported inputs into production would face a larger drop in variable costs and would consequently be expected to increase investment following an appreciation.

The exchange rate pass-through literature has also highlighted the importance of the competitive structure of industry in determining the size of the response to exchange rate changes (see, for example, Dornbusch 1987). Firms in more competitive industries with lower price-over-cost markups have less ability to absorb exchange rate changes in their markups so that the change in prices for these firms following an exchange rate change will be larger. Lower levels of industry markups would therefore be expected to interact with, and amplify, the effects of external exposure on investment.

The few empirical studies available have generally confirmed the conclusions of the theoretical models. In a cross-country survey, Campa and Goldberg (1999) estimated that a net increase of around 1-2% in investment in total manufacturing in the USA would follow a 10% appreciation of the USD, with a wide variation expected in industry response, ranging from an increase of 12% to a decrease of 8.4%. The authors showed that these results were

due to the increasing importance of imported inputs into manufacturing in the USA. Japanese industry generally showed a lower level of response, but with an overall increase in investment also expected following appreciation, and a similarly wide range of industry responses from an increase of 10% to a decrease of 8.3%.

Campa and Goldberg (1999) were unable to find any statistical significance in the exchange rate coefficients for the UK and Canada, which they found surprising given the size and extent of the external orientation of Canadian manufacturing. However, Nucci and Pozzolo (2001) reported that the results of their estimations of a panel data set of about 1000 Italy manufacturing firms also strongly supported the implications of the theoretical model, with the overall effects of swings in the exchange rate on a firm's investment depending on which of the opposing export and imported input channels prevailed.

The rest of the paper is organised as follows. Section 2 outlines a theoretical framework that explicitly incorporates both changes in external exposure and industry markups as determinants of exchange rate effects on profits and investment. The empirical model described in Section 3 is directly derived from this framework, and is estimated for total investment in Australian manufacturing industry and for two investment sub-classes, Equipment, Plant and Machinery, and Buildings and Structures.

The results presented in Section 4 confirm the effects of external exposure and markups expected from the theoretical model. They show that a 10% real appreciation of the Australian dollar (AUD) leads to a net decrease of 4.2% in total investment on average over the period, the combined effect of an 8.0% decrease through the export share channel, and a 3.8% increase through the imported input share channel. Almost all of the investment response occurs through changes in investment in Equipment, Plant and Machinery. Section 5 draws some final conclusions.

## 2. Theoretical Framework

A firm is assumed to choose the optimal level of investment each period ( $I_t$ ) to maximise its market value ( $V_t$ ), which is equivalent to the discounted sum of expected future cash flows.  $K_t$ , the capital stock at the start of period  $t$ , is assumed to be quasi-fixed and subject to a cost of installing new capital  $c(I_t)$  that is increasing and convex, as in a standard adjustment cost model (Chirinko 1993).  $K_t$  is also subject to a standard capital accumulation equation:

$$K_{t+1} = (1 - \delta)K_t + I_t \quad (1)$$

where  $\delta$  is the rate of capital depreciation.

The profit function of the firm exposed to exchange rate changes is represented by  $\Pi(K_t, e_t)$  where  $e_t$  is the real exchange rate in units of domestic currency per unit of foreign currency. Following the model developed by Campa and Goldberg (1999), the maximised value of the firm at time  $t$  is expressed as:

$$V_t(K_t, e_t) = \max_{\{I_\tau\}_{\tau=t}^{\infty}} E \left\{ \sum_{\tau=0}^{\infty} \beta^\tau [\Pi(K_{t+\tau}, e_{t+\tau}) - c(I_{t+\tau}) - I_{t+\tau}] \middle| \Omega_t \right\} \quad (2)$$

where the cash flow for every period is given by the profit function less the overall cost of investment,  $\beta$  is the discount rate, and  $E[\cdot | \Omega_t]$  is the expectations operator conditional on all information available at time  $t$ .

The first order condition derived by maximising the value of the firm in equation (2) subject to equation (1) represents the optimal decision-making rule for investment in period  $t$ . That is, the firm should equate expected marginal profitability, or the discounted stream of expected future profits from an additional unit of investment, to the costs of that additional investment:

$$E \left\{ \sum_{\tau=1}^{\infty} [\beta(1 - \delta)]^\tau \left[ \frac{\partial \Pi(K_{t+\tau}, e_{t+\tau})}{\partial K_{t+\tau}} \right] \middle| \Omega_t \right\} = 1 + \frac{\partial c(I_t)}{\partial I_t} \quad (3)$$

The model assumes only a cost of adjustment function that is increasing and convex. However, for ease of exposition, a standard quadratic cost function with parameters  $\gamma$  and  $\mu$  is used:

$$c(I_t) = \frac{\gamma}{2}(I_t - \mu)^2 \quad (4)$$

Differentiating equation (4), substituting into equation (3) and rearranging gives an expression for  $I_t$ :

$$I_t = \left(\mu - \frac{1}{\gamma}\right) + \frac{1}{\gamma} E \left\{ \sum_{\tau=1}^{\infty} [\beta(1-\delta)]^{\tau} \left[ \frac{\partial \Pi(K_{t+\tau}, e_{t+\tau})}{\partial K_{t+\tau}} \right] \middle| \Omega_t \right\} \quad (5)$$

The firm is assumed to observe the exchange rate each period ( $e_t$ ) and choose output for foreign and domestic markets and quantities of domestic and imported inputs in order to maximise per-period profit:

$$\Pi(K_t, e_t) = \max_{q_t, q_t^*, L_t, L_t^*} p(q_t, e_t)q_t + e_t p^*(q_t^*, e_t)q_t^* - w_t L_t - e_t w_t^* L_t^* \quad (6)$$

$$\text{subject to} \quad q_t + q_t^* = f(K_t, L_t, L_t^*)$$

where  $q_t$  and  $q_t^*$  are the quantities supplied by the firm to domestic and foreign markets respectively,  $p(q_t, e_t)$  and  $p^*(q_t^*, e_t)$  are the demand functions faced by the firm,  $w_t L_t$  and  $e_t w_t^* L_t^*$  are spending on domestically produced and imported inputs,  $L_t$  and  $L_t^*$ , respectively, and  $f(K_t, L_t, L_t^*)$  is homogenous of degree one.

The first order conditions for equation (6) are combined and the resulting gross profit function differentiated to give an expression for the marginal profitability of capital:

$$\frac{\partial \Pi(K_t, e_t)}{\partial K_t} = \frac{1}{K_t} [MKUP_t^{-1} p_t q_t + MKUP_t^{*-1} e_t p_t^* q_t^* - (w_t L_t + e_t w_t^* L_t^*)] \quad (7)$$

where  $MKUP_t$  and  $MKUP_t^*$  are the firm's price-over-cost markups in the domestic and foreign markets respectively. These can be represented as:

$$MKUP_t = \frac{p_t}{MC_t} = \frac{1}{(1 + \eta_t^{-1})} \quad (8)$$

and

$$MKUP_t^* = \frac{e_t p_t^*}{MC_t} = \frac{1}{(1 + \eta_t^{*-1})} \quad (9)$$

where  $MC_t$  is marginal cost and  $\eta_t$  and  $\eta_t^*$  are price elasticities of demand in the domestic and foreign markets respectively.

The model assumes for simplicity that the only source of uncertainty is the exchange rate, and that all exchange rate changes are assumed to be permanent. This implies that the level of the exchange rate in all future periods is expected to be equal to today's exchange rate, and consequently the expected marginal profitability in equations (3) and (5) is also equal to today's marginal profitability as expressed in equation (7).

By using equation (7) to differentiate equation (5) with respect to the exchange rate and rearranging, Campa and Goldberg (1999) derive an expression for the investment response to exchange rate changes:

$$\frac{\partial I_t}{\partial e_t} = \frac{A'}{AMKUP_t} [(\eta_{p,e} - \eta_{MKUP,e})(1 - X_t) + (1 + \eta_{p^*,e} - \eta_{MKUP^*,e}) X_t - (1 + \eta_{w^*,e}) \alpha_t] \frac{de_t}{e_t} \quad (10)$$

where

$$A' = \frac{\beta}{\gamma[1 - \beta(1 - \delta)]} \cdot \frac{TR_t}{K_t}$$

and  $\eta_{p,e}$  and  $\eta_{p^*,e}$  are the exchange rate pass-through elasticities to domestic and foreign prices respectively,  $\eta_{MKUP,e}$  and  $\eta_{MKUP^*,e}$  are the exchange rate elasticities of markups in domestic and foreign markets respectively,  $TR_t$  is total revenues,  $X_t$  is the share of  $TR$  from sales in foreign markets,  $\alpha_t$  is the share of imported inputs in total production costs,  $\eta_{w^*,e}$  is the exchange rate elasticity of imported input costs and  $AMKUP$  is the average markup across all markets.

The three main terms inside the square brackets in Equation (10) identify the three channels through which exchange rate changes can influence investment. Effects on the profitability of domestic sales ( $1-X_t$ ) will depend on the exchange rate elasticities of price and markups in the domestic market. Effects on profitability of export sales ( $X_t$ ) will depend on the exchange rate elasticities of price and markups in foreign markets plus a direct valuation effect on revenue from export sales. These effects on the revenue side will be offset by oppositely signed changes in total production costs, which are dependent on the exchange rate elasticity of imported input costs.

The price and markup elasticities are all dependent on the nature of competition in the relevant markets (Dornbusch 1987). For perfectly competitive firms, domestic prices are equal to marginal costs and markups are accordingly zero, so domestic prices and markups are unaffected by exchange rate changes ( $\eta_{p,e} = \eta_{MKUP,e} = 0$ ). Domestic prices of exports are also unchanged so the foreign currency price of exports must rise fully to reflect currency appreciation, ( $\eta_{p^*,e} = 1$ ), leading to a corresponding reduction in quantities sold. In addition, smaller average markups will amplify the effects on investment in competitive industries from all three channels, through  $(\frac{A'}{AMKUP})$ .

Conversely, firms in imperfectly competitive markets can decrease markups on exported goods following appreciation to maintain constant foreign currency prices ( $\eta_{p^*,e} = 0$ ), reducing the impact on quantities sold. The extent to which foreign currency prices change in response to a currency movement, and the resulting effects on investment, will be directly related to the degree of competition in export markets and inversely related to the size of the markups in the industry.

In all industries, the larger is  $X_t$ , the share of sales in export markets, the larger will be the effects from changes in foreign currency prices. Similarly on the imported input side,

both more competitive markets for inputs (smaller markups and larger  $\eta_{w^*,e}$ ) and a greater proportion of imported inputs in production costs (larger  $\alpha_t$ ) will increase the countervailing effects of imported input costs on profitability and investment.

### 3. Empirical Estimation and Data

The empirical model to be estimated is derived from equation (10) as:

$$\begin{aligned} \Delta I_t = & \beta_0 + \beta_1(AMKUP_{t-1})^{-1} \Delta e_t + \beta_2 X_{t-1} (AMKUP_{t-1})^{-1} \Delta e_t \\ & + \beta_3 \alpha_{t-1} (AMKUP_{t-1})^{-1} \Delta e_t + \beta_4 \Delta sales_{t-1} + \beta_5 \Delta r_{t-1} + \beta_6 \Delta I_{t-1} + \varepsilon_t \end{aligned} \quad (11)$$

where  $I_t$  is investment in private new capital expenditure at constant prices, and  $e_t$  is the real trade-weighted exchange rate in units of domestic currency per unit of foreign currency. From equation (10), the coefficient  $\beta_1$  on the first exchange rate term is a function of  $(\eta_{p,e} - \eta_{MKUP,e})$  in the domestic market. The coefficient  $\beta_2$  on the exchange rate interacted with export share ( $X_t$ ) is a function of the valuation and market effects on the export side  $(1 + \eta_{p^*,e} - \eta_{MKUP^*,e} - \eta_{p,e} + \eta_{MKUP,e})$ . Similarly, the coefficient  $\beta_3$  on the final exchange rate term interacted with imported input share ( $\alpha_t$ ) is a function of imported input elasticity  $(1 + \eta_{w^*,e})$ . All three exchange rate terms interact with average markup ( $AMKUP_t$ ) as in equation (10), incorporating the influence of competitive structure on exchange rate effects.

The discount rate included in the term in  $A'$  in equation (10) is represented by the real interest rate ( $r_t$ ). The estimation also includes a variable for the growth rate of real total sales in the industry ( $\Delta sales_t$ ) to control for other industry-specific factors that may have influenced the growth rate of investment over the period. The lagged values of the interaction terms (export and imported input shares and average markup) and the real interest rate are used to avoid possible correlation with the current exchange rate, and a lag on total sales to avoid possible correlation with current investment. The final term in lagged investment ( $I_{t-1}$ ) is

included to represent the adjustment and implementation lags generally expected in investment projects (Driver and Dowrick 1997, Nucci and Pozzolo 2001). The symbol  $\Delta$  indicates first differences in natural logarithms for all variables except for the real interest rate, which is differenced in level form.

The inclusion of the lagged dependent variable in equation (11) raises the possibility of serial correlation and subsequent bias in the estimates. For this reason, instrumental variables estimation (2SLS) was employed, with additional lags of investment and sales included as instruments. The estimates were corrected for any remaining serial correlation using the Newey-West technique (Newey and West 1987).

Equation (11) was estimated for total investment in Australian Manufacturing industry (ANZSIC Division C) and for the two investment sub-classes, Equipment, Plant and Machinery, and Buildings and Structures, using quarterly data for the period 1988:Q1 to 2001:Q4. Details of data sources are available in the appendix. Export share ( $X_t$ ) is calculated as the ratio of the value of exports to the value of total sales of goods and services. Imported input share ( $\alpha_t$ ) is constructed from sectoral input-output data combined with import value shares for each input sector to give the total value of imported inputs used in manufacturing industry. The share of imported inputs in production is then derived as the ratio of the value of imported inputs to the total cost of production, including both materials and labour inputs.<sup>2</sup>

Marginal costs for the direct calculation of price-over-cost markups are not observable. Domowitz *et al.* (1986) suggest a method for computing a measure of profit margin per unit price:

$$MK_{DHP} = \left( \frac{\text{Value of Sales} + \Delta \text{Inventories} - \text{Payroll} - \text{Cost of Materials}}{\text{Value of Sales} + \Delta \text{Inventories}} \right) \quad (12)$$

---

<sup>2</sup> Further details on the construction of this variable and a discussion of changes in measures of external exposure for Australian manufacturing industries over the period are provided in Swift (2005).

This formula is used to derive a measure for the average markup (*AMKUP*) as “average price-over-average cost” to represent market power in the industry:

$$\begin{aligned}
 AMKUP &= \frac{1}{1 - MK_{DHP}} \\
 &= \frac{\text{Value of Sales} + \Delta \text{Inventories}}{\text{Payroll} + \text{Cost of Materials}}
 \end{aligned}
 \tag{13}$$

This method is not intended to give a definitive measure of industry markups, but it does allow the consistent comparison of changes in profit margins over time as exchange rates change.

#### 4. Results

The results of the estimation of equation (11) for total investment and the two investment sub-classes are given in Table 1. For total investment, the exchange rate variables interacted with export shares and imported input shares are both significant and of the expected sign, indicating that an appreciation (a decrease in  $e_t$ ) leads to a decrease in total investment through the export price channel and an increase through the imported input prices channel. The results for the interacted terms in the regression for equipment, plant and machinery are very similar but with slightly smaller coefficients. Investment in equipment, plant and machinery constituted around 85% of total investment on average over the period, consistent with the results obtained.

The regression for investment in buildings and structures has markedly poorer fit ( $\bar{R}^2 = 0.22$ ) and only the lagged dependent variable is significant. Driver and Dowrick (1997) also found less explanatory power in the equations for buildings and structures in their estimations of the effects of investment intentions on investment in Australian manufacturing industry. Investment in buildings and structures is likely to involve much larger costs, suggesting longer lead times in planning and implementation that may induce “lumpiness” in

investment spending. The wedge thus created between the benefits and costs embodied in an optimal investment policy may lead to parameter and model instability by weakening the link between investment spending and shifts in economic determinants such as exchange rates (Chirinko 1993). The negative and significant coefficients on the one-period lag of investment in all three estimations, also found by Driver and Dowrick (1997), support the idea that investment spending generally has some degree of “lumpiness”, as higher levels of investment spending last period will be followed by lower levels of spending this period whatever the external economic conditions.

**Table 1: Investment in Australian Manufacturing Industry (ANZSIC Div. C)  
1988:Q1-2001:Q4**

Variables	Dependent Variable: <i>Investment</i>		
	<i>Total</i>	<i>Equipment, Plant and Machinery</i>	<i>Buildings and Structures</i>
<i>Constant</i>	0.010 (0.058)	0.052 (0.045)	0.376 (0.498)
$(AMKUP_{t-1})^{-1} \Delta e_t$	-0.748 (0.932)	-1.010 (0.658)	5.767 (7.736)
$X_{t-1} (AMKUP_{t-1})^{-1} \Delta e_t$	4.014* (1.962)	3.633* (1.257)	-1.400 (25.351)
$\alpha_{t-1} (AMKUP_{t-1})^{-1} \Delta e_t$	-3.109** (1.914)	-2.508* (1.332)	-5.525 (19.138)
$\Delta sales_{t-1}$	0.002 (0.001)	0.002* (0.001)	-0.006 (0.010)
$\Delta r_{t-1}$	0.208* (0.102)	0.225* (0.080)	-0.149 (0.856)
$\Delta I_{t-1}$	-0.840* (0.089)	-0.806* (0.089)	-0.491* (0.103)
$\bar{R}^2$	0.76	0.77	0.22

Note: Each equation is estimated using 2SLS and corrected for fourth-order serial correlation.

\* and \*\* indicate significance at 5% and 10% levels respectively.

Standard errors are reported in brackets below parameter estimates.

The coefficient on the real interest rate for the first two regressions is significant, but small and of the wrong sign. To check that this did not indicate the need to allow for a longer time delay on the interest rate effect, all three equations were re-estimated with lags up to five quarters on the real interest rate variable. Insignificant lags were eliminated using the general-to-specific methodology, but only the first lag remained significant in all three regressions. Interestingly, Campa and Goldberg (1995) found similar small but positive and significant coefficients in their estimations of the effects of exchange rate changes on investment in manufacturing industry in the United States. Campa and Goldberg (1995) offered no explanation for their findings, but the relative size of the coefficients for both Australia and the USA support the general conclusion of neoclassical models of investment that effects on output or sales, as generated here by exchange rate changes, have the dominant effect on investment with user cost having a minor role (Chirinko 1993).

The implications for Australian industry of the investment effects of exchange rate changes can be shown by combining the estimated coefficients on the interacted exchange rate terms in Table 1 with industry-specific data on export share, imported input share and markups. Table 2 gives the responses expected for total manufacturing industry and the 2-digit ANZSIC manufacturing sub-divisions following a 10% real appreciation of the AUD. Ideally, the exchange rate coefficients would also be allowed to vary between sub-divisions, but the figures calculated here do show the variation that can be expected in effects between industries as a result of differences in markup and the degree of external exposure.

A 10% real appreciation leads to an overall net decrease of around 4.2% in investment for Australian manufacturing as a whole, but effects vary from a 1.2% net increase in investment for printing, publishing and recording media to a 15% decrease for metal products. These results contrast with those reported by Campa and Goldberg (1999) in their cross-

country survey. They estimated a net increase in investment in total manufacturing in both the USA and Japan following a 10% appreciation of the domestic currency, with a wider variation in industry response than that found here.

**Table 2: Estimated effects of a 10% real appreciation of the AUD on investment in Australian Manufacturing Industries**

<i>Industry (ANZSIC code)</i>	<i>Total Investment</i>		<i>Investment in Equipment, Plant and Machinery</i>	
	<i>Export channel</i>	<i>Imported input channel</i>	<i>Export channel</i>	<i>Imported input channel</i>
Div. C: Total Manufacturing	- 8.0%	3.8%	-7.3%	3.1%
Sub-Divisions:				
21 Food, Beverages and Tobacco Manufacturing	- 8.9%	1.5	-8.1%	1.2%
22 Textile, Clothing, Footwear and Leather Manufacturing	- 8.3%	4.4%	-7.5%	3.6%
23 Wood and Paper Product Manufacturing	- 2.7%	2.7%	-2.5%	2.2%
24 Printing, Publication and Recording Media	- 1.0%	2.2%	-0.9%	1.8%
25 Petroleum, Coal and Chemical Manufacturing	- 5.1%	5.0%	-4.6%	4.0%
26 Non-Metallic Mineral Product Manufacturing	- 1.0%	1.5%	-0.9%	1.2%
27 Metal Product Manufacturing	- 16.7%	3.3%	-15.1%	2.6%
28 Machinery and Equipment Manufacturing	- 8.9%	7.0%	-8.0%	5.6%
29 Other Manufacturing	- 4.8%	3.6%	-4.3%	2.9%

Note: The estimates are calculated using period averages of export share, imported input shares and markups for each industry, combined with the relevant coefficients from Table 1.

However, the four Australian industries showing the largest effects in Table 2 (21, 22, 27 and 28) are those with the largest export shares, averaging over 20% export share over the period, and in the case of metal products, over 40%. They are also among the largest sub-divisions overall, together averaging more than 60% of the total sales of the manufacturing industries. These results highlight the continued importance of the export channel for

exchange rate effects for Australia. They also emphasise the importance of country and industry-specific influences in determining the direction and size of the response to exchange rate changes.

The remaining industries, more than half the industry sub-divisions (23, 24, 25, 26 and 29), experience net changes of around 1% or less, indicating that even quite substantial reductions in investment through the export price channel can be counterbalanced by gains through the prices of imported inputs, as for example in petroleum, coal and chemical products.

## **5. Conclusion**

This paper provides quantitative measures of the size and direction of the effects of exchange rate changes on investment in Australian manufacturing industry between 1988 and 2001. The empirical results confirm the conclusions of the theoretical model that the magnitude of the effects varies with the external exposure of industry, positively with export share of sales and negatively with the share of imported inputs into production.

For individual manufacturing subdivisions, the expected response to a 10% appreciation of the AUD varies from a 1.2% net increase in total investment to a 15% net decrease. For the manufacturing division as a whole, the decrease of around 4.2% is a result of an 8% decrease in investment through the export price channel and a 3.8% increase through the imported input price channel. Almost all of the investment response occurs through investment in equipment, plant and machinery.

For Australia, the estimates suggest that export share remains the most important channel for exchange rate effects overall, although there are significant differences between industries. The results found here demonstrate the need for further research to address the

determinants of differences in exchange rate effects both between industries and between countries.

### **Appendix 1: Data**

Investment ( $I_t$ ): Data on total investment, and investment in equipment, plant and machinery, and buildings and structures, at current prices are taken from ABS, *Private New Capital Expenditure and Expected Expenditure, Australia*, Cat. no. 5625.0. They are deflated by the chain price indices for total private gross fixed capital formation from ABS, *Australian National Accounts: National Income, Expenditure and Product*, Cat no. 5206.0.

Exchange rate ( $e_t$ ): Data on the real trade-weighted index are taken from *Real Exchange Rate Indices – Quarterly* on the RBA website ([www.rba.gov.au/Statistics/](http://www.rba.gov.au/Statistics/))

Interest rate ( $r_t$ ): The real interest rate is calculated as the quarterly average of the interest rate on two-year Treasury bonds from RBA, *Interest Rates and Yields: Money Market and Commonwealth Government Securities*, Occasional Paper no. 10 (updated), minus the expected change in manufacturing selling prices from ABS, *Australian Business Expectations*, Cat. no. 5250.0.

Export share ( $X_t$ ) and Sales ( $sales_t$ ): The value of exports is taken from ABS, *International Trade in Goods and Services, Australia*, Cat. no. 5368.0. Data on sales of goods and services are taken from ABS, *Business Indicators, Australia*, Cat. no. 5676.0.

Imported Input Shares ( $\alpha^i$ ): Data on the input-output structure of production are taken from the ABS, *Australian National Accounts: Input-Output Tables*, Cat. no. 5209.0 for 1996/97. Import shares for each input industry are calculated as the ratio of the value of imports from ABS, *International Trade in Goods and Services, Australia*, Cat. no. 5368.0, to the value of sales of goods and services for each industry from ABS, *Summary of Industry Performance, Australia* Cat. no. 8140.0.55.002. Labour costs are taken from ABS, *Wage and Salary*

*Earners, Australia*, Cat. no. 6248.0, and deflated by the price index for materials used in manufacturing from ABS, *Producer Price Index*, Cat. no. 6427.0.

Average Markup ( $AMKUP_t$ ): Data on company gross operating profits, sales and inventories are taken from ABS, *Business Indicators, Australia*, Cat. no. 5676.0.

## References

Campa, J. and Goldberg, L. S. 1995, 'Investment in Manufacturing, Exchange Rates and External Exposure', *Journal of International Economics*, vol. 38, no. 3-4, pp. 297-320.

Campa, J. M. and Goldberg, L. S. 1999, 'Investment, Pass-Through and Exchange Rates: A Cross-Country Comparison', *International Economic Review*, vol. 40, no. 2, pp. 287-314.

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

Domowitz, I., Hubbard, R. G. and Petersen, B. C. 1986, 'Business Cycles and the Relationship between Concentration and Price-Cost Margins', *Rand Journal of Economics*, vol. 17, no. 1, pp. 1-17.

Dornbusch, R. 1987, 'Exchange Rates and Prices', *American Economic Review*, vol. 77, no. 1, pp. 93-106.

Driver, C. and Dowrick, S. 1997, 'Investment Intentions as an Indicator of Actual Investment in Australian Manufacturing', *Australian Economic Papers*, vol. 36, no. 68, pp. 90-105.

Goldberg, P. K. and Knetter, M. M. 1997, 'Goods Prices and Exchange Rates: What Have We Learned?', *Journal of Economic Literature*, vol. 35, no. 3, pp. 1243-1272.

- Newey, W. and West, K. 1987, 'A Simple Positive-Definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix', *Econometrica*, vol. 55, no. 3, pp. 703-708.
- Nucci, F. and Pozzolo, A. F. 2001, 'Investment and the exchange rate: An analysis with firm-level panel data', *European Economic Review*, vol. 45, no. 2, pp. 259-283.
- Swift, R. F. 2005, 'The Changing External Exposure of Australian Industry', *Australian Economic Review*, *forthcoming*.