CENTRE of POLICY STUDIES and the IMPACT PROJECT

Eleventh Floor
Menzies Building
Monash University Wellington Road
CLAYTON Vic 3168 AUSTRALIA
Telephone: (03) 565 2398, (03) 565 5112 — from overseas: 61 3 565 2398 or 61 3 565 5112
Fax numbers: (03) 565 2426, (03)565 5486 — from overseas: 61 3 565 2426 or 61 3 565 5486
e-mail impact@vaxc.cc.monash.edu.au

Exchange Rate Pass-Through Elasticities for the MONASH Model: A Disaggregate Analysis of Australian Manufactured Imports

by

Jayant Menon

Centre of Policy Studies
Monash University

Working Paper No. OP-76 July 1993

ISSN 1031 9034 ISBN 0 642 10281 3

The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to quantitative analysis of issues relevant to Australian economic policy. The Impact Project is a cooperative venture between the Australian Federal Government and Monash University, La Trobe University, and the Australian National University. During the three years January 1993 to December 1995 COPS and Impact will operate as a single unit at Monash University with the task of constructing a new economy-wide policy model to be known as *MONASH*. This initiative is supported by the Industry Commission on behalf of the Commonwealth Government, and by several other sponsors. The views expressed herein do not necessarily represent those of any sponsor or government.

ABSTRACT

The objective of this study is to analyse the exchange rate pass-through relationship for Australian imports of manufactures covering the period 1981q3 to 1991q2. The analysis is conducted in two stages. First, pass-through coefficients are estimated for total manufactures and 50 product categories contained therein. This is done by applying an econometric procedure which avoids the pit-falls in previous studies to a carefully assembled data set. Particular attention is paid to dealing with the time series properties of the data. Second, the determinants of inter-product differences in the degree of pass-through is analysed. This is done by relating the pass-through coefficients to a series of variables representing foreign control, non-tariff barriers (NTBs), product characteristics and market structure within a cross-section regression framework. A number of interesting results emerge from the analysis. First, pass-through is incomplete for most products, with significant differences in the degree of pass-through across products. Second, recursive estimation rejects the hypotheses of the "hysteresis" effect in Australian import prices, and the asymmetric pass-through of exchange rate depreciations and appreciations in all cases. Finally, the results suggest that quantitative restrictions, foreign control, concentration, product differentiation and the import share of the domestic market are negatively related to pass-through, where as the substitutability between imported and domestically produced goods is positively related to pass-through.

J.E.L. Classification numbers: F31, F32, F17

CONTENTS

LIST OF TABLES

Figure 3(47)

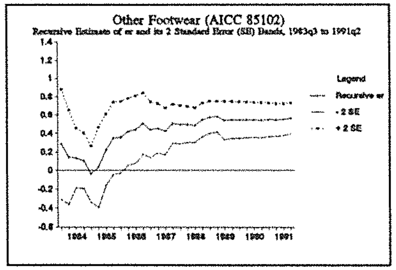


Figure 3(48)

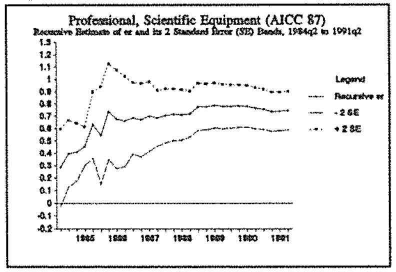


Figure 3(49)

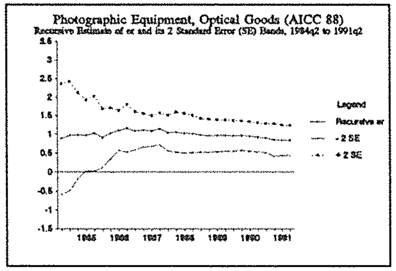


Figure 3(50)

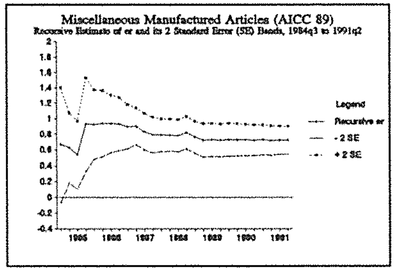


Figure 3(51)

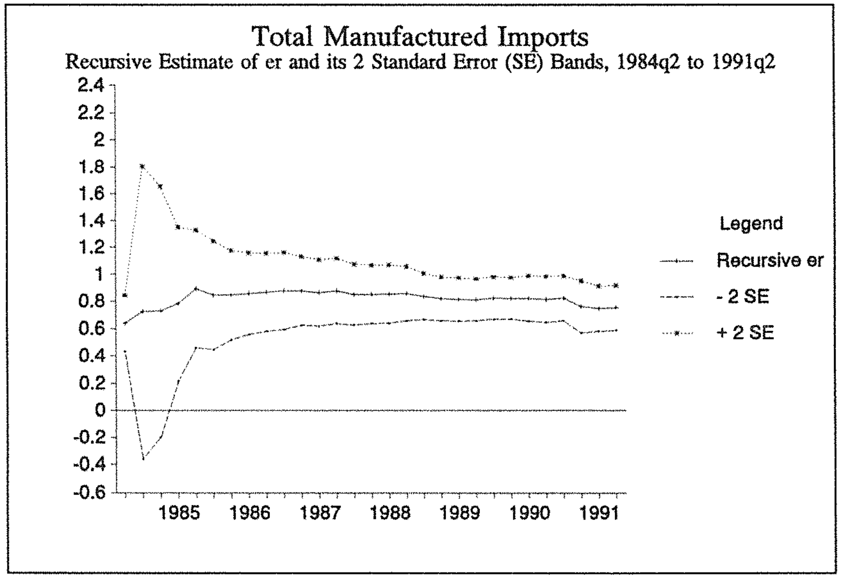


Figure 3(39)

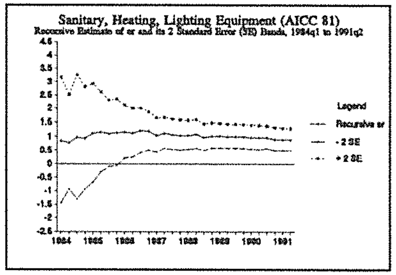


Figure 3(40)

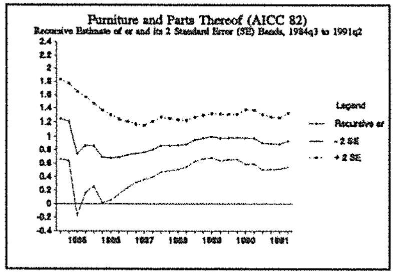


Figure 3(41)

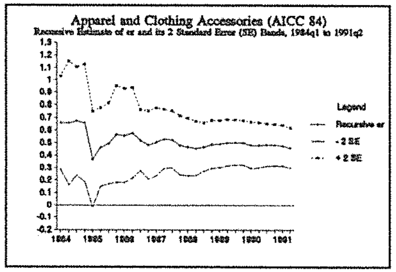


Figure 3(42)

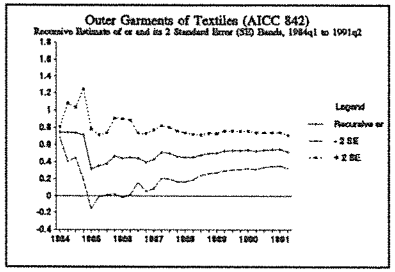


Figure 3(43)

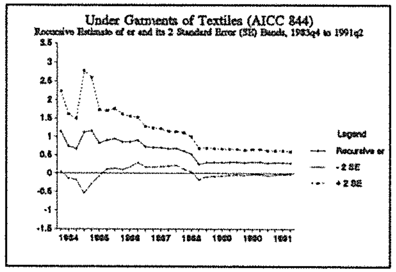


Figure 3(44)

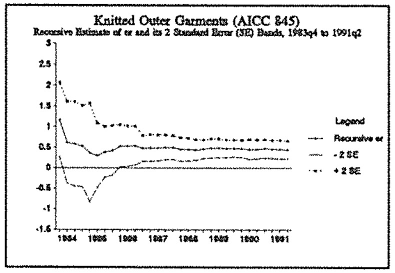


Figure 3(45)

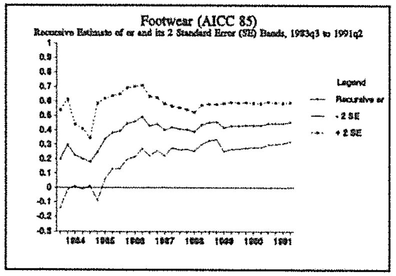
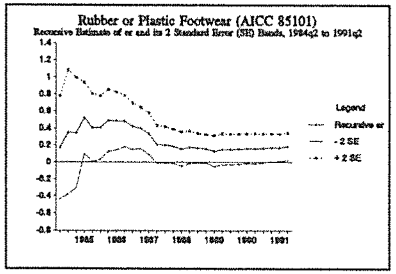


Figure 3(46)



LIST OF FIGURES

Figure 3(31)

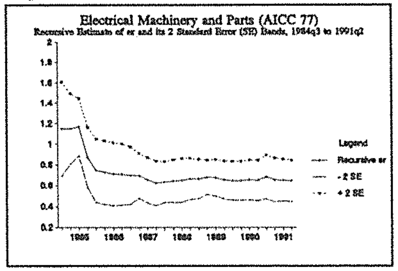


Figure 3(32)

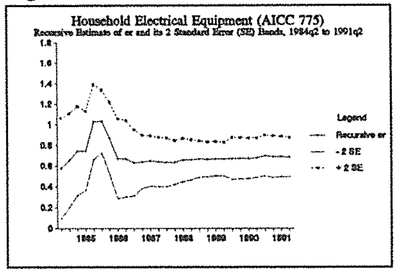


Figure 3(33)

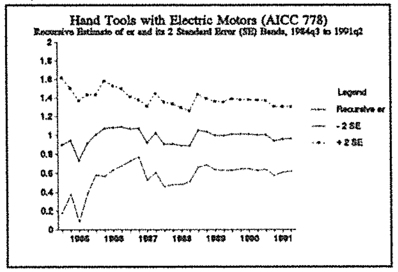


Figure 3(34)

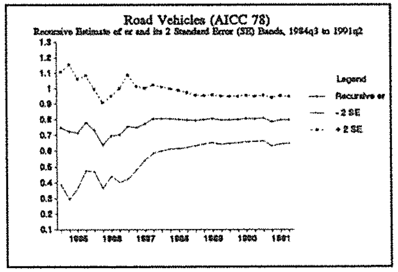


Figure 3(35)

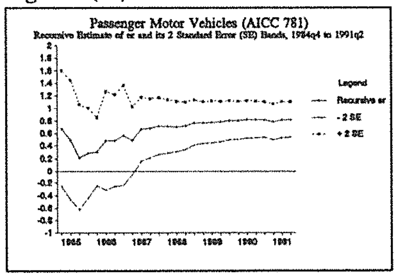


Figure 3(36)

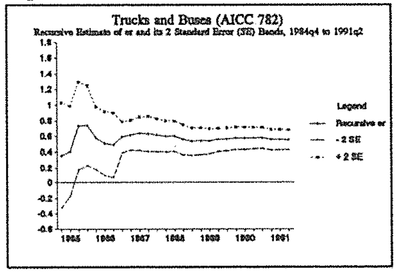


Figure 3(37)

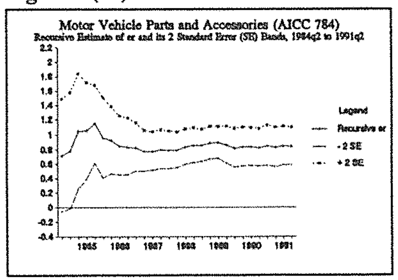


Figure 3(38)

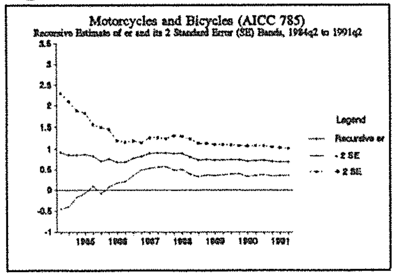


Figure 3(23)

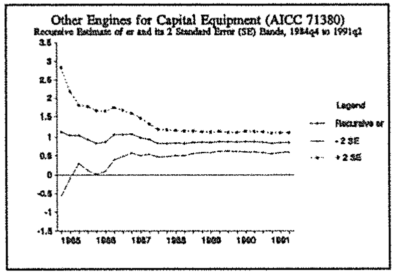


Figure 3(24)

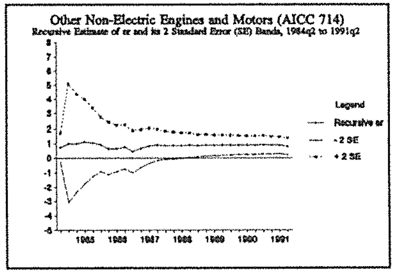


Figure 3(25)

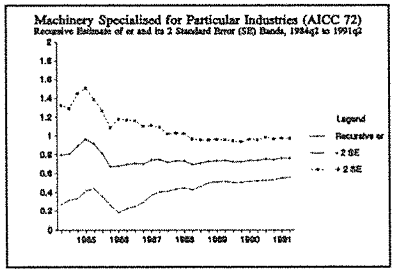


Figure 3(26)

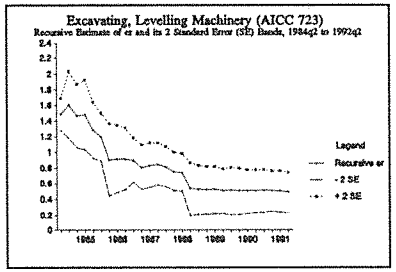


Figure 3(27)

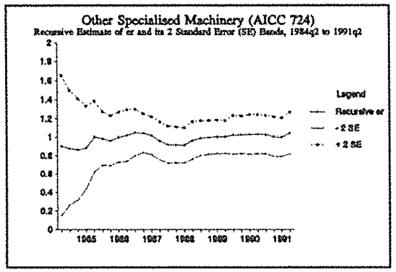


Figure 3(28)

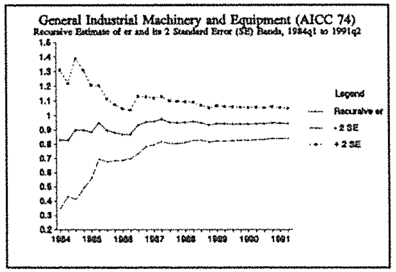


Figure 3(29)

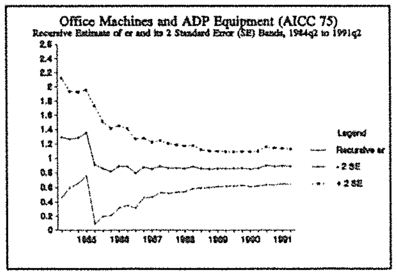
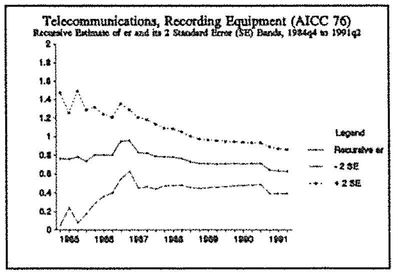


Figure 3(30)



Exchange Rate Pass-Through Elasticities for the *MONASH* Model: A Disaggregate Analysis of Australian Manufactured Imports[1]

by

Jayant Menon
Centre of Policy Studies
Monash University

1. Introduction

The debate over fixed versus flexible exchange rates is one of the longest running sagas in the international economics literature. The case for flexible exchange rates, as it was initially and forcefully put by Friedman (1953) and Johnson (1969), had as one of its pillars the claim that it would provide for a more efficient system of international adjustment. In this context, the advent of floating exchange rates after the breakdown of the Bretton Woods system was greeted with enthusiasm, as it was felt that currencies had moved way out of line from their equilibrium rates during the Bretton Woods era. Under the floating exchange rate regimes, foreign exchange markets around the world have been characterised by a considerable amount of variability. The Australian dollar (AUD) has not been an exception. The initial enthusiasm about the expected equilibrating role of floating exchange rates began to wane, however, as the trade balances of major trading nations continued to show remarkable resilience to such changes.

This has led to a frantic search for explanations to account for this "adjustment puzzle". The conventional explanations couched in terms of elasticity pessimism

(1) This study is based on my doctoral dissertation (Menon, 1992c) read at the University of Melbourne. I owe my biggest intellectual debt to my supervisors, Peter Dixon and Premachandra Athukorala. Their dedication to supervising this thesis over the past three and a half years has been nothing short of outstanding. I received very useful comments from the thesis examiners, Mordechai Kreinin and Bee Yan Aw-Roberts. Useful suggestions were also received from Robert Feinberg, Jon Kendall, John Freebairn, Tom Taylor, Larry Sjasstad, Brian Parmenter and Alan Powell. Needless to say, I remain solely responsible for any errors of omission or commission. For assistance with the compilation and preparation of the data base, I wish to thank Geoff Brown, Peter Cordy and Paul Emery. I am grateful for financial assistance received from the Institute of Applied Economic and Social Research at the University of Melbourne and the Centre of Policy Studies at Monash University for the purchase of the large amount of unpublished data used in this study. I am also grateful to Victoria University and Chisholm College at La Trobe University for granting me study leave to complete this study.

have little to offer in resolving this issue; there is now a vast empirical literature that has convincingly established the case that Marshall-Lerner conditions are easily satisfied in most countries (see Goldstein and Khan, 1985). In this context, a number of authors have been motivated to step back and examine more closely the underlying relationship between exchange rates and prices of internationally traded goods, now popularly known as the exchange rate pass-through relationship[2]. Exchange rate pass-through refers to the degree to which exchange rate changes are reflected in the destination currency prices of traded goods.

The reason for the inability of even the "elasticity optimists" to account for the sluggishness of trade flows to exchange rate changes may lie with the fact that they *assume* that exchange rate changes are fully passed-through to prices of traded goods. If exchange rate changes are not fully or substantially reflected in the selling prices of traded goods, then the anticipated quantity adjustment will be retarded even if the degree of demand elasticity is sufficiently large. In other words, a low pass-through would make it possible for trade flows to remain relatively insensitive to exchange rate changes, despite demand being highly elastic. Furthermore, if significant lags exist in the transmission of exchange rate changes to prices, coupled with the subsequent lag in the quantity-response to the relative price change, then the overall balance of payments adjustment process could be severely retarded.

The pass-through issue has been prominent in the policy debates in Australia following the massive depreciation of the AUD over the 1985-86 period, and the sustained appreciation since then. The widening current account deficit, and the lack of import replacement that followed the depreciation raised considerable concern among policy makers, especially in light of most studies pointing to a relatively high elasticity of import demand (see Gordon, 1986; Athukorala and Menon, 1988; Phillips, 1989).

Following the period of depreciation, concern has shifted towards the failure of import prices to fall in response to the strengthening of the AUD over recent years. This concern was so great that the then Treasurer, Mr. Keating, announced an inquiry by the Prices Surveillance Authority (PSA) into import prices. In making the announcement, Mr. Keating had the following to say: "...it is clear that the benefits of the recent exchange rate appreciation are not yet widely evident in

(2) In this paper, the terms "exchange rate pass-through" and "pass-through" are used interchangeably.

Figure 3(15)

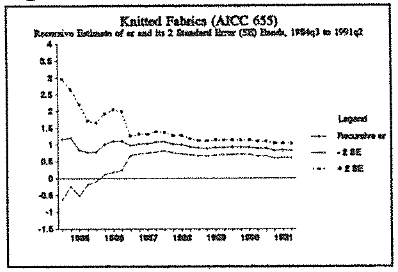


Figure 3(16)

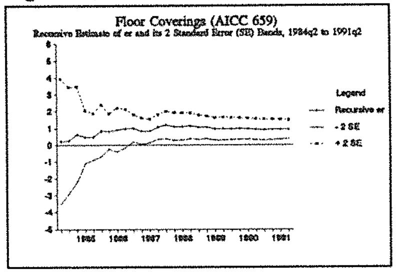


Figure 3(17)

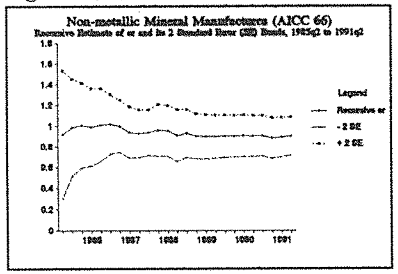


Figure 3(18)

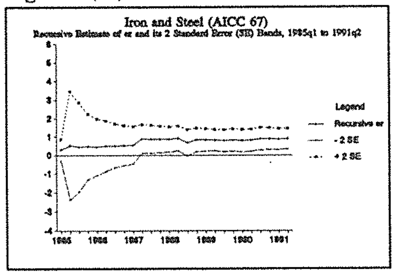


Figure 3(19)

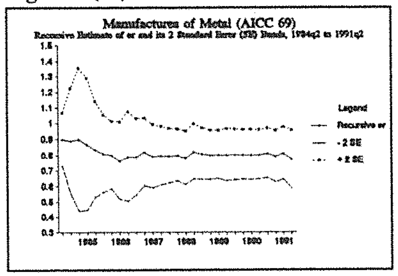


Figure 3(20)

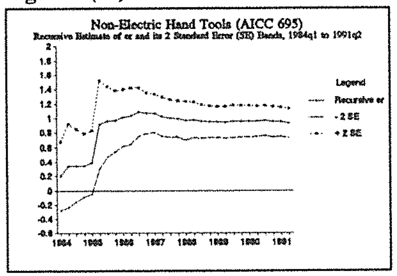


Figure 3(21)

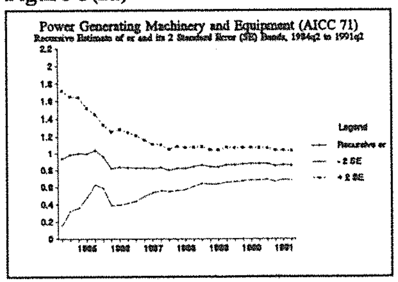


Figure 3(22)

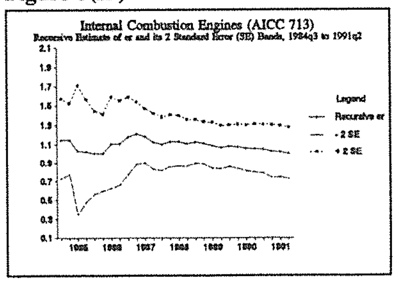


Figure 3(7)

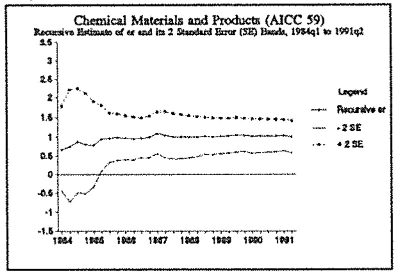


Figure 3(8)

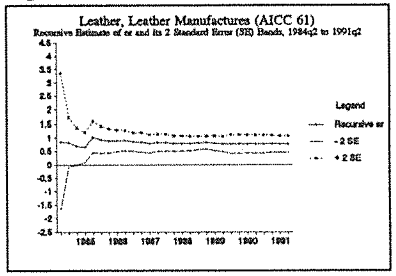


Figure 3(9)

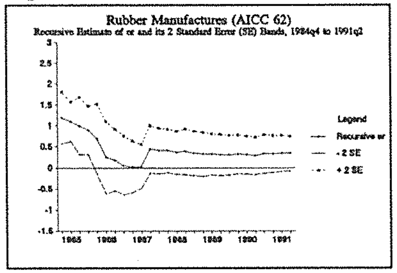


Figure 3(10)

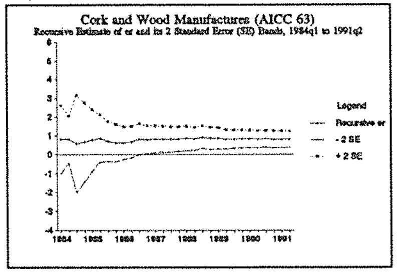


Figure 3(11)

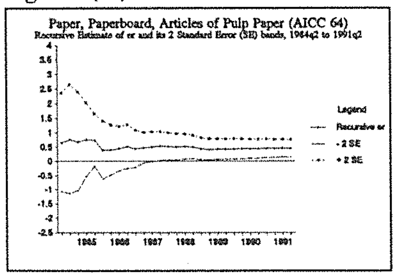


Figure 3(12)

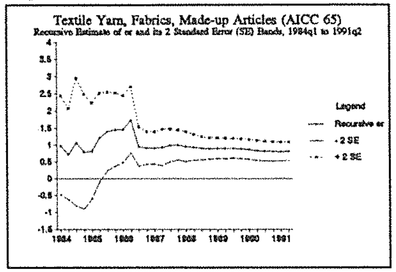


Figure 3(13)

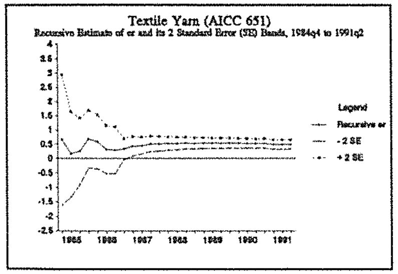
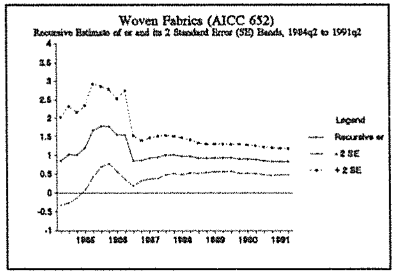


Figure 3(14)



consumer prices" (*The Age*, 19 November 1988). More recently, the current Treasurer, Mr. Dawkins, has called for a review of the initial decision to float the AUD and has proposed a return to a more managed regime, thus reflecting the widely held view that the floating system has failed to achieve its stated objectives. This is also the policy conclusion arrived at by Krugman (1989), based on his conjecture that "exchange rates no longer seem to work" as a result of the pervasive influence of the pass-through and pricing to market phenomenon in the 1980s.

The objective of this study is to provide an in-depth analysis of the exchange rate pass-through relationship and the hysteresis effect for Australian imports of manufactures covering the period 1981q3 to 1991q2. First, it seeks to establish the degree to which import prices in domestic currency (AUDs) have responded to the massive fluctuations in the AUD during this period. Exchange rate pass-through elasticities are estimated for total manufactured imports and 50 product categories defined at the 2-digit level of the AICC. These elasticities will form part of the elasticity files of the *MONASH* Model currently being developed at the Centre of Policy Studies at Monash University. This is done by applying an econometric procedure which avoids the pit-falls in previous studies to a carefully assembled data set. To avoid the problems of "spurious" regressions, the econometric methodology is chosen on the basis of the time-series properties of the data.

The concept of "hysteresis" in import prices has received a lot of attention of late, particularly in the US (Baldwin, 1988; Krugman, 1989; Dixit, 1989). This study aims to test the hysteresis hypothesis for the Australian case by employing a more general and formal methodology than the conventional structural stability tests commonly used in previous studies. In this study, the recursive estimation procedure, which is a special case of the Kalman filter, is used to test this hypothesis. Recursive estimation also provides a better framework to test the now fashionable hypothesis of asymmetric pass-through during periods of depreciation and appreciation of the exchange rate.

After estimating the pass-through coefficients for each of the product categories, we proceed to investigate the determinants of inter-product differences in the degree of pass-through. Previous attempts at explaining inter-product differences in pass-through have yielded inconclusive results by focussing only on market structure and product characteristics (see Phillips, 1988; Kreinin *et al*, 1987; Fischer, 1989b). Apart from market structure and product characteristics, our analysis attempts to capture the role played by structural characteristics and the institutional setting within which importing activities are undertaken in individual product categories. For the first time, based on a theory developed on the effects of multinational corporations (MNCs) on trade pricing (Section 2.2), we attempt to explain inter-product differences in pass-through by the presence of MNCs on the international trade scene. We also formally test what has become commonly known in the pass-through literature as the "Bhagwati hypothesis" (Section 2.3), by investigating the effects of non-tariff barriers (NTBs) on the pass-through relationship across product categories.

In addition to its contribution to the Australian policy debate, this study should also have something to contribute to the general literature on pass-through. First, most previous studies on pass-through, including Phillips (1988) and Lattimore (1988) on the Australian experience, have ignored the time series properties of the data in conducting their estimations. Given that the data used to estimate pass-through is usually trended, it is likely that previous estimates of pass-through may have been biased as a result of the non-stationarity of the data. Second, studies on pass-through using data disaggregated at the product level are still relatively sparse in the empirical literature. Apart from overcoming the problem of "aggregation bias", disaggregating the data would enable more accurate estimation of the time-lags involved in the pass-through process (Hooper and Mann, 1989).

Third, most previous studies are subject to limitations imposed by inadequate data. In particular, there are reasons to suspect that the use of defective data with respect to both import and "world" prices would have biased the reported pass-through estimates. In the absence of actual import prices, these studies have been forced to rely on price proxies such as unit values - which suffer from a number of well-known deficiencies, and which become particularly severe in the case of manufactures. In this study, we use actual import prices, and overcome problems associated with a "world" price index by employing a foreign cost of production index instead. Finally, much of the empirical work on pass-through has concentrated on the experience of "large country" cases, especially that of the US and Japan. Generalisations based on the experience of these countries for the smaller and more trade-dependent economies such as Australia would be highly questionable. It is expected that evidence for the small-country case of Australia using data disaggregated at the product level will add variety in the form of a greater coverage of country/commodity situations to this literature.

The paper is organised in 6 sections. Section 2 discusses the theory underlying the pass-through relationship. The models and data used to estimate the degree and

Figure 3
Recursive Estimate of Exchange Rate Pass-through Coefficient (*er*) and its Two Standard Error (SE) Bands for Total Manufacturing and Manufacturing Products Disaggregated at the 2 and 3-Digit Level of the AICC

Figure 3(1)

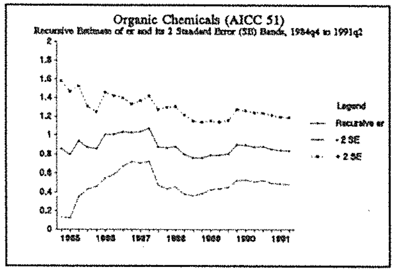


Figure 3(2)

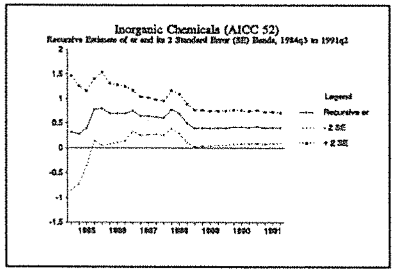


Figure 3(3)

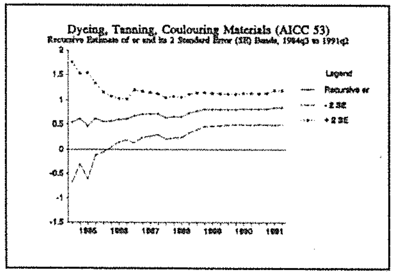


Figure 3(4)

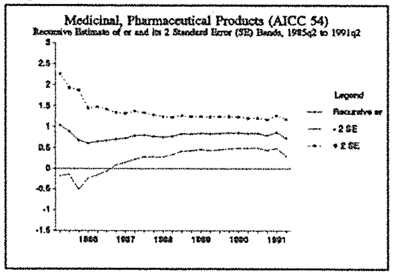


Figure 3(5)

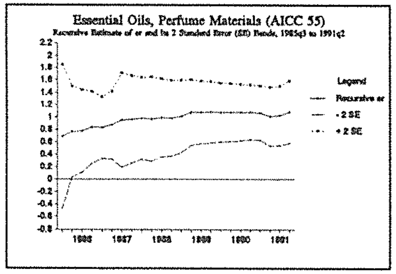


Figure 3(6)

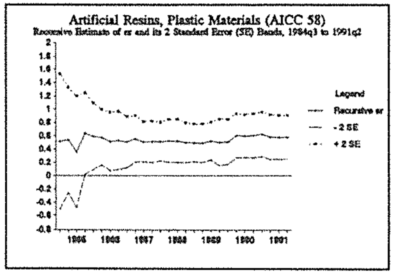


Table B4 (Cont.)

(51) **Total manufactured imports**

$$\Delta pm_t = \underset{(-2.08)}{-0.01} + \underset{(14.60)^{***}}{0.59\Delta er_t} + \underset{(3.92)^{***}}{0.17\Delta er_{t-1}} + \underset{(2.94)^{***}}{0.76\Delta cp_t} + \underset{(2.57)^{***}}{0.66\Delta pd_t}$$

Adjusted R^2 = 0.91, SEE = 0.01, $F(7,30)$ = 52.83, DW = 2.01, VDT(5,24) = 0.62
LM4(4,26) = 0.70, RESET(1,29) = 1.50, NORM(2) = 1.21, HT(1,36) = 1.95.

Notes:
1) All variables are expressed in natural logarithms; Δ is the difference operator, and the superscript on Δ denotes the order of the differences; Critical values for the diagnostic tests at the 5 percent level of significance (with degrees of freedom in parenthesis) are as follows. LM4(4,20) = 2.78; HT(1,35) = 4.78; RESET(1,23) = 4.17; NORM(2) = 10.59; VDT (5,24) = 4.93; EXO(1,23) = 4.17. Apart from the normality test, which is distributed as $\chi^2(2)$, the others are based on the F-distribution. Critical values for the t-ratios for a sample of 40 are as follows: 10 percent = 1.303 (*), 5 percent = 1.684 (**) and 1 percent = 2.423 (***). The definitions of each of the test statistics are as follows: DW: Durbin-Watson statistic; NORM: Jarque-Bera test for Normality of the Residuals; RESET: Ramsey's test for functional form misspecification; HT: the general Breusch-Pagan procedure for heteroscedasticity; SEE: Standard error of equation; LM4: Lagrangian Multiplier test for forth-order serial correlation; ARCH: Engle's auto-regressive conditional heteroscedasticity test; VDT: Variable deletion test; EXO: Wu-Hausman test of exogeniety.

explain the differences in pass-through are the subject of Section 3. Section 4 discusses the econometric methodology, while Section 5 presents the results. A final section summarises the major findings and considers some of the policy implications of incomplete pass-through.

2. Theory

There are a number of reasons for which pass-through may be incomplete. These factors relate to market structure, product characteristics and hysteretic effects, intra-firm pricing practices of MNCs, and the effects of NTBs on the adjustment of traded goods prices to exchange rate changes.

2.1 Market Structure, Product Characteristics and Hysteresis

The theoretical explanations of incomplete pass-through have emphasised the role of market structure first, followed by product differentiation. These authors have been concerned to explain whether the empirical data on pass-through merely reflects short-run squeezing of profit margins by exporters, or if particular types of market organisation always lead to only a limited response of prices to exchange rate changes.

Under conditions of imperfect competition, pricing will no longer be at marginal cost, and firms would be in a position to charge a mark-up on costs to earn above normal profits even in the long run. The important issue that needs to be addressed in the context of imperfect competition relates to how this mark-up over marginal cost might vary in response to an exchange rate change. Two factors come to mind almost immediately: (i) the degree of substitutability between the domestic and imported good, as determined by the degree of product differentiation, and (ii) the degree of market integration or separation. Both these factors can be viewed as forces that come into play to determine the price-setting power of firms, and will affect the leverage available to them in responding to exchange rate changes. The lower the degree of substitutability between these goods, and the lower the degree of market integration, the greater will be the market power of sellers.

Dornbusch (1987) considers the Dixit-Stiglitz (1977) model and Salop's (1979) model of competition on a circle to capture the effect of imperfect substitutability and product differentiation on the price response to exchange rate changes. He finds that the degree of pass-through is directly related to the degree of substitutability between the domestic and imported good. Fischer (1989a) considers the case where firms are Bertrand competitors (or Nash price setters) and where foreign firms produce for both the home and export market, but do not practice price discrimination. He finds that if markets are segmented so that arbitrage is limited, an appreciation will lead to a higher pass-through if the domestic market is monopolistic relative to the foreign market.

Manufactured goods are typically viewed as being highly differentiated and frequently sold in imperfectly competitive and segmented markets where arbitrage is costly, and mostly unprofitable. There is a considerable amount of empirical evidence to support both these views about manufactured goods. First, there is the large number of empirical studies that point to the failure of the law of one price for manufactured goods at the most disaggregated level for which data are available. These studies can be divided into the following two categories, which we will call Test 1 and Test 2 of the law of one price: (i) Test 1 of the law of one price compares the price of imports and domestic-competing goods sold in the domestic market, and (ii) Test 2 compares the price of the domestic good sold on the domestic and the export market, or in two different export markets.

Test 1 is designed to capture the effect of imperfect substitutability between goods produced by different countries but sold in the *one market* as an independent cause of violation of the law of one price. Test 2 focuses on the good produced in one country but sold in different markets. Violation of Test 2 would be attributable to segmented markets which prevent differences in price of the *same good* from being arbitraged away. Examples of violation of Test 1 are Isard (1977), Kravis and Lipsey (1978), and Richardson (1978). Examples of violation of Test 2 are Knetter (1989), Marston (1990), and Kasa (1992). The results from these studies overwhelmingly support the view that there are significant and non-transitory differences in prices following exchange rate changes, as a result of either imperfect substitution between goods or the presence of segmented markets.

Second, the pervasiveness of intra-industry trade in manufactures and the failure to observe *either* the domestic or the foreign good capturing the whole market (when produced under constant or decreasing costs) lends further support to the view that domestic and foreign manufactured goods are imperfect substitutes (see, for instance, Greenaway and Milner, 1986; Goldstein and Khan, 1985).

Apart from imperfect substitutability and segmented markets, a number of recent studies have examined how different market structures, and different assumptions

Table B4 (Cont.)

(48) **Professional, scientific and controlling instruments** (AICC 87)

$$\Delta pm_t = \underset{(1.55)^{*}}{0.01} + \underset{(10.50)^{***}}{0.73\Delta er_t} + \underset{(3.07)^{***}}{0.22\Delta er_{t-1}} + \underset{(0.92)}{0.52\Delta cp_{t-2}} + \underset{(1.02)}{0.18\Delta cp_{t-1}}$$

Adjusted R^2 = 0.77, SEE = 0.02, $F(7,29)$ = 18.26, DW = 1.03, VDT(5,24) = 0.45
LM4(4,25) = 3.49, RESET(1,28) = 0.02, NORM(2) = 0.35, HT(1,35) = 0.96.

(49) **Photographic equipment and optical goods** (AICC 88)

$$\Delta pm_t = \underset{(-0.50)}{-0.01} + \underset{(7.11)^{***}}{0.65\Delta er_t} + \underset{(1.71)^{**}}{0.19\Delta er_{t-1}} + \underset{(1.33)^{*}}{1.01\Delta cp_{t-1}} + \underset{(0.40)}{0.13\Delta pd_t}$$

Adjusted R^2 = 0.61, SEE = 0.03, $F(7,30)$ = 9.26, DW = 2.32, VDT(5,24) = 0.45
LM4(4,26) = 1.09, RESET(1,29) = 0.15, NORM(2) = 2.68, HT(1,36) = 1.87.

(50) **Miscellaneous manufactured articles** (AICC 89)

$$\Delta pm_t = \underset{(-0.07)}{-0.01} + \underset{(12.61)^{***}}{0.55\Delta er_t} + \underset{(3.72)^{***}}{0.17\Delta er_{t-1}} + \underset{(1.30)^{*}}{0.45\Delta cp_t} + \underset{(0.84)}{0.30\Delta cp_{t-1}} + \underset{(0.33)}{0.09\Delta pd_t}$$

Adjusted R^2 = 0.82, SEE = 0.01, $F(8,29)$ = 22.78, DW = 2.05, VDT(4,24) = 0.42
LM4(4,25) = 1.03, RESET(1,28) = 2.24, NORM(2) = 3.60, HT(1,36) = 2.66.

Standard Errors (SEs) adjusted using White's Heteroscedasticity-Consistent Covariance Matrix

50c)
$$\Delta pm_t = \underset{(-0.06)}{-0.01} + \underset{(9.88)^{***}}{0.55\Delta er_t} + \underset{(3.00)^{***}}{0.17\Delta er_{t-1}} + \underset{(1.19)}{0.45\Delta cp_t} + \underset{(1.01)}{0.30\Delta cp_{t-1}} + \underset{(0.37)}{0.09\Delta pd_t}$$

Table B4 (Cont.)

(44) **Knitted outer garments** (AICC 845)

$$\Delta pm_t = \underset{(1.34)^{*}}{0.01} + \underset{(4.11)^{***}}{0.45\Delta er_t} + \underset{(1.67)^{**}}{0.70\Delta cp_{t-1}}$$

Adjusted R^2 = 0.35, SEE = 0.03, *F*(5,32) = 5.05, DW = 2.14, VDT(7,24) = 1.00
LM4(4,28) = 0.12, RESET(1,31) = 0.91, NORM(2) = 2.46, HT(1,36) = 0.44.

(45) **Footwear** (AICC 85)

$$\Delta pm_t = \underset{(1.27)}{0.02} + \underset{(6.73)^{***}}{0.46\Delta er_t} + \underset{(1.92)^{**}}{0.53\Delta cp_t}$$

Adjusted R^2 = 0.52, SEE = 0.02, *F*(5,33) = 9.24, DW = 1.87, VDT(7,24) = 0.39
LM4(4,29) = 0.98, RESET(1,32) = 3.88, NORM(2) = 3.76, HT(1,37) = 0.01.

(46) **Rubber or plastic footwear** (AICC 85101)

$$\Delta pm_t = \underset{(-0.64)}{-0.01} + \underset{(2.32)^{**}}{0.18\Delta er_t} + \underset{(1.54)^{*}}{0.55\Delta cp_t} + \underset{(0.68)}{0.27\Delta pd_t} + \underset{(0.88)}{0.34\Delta pd_{t-1}}$$

Adjusted R^2 = 0.41, SEE = 0.02, *F*(7,30) = 2.89, DW = 2.01, VDT(5,24) = 0.52
LM4(4,26) = 0.99, RESET(1,29) = 0.01, NORM(2) = 1.97, HT(1,36) = 3.39.

(47) **Other footwear** (AICC 85)

$$\Delta pm_t = \underset{(1.00)}{0.01} + \underset{(6.68)^{***}}{0.56\Delta er_t} + \underset{(1.44)^{*}}{0.55\Delta cp_t}$$

Adjusted R^2 = 0.53, SEE = 0.03, *F*(5,33) = 9.51, DW = 1.77, VDT(7,24) = 0.49
LM4(4,29) = 1.66, RESET(1,32) = 3.26, NORM(2) = 1.83, HT(1,37) = 0.01.

about the behaviour of firms will affect pass-through. Dornbusch (1987) considers the case of a Cournot industry with a linear demand curve and constant costs and shows that the degree of pass-through is positively related to the ratio of the number of foreign firms to total firms and on the total number of firms. Sibert (1992) extends this aspect of Dornbusch's (1987) analysis and examines the effects that different degrees of collusion and market shares of foreign firms have on pass-through. Sibert finds that Dornbusch's result that pass-through is increasing in the number of foreign firms generalises to a variety of behavioural assumptions.

Let us consider the case of the Cournot oligopoly model in some detail. The Cournot case is useful not only because it is probably the most widely accepted benchmark, but also because this formulation concentrates on features of the market structure in explaining the price response by assuming perfect substitutability between the domestic and imported good. The analysis is based on Dornbusch (1987) and Venables (1990).

Suppose that there are n^D domestic firms, all of which are identical, and n^F foreign firms, all of which are identical to each other, but not to the domestic firms. In a Cournot setting, we assume that each firm chooses its sales in the domestic market given the sales of the other firms, and then price is determined from the demand curve.

The profits of the n^D domestic firms are given by:

$$\pi^D = Px^D - C^D(x)^D \quad (1)$$

and for the n^F foreign firms:

$$\pi^F = Px^F - ER\, C^F x^F \quad (2)$$

where x^D and x^F are the outputs of the domestic and the foreign firms, and $C^D(x^D)$ is the cost function of domestic firms, P is the market price, and ER is the exchange rate (foreign currency price of domestic currency). For simplicity, we assume that marginal cost of foreign firms, C^F, is constant in their currency.

We can write the inverse demand function as $P(X)$, where $X = n^D x^D + n^F x^F$.

Profit maximisation by each firm, given the output of the other firms, yields the following first-order conditions for the domestic and foreign firms:

$$P\{1 - x^D / (\epsilon_D X)\} = C^D \qquad (3)$$

and

$$P\{1 - x^F / (\epsilon_D X)\} = ER\, C^F \qquad (4)$$

where ϵ_D is the elasticity of domestic demand.

By denoting the market shares of each domestic and foreign firm as β^D and β^F, we can re-write equations (3) and (4) in the following way. The necessary conditions for profit maximisation for each of the n^D domestic firms are:

$$P(1 - \beta^D/\epsilon_D) = C^D \qquad (5)$$

and for each of the n^F foreign firms:

$$P(1 - \beta^F/\epsilon_F) = ER\, C^F \qquad (6)$$

where C^D and C^F represent the marginal cost of domestic and foreign firms, respectively.

From equations (5) and (6), we can see that the firm's mark-up on marginal cost in determining its price is an increasing function of its market share. This outcome is easily seen for the extreme cases of pure monopoly and perfect competition, where β is 1 and close to 0, respectively.

In order to determine the equilibrium price in the market, we add up the n^D equations (equation 5) plus the n^F equations (equation 6), noting that the sum of market shares equals one, i.e., $n^D\beta^D + n^F\beta^F = 1$.

The equilibrium price in the market is then given by:

$$P = \epsilon_D\{n^D C^D + n^F ER\, C^F\}/\{\epsilon_D(n^F + n^D) - 1\} \qquad (7)$$

Equation (7) states that the market price depends on the sum of marginal costs (in domestic currency terms) of all firms in the market. Since a change in the exchange rate, *ER*, affects only the n^F foreign firms, it is clear that there will be less than 100 per cent pass-through.

To see how the number of domestic firms relative to foreign firms will affect the degree of pass-through, assume that marginal costs are constant, and that foreign

Table B4 (Cont.)

(40) **Furniture and parts thereof** (AICC 82)

$$\Delta pm_t = \underset{(0.96)}{0.01} + \underset{(7.39)^{***}}{0.72\Delta er_t} + \underset{(0.36)}{0.05\Delta er_{t-1}} + \underset{(2.04)^{**}}{0.59\Delta cp_t} + \underset{(0.29)}{0.09\Delta cp_{t-1}} + \underset{(1.66)^{**}}{0.29\Delta pm_{t-1}}$$

Adjusted R^2 = 0.60, SEE = 0.03, *F*(9,28) = 7.17, DW = 2.04, VDT(4,24) = 0.08
LM4(4,25) = 1.59, RESET(1,28) = 0.24, NORM(2) = 1.69, HT(1,36) = 0.05.

(41) **Articles of apparel and clothing accessories** (AICC 84)

$$\Delta pm_t = \underset{(1.37)^{*}}{0.01} + \underset{(5.77)^{***}}{0.46\Delta er_t} + \underset{(1.63)^{**}}{0.52\Delta cp_t} + \underset{(0.69)}{0.23\Delta cp_{t-1}}$$

Adjusted R^2 = 0.49, SEE = 0.02, *F*(6,31) = 6.93, DW = 1.79, VDT(6,24) = 0.89
LM4(4,27) = 0.05, RESET(1,30) = 0.35, NORM(2) = 0.46, HT(1,36) = 0.48.

(42) **Outer garments of textile** (AICC 842)

$$\Delta pm_t = \underset{(1.56)}{0.01} + \underset{(5.30)^{***}}{0.52\Delta er_t} + \underset{(1.65)^{**}}{0.47\Delta cp_t} + \underset{(0.23)}{0.09\Delta cp_{t-1}}$$

Adjusted R^2 = 0.41, SEE = 0.02, *F*(6,31) = 5.35, DW = 1.56, VDT(6,24) = 0.59
LM4(4,27) = 0.61, RESET(1,30) = 0.79, NORM(2) = 0.64, HT(1,36) = 0.02.

(43) **Under garments of textile** (AICC 844)

$$\Delta pm_t = \underset{(-1.60)}{-0.03} + \underset{(1.73)^{**}}{0.27\Delta er_t} + \underset{(3.18)^{***}}{1.01\Delta cp_{t-1}} + \underset{(0.92)}{1.11\Delta pd_t}$$

Adjusted R^2 = 0.26, SEE = 0.04, *F*(6,32) = 3.15, DW = 2.26, VDT(6,24) = 1.04
LM4(4,28) = 1.21, RESET(1,31) = 2.65, NORM(2) = 2.37, HT(1,37) = 0.02.

Table B4 (Cont.)

(36) **Trucks and buses** (AICC 782)

$$\Delta pm_t = \underset{(0.63)}{0.01} + \underset{(8.73)}{0.55\Delta er_t} + \underset{(1.69)^{**}}{0.50\Delta cp_t} + \underset{(1.79)^{*}}{0.80\Delta^2 pd_t} + \underset{(1.05)}{0.48\Delta^2 pd_{t-1}}$$

Adjusted $R^2 = 0.72$, SEE = 0.02, $F(7,29) = 14.19$, DW = 2.38, VDT(5,23) = 0.92
LM4(4,25) = 1.19, RESET(1,28) = 4.56, NORM(2) = 0.15, HT(1,35) = 3.38.

(37) **Motor vehicle parts and accessories** (AICC 784)

$$\Delta pm_t = \underset{(-0.98)}{-0.01} + \underset{(10.51)^{***}}{0.67\Delta er_t} + \underset{(2.85)^{***}}{0.18\Delta er_{t-1}} + \underset{(1.76)^{**}}{1.11\Delta cp_{t-1}} + \underset{(2.03)^{**}}{0.32\Delta pd_t}$$

Adjusted $R^2 = 0.82$, SEE = 0.02, $F(7,30) = 25.19$, DW = 2.03, VDT(5,24) = 0.27
LM4(4,26) = 1.08, RESET(1,29) = 0.10, NORM(2) = 0.53, HT(1,36) = 1.02.

(38) **Motorcycles and bicycles** (AICC 785)

$$\Delta pm_t = \underset{(-1.79)^{**}}{-0.02} + \underset{(7.08)^{***}}{0.59\Delta er_t} + \underset{(1.22)}{0.10\Delta er_{t-1}} + \underset{(1.12)}{1.06\Delta cp_{t-2}}$$

Adjusted $R^2 = 0.61$, SEE = 0.03, $F(6,30) = 10.37$, DW = 1.99, VDT(6,24) = 0.46
LM4(4,26) = 0.33, RESET(1,29) = 3.66, NORM(2) = 0.83, HT(1,35) = 2.96.

(39) **Sanitary, heating, lighting fixtures and fittings** (AICC 81)

$$\Delta pm_t = \underset{(0.17)}{0.01} + \underset{(6.25)^{***}}{0.63\Delta er_t} + \underset{(2.84)^{***}}{0.27\Delta er_{t-1}} + \underset{(1.47)^{*}}{0.83\Delta cp_t}$$

Adjusted $R^2 = 0.54$, SEE = 0.03, $F(6,31) = 8.12$, DW = 2.28, VDT(6,24) = 0.87
LM4(4,27) = 1.29, RESET(1,30) = 0.68, NORM(2) = 1.04, HT(1,36) = 0.09.

and domestic marginal costs are equal. Pass-through is now given by:

$$\partial P/\partial ER = n^F / (n^F + n^D) \qquad (8)$$

From equation (8), it is shown that the degree of pass-through is a decreasing function of the ratio of domestic to foreign firms. We can see, for instance, that an equal number of domestic and foreign firms will result in a pass-through of 50 per cent, where as pass-through will fall to 33 per cent if there are twice as many domestic firms as there are foreign firms.

To see how the total number of firms in the market will affect pass-through, we go back to equations (3) and (4), totally differentiating the equilibrium around a point where $C^D = ER\ C^F$. Making the assumption that ϵ_D is constant, we can now write the formula for pass-through as:

$$\partial P/\partial ER = \{\sigma^F N\ ER\ C^F / N\ (1 - \sigma^F)C^D + \sigma^F\ ER\ C^F\} \qquad (9)$$

where $N = n^F + n^D$ = total number of firms, and $\sigma^F = n^F/N$ = share of foreign firms in the market.

From equation (9), we can see that $\partial P/\partial ER$ is strictly increasing in N, and as N approaches infinity, $\partial P/\partial ER$ approaches 1. We can also see that if $\epsilon^D{}_S$ = infinity, then equation (9) simply reduces to equation (8) above.

The approach that emphasises dynamic and inter-temporal behaviour underlies the more recent "hysteresis" models of pricing (Baldwin, 1988; Krugman, 1989; Dixit, 1989). The hysteresis models builds on the notion of irretrievable sunk costs associated with entry-exit decisions in world markets. It is based on the idea that the volatile climate of floating exchange rates has induced firms to adopt a "wait and see" approach. These models show that firms are less likely to enter a market following a "temporary" and/or "small" exchange rate change if there are significant sunk costs involved. These costs may include the establishment of a distribution and after-sales network, and the building-up of reputation. The entry decision will be hindered further if consumers show brand loyalty, thus lowering the prospects of earning sufficient initial profits to justify the entry decision.

Firms will also be deterred from leaving the market under these conditions, and may continue to service the market despite not being able to cover variable costs. Apart from losing the investment in reputation and other sunk costs, these firms may also consider the additional costs of re-entry in the future, especially if the exchange rate change is short-lived.

The hysteresis effect suggests that competition in the market will remain unchanged as long as exchange rate changes fluctuate within a set band, and that this band will be greater the higher the costs associated with entry and exit. This will result in a lower rate of pass-through, as firms fight to either stay in the market or deter entry. If the exchange rate moves outside this band, however, then entry and exit decisions will follow that permanently alter the structure of the market. That is, the new firms that have entered the market will not leave easily either, and the firms that have left may never re-enter. This may produce a structural break in the observed pass-through relationship, as the new competitive structure of the market may not be consistent with the historical rate of pass-through.

2.2 Multinational Corporations (MNCs) and Intra-Firm Trade

The massive instability in foreign exchange markets, and in particular the large exchange rate movements which have come to characterise floating exchange rates, have induced MNCs to actively employ intra-firm pricing policies which prevent or at least stagger the full transmission of exchange rate changes to selling prices in individual markets. This practice has facilitated the stabilisation of prices in domestic markets, and allowed subsidiaries of MNCs to avoid significant loss of market share following large exchange rate depreciations. Based on a survey-study of the pricing behaviour of UK firms following devaluation, Holmes (1978, p.118) reports that "the existence of a directly owned sales subsidiary appeared to be a helpful factor in enabling the firm to base its prices more accurately on what the market would bear. ... There was in fact a tendency for firms using their own subsidiaries for sales activities to hold prices in foreign currency". Dunn (1970) provides anecdotal evidence of MNCs employing their sales subsidiaries to facilitate similar pricing strategies in Canada.

There exists a number of ways in which MNCs can shield themselves against exchange rate uncertainty, or large and unfavourable exchange rate shocks. One of the most common and straight forward methods involves the use of internal or intra-corporate exchange rates that apply to intra-firm transactions. These exchange rates may vary significantly from the external or true exchange rate for prolonged periods, since they serve merely as a *clearing mechanism* for intra-firm trade. The use of these internal exchange rates by MNCs in order to achieve global profit-maximising objectives has long been recognised in the literature. In

Table B4 (Cont.)

(33) **Hand tools with electric motors** (AICC 778)

$$\Delta pm_t = \underset{(-0.43)}{-0.01} + \underset{(8.94)^{***}}{0.70\Delta er_t} + \underset{(2.83)^{***}}{0.26\Delta er_{t-1}} + \underset{(1.91)^{**}}{0.51\Delta cp_t} + \underset{(1.69)^{**}}{0.43\Delta cp_{t-2}}$$

Adjusted R^2 = 0.75, SEE = 0.02, $F(7,29)$ = 16.64, DW = 1.81, VDT(5,24) = 0.69
LM4(4,25) = 0.52, RESET(1,28) = 2.78, NORM(2) = 0.14, HT(1,35) = 0.01.

(34) **Road vehicles** (AICC 78)

$$\Delta pm_t = \underset{(-0.24)}{-0.01} + \underset{(17.79)^{***}}{0.66\Delta er_t} + \underset{(3.82)^{***}}{0.15\Delta er_{t-1}} + \underset{(0.47)}{0.26\Delta cp_t} + \underset{(1.50)^{*}}{0.76\Delta cp_{t-1}}$$

Adjusted R^2 = 0.90, SEE = 0.01, $F(7,30)$ = 50.35, DW = 2.39, VDT(5,23) = 0.97
LM4(4,26) = 0.33, RESET(1,29) = 4.01, NORM(2) = 0.18, HT(1,36) = 11.16.

Standard Errors (SEs) adjusted using White's Heteroscedasticity-Consistent Covariance Matrix

34c) $$\Delta pm_t = \underset{(-0.51)}{-0.01} + \underset{(14.27)^{***}}{0.66\Delta er_t} + \underset{(4.11)^{***}}{0.14\Delta er_{t-1}} + \underset{(2.44)^{***}}{1.02\Delta cp_{t-1}} + \underset{(0.51)}{0.16\Delta pd_{t-2}}$$

(35) **Passenger motor vehicles** (AICC 781)

$$\Delta pm_t = \underset{(-1.09)}{-0.02} + \underset{(10.26)^{***}}{0.69\Delta er_t} + \underset{(1.53)^{*}}{0.12\Delta er_{t-1}} + \underset{(0.32)}{0.39\Delta cp_t} + \underset{(0.52)}{0.65\Delta cp_{t-1}} + \underset{(1.20)}{0.66\Delta^2 pd_{t-2}}$$

Adjusted R^2 = 0.77, SEE = 0.03, $F(8,28)$ = 16.30, DW = 2.39, VDT(4,24) = 0.08
LM4(4,24) = 1.68, RESET(1,27) = 0.45, NORM(2) = 0.61, HT(1,35) = 2.98.

Table B4 (Cont.)

(30) **Telecommunications and sound recording equipment** (AICC 76)

$$\Delta pm_t = \underset{(-1.98)^{**}}{-0.02} + \underset{(7.34)^{***}}{0.42\Delta er_t} + \underset{(3.47)^{***}}{0.20\Delta er_{t-1}} + \underset{(1.98)^{**}}{0.12\Delta er_{t-2}} + \underset{(0.61)}{0.18\Delta cp_{t-1}} + \underset{(0.50)}{0.24\Delta pd_t}$$

Adjusted R^2 = 0.73, SEE = 0.02, $F(8,28)$ = 13.06, DW = 1.84, VDT(4,24) = 1.62
LM4(4,24) = 0.35, RESET(1,27) = 3.15, NORM(2) = 5.81, HT(1,35) = 2.82.

(31) **Electrical machinery and appliances** (AICC 77)

$$\Delta pm_t = \underset{(-1.45)^{*}}{-0.01} + \underset{(10.94)^{***}}{0.52\Delta er_t} + \underset{(2.73)^{***}}{0.13\Delta er_{t-1}} + \underset{(0.16)}{0.10\Delta cp_t} + \underset{(0.86)}{0.48\Delta cp_{t-2}} + \underset{(0.92)}{0.28\Delta pd_t} + \underset{(1.38)^{*}}{0.24\Delta pd_{t-2}}$$

Adjusted R^2 = 0.82, SEE = 0.01, $F(9,27)$ = 19.78, DW = 1.56, VDT(3,24) = 1.81
LM4(4,23) = 2.32, RESET(1,26) = 0.13, NORM(2) = 0.06, HT(1,35) = 0.23.

(32) **Household electrical equipment** (AICC 75)

$$\Delta pm_t = \underset{(-1.71)}{-0.01} + \underset{(11.78)^{***}}{0.55\Delta er_t} + \underset{(2.71)^{***}}{0.13\Delta er_{t-1}} + \underset{(1.51)^{*}}{0.65\Delta cp_{t-1}} + \underset{(2.33)^{**}}{0.68\Delta pd_t}$$

Adjusted R^2 = 0.81, SEE = 0.01, $F(7,30)$ = 22.83, DW = 1.72, VDT(5,24) = 0.29
LM4(4,26) = 1.60, RESET(1,29) = 1.08, NORM(2) = 5.51, HT(1,36) = 0.66.

the past, they have been used to protect intra-corporate debtors against the full valuation effects of major exchange rate fluctuations (Helleiner, 1985), and to allocate funds between subsidiaries of the MNC in line with its international liquidity policy (Grassman, 1973).

These exchange rates can also be manipulated to reflect global decisions relating to pricing and the absorption of exchange rate movements. Evidence supplied to the PSA (1989) suggests that the use of intra-corporate exchange rates is widespread among MNCs operating in Australia, and that its use is designed primarily to guard against unfavourable price consequences of large exchange rate movements. They further note that the widespread use of these internal exchange rates have severely weakened the link between exchange rates and import prices.

Unlike arms length transactions, intra-firm trade is susceptible to the manipulation of the timing of payment on purchases from subsidiaries to coincide with more favourable exchange rates. As Grassman (1973, p.105) puts it:
"the observation of certain definite payments conditions is of minor consequence within (MNCs), which therefore choose the freest and least-specific form of payment. We have found that there is considerable scope for payment adjustments in the internal transactions of multinational firms. ... There is generally more room to manoeuvre".

The leverage available to the MNC to determine the timing of payment on contracts through flexible internal credit arrangements would enhance the ability of subsidiaries to price to the market independently of current exchange rates. For instance, a subsidiary would be in a much better position to continue to sell at pre-depreciation prices, in order to preserve market share, if it had the cooperation of the overseas supplier to defer payment until such time in the future when the currency recovers. Carse *et al* (1980, p.93) find that such flexible methods of settlement are almost solely to be found in the case of intra-MNC trade, with credit terms twice as long or longer than for independent firms. They conclude that the degree to which such arrangements are exploited depend almost exclusively on the circumstances facing the firm; it is this flexibility that enables the MNC to use it as a decision variable.

The ability to choose the currency denomination of contracts would serve to facilitate this pricing strategy. By invoicing in the currency of the importing country, and with the ability to determine the timing of the payment, the MNC is in a position where exchange rate fluctuations that occur in the interim can be

effectively bypassed. In other words, the bargaining problem that besets arms-length trade no longer applies to intra-firm trade, and the currency denomination of contracts becomes a choice variable that can be used to facilitate competitive pricing strategies (Mirus and Yeung, 1987). In the Australian case for instance, evidence presented to the PSA's (1989, p.51) inquiry confirms this view:
"... imports by subsidiaries of multinational companies from parent companies overseas are frequently denominated in Australian dollars ... In this way, the parent company bears the cost of exchange rate movements, at least in the short-term. The parent company can balance its global exchange risks, while allowing greater stability of prices and profit margins in Australia, where domestic producers may be the major source of competition".

As noted earlier, a vast literature exists on the various tools and techniques available to, and frequently used by, MNCs in the pursuit of global profit maximisation objectives. The problem with this literature is that it has thus far failed to recognise that the volatile climate of floating exchange rates poses a much more serious and pressing problem for MNCs. This involves the response mechanism of MNCs to prevent massive and sustained exchange rate movements from either forcing them into pricing themselves out of the market, or squeezing profit margins to the point where significant losses are incurred to remain competitive in export markets. Faced with these options, it should not seem surprising that MNCs have employed the available means (as discussed above) to effectively side-step the exchange rate, and the problems it poses. It is as a consequence of the employment of these means that the pass-through relationship is radically altered.

2.3 Non-Tariff Barriers (NTBs)

The important role played by the increasing presence of NTBs to international trade in affecting the pass-through relationship has been recently emphasised by Bhagwati (1988) and Branson (1989). In the US case, where much of the interest in pass-through has concentrated, Bhagwati (1988, p.1) claims that "a major and indeed obvious explanation (for the change in the pass-through relationship) has simply been missed. It lies, of course, in the fact that the early 1980s (when the US dollar was overvalued) saw a significant rise in non-tariff barriers ...". This view is supported by Branson (1989), who clearly spells out the process by which NTBs influence the pass-through outcome: "The increase in the coverage of NTBs as the dollar depreciated would hold up import prices. Then as the dollar depreciated from 1985, the premium on NTB-restricted imports would fall instead of import prices rising. Pass-through would imply reduction of the premium on imports rather than rising prices...". In other words, depreciations in the presence of

Table B4 (Cont.)

(26) **Excavating, levelling machinery** (AICC 723)

$$\Delta pm_t = \underset{(-0.84)}{-0.02} + \underset{(3.85)^{***}}{0.49\Delta er_t} + \underset{(0.88)}{1.01\Delta cp_t} + \underset{(0.72)}{0.24\Delta pd_t} + \underset{(0.65)}{0.21\Delta pd_{t-1}}$$

Adjusted $R^2 = 0.66$, SEE = 0.03, $F(7,30) = 3.76$, DW = 1.77, VDT(5,24) = 0.54
LM4(4,26) = 0.63, RESET(1,29) = 3.35, NORM(2) = 3.93, HT(1,36) = 0.08.

(27) **Other specialised machinery** (AICC 724)

$$\Delta pm_t = \underset{(-0.47)}{-0.01} + \underset{(16.64)^{***}}{0.89\Delta er_t} + \underset{(2.68)^{***}}{0.16\Delta er_{t-1}} + \underset{(0.97)}{0.95\Delta cp_t} + \underset{(0.63)}{0.12\Delta pd_{t-1}}$$

Adjusted $R^2 = 0.89$, SEE = 0.01, $F(7,30) = 43.33$, DW = 1.53, VDT(5,24) = 0.78
LM4(4,26) = 1.65, RESET(1,29) = 0.30, NORM(2) = 0.36, HT(1,36) = 0.76.

(28) **General industrial machinery and equipment** (AICC 74)

$$\Delta pm_t = \underset{(-0.74)}{-0.01} + \underset{(28.41)^{***}}{0.73\Delta er_t} + \underset{(8.18)^{***}}{0.22\Delta er_{t-1}} + \underset{(3.30)^{***}}{1.06\Delta cp_{t-1}}$$

Adjusted $R^2 = 0.96$, SEE = 0.01, $F(6,31) = 157.03$, DW = 2.33, VDT(6,24) = 1.50
LM4(4,27) = 2.62, RESET(1,30) = 2.34, NORM(2) = 1.13, HT(1,36) = 0.76.

(29) **Office machines and ADP equipment** (AICC 75)

$$\Delta pm_t = \underset{(-1.40)}{-0.01} + \underset{(12.43)^{***}}{0.74\Delta er_t} + \underset{(2.40)^{**}}{0.15\Delta er_{t-1}} + \underset{(1.43)^{*}}{0.67\Delta cp_t} + \underset{(1.37)^{*}}{0.11\Delta cp_{t-1}}$$

Adjusted $R^2 = 0.82$, SEE = 0.02, $F(7,30) = 25.72$, DW = 1.96, VDT(5,24) = 0.83
LM4(4,26) = 3.36, RESET(1,29) = 2.22, NORM(2) = 4.47, HT(1,36) = 0.02.

Table B4 (Cont.)

(23) **Other engines for capital equipment** (AICC 71380)

$$\Delta pm_t = \underset{(-1.93)^{**}}{-0.02} + \underset{(10.18)^{***}}{0.66\Delta er_t} + \underset{(3.09)^{***}}{0.20\Delta er_{t-1}} + \underset{(1.36)^{*}}{1.19\Delta cp_t} + \underset{(0.50)}{0.54\Delta cp_{t-1}}$$

Adjusted R^2 = 0.75, SEE = 0.02, $F(8,28)$ = 14.81, DW = 2.48, VDT(4,24) = 1.43
LM4(4,24) = 2.86, RESET(1,27) = 1.06, NORM(2) = 1.28, HT(1,35) = 0.65.

(24) **Other non-electric engines and motors** (AICC 714)

$$\Delta pm_t = \underset{(-0.51)}{-0.01} + \underset{(5.30)^{***}}{0.79\Delta er_t} + \underset{(0.35)}{0.02\Delta er_{t-1}} + \underset{(0.98)}{1.17\Delta cp_t} + \underset{(0.85)}{0.11\Delta pd_{t-1}}$$

Adjusted R^2 = 0.50, SEE = 0.04, $F(7,30)$ = 4.29, DW = 1.94, VDT(5,24) = 0.92
LM4(4,26) = 0.70, RESET(1,29) = 0.05, NORM(2) = 6.95, HT(1,36) = 0.07.

(25) **Machinery specialised for particular industries** (AICC 72)

$$\Delta pm_t = \underset{(-2.29)^{**}}{-0.02} + \underset{(12.63)^{***}}{0.66\Delta er_t} + \underset{(2.01)^{**}}{0.10\Delta er_{t-1}} + \underset{(1.34)^{*}}{1.17\Delta cp_{t-1}} + \underset{(1.77)^{**}}{0.56\Delta pd_t}$$

Adjusted R^2 = 0.85, SEE = 0.01, $F(7,30)$ = 31.08, DW = 1.81, VDT(5,24) = 1.09
LM4(4,26) = 1.32, RESET(1,29) = 3.74, NORM(2) = 0.57, HT(1,36) = 1.05.

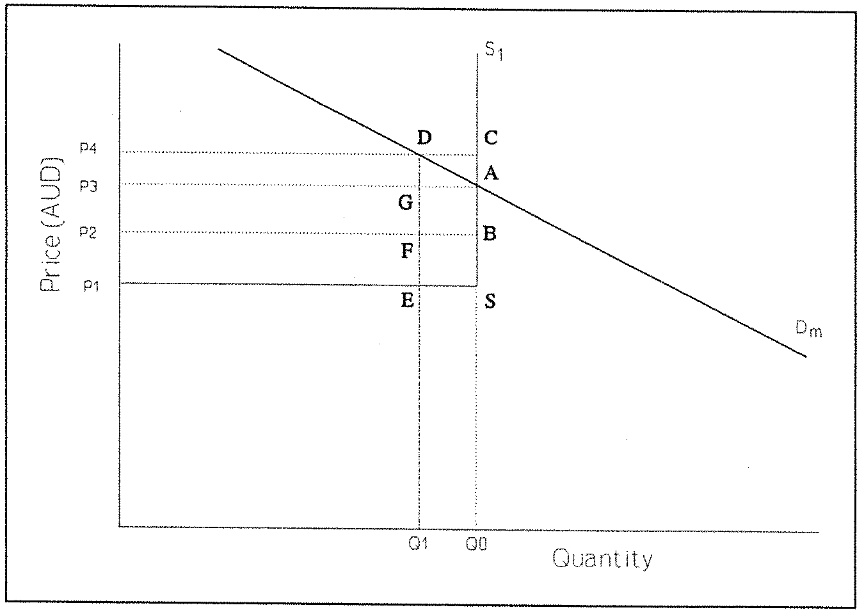
import restraints will generally cut into the import premium first, thus absorbing much of its impact, before it is reflected in prices. It is only when the depreciation is large enough to push prices to the point where quantity restrictions are no longer binding that we will observe some pass-through[3].

The effects of quantitative restrictions (QRs) in limiting the pass-through of exchange rate changes to import prices is depicted in Figure 1. To highlight the role of QRs in limiting pass-through, Figure 1 considers the case of a "small" country which is a price-taker with respect to its imports. D_m is the demand curve for imports, and the supply curve for imports is composed of the horizontal segment P_1S and the vertical segment SS_1. The supply curve is perfectly elastic at the world price of P_1 (reflecting the "small" country assumption), and becomes perfectly inelastic when it encounters the QR at quantity Q_o. The initial equilibrium is at point A, at market price P_3 and quantity Q_o. As a result of the quantitative restraint, the seller is able to extract P_1SAP_3 in quota rents.

Assume that there is initially a "small" depreciation of the currency. While the vertical portion of the supply curve will remain unchanged, the horizontal portion will now shift to P_2B. The market price will remain at P_3, however, and the depreciation is absorbed into the quota rents extracted by the seller (now reduced to P_2BAP_3). The pass-through of the depreciation is zero. Now consider the case where the depreciation is large enough to push the price up to the point where the quota is no longer binding. The depreciation pushes the horizontal portion of the supply curve up to P_4C, which is higher than the original market price of P_3. The equilibrium quantity now falls below the quota limit to Q_1. From Figure 1, it is easily seen that pass-through is going to be less than complete. The pass-through (*PT*) of the depreciation in this instance is going to be:

(3) It is important to note the differential effect that quantitative restraints and tariffs have on pass-through. A tariff imposed on a product raises the supply price for every quantity by the amount of the tariff. This may not by itself have any effect on the degree of pass-through. For instance, a tariff imposed on a product sold under competitive conditions would be fully passed-through to selling prices. Tariffs are likely to affect the pass-through relationship only when imposed on a product sold in a market characterised by imperfect competition. Under these conditions, foreign sellers may use their market power to translate changes to tariff levels into monopoly profits, rather than passing them on to prices. Quantitative restraints, on the other hand, will affect the pass-through relationship even under conditions of perfect competition. Unlike tariffs, the effect that quantitative restrictions will have on the pass-through relationship does not depend on particular market structures. The price and output effects of the imposition or the removal of a tariff or quota in a perfectly competitive market will be equivalent, however.

Figure 1
Exchange Rate Pass-Through in the Presence of Quantitative Restrictions (QRs)



$$PT = \{(P_4 - P_3)/P_3\} \,/\, \{(P_4 - P_1)/P_1\} < 1 \qquad (10)$$

3. The Models and Data

3.1 The Models

Previous studies in this area have employed import price equations derived within the mark-up framework developed by Nordhaus (1970) and popularised by Hooper and Mann (1989) to measure pass-through. The theory of exchange rate pass-through developed in Section 2 implies such a model. Furthermore, given that manufactured goods are typically differentiated and frequently sold in markets that are imperfectly competitive, the mark-up model seems appropriate in our case. This framework allows for possible strategic interaction between domestic and foreign firms in the form of limiting the impact of exchange rate changes on competitiveness through variations in the mark-up.

Table B4 (Cont.)

(19) **Manufactures of metal** (AICC 69)

$$\Delta pm_t = \underset{(-0.51)}{-0.01} + \underset{(12.01)^{***}}{0.54\Delta er_t} + \underset{(1.91)^{**}}{0.16\Delta er_{t-1}} + \underset{(2.01)^{**}}{0.92\Delta cp_t} + \underset{(1.16)}{0.49\Delta cp_{t-1}} + \underset{(2.29)^{**}}{0.18\Delta pm_{t-1}}$$

Adjusted $R^2 = 0.83$, SEE = 0.01, $F(8,29) = 23.16$, DW = 1.64, VDT(5,24) = 0.47
LM4(4,26) = 1.89, RESET(1,29) = 0.37, NORM(2) = 0.19, HT(1,36) = 0.64.

(20) **Non-electric hand tools** (AICC 695)

$$\Delta pm_t = \underset{(-0.66)}{-0.01} + \underset{(12.95)^{***}}{0.63\Delta er_t} + \underset{(5.62)^{***}}{0.30\Delta er_{t-1}} + \underset{(2.31)^{**}}{1.13\Delta cp_t}$$

Adjusted $R^2 = 0.84$, SEE = 0.01, $F(6,31) = 32.92$, DW = 1.54, VDT(6,24) = 1.39
LM4(4,27) = 1.23, RESET(1,30) = 3.13, NORM(2) = 1.50, HT(1,36) = 0.13.

(21) **Power generating machinery and equipment** (AICC 71)

$$\Delta pm_t = \underset{(-1.41)^{*}}{-0.01} + \underset{(15.72)}{0.69\Delta er_t} + \underset{(3.60)^{***}}{0.16\Delta er_{t-1}} + \underset{(0.70)}{0.57\Delta cp_t} + \underset{(0.46)}{0.39\Delta cp_{t-1}} + \underset{(0.71)}{0.51\Delta cp_{t-2}} + \underset{(0.69)}{0.19\Delta pd_t}$$

Adjusted $R^2 = 0.92$, SEE = 0.01, $F(9,27) = 34.27$, DW = 2.42, VDT(3,24) = 1.94
LM4(4,23) = 1.41, RESET(1,26) = 0.53, NORM(2) = 0.86, HT(1,36) = 0.14

(22) **Internal combustion engines** (AICC 713)

$$\Delta pm_t = \underset{(-1.92)}{-0.03} + \underset{(10.52)^{***}}{0.71\Delta er_t} + \underset{(3.59)^{***}}{0.27\Delta er_{t-1}} + \underset{(1.34)^{*}}{1.62\Delta cp_t} + \underset{(0.48)}{0.61\Delta cp_{t-1}} + \underset{(0.09)}{0.04\Delta pd_t} + \underset{(0.19)}{0.07\Delta pd_{t-2}}$$

Adjusted $R^2 = 0.79$, SEE = 0.02, $F(10,26) = 14.39$, DW = 2.36, VDT(2,24) = 0.11
LM4(4,22) = 0.68, RESET(1,25) = 3.37, NORM(2) = 0.42, HT(1,35) = 2.37.

Table B4 (Cont.)

(15) **Knitted fabrics** (AICC 655)

$$\Delta pm_t = \underset{(-0.79)}{-0.01} + \underset{(7.21)^{***}}{0.85\Delta er_t} + \underset{(0.64)}{0.18\Delta cp_t} + \underset{(1.84)^{**}}{0.78\Delta pd_{t-1}}$$

Adjusted R^2 = 0.71, SEE = 0.03, $F(6,31)$ = 9.96, DW = 2.07, VDT(6,24) = 1.64
LM4(4,27) = 0.89, RESET(1,30) = 0.16, NORM(2) = 0.22, HT(1,36) = 0.19.

(16) **Floor coverings** (AICC 659)

$$\Delta pm_t = \underset{(-0.48)}{-0.01} + \underset{(5.54)^{***}}{0.54\Delta er_t} + \underset{(2.35)^{**}}{0.23\Delta er_{t-1}} + \underset{(1.58)^{*}}{0.16\Delta er_{t-2}} + \underset{(0.50)}{0.13\Delta cp_t} + \underset{(0.58)}{0.15\Delta cp_{t-1}} + \underset{(0.73)}{0.28\Delta pd_{t-1}}$$

Adjusted R^2 = 0.51, SEE = 0.03, $F(9,27)$ = 5.19, DW = 2.15, VDT(1,26) = 1.32
LM4(4,23) = 0.49, RESET(1,26) = 1.16, NORM(2) = 0.92, HT(1,35) = 0.11.

(17) **Non-metallic mineral manufactures** (AICC 66)

$$\Delta pm_t = \underset{(0.80)}{0.01} + \underset{(16.21)^{***}}{0.71\Delta er_t} + \underset{(3.91)^{***}}{0.19\Delta er_{t-1}} + \underset{(1.47)^{*}}{0.78\Delta cp_t} + \underset{(0.10)}{0.05\Delta cp_{t-1}}$$

Adjusted R^2 = 0.88, SEE = 0.01, $F(7,30)$ = 40.78, DW = 2.29, VDT(5,24) = 0.47
LM4(4,26) = 0.32, RESET(1,29) = 0.54, NORM(2) = 0.90, HT(1,36) = 0.01.

(18) **Iron and steel** (AICC 67)

$$\Delta pm_t = \underset{(-0.91)}{-0.01} + \underset{(6.02)^{***}}{0.54\Delta er_t} + \underset{(1.78)^{**}}{0.15\Delta er_{t-1}} + \underset{(2.04)^{**}}{0.19\Delta er_{t-2}} + \underset{(3.64)^{***}}{1.08\Delta cp_t} + \underset{(0.37)}{0.14\Delta cp_{t-1}} + \underset{(1.09)}{0.44\Delta pd_t}$$

Adjusted R^2 = 0.67, SEE = 0.03, $F(9,27)$ = 5.98, DW = 2.08, VDT(3,24) = 0.95
LM4(4,23) = 0.13, RESET(1,26) = 2.48, NORM(2) = 7.24, HT(1,35) = 3.55.

We begin by assuming that foreigners set their foreign currency export price (*PX*) as a mark-up (π) on their production cost in foreign currency (*CP*):

$$PX = \pi CP \tag{11}$$

The mark-up is expressed in ratio form (i.e., $\pi = (1 + \lambda)$, where λ is the profit margin). The AUD import price (PM) is therefore given by:

$$PM = PX\,ER = (\pi CP)\,ER \tag{12}$$

The profit mark-up is hypothesised to depend on competitive pressures in the domestic market, and the exchange rate. The gap between the price of import-competing goods (*PD*) and the exporter's production cost is used to proxy the competitive pressure. The influence of domestic demand conditions on the import pricing decision is also captured by *PD*. The profit mark-up is thus modelled as:

$$\pi = \{PD / (CP\,ER)\}^{\alpha} \tag{13}$$

Substituting (13) into (12) we obtain:

$$PM = \{(PD / CP\,ER)^{\alpha}\}\,CP\,ER \tag{14}$$

Denoting logarithms of the variables as lower-case letters, and after some manipulation, we have:

$$pm = \alpha\,pd + (1-\alpha)\,cp + (1-\alpha)\,er \tag{15}$$

The model as specified above implies a rate of pass-through that is equal in magnitude for changes in foreign costs and the exchange rate. The coefficient of *pd* is α, which is the residual of the coefficients of *cp* and *er*. The cross-coefficient restrictions implied by this model suggests that *pd* has no (full) effect in determining import prices if pass-through is complete (zero). We will check these cross-coefficient restrictions when we implement the model.

We now proceed to derive the model for the second stage of our analysis where we examine the determinants of inter-product differences in the degree of pass-through. The theory of pass-through developed in Section 2 suggests the following model:

$$\underset{}{PT} = f(\underset{(-)}{TIDS},\ \underset{(-)}{CIDS},\ \underset{(+)}{ES},\ \underset{(-)}{PDIF},\ \underset{(-)}{CON4},\ \underset{(-)}{FCM},\ \underset{(-)}{FIT},\ \underset{(-)}{QR}) \quad (16)$$

where PT = estimated pass-through coefficient, $TIDS$ = import-domestic sales ratio, $CIDS$ = competitive imports-domestic sales ratio, ES = elasticity of substitution between domestically produced and imported goods, $PDIF$ = product differentiation variable, $CON4$ = 4-firm concentration ratio, FCM = foreign control of imports, FIT = foreign investment in turnover, and QR = quantitative restriction variable. The expected relationship with the degree of pass-through is indicated by the signs below each variable.

3.2 Data

Following the standard practice of studies on international trade in manufactures, our analysis focuses on non-resource based manufactured goods defined to cover products belonging to Sections 5 to 8 of the Australian Import Commodity Classification (AICC, which is based on the SITC). The analysis covers total manufactures and 50 product categories defined at the 2, 3, 4 and 5 digit level of the AICC for the period 1981q3 to 1991q2. To overcome the data limitations of previous work, a considerable amount of time and energy has been devoted to the construction of the requisite data for individual products. In the absence of a ready-made data base for our analysis, we had to construct our own data series for most of the variables using scattered secondary sources. Here we consider some salient features of the data base, leaving a complete listing of variables and their method of construction and data sources to Appendix A.

The data that have been most susceptible to error in previous studies have been the measure of import "prices" used. In this study, we have been fortunate to have gained access to a disaggregated set of actual import prices to serve as the dependent variable, rather than having to rely on price proxies such as import unit values that suffer from a number of well-known deficiencies (see Appendix A). The bias introduced into estimates of pass-through as a result of measurement errors inherent in price proxies is highlighted by Alterman (1991) when he compares the results obtained using import prices versus import unit values. The discrepancy between the estimates is large enough to warrant concern over the reliability of pass-through estimates obtained using price proxies.

Previous studies have employed a "world" price variable (in the form of import-weighted export prices of major supplying countries) to capture changes in

Table B4 (Cont.)

(11) **Paper, paperboard and articles thereof** (AICC 64)

$$\Delta pm_t = \underset{(-2.57)^{***}}{-0.03} + \underset{(3.69)^{***}}{0.28\Delta er_t} + \underset{(2.28)^{**}}{0.18\Delta er_{t-1}} + \underset{(2.88)^{***}}{1.40\Delta cp_{t-1}} + \underset{(2.13)^{**}}{0.72\Delta pd_t}$$

Adjusted R^2 = 0.52, SEE = 0.02, $F(7,30)$ = 6.61, DW = 2.50, VDT(5,24) = 0.99
LM4(4,26) = 1.68, RESET(1,29) = 2.71, NORM(2) = 0.67, HT(1,36) = 0.28.

(12) **Textile yarn, fabrics and made-up articles** (AICC 65)

$$\Delta pm_t = \underset{(-0.21)}{-0.01} + \underset{(9.67)^{***}}{0.69\Delta er_t} + \underset{(2.21)^{**}}{0.15\Delta er_{t-1}} + \underset{(0.92)}{0.14\Delta cp_{t-1}}$$

Adjusted R^2 = 0.73, SEE = 0.02, $F(6,31)$ = 17.59, DW = 1.61, VDT(6,24) = 0.37
LM4(4,27) = 1.34, RESET(1,30) = 1.57, NORM(2) = 0.43, HT(1,36) = 1.02.

(13) **Textile yarn** (AICC 651)

$$\Delta pm_t = \underset{(0.82)}{0.01} + \underset{(6.14)^{***}}{0.48\Delta er_t} + \underset{(0.65)}{0.13\Delta cp_{t-1}} + \underset{(2.85)^{***}}{1.10\Delta^2 pd_t} \quad \underset{(1.15)}{0.45\Delta^2 pd_{t-1}}$$

Adjusted R^2 = 0.63, SEE = 0.02, $F(7,29)$ = 9.64, DW = 2.10, VDT(5,23) = 1.59
LM4(4,25) = 0.93, RESET(1,28) = 0.68, NORM(2) = 4.33, HT(1,35) = 0.13.

(14) **Woven fabrics** (AICC 652)

$$\Delta pm_t = \underset{(-1.13)}{-0.01} + \underset{(8.49)^{***}}{0.75\Delta er_t} + \underset{(0.88)}{0.08\Delta er_{t-1}} + \underset{(0.34)}{0.09\Delta cp_{t-1}}$$

Adjusted R^2 = 0.68, SEE = 0.03, $F(6,31)$ = 13.65, DW = 1.61, VDT(6,24) = 1.19
LM4(4,27) = 0.90, RESET(1,30) = 1.68, NORM(2) = 1.79, HT(1,36) = 1.01.

Table B4 (Cont.)

(7) **Chemical materials and products** (AICC 59)

$$\Delta pm_t = \underset{(0.37)}{0.01} + \underset{(7.60)^{***}}{0.79\Delta er_t} + \underset{(2.03)^{**}}{0.22\Delta er_{t-1}} + \underset{(1.11)}{0.52\Delta cp_{t-1}} + \underset{(0.43)}{0.20\Delta cp_{t-2}} + \underset{(1.48)^{*}}{0.68\Delta pd_{t-2}}$$

Adjusted R^2 = 0.72, SEE = 0.03, *F*(8,28) = 9.09, DW = 2.30, VDT(4,24) = 0.29
LM4(4,24) = 1.45, RESET(1,27) = 0.001, NORM(2) = 0.28, HT(1,35) = 0.89.

(8) **Leather manufactures and dressed fur-skins** (AICC 61)

$$\Delta pm_t = \underset{(-0.08)}{-0.01} + \underset{(5.02)^{***}}{0.76\Delta er_t} + \underset{(2.11)^{**}}{0.57\Delta pd_t} + \underset{(1.32)^{*}}{0.37\Delta pd_{t-1}}$$

Adjusted R^2 = 0.61, SEE = 0.04, *F*(6,31) = 8.10, DW = 1.83, VDT(6,24) = 1.63
LM4(4,27) = 0.52, RESET(1,30) = 0.12, NORM(2) = 8.84, HT(1,36) = 0.28.

(9) **Rubber manufactures** (AICC 62)

$$\Delta pm_t = \underset{(-0.41)}{-0.01} + \underset{(3.06)^{***}}{0.21\Delta er_t} + \underset{(1.68)^{**}}{0.10\Delta er_{t-1}} + \underset{(0.72)}{0.45\Delta cp_{t-1}} + \underset{(0.92)}{0.43\Delta pd_t}$$

Adjusted R^2 = 0.41, SEE = 0.02, *F*(8,28) = 2.46, DW = 1.46, VDT(4,24) = 1.71
LM4(4,24) = 1.81, RESET(1,27) = 0.01, NORM(2) = 1.42, HT(1,35) = 0.48.

(10) **Cork and wood manufactures** (AICC 63)

$$\Delta pm_t = \underset{(-0.82)}{-0.02} + \underset{(5.68)^{***}}{0.66\Delta er_t} + \underset{(1.62)^{**}}{0.14\Delta er_{t-1}} + \underset{(0.78)}{0.27\Delta cp_t} \quad \underset{(0.94)}{0.58\Delta pd_t} + \underset{(1.21)}{0.84\Delta pd_{t-2}}$$

Adjusted R^2 = 0.62, SEE = 0.02, *F*(8,28) = 5.75, DW = 2.31, VDT(4,24) = 2.99
LM4(4,24) = 1.16, RESET(1,27) = 0.39, NORM(2) = 9.31, HT(1,35) = 0.11.

competitiveness of export sales to Australia. The problem with this index is that it represents the pricing decision on exports to *all* markets, and becomes particularly inappropriate for products in which "pricing to market" and incomplete pass-through behaviour is common place. The findings of the studies overseas would imply that the "world" price variable *already* incorporates the incomplete pass-through on sales to other markets. The world price index, and the resulting pass-through estimate, would be valid only if exporters do not price discriminate across markets, but preserve a rate of pass-through that is consistent across markets. Only then will the world price index accurately measure the supply price of exports to Australia, since it will not be distorted by a different rate of pass-through on sales to other markets. Given the problems with the "world" price variable, we use a foreign-producer cost of production index that is unaffected by the "pricing to market" problem. Unlike export prices, the cost of production index in any one country does not depend on the export market being targetted (see Knetter, 1989).

4. Econometric Procedure

4.1 Unit Roots and Cointegration

In estimating time-series models, the time-series properties of the data will have an important influence on the specification of the econometric model and on the choice of estimator. A recent development has been the formal analysis of the trend properties of time-series data. The conventional approach to time-series econometrics is based on the implicit assumption that the underlying data series are stationary. Recent advances in time-series econometrics has shed serious doubt on this assumption. There is now a considerable body of literature that suggests that a large number of macroeconomic series and asset prices are non-stationary (see Nelson and Plosser, 1982; Corbane and Ouliaris, 1986; Perron, 1988).

First it is useful to formally illustrate the properties of non-stationarity. Consider a stochastic process X_t, which will be stationary if its mean, variance and covariances are time-invariant. X_t is said to be stationary if the following conditions are satisfied for all values of t:

$$E(X_t) = \mu \qquad (17)$$

$$E\{(X_t - \mu)^2\} = \chi(0) \qquad (18)$$

$$E\{(X_t - \mu)(X_{t-\tau} - \mu)\} = \chi(\tau), \quad \tau = 1, 2, \ldots \qquad (19)$$

Equations (17) and (18) require the process to have a constant mean and variance, while equation (19) states that the covariance between any two values of X_t from the series, or the autocovariance, depends only on the *distance apart in time* between those two values.

Integrated variables are a specific class of non-stationary variables with important economic and statistical properties. These are derived from the presence of unit roots which give rise to stochastic trends, as opposed to pure deterministic trends, with innovations to an integrated process being permanent instead of transient. Engle and Granger (1987) provide the following formal definition of integration:

> A series with no deterministic component which has a stationary, invertible, autoregressive moving average (ARMA) representation after differencing d times, is said to be integrated of order d, denoted $X_t \sim I(d)$.

Thus, a time series integrated of order zero is stationary in levels, while a time series integrated of order one is stationary in first differences. Examples of $I(0)$ series include a white noise series and a stable first-order autoregressive {AR(1)} process, while a random walk process is an example of an $I(1)$ series.

The application of conventional estimation procedures to data that are non-stationary will yield statistically reliable results only if the level variables are able to form a valid cointegrating vector. To elucidate the concept of cointegration, consider initially a pair of series which we will call X_t and Y_t, each of which is $I(1)$ and having no drift or trend in mean[4]. It is generally the case that any linear combination of these series will also be $I(1)$, just as a linear combination of $I(0)$ and $I(1)$ variables will be dominated by the $I(1)$ variables (this is so because a deterministic trend will dominate a stationary variable). However, if there exists a constant α, such that:

$$Z_t = X_t - \alpha Y_t \qquad (20)$$

is $I(0)$, then X_t and Y_t will be said to be cointegrated. If α exists it will be unique and called the cointegrating parameter (or, more generally, $(1, -\alpha)$ called the cointegrating vector). It is clear from equation (20) above that X_t and Y_t must share

(4) The assumption that X_t and Y_t have no trend or drift in mean is purely a simplifying assumption, and can be relaxed without jeopardising the result (see Granger 1986, pp. 216-7).

Table B4 (Cont.)

(4) **Medicinal, pharmaceutical products** (AICC 54)

$$\Delta pm_t = \underset{(-0.69)}{-0.01} + \underset{(4.42)^{***}}{0.47\Delta er_t} + \underset{(2.38)^{**}}{0.27\Delta er_{t-1}} + \underset{(0.68)}{0.28\Delta cp_{t-1}} + \underset{(0.23)}{0.17\Delta pd_t} + \underset{(1.24)}{0.87\Delta pd_{t-2}}$$

Adjusted R^2 = 0.53, SEE = 0.04, F(8,28) = 3.94, DW = 1.38, VDT(4,24) = 0.27
LM4(4,24) = 1.13, RESET(1,27) = 1.24, NORM(2) = 5.07, HT(1,35) = 0.33.

(5) **Essential oils and perfume materials** (AICC 58)

$$\Delta pm_t = \underset{(-1.19)}{-0.02} + \underset{(8.08)^{***}}{0.66\Delta er_t} + \underset{(3.58)^{***}}{0.31\Delta er_{t-1}} + \underset{(1.42)^{*}}{0.12\Delta er_{t-2}} + \underset{(0.71)}{0.25\Delta cp_t} + \underset{(1.34)^{*}}{0.47\Delta cp_{t-2}} + \underset{(0.31)}{0.24\Delta pd_t} + \underset{(0.60)}{0.44\Delta pd_{t-2}}$$

Adjusted R^2 = 0.72, SEE = 0.02, F(10,26) = 10.23, DW = 2.35, VDT(2,24) = 0.24
LM4(4,22) = 1.55, RESET(1,25) = 3.68, NORM(2) = 2.08, HT(1,35) = 0.04.

(6) **Artificial resins and plastic materials** (AICC 58)

$$\Delta pm_t = \underset{(-1.52)}{-0.01} + \underset{(6.39)^{***}}{0.49\Delta er_t} + \underset{(0.90)}{0.07\Delta er_{t-1}} + \underset{(0.56)}{0.16\Delta cp_t} + \underset{(1.95)^{**}}{0.60\Delta cp_{t-2}} + \underset{(2.71)^{***}}{0.46\Delta pd_t} + \underset{(0.70)}{0.12\Delta pd_{t-1}}$$

Adjusted R^2 = 0.60, SEE = 0.02, F(9,27) = 6.94, DW = 1.80, VDT(3,24) = 0.05
LM4(4,23) = 1.08, RESET(1,26) = 0.46, NORM(2) = 5.17, HT(1,35) = 0.14.

Table B4[1]
Estimation Results from Difference Models

(1) **Organic chemicals** (AICC 51)

$$\Delta pm_t = \underset{(-1.91)^{**}}{-0.02} + \underset{(6.88)^{***}}{0.61\Delta er_t} + \underset{(2.53)^{***}}{0.22\Delta er_{t-1}} + \underset{(0.53)}{0.12\Delta pd_{t-1}} + \underset{(2.36)^{**}}{0.61\Delta pd_{t-2}}$$

Adjusted $R^2 = 0.59$, SEE = 0.02, $F(7,29) = 8.19$, DW = 1.40, VDT(5,24) = 0.90
LM4(4,25) = 2.57, RESET(1,28) = 0.53, NORM(2) = 0.75, HT(1,35) = 0.09.

(2) **Inorganic chemicals** (AICC 52)

$$\Delta pm_t = \underset{(-0.37)}{-0.01} + \underset{(2.25)^{**}}{0.40\Delta er_t} + \underset{(1.63)^{*}}{0.89\Delta cp_{t-1}} + \underset{(3.83)^{***}}{0.52\Delta pm_{t-1}}$$

Adjusted $R^2 = 0.38$, SEE = 0.04, $F(6,31) = 4.70$, DW = 1.65, VDT(6,24) = 1.03
LM4(4,27) = 1.87, RESET(1,30) = 1.10, NORM(2) = 2.10, HT(1,36) = 0.62.

(3) **Dyeing, tanning, colouring materials** (AICC 53)

$$\Delta pm_t = \underset{(0.08)}{0.001} + \underset{(7.76)^{***}}{0.67\Delta er_t} + \underset{(2.00)^{**}}{0.18\Delta er_{t-1}} + \underset{(0.48)}{0.13\Delta cp_{t-1}} + \underset{(1.07)}{0.25\Delta pd_t} + \underset{(0.85)}{0.20\Delta pd_{t-1}}$$

Adjusted $R^2 = 0.67$, SEE = 0.03, $F(8,29) = 10.44$, DW = 1.89, VDT(4,24) = 0.28
LM4(4,25) = 0.07, RESET(1,28) = 0.001, NORM(2) = 0.15, HT(1,36) = 6.55.

Standard Errors (SEs) adjusted using White's Heteroscedasticity-Consistent Covariance Matrix

$$\Delta pm_t = \underset{(0.09)}{0.001} + \underset{(5.84)^{***}}{0.67\Delta er_t} + \underset{(1.92)^{**}}{0.18\Delta er_{t-1}} + \underset{(0.38)}{0.13\Delta cp_{t-1}} + \underset{(0.83)}{0.25\Delta pd_t} + \underset{(0.87)}{0.20\Delta pd_{t-1}}$$

a very special relationship since Z_t has temporal properties that are quite different from those of either of its components. In other words, although X_t and Y_t are $I(1)$ and so have dominating low-frequency or "long wave" components, Z_t does not. The answer lies in the fact that X_t and αY_t must have low-frequency or stochastic trend components which virtually cancel out to produce Z_t, which is stationary. Furthermore, since the difference between these series is stationary, the error term in the regression will have well-defined first and second moments, enabling the use of OLS without being subject to the well-known problems of "spurious" regression outlined by Granger and Newbold (1974).

With these factors in mind, we proceed in the following manner. First, we test for the presence of unit roots in the variables. There are a wide range of statistical tests that can be used for this purpose (see Dolado *et al*, 1990). In this study, we use three alternative tests, namely the Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and Johansen tests. Second, we check for the possibility that the set of variables for each product may be able to form a valid cointegrating vector. We employ two different approaches in testing for cointegration. They are the Engle-Granger (1987) procedure and the Johansen (1988) ML procedure. Even though these two approaches are usually considered to be alternatives rather than complements, we decided not to rely solely on the (now preferred) Johansen procedure because the critical values and small sample performance of many of these tests are not fully known for a wide range of models (Hall, 1986). For the equations for which cointegrating relationships cannot be identified, we employ the time-series analyst's prescription to modelling non-stationary series by modelling in differences. The model-building methodology that we employ is the general to specific modelling approach. The tests for unit roots, the Engle Granger and Johansen estimation procedures, and the general-to-specific approach to model building are discussed in turn below.

4.2 Tests for Unit Roots

The DF test is the most widely used, and has been found to be similar to most alternative tests in terms of its asymptotic properties (Engle and Granger, 1987). The ADF test is based on the DF test, but transformed to include as many lagged values of the dependent variable as necessary to achieve residual whiteness. The order of the augmentation is determined on the basis of the Lagrange Multiplier (LM) test for serial correlation, which is valid even in the presence of the lagged dependent variable. The pth order ADF test statistic is given by the t-ratio of α_2 in the ADF regression:

$$\Delta X_t = \alpha_0 + \alpha_1 T + \alpha_2 X_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta_i X_{t-i} + \mu_t \qquad (21)$$

where Δ is the difference operator (i.e., $\Delta X_t = X_t - X_{t-1}$), T is a time trend and μ_t is the error term which is empirical white noise. We seek to test the null hypothesis of $\alpha_2 = 0$. That is, as long as α_2 is larger than the relevant critical value, we cannot reject the null of a unit root. Note that under the null hypothesis, α_2 will not have the standard t distribution, but will instead be a function of Brownian motion. In fact, Dickey and Fuller (1979) show that under the null, the least-squares estimate of α_2 is not distributed around a value of unity, but rather around a value less than one. In order to overcome this problem, the critical values for the DF and ADF tests are computed using the response surface estimates provided by Mackinnon (1991). In conducting these tests, we follow the procedure suggested by Dickey and Pantula (1988), and test for higher order (3) unit roots and then test down. The Johansen statistic is used to determine whether there is "cointegration in one variable", which is equivalent to testing whether the variable is $I(0)$ (see Taylor, 1991). Since this test is based on the Johansen test for cointegration, it is discussed below.

4.3 The Engle-Granger and Johansen ML Estimation Procedures

The Engle-Granger procedure, which is also known as the two-step procedure, involves running the regression of the contemporaneous variables in levels form, known as the cointegrating regression, and testing the cointegrating residuals to determine if they are $I(0)$. If the levels regression equation is able to form a cointegrating relationship, then this will enable us to obtain the equilibrium relationship between the non-stationary variables without specifying short-run dynamics. Stock (1987) has shown that the coefficient estimates from the cointegrating regression will be *consistent* and *highly efficient*. In fact, these estimates will be "super consistent", converging to their true parameter values at a faster rate than standard econometric estimates, despite the omission of dynamics. The coefficient estimates from the cointegrating regression will converge to their true values at the rate $1/T$ (where T is the sample size), rather than the usual rate of $1/(T)^{1/2}$.

We test the cointegrating residuals by applying the DF, ADF and the Cointegrating Regression Durbin-Watson (CRDW) tests. The DF and ADF tests examine the residuals of the cointegrating regression directly by performing a unit root test on

Table B3 (Cont.)

(10) **Knitted outer garments** (AICC 845)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	28.660	27.067
$r \leq 1$	18.613	20.967
$r \leq 2$	5.440	14.069
$r \leq 3$	1.279	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.5414er_t + 1.1628cp_t - 0.7194pd_t$$

(11) **Photographic equipment and optical goods** (AICC 88)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	33.212	27.067
$r \leq 1$	11.790	20.967
$r \leq 2$	5.445	14.069
$r \leq 3$	1.699	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.9242er_t + 0.8430cp_t - 0.7363pd_t$$

(12) **Total manufactured imports**

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	48.165	27.067
$r \leq 1$	17.175	20.967
$r \leq 2$	9.361	14.069
$r \leq 3$	3.264	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.6627er_t + 0.2538cp_t + 0.3348pd_t$$

Table B3 (Cont.)

(7) **General industrial machinery and equipment** (AICC 74)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	53.111	27.067
$r \leq 1$	27.713	20.967
$r \leq 2$	9.216	14.069
$r \leq 3$	4.820	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.9198er_t + 0.9685cp_t - 0.0106pd_t$$

(8) **Road vehicles** (AICC 78)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	60.061	27.067
$r \leq 1$	17.786	20.967
$r \leq 2$	4.919	14.069
$r \leq 3$	1.981	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.7841er_t + 1.6337cp_t + 0.2903pd_t$$

(9) **Motor vehicle parts and accessories** (AICC 784)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	29.822	27.067
$r \leq 1$	16.647	20.967
$r \leq 2$	5.620	14.069
$r \leq 3$	4.665	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.8652er_t + 1.2633cp_t + 0.1841pd_t$$

them. The Monte Carlo results reported by Engle and Granger (1987) suggest that the critical values for these tests are more stable than those for the CRDW test. The CRDW test is due to Bhargava (1980) and Sargan and Bhargava (1983), and tests whether the DW from the cointegrating regression is significantly greater than zero, based on the null that the cointegrating residuals are $I(1)$. The critical values are provided by Sargan and Bhargava (1983). The CRDW test provides a useful complement to the DF and ADF tests. Banerjee *et al* (1986) indicate their preference for this test on the grounds that its distribution is invariant to nuisance parameters such as a constant.

The tests of cointegration on residuals derived in this manner do have their limitations, however. Johansen (1988) points to a number of serious problems. First, should a cointegrating relationship be identified, the assumption is made that the cointegrating vector is unique. This need not be true in anything more complex than the two variable case, and the above tests provide no framework for addressing this issue. In general, if we are considering N non-stationary variables there may exist anything up to N - 1 distinct cointegrating vectors. Second, these test procedures do not have well defined limiting distributions, and as such testing for cointegration is no longer a straightforward exercise. Johansen (1988) suggests an ML estimation procedure which offers solutions to both of these problems. The Johansen ML procedure provides log-likelihood ratio test statistics for determining the *number* of cointegrating vectors which exist between a set of variables using the maximal eigenvalue procedure. It also provides test statistics for the number of cointegrating vectors identified which have an exact limiting distribution which is a function of only one parameter. Furthermore, Phillips (1987) argues that the Johansen technique is likely to be applicable in the presence of heterogeneously distributed errors.

There are also a number of concerns that relate to the parameter estimates obtained from applying the Engle-Granger procedure. First, we note that Stock's (1987) consistency results for parameter estimates from the cointegrating regression are asymptotic results. Stock (1987) shows that the bias in finite-samples will be in the order of $1/T$, where T is the sample size. Banerjee *et al* (1986) investigate this potential finite-sample bias in considerable detail, and raise serious doubts about the small sample properties of the Engle-Granger procedure. They show that the bias in is related to $(1-R^2)$, and that this bias may decline much more slowly than the theoretical rate.

In practical applications there are a number of other problems that are perhaps more serious than the small sample bias. If there is more than one cointegrating vector which links the variables together, then the estimates from the Engle-Granger procedure may simply represent complex linear combinations of all the cointegrating vectors. These estimates will be meaningless. Finally, the Engle-Granger two-step estimation procedure, unlike the Johansen procedure, is unable to accommodate dynamics in the cointegrating regression. For these reasons, we employ the Johansen ML procedure as a final test of cointegration. In cases where the other test statistics are borderline with respect to cointegration, the Johansen statistic is used as the decisive test.

A formal and complete exposition of the Johansen procedure can be found in Johansen (1988), and shorter or summarised versions are provided by Hall (1989) and Cuthbertson *et al* (1992). We will concentrate on providing a brief and intuitive account of the Johansen procedure. The Johansen procedure starts from a general vector autoregression (VAR) model which is parameterised as a system error correction model so that the VAR consists mostly of lagged first difference terms (which are therefore by assumption stationary) and a set of lagged levels terms. If we denote the length of the lag chosen in the VAR as k, and the number of variables as n, then the VAR will contain (n x k-1) difference terms, and n levels terms each of which is lagged by k periods. It is clear that OLS could be applied to this system to provide a consistent estimate of the long run parameters for each equation, as demonstrated by Stock (1987). The problem, however, lies in the fact that these estimates may simply represent complex linear combinations of all the cointegrating vectors which link these variables together. If this happens we cannot interpret the resulting equation in an economically meaningful way.

It is not possible to separate out these individual relationships by OLS based methods. In order to achieve this an ML procedure is used and the following two sets of variables are defined: (i) the residuals obtained from regressing each of the contemporaneous difference terms on all of the lagged difference terms, and (ii) the residuals obtained from regressing each of the lagged levels terms on all of the lagged difference terms. The first set of variables can be viewed as the first difference of the data adjusted for the dynamics in the system, where as the second set represents the levels of the variables adjusted for the dynamics of the system. The first set will also be stationary by definition, where as the second set will be integrated at the order of the original data (in our case mostly $I(1)$).

The essence of the Johansen procedure lies with the realisation that the combinations of the levels variables which produce a high correlation with the

Table B3 (Cont.)

(4) **Non-electric hand tools** (AICC 695)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	38.999	27.067
$r \leq 1$	15.168	20.967
$r \leq 2$	2.837	14.069
$r \leq 3$	0.367	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.8631er_t + 0.9767cp_t + 0.4286pd_t$$

(5) **Power generating machinery and equipment** (AICC 71)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	32.937	27.067
$r \leq 1$	25.840	20.967
$r \leq 2$	10.699	14.069
$r \leq 3$	4.762	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.8292er_t + 0.4568cp_t + 0.2529pd_t$$

(6) **Excavating and levelling machinery** (AICC 723)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	33.522	27.067
$r \leq 1$	9.334	20.967
$r \leq 2$	2.912	14.069
$r \leq 3$	0.453	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.4984er_t + 0.4209cp_t + 0.2071pd_t$$

Table B3
Cointegration Tests and Estimation Results of Johansen ML Procedure

(1) **Floor coverings** (AICC 659)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	32.029	27.067
$r \leq 1$	19.297	20.967
$r \leq 2$	10.998	14.069
$r \leq 3$	1.947	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 1.0906er_t + 0.3291cp_t + 0.2924pd_t$$

(2) **Non-metallic mineral products** (AICC 66)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	39.980	27.067
$r \leq 1$	13.887	20.967
$r \leq 2$	6.835	14.069
$r \leq 3$	0.067	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.8981er_t + 1.1807cp_t - 0.0965pd_t$$

(3) **Metal manufactures** (AICC 69)

(a) Tests for cointegration (VAR lag length = 1)

Null hypothesis	Likelihood ratio statistic	5% critical value
Number of cointegrating vectors r		
$r = 0$	42.087	27.067
$r \leq 1$	16.095	20.967
$r \leq 2$	2.761	14.069
$r \leq 3$	0.206	3.762

(b) Estimated cointegrating vector (largest eigenvalue only)

$$pm_t = 0.6307er_t + 1.0625cp_t + 0.3690pd_t$$

difference variables are in fact the cointegrating vectors. Furthermore, the standard technique of canonical correlation will provide estimates of all of the distinct cointegrating vectors which may link a set of variables together. Finally, the associated eigenvalues may be used to construct a likelihood ratio test of the number of truly distinct cointegrating vectors which have been found.

4.4 The General to Specific Approach to Model Building

This approach to dynamic modelling is also known as the LSE approach, and is originally due to J.D. Sargan and has been popularised by David Hendry and others (see Sargan, 1964; Davidson *et al*, 1978; Hendry and Mizon, 1978). This approach to model building may be summarised as "intended over-parametisation with data based simplification", or as a "top-down" approach. We begin with a very general dynamic model which is "over-parametised" in the sense that it has more lags than we would normally consider to be necessary. In choosing the lag length, we were guided by the related literature in this area (see Menon, 1992d) and degrees of freedom considerations. The general model is specified to include lags extending to two quarters on all of the explanatory variables:

$$\Delta^i pm_t = CON + \sum_{j=0}^{n} [\, \Omega_j \Delta^i er_{t-j} + \phi_j \Delta^i cp_{t-j} + \gamma_j \Delta^i pd_{t-j} \,] \tag{22}$$

where lower-case letters refer to natural logarithms of the variables, CON is the constant term, and Δ is the difference operator, with the superscript (i) referring to the order of the difference (e.g., $\Delta pm_t = pm_t - pm_{t-1}$, and $\Delta^2 pm_t = \Delta pm_t - \Delta pm_{t-1}$). This model represents our maintained hypothesis. This model is progressively simplified with a sequence of "simplification tests" to achieve orthogonality. The main test that we employ is the *F*-test for variable deletion, which is a special version of the likelihood ratio test. This test allows us to assess the acceptability of the restrictions that we impose sequentially on our general model in the specification search for our specific model, which is data acceptable or is the "data coherent specialisation". We also employ a battery of diagnostic tests to guide us in the process of seeking out our specific model.

4.5 Recursive Estimation

A structural break in the pass-through relationship has been interpreted as indicating the presence of hysteresis in import prices (Baldwin, 1988). In the literature, the stability of the pass-through relationship has commonly been tested using the standard Chow test (see Menon 1992d). This test requires that we make the assumption that a possible break point is known *a priori*, so that we may proceed to simply test this point. We compared plots of the import price, "full-pass-through import price" and effective exchange rates to discover if the pass-through relationship may have changed following the depreciation of 1985, but the graphical evidence proved to be inconclusive[5]. In other words, we do not have any strong prior knowledge of specific structural breaks in the equations. Under these circumstances, what is required is a more general framework to investigate the stability of the model. Such a framework is provided by recursive estimation, which may be viewed as a special case of the Kalman filter (see Cuthbertson *et al*, 1992).

Recursive estimation may be thought of as a series of conventional OLS estimation of the same model where the data period is increased successively by one period. To illustrate, consider the following bivariate regression:

$$X_i = \hat{\beta}_t Y_i + \hat{u}_i \qquad i = 1 \ldots t; \; t = k \ldots T \qquad (23)$$

Recursive estimation of equation X produces a time series of estimates of β, $\hat{\beta}_t$ which varies as the data set is varied. It is intuitively clear that any variation in $\hat{\beta}_t$ as we move through time should be small and random if the model is structurally stable. The examination of the time series pattern of the recursive estimates is only one test of the hysteresis effect, however. Recursive estimation provides the basis for a number of other useful checks on the stability of the model. The checks involve using the recursive residuals, which are defined as:

$$v_t = X_t - \hat{\beta}^{/}_{t-1} Y_t \qquad t = k + 1 \ldots T \qquad (24)$$

It is clear that v_t amounts to the one-step-ahead forecasting error of standard OLS estimation. Next we consider the standardised recursive residuals. We know that β is constant and $u_t \sim N(0, \sigma)$ under the null hypothesis. Then:

(5) These plots are presented in Menon (1992c, pp.175-85). They are also available from the author on request.

Table B2 (Cont.)

AICC	Industry	DF/ADF	CRDW
724	Other specialised machinery	-3.2070**	0.8796**
74	General industrial machinery	-5.0988***	1.7362***
75	Office machines,ADP equipment	-3.1744**	0.8210**
76	Telecommunications,recording equip	-2.5366	0.8098**
77	Electrical machinery and parts	-3.0991**	0.9078**
775	Household electrical equipment	-2.5995	0.7674*
778	Hand tools with electric motors	-2.8934*	0.7204*
78	Road vehicles	-3.4716**	0.9782**
781	Passenger motor cars	-3.1029**	0.7404*
782	Trucks and buses	-3.0620**	0.8908**
784	Motor vehicle parts and accessories	-4.2838***	1.3528***
785	Motorcycles and bicycles	-3.1440**	0.8294**
81	Sanitary, heating, lighting equipment	-3.2454**	0.8996**
82	Furniture and parts thereof	-2.0211	0.4018
84	Apparel and clothing accessories	-3.2917**	1.1546***
842	Outer garments of textiles	-1.9365	0.6224
844	Under garments of textiles	-3.7426***	1.0903***
845	Knitted outer garments	-4.2133***	1.3878***
85	Footwear	-2.8072*	0.7186*
85101	Rubber or plastic footwear	-3.6967***	1.0360***
85102	Other footwear	-2.6396*	0.6628
87	Professional, scientific equipment	-2.6065*	0.5228
88	Photographic,optical goods	-4.8561***	1.5616***
89	Miscellaneous manufactured articles	-2.9866**	0.8504**
	Total Manufactured Imports	-3.9438***	1.2448***

Notes:
(1) Approximate critical values (sample size = 50) DF/ADF; 10% = -2.60 (*), 5% = -2.93 (**), 1% = -3.58 (***). CRDW test; 10% = 0.69 (*), 5% = 0.78 (**), 1% = 1.0 (***). The asterisk(s) indicate(s) the rejection of the null hypothesis (at the specified level of significance) that the variable is an integrated process.

Table B2
Results of Dickey-Fuller/Augmented Dickey-Fuller and Cointegrating Regression Durbin-Watson Tests for Cointegration

AICC	Industry	DF/ADF	CRDW
51	Organic chemicals	-2.9086*	0.7478*
52	Inorganic chemicals	-1.8346	0.2774
53	Dyeing,tanning,colouring material	-2.4317	0.5428
54	Medicinal,pharmaceutical products	-2.3289	0.6534
55	Essential oils, perfume materials	-3.8777***	1.0088***
58	Artificial resins, plastic materials	-2.5933	0.3788
59	Chemical materials and products	-2.8447	1.0340***
61	Leather, leather manufactures	-1.6052	0.4906
62	Rubber manufactures	-2.7989*	0.6536
63	Cork and wood manufactures	-3.7307***	1.1280***
64	Paper,paperboard,articles of paper	-3.2213**	0.8742**
65	Textile yarn,fabrics,madeup articles	-2.1575	0.4532
651	Textile yarn	-2.4781	0.4926
652	Woven fabrics	-1.7923	0.2710
655	Knitted fabrics	-3.7501***	1.1235***
659	Floor coverings	-4.3946***	1.3968***
66	Non-metallic mineral manufactures	-4.1805***	0.7800**
67	Iron and steel	-2.4216	0.5926
69	Manufactures of metal	-4.1076***	1.5214***
695	Non-electric hand tools	-3.9868***	1.0939***
71	Power generating machinery	-4.9242***	1.5894***
713	Internal combustion engines	-3.6228***	0.8964**
71380	Other engines for capital equipment	-3.2553**	0.7516*
714	Other non-electric engines,motors	-2.1086	0.3690
72	Machinery specialised for industries	-2.9083*	0.7334*
723	Excavating, levelling machinery	-3.6740***	1.0698***

$$v_t \sim N(0,\sigma^2,d_t^2) \quad (25)$$

where: $$d_t = (1 + x_r^{\prime}(X_{r-1}^{\prime}X_{r-1})^{-1}x_r)^{-1} \quad (26)$$

and $$X_{r-1}^{\prime} = (x_1, \ldots, x_{r-1}) \quad (27)$$

We may then define the standardised recursive residuals as:

$$w_t = v_t / d_t \sim N(0, \sigma^2) \quad (28)$$

The standardised recursive residuals have a number of advantages over the OLS residuals, although they follow the same distribution. While the OLS residuals are constrained to sum to zero when a constant term is included in the regression, this is not true of the recursive residuals. As a result, we may inspect the plots of the recursive residuals for any systematic departure from zero, which would indicate misspecification of time variation in the residuals. The second important property of the recursive residuals is that it enables us to construct a series of one-period ahead Chow-tests, each testing the hypothesis that a structural break occurs in a successively later period. To demonstrate this, we first show that:

$$RSS_t = RSS_{t-1} + w_t^2 \quad (29)$$

That is, the residual sum of squares (RSS) for an OLS estimation over period 1 to t is given by the RSS over the period 1 to $(t - 1)$ plus the squared standardised recursive residual for time t.

Finally, the properties of the recursive residuals enables us to implement the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests of Brown, Durbin and Evans (1975). The CUSUM test is simply the sum of the recursive residuals normalised by the standard error of the residuals:

$$CUSUM_t = (1/s) \sum_{i=k+1}^{t} w_i \quad (30)$$

where s is the full sample estimate of the standard error of the regression.

The CUSUMSQ test is the sum of the recursive residuals normalised by the standard error of the residuals:

$$CUSUMSQ_t = \left(\sum_{i=k+1}^{t} w_i^2\right) / \left(\sum_{j=k+1}^{T} w_j^2\right) = RSS_t / RSS_T \quad (31)$$

where T is the full sample period, so that at T, CUSUMSQ = 1.

5. Results

This section presents the results for the degree of pass-through, the recursive estimates of pass-through to check for hysteresis in import prices, and the determinants of inter-product differences in pass-through for total manufactured imports and the 50 product categories contained therein.

5.1 Degree of Exchange Rate Pass-through

The results of the unit root and cointegration tests, and the detailed econometric results are presented in Appendix B. The results of the DF, ADF and Johansen tests for each of the variables are summarised in Table B1 in Appendix B. It is clear that none of the variables are stationary in levels. Almost all of the variables achieve stationarity after differencing once. The domestic price variable for textile yarn (AICC 651), passenger motor vehicles (AICC 781), trucks and buses (AICC 782) and motorcycles and bicycles (AICC 785) achieved stationarity after differencing twice. We may then conclude that the domestic price variable for the above-mentioned products is *I*(2), where as the rest of the variables are *I*(1). Since all of the variables are non-stationary, then modelling in levels is justified only if the level variables are able to form a cointegrating vector[6].

The results for the DF, ADF and CRDW tests applied to the cointegrating residuals from the Engle-Granger regression for total manufactures and the 50 product categories are reported in Table B2. The Johansen test results for the products for which at least one cointegrating vector could be identified are reported in Table B3; the likelihood ratio test statistics (together with their 5 percent critical values) for the presence of up to 3 cointegrating vectors are also reported. From Table B3, we find that the hypothesis of one cointegrating vector is favoured in all cases. Cointegrating relationships were identified for total manufactured imports and only 11 product categories[7]. This could be partly due to the fact that our sample period

(6) As discussed in Section 4.1, unless the variables cointegrate, modelling in levels will lead to results that may be subject to the many problems of "spurious regression" outlined in Granger and Newbold (1974). The solution in this instance is to model in stationary differences of the variables.

(7) The 11 products categories are Floor coverings (AICC 659), Non-metallic mineral manufactures (AICC 66), Manufactures of metal (AICC 69), Non-electric hand tools (AICC 695), Power generating machinery and equipment (AICC 71), Excavating and levelling machinery (AICC 723), General industrial machinery and equipment (AICC 74), Road vehicles (AICC 78), Motor vehicle parts and accessories (AICC 784), Knitted outer garments (845), and Photographic equipment and optical goods (AICC 88).

Table B1 (Cont.)

(49) Photographic apparatus, equipment and supplies, and optical goods (AICC 88)

	DF/ADF	JOHANSEN
pm	-1.0123	2.1305
Δpm	-4.3522***	22.0393**
pd	-2.9265	2.0631
Δpd	-5.3129***	25.0134**
er	-0.9038	3.0329
Δer	-4.2589***	23.9127**
cp	-1.6859	2.4729
Δcp	-4.6349***	24.5069**

(50) Miscellaneous manufactured articles (AICC 89)

	DF/ADF	JOHANSEN
pm	-1.1156	3.8358
Δpm	-5.8154***	22.7441**
pd	-0.7021	5.1014
Δpd	-4.0838***	9.8571**
er	-1.0709	3.6871
Δer	-6.1765***	25.1916**
cp	-1.5970	1.7087
Δcp	-5.2667***	22.1258**

(51) Total manufactured imports

	DF/ADF	JOHANSEN
pm	-0.9047	3.2704
Δpm	-6.1596***	25.0155**
pd	-1.4967	4.2091
Δpd	-5.1916***	18.1587**
er	-1.0037	3.0409
Δer	-4.3118***	23.7492**
cp	-0.4950	0.1367
Δcp	-3.5915***	10.3020**

Notes:
(1) For the DF and ADF tests, the significance levels were determined using the critical values reported in Mackinnon (1991). Critical values (sample size = 40): 10% = -2.60 (*), 5% = -2.93 (**), 1% = -3.58 (***). Critical values for the Johansen statistic is the LR test statistic for cointegration in one variable based on maximum eigenvalue of the stochastic matrix. Critical values (sample size = 40) are: 10% = 6.5030 (*), 5% = 8.1760 (**).

Table B1 (Cont.)

(45) Footwear (AICC 85)

	DF/ADF	JOHANSEN
pm	-2.2145	3.5709
Δpm	-5.9021***	24.5478**
pd	-0.3479	4.6480
Δpd	-6.1358***	21.5220**
er	-1.5190	1.3864
Δer	-5.5304***	23.4577**
cp	-2.2068	11.5717
Δcp	-4.8707***	15.5397**

(46) Rubber or plastic footwear (AICC 85101)

	DF/ADF	JOHANSEN
pm	-2.2725	6.5435
Δpm	-3.9349***	32.3351**
pd	-0.8845	4.6480
Δpd	-3.8860***	21.5220**
er	-1.5980	1.3864
Δer	-5.5304***	23.4577**
cp	-2.2068	11.5717
Δcp	-4.87076***	15.5397**

(47) Other footwear (AICC 85102)

	DF/ADF	JOHANSEN
pm	-2.1003	2.4367
Δpm	-5.5751***	22.9780**
pd	-0.3479	4.6480
Δpd	-6.1358***	21.5220**
er	-1.5190	1.3864
Δer	-5.5304***	23.4577**
cp	-2.2068	11.5717
Δcp	-4.8707***	15.5397**

(48) Professional, scientific and controlling instruments and apparatus (AICC 87)

	DF/ADF	JOHANSEN
pm	-0.9906	3.4082
Δpm	-3.7970***	19.4296**
pd	-2.4202	2.0631
Δpd	-5.8757***	25.0134**
er	-1.1615	4.3839
Δer	-6.1142***	24.4741**
cp	-2.1357	0.7459
Δcp	-6.8007***	31.9465**

is relatively short. In small samples, the long-run or low-frequency properties of the data may only be dimly reflected, thus reducing the probability of identifying a cointegrating relationship between the variables. Cointegration tests are considered to lack power in small samples. On the bright side, given that test power will be reduced in small samples, any rejections of the null hypothesis of non-cointegration that do occur will hold *a fortiori*.

In light of the small number of cointegrating relationships, we decided to proceed in the following manner. First, we employed the Johansen ML procedure to estimate the equations for which cointegrating relationships could be identified. Second, we employed what has come to be popularly known as the time-series analyst's prescription to modelling non-stationary series which do not cointegrate by modelling in differences. To ensure completeness, this approach was applied to all of our products[8]. Third, we compare the results from our cointegrating regressions with those obtained from the regressions fitted to differences.

The results of the Johansen ML estimation for products for which cointegrating relationships could be found are reported in Table B3. The cointegrating parameters have been normalised on *pm*, and are based on the largest eigenvalues. To determine the lag length in the VAR, we used the likelihood ratio criterion. We started with a four lag system and tested down to the minimum number of significant lags using standard likelihood ratio tests[9]. Using this criterion the optimal lag length proved to be one, although the preferred parameter estimates proved to be qualitatively unchanged for VAR lag lengths of 1 to 4[10]. Finally, an unrestricted constant term and seasonal dummies are included in the VAR, as in Johansen and Juselius (1989).

(8) Since most of the variables are *I*(1), we run regressions fitted mainly to first differences. In the small number of cases where two unit roots were found, we take second differences of the variable.

(9) The degrees of freedom correction proposed by Sims (1980) was utilised. An alternative procedure in determining the lag depth of the VAR is to use the Akaike Information Criterion (Akaike, 1974). This procedure involves identifying the lag depth at which the Akaike Information Criterion is minimised and then test down to the minimum number of jointly significant lags without inducing serial correlation in the residuals. We decided against employing this procedure in the light of the evidence of Sawa (1978), who finds that minimising the Akaike Information Criterion may lead to over-parameterisation.

(10) While the parameter estimates from the eigenvectors remain relatively invariant to extensions in the lag length in the VAR, the maximum number of unique cointegrating vectors (*r*) tends to increase for a given finite sample size (see Hall, 1991). Since the optimal lag length our VAR proved to be 1, this problem did not interfere with our task of identifying an acceptable eigenvector.

With respect to the difference models, we began estimations by testing whether the right-hand side variables were econometrically exogenous. This was done using the Wu-Hausman (EXO) test (Wu, 1973; Hausman, 1978). The lagged dependent variable and lagged values of the explanatory variables were used as instruments. This test was particularly important for our model since there were some *a priori* grounds to suspect that the domestic-competing price (*pd*) variable might be jointly determined with the import price (*pm*) variable. In almost all instances, we were able to reject the null hypothesis that *pd* and *pm* were jointly determined. We were unable to reject the null for inorganic chemicals (AICC 52), electrical machinery and parts (AICC 77), trucks and buses (AICC 782), and professional and scientific equipment (AICC 87). For these products, *pd* was approximated by its fitted value from a first stage regression employing the same variables used as instruments in the Wu-Hausman test.

For the rest of the difference models, we found that the right-hand-side variables were not correlated with the error term. The use of OLS for estimation was justified in these cases. We followed the general to specific methodology suggested by David Hendry and others in our specification search for a parsimonious model.

The results for the final parsimonious models together with the relevant diagnostic test statistics are reported in Table B4. All the equations pass the F-test for the overall fit at the one percent level of significance. Given that the equations attempt to explain *changes* in import price, the somewhat low *Adjusted* R^2s are not unusual. The standard error of the equations (SEE) is very low, generally lying between 1 and 2 percent.

Serial correlation was detected in the case of inorganic chemicals (AICC 52), metal manufactures (AICC 69), other engines for capital equipment (AICC 71380), office machines and ADP equipment (AICC 75), electrical machinery and equipment (AICC 77), and professional and scientific equipment (AICC 87). In these cases, the re-specification of the equation to include a lagged dependent variable and/or retaining some lagged values of the independent variables which were statistically insignificant proved successful in removing the serial correlation. To avoid "lag mining" however, we used the *F*-test for variable deletion to chose the appropriate lag length.

For most of our equations, heteroscedasticity in the residuals did not appear to be a problem. In cases where heteroscedasticity was detected, the *t*-statistics obtained using White's heteroscedastic consistent covariance matrix are reported in addition

Table B1 (Cont.)

(41) Articles of apparel and clothing accessories (AICC 84)

	DF/ADF	JOHANSEN
pm	-1.2011	6.7299
Δ*pm*	-6.3469***	23.4089**
pd	-2.7857	0.0401
Δ*pd*	-6.3401***	29.3127**
er	-1.5125	1.4737
Δ*er*	-5.4131***	22.6229**
cp	-1.2825	9.1717
Δ*cp*	-4.5065***	15.7303**

(42) Outer garments of textile (AICC 842)

	DF/ADF	JOHANSEN
pm	-1.6037	4.6571
Δ*pm*	-5.9628***	24.3723**
pd	-2.7857	0.0401
Δ*pd*	-6.3401***	29.3127**
er	-1.5125	1.4737
Δ*er*	-5.4131***	22.6229**
cp	-1.2825	9.1717
Δ*cp*	-4.5065***	15.7303**

(43) Under garments of textile (AICC 844)

	DF/ADF	JOHANSEN
pm	-1.9211	5.6568
Δ*pm*	-6.4414***	27.4227**
pd	-2.7857	0.0401
Δ*pd*	-6.3401***	29.3127**
er	-1.5125	1.4737
Δ*er*	-5.4131***	22.6229**
cp	-0.8874	9.1717
Δ*cp*	-5.4272***	15.7303**

(44) Knitted outer garments (AICC 845)

	DF/ADF	JOHANSEN
pm	-0.9291	5.3175
Δ*pm*	-7.0433***	26.7095**
pd	-2.7857	0.0401
Δ*pd*	-6.3401***	29.3127**
er	-1.5125	1.4737
Δ*er*	-5.4131***	22.6229**
cp	-1.2825	9.1717
Δ*cp*	-4.5065***	15.7303**

Table B1 (Cont.)

(37) Motor vehicles parts and accessories (AICC 784)

	DF/ADF	JOHANSEN
pm	-1.1549	2.6032
Δ*pm*	-5.2351***	20.0767**
pd	-1.8847	2.2155
Δ*pd*	-4.2698***	21.7313**
er	-0.7943	2.1644
Δ*er*	-5.4973***	22.3970**
cp	-1.7813	1.3436
Δ*cp*	-5.0040***	20.4073**

(38) Motorcycles and bicycles (AICC 785)

	DF/ADF	JOHANSEN
pm	-1.0782	2.8542
Δ*pm*	-5.7462***	23.9105**
pd	-1.2507	0.9361
Δ*pd*	-2.3383	5.0382
Δ^2pd	-8.4877***	40.4957**
er	-0.7943	2.1644
Δ*er*	-5.4973***	22.3970**
cp	-2.1030	0.3405
Δ*cp*	-5.1424***	21.3669**

(39) Sanitary, heating, plumbing and lighting fixtures and fittings (AICC 81)

	DF/ADF	JOHANSEN
pm	-1.0408	2.3247
Δ*pm*	-5.2534***	20.8677**
pd	-0.7021	5.1014
Δ*pd*	-3.9719***	9.8571**
er	-0.8119	2.2217
Δ*er*	-5.9723***	24.8765**
cp	-1.2701	0.2619
Δ*cp*	-3.8235***	13.2397**

(40) Furniture and parts thereof (AICC 82)

	DF/ADF	JOHANSEN
pm	-1.3114	3.8237
Δ*pm*	-4.7248***	17.3341**
pd	-3.4721	4.3004
Δ*pd*	-6.4909***	26.3616**
er	-1.5373	2.0037
Δ*er*	-5.8079***	24.3334**
cp	-1.5993	0.1083
Δ*cp*	-4.4628***	16.7602**

to the conventional *t*-ratios. These are for dyeing, tanning and colouring materials (AICC 53), road vehicles (AICC 78), and miscellaneous manufactures (AICC 89). When we compare the original and corrected *t*-statistics for each of the coefficients in turn, we find that they are not very different in all cases. All in all, our equations appear to perform relatively well in terms of these diagnostic tests.

The coefficient of *er* is significant at the 5 percent level or better in all cases. The coefficient of *pd* is insignificant in most cases, and particularly for products that record high rates of pass-through. The coefficient on *cp* significant at the 10 percent level or better for the majority of products. In cases where the coefficient of *cp* is significant, the size of the coefficient is usually close or equal to the size of the coefficient of *er*. In other words, the pass-through of exchange rate changes and foreign costs are equal or close to equal in most cases. This finding suggests that the cross-coefficient restrictions implied by our model are satisfied in most cases (see Section 5.2). The relative symmetry in these pass-through rates is also in line with the findings of Hooper and Mann (1989) for the US case.

Table 1 presents the pass-through results for the cointegrating regressions estimated using the Johansen ML procedure for the 11 product categories for which cointegrating relationships could be identified and for total manufactures. Table 2 presents the pass-through results (sum of the coefficients) for the difference model for all 50 products and total manufactures. The mean pass-through estimate from the Johansen procedure is 79.28, with a standard deviation of 17.57. The mean pass-through estimate from the difference model is 71.70, with a standard deviation of 22.11.

When we compare the pass-through estimates from the difference model with the estimates from the Johansen ML estimation for the products for which cointegrating relationships could be identified, we find that they are very similar in almost all cases. The simple correlation coefficient between these estimates is 0.82. The only significant discrepancy is for floor covering (AICC 659), where the Johansen estimate is significantly higher than the estimate from the difference model. For the remaining 11 estimates, 7 lie within a 5 percent range of each other, 2 within a 10 percent range, and 3 within a 20 percent range.

Information on the dynamics of the pass-through process is discernible from Table B4. There is little evidence of a protracted adjustment in import prices to exchange rate changes. The lags are relatively short and never extend beyond 2 quarters. The shortest lags appear to centre around the quota-protected products.

The short lags identified in this study accords with previous Australian studies but contrasts with the findings in recent studies conducted in the US (see Menon, 1992d). The US studies have identified a much more protracted adjustment period, with lags extending to five quarters (e.g., Krugman and Baldwin, 1987) or longer (e.g., Helkie and Hooper, 1988). In fact, Hooper and Mann (1989, p.316) suggest that a lag length of eight quarters is considered the conventional wisdom in the US.

Table 1
Exchange Rate Pass-through Estimates from the Johansen ML Estimations

AICC	Product Description	Johansen ML
659	Floor coverings	109.06
66	Non-metallic mineral manufactures	89.91
69	Manufactures of metal	63.07
695	Non-electric hand tools	86.31
71	Power generating machinery and equipment	82.92
723	Excavating, levelling machinery	49.84
74	General industrial machinery and equipment	91.98
78	Road vehicles	78.41
784	Motor vehicle parts and accessories	86.52
845	Knitted outer garments	54.14
88	Photographic equipment, optical goods	92.42
	Total manufactures	66.27

Source: Table B3

Table B1 (Cont.)

(33) Hand tools with electric motors (AICC 778)

	DF/ADF	JOHANSEN
pm	-1.0429	1.7658
Δpm	-4.2322***	15.4416**
pd	-0.5761	2.5093
Δpd	-4.5311***	15.6319**
er	-0.9486	2.5231
Δer	-5.6228***	23.1180**
cp	-2.9100	9.8734
Δcp	-5.7195***	23.7368**

(34) Road vehicles (AICC 78)

	DF/ADF	JOHANSEN
pm	-0.5424	3.3709
Δpm	-5.2717***	19.5409**
pd	-1.2507	0.9361
Δpd	-4.2698***	21.7313**
er	-0.9177	2.1618
Δer	-3.8801***	22.3743**
cp	-1.0804	0.4253
Δcp	-4.0392***	14.5532**

(35) Passenger motor cars (AICC 781)

	DF/ADF	JOHANSEN
pm	-0.6168	3.3260
Δpm	-5.4529***	20.4259**
pd	-1.2507	0.9361
Δpd	-2.3383	5.0832
$\Delta^2 pd$	-8.4877***	40.4957**
er	-0.7943	2.1644
Δer	-5.4973***	22.3970**
cp	-1.3124	1.9378
Δcp	-3.4826**	11.4285**

(36) Trucks and buses (AICC 782)

	DF/ADF	JOHANSEN
pm	-0.3807	2.8870
Δpm	-6.0958***	24.9689**
pd	-1.2507	0.9361
Δpd	-2.3383	5.0382
$\Delta^2 pd$	-8.4877***	40.4957**
er	-0.7943	2.1644
Δer	-5.4973***	22.3970**
cp	-2.1078	0.3621
Δcp	-6.6068***	30.7848**

Table B1 (Cont.)

(29) Office machines and automatic data processing equipment (AICC 75)

	DF/ADF	JOHANSEN
pm	-1.2121	3.4459
Δpm	-5.4866***	21.4644**
pd	-0.6676	9.7868
Δpd	-4.4982***	12.3395**
er	-1.0357	3.4698
Δer	-6.0476***	24.7849**
cp	-0.4352	1.7161
Δcp	-4.5262***	17.5768**

(30) Telecommunications, sound recording and reproducing equipment (AICC 76)

	DF/ADF	JOHANSEN
pm	-0.1442	1.4772
Δpm	-4.4848***	15.7001**
pd	-0.6676	9.7868
Δpd	-4.4982***	12.3395**
er	-0.7733	2.3179
Δer	-5.5475***	22.5511**
cp	-1.3769	0.6198
Δcp	-6.0013***	26.8843**

(31) Electrical machinery, apparatus and appliances (AICC 77)

	DF/ADF	JOHANSEN
pm	-1.0253	3.6956
Δpm	-4.0549***	20.7097**
pd	-0.1787	3.9610
Δpd	-3.6799***	17.2216**
er	-1.0205	2.5231
Δer	-4.0228***	23.1180**
cp	-2.9100	9.8734
Δcp	-5.7195***	23.7368**

(32) Household electrical equipment (AICC 775)

	DF/ADF	JOHANSEN
pm	-0.9476	2.9457
Δpm	-4.1100***	20.8030**
pd	-1.3084	3.3848
Δpd	-4.4543***	15.9643**
er	-0.9486	2.5231
Δer	-5.6228***	23.1180**
cp	-2.6969	11.0889
Δcp	-4.1267***	14.3857**

Table 2
Exchange Rate Pass-through Estimates from the Difference Models

AICC	Product Description	Pass-through
51	Organic chemicals	83.54
52	Inorganic chemicals	58.25
53	Dyeing, tanning, colouring materials	84.57
54	Medicinal, pharmaceutical products	73.75
55	Essential oils, perfume materials	96.77
58	Artificial resins, plastic materials	48.73
59	Chemical materials and products	100.57
61	Leather, leather manufactures	76.29
62	Rubber manufactures	31.03
63	Cork and wood manufactures	80.38
64	Paper, paperboard, articles of pulp paper	45.39
65	Textile yarn, fabrics, made-up articles	81.25
651	Textile yarn	48.46
652	Woven fabrics	75.21
655	Knitted fabrics	85.43
659	Floor coverings	76.80
66	Non-metallic mineral manufactures	90.04
67	Iron and steel	88.81
69	Manufactures of metal	69.54
695	Non-electric hand tools	92.74
71	Power generating machinery, equipment	85.01
713	Internal combustion engines	97.78
71380	Other engines for capital equipment	85.71
714	Other non-electric engines and motors	78.95
72	Machinery specialised for industries	76.49

Table 2 (Cont.)

AICC	Product Description	Pass-through
723	Excavating, levelling machinery	49.01
724	Other specialised machinery	104.45
74	General industrial machinery, equipment	94.52
75	Office machines and ADP equipment	88.55
76	Telecommunications, recording equipment	74.13
77	Electrical machinery and parts	65.48
775	Household electrical equipment	68.48
778	Hand tools with electric motors	96.23
78	Road vehicles	81.27
781	Passenger motor cars	69.46
782	Trucks and buses	55.34
784	Motor vehicle parts and accessories	84.73
785	Motorcycles and bicycles	58.56
81	Sanitary, heating, lighting equipment	89.89
82	Furniture and parts thereof	72.11
84	Apparel and clothing accessories	45.92
842	Outer garments of textiles	51.67
844	Under garments of textiles	28.26
845	Knitted outer garments	44.51
85	Footwear	45.57
85101	Rubber or plastic footwear	18.48
85102	Other footwear	56.40
87	Professional, scientific equipment	95.11
88	Photographic equipment, optical goods	83.65
89	Miscellaneous manufactured articles	72.36
	Total manufactures	75.19

Source: Table B4

Table B1 (Cont.)

(25) Machinery specialised for particular industries (AICC 72)

	DF/ADF	JOHANSEN
pm	-1.2057	3.8113
Δpm	-5.7218***	22.5316**
pd	-0.1787	3.9610
Δpd	-3.6799***	17.2216**
er	-1.1049	2.5817
Δer	-5.6086***	23.1827**
cp	-1.1042	0.1112
cp	-3.2440**	9.9863**

(26) Excavating, levelling machinery (AICC 723)

	DF/ADF	JOHANSEN
pm	-1.9018	2.3043
Δpm	-5.9746***	25.7080**
pd	-0.2279	2.7113
Δpd	-4.2017***	14.0825**
er	-1.1049	2.5817
Δer	-5.6086***	23.1827**
cp	-1.3199	0.0703
Δcp	-4.2547***	15.5233**

(27) Other specialised machinery (AICC 724)

	DF/ADF	JOHANSEN
pm	-0.8265	2.1797
Δpm	-4.6604***	17.0823**
pd	-3.3962	6.1147
Δpd	-7.3584***	30.1806**
er	-1.1049	2.5817
Δer	-5.6086***	23.1827**
cp	-1.1800	0.1112
Δcp	-3.2440**	9.9863**

(28) General industrial machinery and equipment (AICC 74)

	DF/ADF	JOHANSEN
pm	-1.0162	3.0848
Δpm	-4.9808***	18.6548**
pd	-2.1162	7.4080
Δpd	-5.1903***	16.6445**
er	-1.0731	2.8727
Δer	-5.2773***	23.6067**
cp	-3.1862	6.5939
Δcp	-5.4050***	21.8860**

Table B1 (Cont.)

(21) Power generating machinery and equipment (AICC 71)

	DF/ADF	JOHANSEN
pm	-1.1025	3.2910
Δpm	-5.1809***	20.0441**
pd	-0.1787	3.9610
Δpd	-3.6799***	17.2216**
er	-1.0313	2.8614
Δer	-5.8518***	24.2701**
cp	0.0914	1.5594
Δcp	-3.4787**	10.4321**

(22) Internal combustion engines (AICC 713)

	DF/ADF	JOHANSEN
pm	-1.1027	4.4693
Δpm	-5.6375***	21.8379**
pd	-2.1162	7.4080
Δpd	-5.1903***	16.6445**
er	-1.0313	2.8614
Δer	-5.8518***	24.2701**
cp	-0.4465	0.5454
Δcp	-4.2723***	15.3112**

(23) Other engines for capital equipment (AICC 71380)

	DF/ADF	JOHANSEN
pm	-1.6792	2.9866
Δpm	-5.7698***	24.4967**
pd	-2.1161	7.4080
Δpd	-5.1903***	16.6445**
er	-1.0313	2.8614
Δer	-5.8518***	24.2701**
cp	-0.1312	1.9083
Δcp	-4.6276***	16.6400**

(24) Other non-electric engines and motors (AICC 714)

	DF/ADF	JOHANSEN
pm	-1.4629	4.3940
Δpm	-6.3827***	27.3829**
pd	-4.1800	1.5262
Δpd	-5.5784***	23.7373**
er	-1.0313	2.8614
Δer	-5.8518***	24.2701**
cp	-0.3196	1.0624
Δcp	-4.5321***	16.5940**

The pass-through estimates appear to vary quite significantly across products. The estimates range from 18.48 percent for rubber or plastic footwear (AICC 85101) to 104.5 percent for other specialised machinery (AICC 724). This diversity is apparent from the frequency distribution of the pass-through estimates presented in Table 3. While about 20 percent of the estimates record a value of 90 percent or above, a similar percentage lie at or below 50 percent. Notwithstanding the diversity in pass-through rates across products, it is clear that a significant number are clustered towards the upper end of the distribution. Close to half the products, as well as total manufactured imports, record a pass-through rate of 75 percent or above.

The diversity in pass-through rates across products also raises the question of possible aggregation bias in the estimate of pass-through obtained for total manufactured imports. To test this, we constructed an aggregate measure of pass-through by weighting the estimates for individual products using import shares for 1985-86, which is the mid-point of the sample period. The weighted average pass-through measure thus obtained is 77.55 percent as compared with 75.19 percent, the estimate from the aggregate (total manufactures) equation. This comparison suggests that there is very little danger of aggregation bias as far as our results from the difference model is concerned[11].

The aggregation bias is much more severe when we compare our weighted-average measure with the estimate for total manufactures obtained from our cointegrating regression. The aggregate estimate obtained using the Johansen ML procedure is 66.27 percent, which is about 15 percent lower than the weighted-average measure. These comparisons suggest that, if anything, the aggregation bias is likely to lead to an under rather than an over estimation of pass-through[12].

(11) The concern over aggregation bias is greatest when import unit values are used as proxies for import prices (Lipsey *et al*, 1992; Alterman, 1991). The lack of aggregation bias might be due to the fact that we use actual import prices rather than price proxies.

(12) It should be noted that these two estimates are not strictly comparable. The more appropriate measure in this instance would have been a weighted-average measure based on the Johansen estimates. This was not possible because cointegrating relations could only be identified for 11 product categories.

Table 3
Frequency Distribution of Exchange Rate Pass-through Estimates

Range	Number of Products	Percentage of Products
PT ≥ 90 percent	9	18.00
PT ≥ 80 percent	21	42.00
PT ≥ 70 percent	31	62.00
PT ≥ 51 percent	40	80.00
PT ≤ 50 percent	10	20.00
Total	50	100.00

Source: Table 2

Finally, a comparison of our pass-through estimates with those reported in previous Australian studies is in order. It is clear that such a comparison must be essentially highly conjectural given the many important differences that exist between this and previous Australian studies. These differences relate mainly to model specification, method of estimation, data base, time coverage and the level of disaggregation. More importantly, both Phillips (1988) and Lattimore (1988) apply conventional econometric estimation techniques without first examining the time series properties of the data. As the unit root tests revealed (Table B1), all the data series used to estimate pass-through are non-stationary. It is highly likely that the estimates from these studies would have been biased as a result of "spurious" regressions. These differences suggest that we should limit the exercise to an overall comparison of the results based on the average order of magnitude.

Table B1 (Cont.)

(17) Non-metallic manufactures (AICC 66)

	DF/ADF	JOHANSEN
pm	-1.3668	0.6741
Δ*pm*	-5.2334***	21.8480**
pd	-2.4820	1.9188
Δ*pd*	-3.6188***	11.5368**
er	-1.1703	2.0303
Δ*er*	-5.5823***	23.4374**
cp	-0.9747	0.0993
Δ*cp*	-4.6112***	17.9068**

(18) Iron and steel (AICC 67)

	DF/ADF	JOHANSEN
pm	-1.4180	1.4963
Δ*pm*	-6.1379***	26.8630**
pd	-1.9354	0.1831
Δ*pd*	-5.4747***	23.4444**
er	-0.8088	2.0879
Δ*er*	-5.4672***	22.2624**
cp	-0.4964	1.0178
Δ*cp*	-3.4724**	10.9318**

(19) Manufactures of metal (AICC 69)

	DF/ADF	JOHANSEN
pm	-1.4500	1.6804
Δ*pm*	-4.5921***	17.4593**
pd	-3.2170	1.6964
Δ*pd*	-4.0605***	29.5115***
er	-1.0497	2.5532
Δ*er*	-5.8194***	24.2996***
cp	-0.4316	0.5284
Δ*cp*	-4.8409***	18.6813***

(20) Non-electric hand tools (AICC 695)

	DF/ADF	JOHANSEN
pm	-0.9093	1.3965
Δ*pm*	-4.8206***	18.7657**
pd	-2.4538	0.0074
Δ*pd*	-5.6299***	24.5917**
er	-1.0497	2.5532
Δ*er*	-5.8194***	24.2996**
cp	-0.4316	0.5284
Δ*cp*	-4.8409***	18.6813**

Table B1 (Cont.)

(13) Textile yarn (AICC 651)

	DF/ADF	JOHANSEN
pm	-0.7111	4.7524
Δ*pm*	-6.3354***	24.1465**
pd	-0.0309	3.0876
Δ*pd*	-2.6950*	5.3708
Δ^2*pd*	-8.6885***	42.0402**
er	-0.9354	2.1748
Δ*er*	-5.6137***	23.0705**
cp	-2.3856	4.6148
Δ*cp*	-5.9181***	25.9154**

(14) Woven fabrics (AICC 652)

	DF/ADF	JOHANSEN
pm	-1.1546	2.2910
Δ*pm*	-4.3539***	22.4351**
pd	-2.4467	0.9383
Δ*pd*	-4.3847***	24.0693**
er	-0.9353	2.1748
Δ*er*	-5.6137***	23.0705**
cp	-1.7959	4.3163
Δ*cp*	-3.9693***	21.9507**

(15) Knitted fabrics (AICC 655)

	DF/ADF	JOHANSEN
pm	-0.6025	2.7244
Δ*pm*	-5.6904***	22.3508**
pd	-2.4467	0.9383
Δ*pd*	-5.6670***	24.0609**
er	-0.9353	2.1748
Δ*er*	-5.6137***	23.0705**
cp	-2.2455	4.8355
Δ*cp*	-5.0871***	22.1486**

(16) Floor coverings (AICC 59)

	DF/ADF	JOHANSEN
pm	-0.4841	2.5311
Δ*pm*	-4.9293***	17.8656**
pd	-0.7554	0.1148
Δ*pd*	-3.3870**	10.6556**
er	-0.9353	2.1748
Δ*er*	-5.6137***	23.0705**
cp	-1.7688	2.7121
Δ*cp*	-6.2073***	27.5531**

Table 4
Estimates of Pass-through: Comparison with Previous Australian Studies

AI CC	Product Description	Our estimates	Phillips (1988)	Lattimore (1988)
51	Organic chemicals	83.54	87.70	52.00
52	Inorganic chemicals	58.25	n.a.	52.00
53	Dyeing, tanning, colouring materials	84.57	98.10	52.00
54	Medicinal, pharmaceutical products	73.75	n.a.	52.00
55	Essential oils, perfume materials	96.77	76.30	52.00
58	Artificial resins, plastic materials	48.73	67.10	52.00
59	Chemical materials and products	100.57	n.a.	52.00
61	Leather, leather manufactures	76.29	70.60	n.a.
62	Rubber manufactures	31.03	53.90	n.a.
63	Cork and wood manufactures	80.38	95.70	131.30
64	Paper,paperboard,articles of pulp paper	45.39	55.80	74.5
65	Textile yarn, fabrics, made-up articles	81.25	98.00	110.50
66	Non-metallic mineral manufactures	90.04	100.20	99.90
67	Iron and steel	88.81	87.00	n.a.
69	Manufactures of metal	69.54	83.50	88.40
71	Power generating machinery,equipment	85.01	94.70	91.50
72	Machinery specialised for industries	76.49	89.50	91.50
74	General industrial machinery,equipment	94.52	99.90	91.50
75	Office machines and ADP equipment	88.55	20.50	n.a.
76	Telecommunications,recording equip.	74.13	86.80	n.a.
77	Electrical machinery and parts	65.48	83.20	91.50
78	Road vehicles	81.27	100.50	112.30
81	Sanitary, heating, lighting equipment	89.89	n.a.	92.50
82	Furniture and parts thereof	72.11	87.70	n.a.
84	Apparel and clothing accessories	45.92	59.20	66.90
85	Footwear	45.57	66.50	66.90
87	Professional, scientific equipment	95.11	126.90	n.a.
88	Photographic equipment, optical goods	83.65	n.a.	n.a.
89	Miscellaneous manufactured articles	72.36	n.a.	92.50
	Total manufactures	75.19	84.20	n.a.

Since the lowest level of disaggregation for the other studies is at the 2-digit level, Table 4 does not contain estimates that we obtained for the 20 products at finer levels of disaggregation. We were able to make matching comparisons for 24 products in the case of Phillips (1988), and 21 products in the case of Lattimore (1988). Our discussion will concentrate on the comparison with Phillips' (1988) results, because the matching with the "industry" based results of Lattimore (1988) is more crude.

An overall comparison based on the average order of magnitude shows that our pass-through estimates are lower in the majority of cases. In fact, 20 out of the 24 matched products (or 83.34 percent) record pass-through rates that are lower than those reported by Phillips. Out of these, about half are lower by 20 percent or more. The largest discrepancy between the estimates is for office machines and ADP equipment (AICC 75), where our pass-through estimate of 88.55 percent is almost 4 times higher than that reported by Phillips. This discrepancy is important not only because it is the largest, but because studies such as Citrin (1989) and Lawrence (1990) have questioned previous estimates of (aggregate) incomplete pass-through in the US based on what they claim to have been biased pass-through estimates for this product category. They argue that the aggregate pass-through relationship has been biased as a result of the failure to adequately account for the sharp declines in costs as a result of the rapid rate of technological change in this product category, particularly computer equipment, in the 1980s. Given that Australian imports of office machines and ADP equipment have recorded the largest increase in its share of total imports in the 1980s (rising from 4.6 percent in 1981-82 to 9.2 in 1990-91), a biased estimate of pass-through for this product category is likely to severely distort the aggregate relationship in the Australian context.

The reason for the massive difference in the estimates may lie in the fact that Phillips does not directly account for foreign cost changes in his model. The failure to capture this influence accurately could explain why Phillips' pass-through estimate for this product is so low. It also shows that a "world price index", based on relatively broad export price indices of major trading partners, does not always capture these influences adequately. In this instance, Phillips employs the world price index for telecommunications apparatus "as the best available proxy for this industry", which, as Figure 2 below shows, is highly inappropriate. The correct world price index is significantly at odds with the proxy employed by Phillips, especially since it fails to capture the sharp decline in office machines and ADP equipment prices in the second half of the 1980s.

Table B1 (Cont.)

(9) Rubber Manufactures (AICC 62)

	DF/ADF	JOHANSEN
pm	-0.9306	4.1686
Δ*pm*	-5.0977***	17.5407**
pd	-0.5916	1.7609
Δ*pd*	-5.3102***	20.2020**
er	-0.7881	2.6681
Δ*er*	-5.7326***	23.2603**
cp	-0.7586	0.3089
Δ*cp*	-4.5634***	16.3394**

(10) Cork and wood manufactures (excluding furniture) (AICC 63)

	DF/ADF	JOHANSEN
pm	-2.1941	1.3015
Δ*pm*	-6.4807***	29.0004**
pd	-0.6684	2.7097
Δ*pd*	-4.6764***	15.9327**
er	-1.6326	1.6663
Δ*er*	-5.0592***	20.4416**
cp	-2.1395	0.7854
Δ*cp*	-4.9586***	20.2071**

(11) Paper, paperboard and articles of pulp paper (AICC 64)

	DF/ADF	JOHANSEN
pm	-2.1731	2.6435
Δ*pm*	-7.1982***	32.4812**
pd	-2.3934	2.8027
Δ*pd*	-6.6965***	27.9617**
er	-1.1196	2.4571
Δ*er*	-5.2160***	20.8819**
cp	-1.4248	0.0581
Δ*cp*	-3.6751***	12.4076**

(12) Textile yarn, fabrics and made-up articles (AICC 65)

	DF/ADF	JOHANSEN
pm	-0.7373	2.8374
Δ*pm*	-5.3050***	19.9597**
pd	-0.5226	2.3224
Δ*pd*	-3.5334***	9.9240**
er	-0.9353	2.1748
Δ*er*	-5.6137***	23.0705**
cp	-2.3594	5.4406
Δ*cp*	-5.1867***	21.3538**

Table B1 (Cont.)

(5) Essential oils, perfume materials, polishing ,cleansing preparations (AICC 55)

	DF/ADF	JOHANSEN
pm	-1.6325	4.2709
Δ*pm*	-5.5754***	22.3991**
pd	-2.9313	6.1560
Δ*pd*	-6.2138***	22.1486**
er	-1.4848	3.2809
Δ*er*	-5.6056***	23.2759**
cp	-1.9210	0.4704
Δ*cp*	-3.7067***	13.0673**

(6) Artificial resins and plastic materials (AICC 58)

	DF/ADF	JOHANSEN
pm	-1.0120	3.8193
Δ*pm*	-6.8447***	28.6491**
pd	-0.3911	1.6097
Δ*pd*	-3.9403***	12.9041**
er	-1.1888	2.9802
Δ*er*	-5.7722***	23.9852**
cp	-0.9623	0.9299
Δ*cp*	-4.6687***	16.0690**

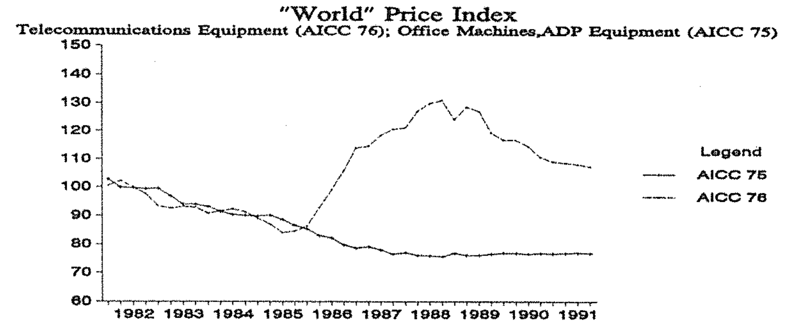
(7) Chemical materials and products (AICC 59)

	DF/ADF	JOHANSEN
pm	-1.8492	0.3582
Δ*pm*	-4.1197***	29.8347**
pd	-1.5996	3.0006
Δ*pd*	-6.6483***	26.4390**
er	-1.4038	3.2443
Δ*er*	-5.7469***	24.1060**
cp	-0.6955	0.8977
Δ*cp*	-3.7456***	11.7283**

(8) Leather, leather manufactures and dressed fur-skins (AICC 61)

	DF/ADF	JOHANSEN
pm	-2.5418	1.4580
Δ*pm*	-4.7893***	18.9708**
pd	-1.0791	4.8128
Δ*pd*	-3.9282***	11.2391**
er	-1.6014	1.9770
Δ*er*	-4.2747***	15.9619**
cp	0.9869	15.9802
Δ*cp*	-4.2501***	6.6005*

Figure 2



While this would explain why Phillips' pass-through estimate for this product is much lower than ours, it does not explain why his estimates are higher in almost all other cases. While it is true, as Phillips contends, that a more appropriately constructed world price index would result in a higher estimate of pass-through, it is less certain that this estimate would be an *accurate* measure of pass-through. In other words, the problem may not lie so much with the way in which the index is constructed, but with the measure itself. As discussed in Section 3.2, a "world" price index may already incorporate the incomplete pass-through effect, and may not accurately reflect the supply price to a "small" country like Australia if exporters price discriminate across markets.

To illustrate, consider the following example of Japanese exports of motor cars to Australia. According to Feenstra (1989), the pass-through on Japanese exports of motor cars to the US in the 1980s is about 70 percent, which implies that export prices in Yen would have been cut by about 20 percent (i.e., 30 percent times the exchange rate change of about 70 percent). Since the US is the major market for such exports, it is highly likely that the Japanese (multilateral) export price index would have been affected (i.e., lowered by an amount equal to 20 percent times the share of exports to the US in Japan's total exports) by the decision to limit the pass-through on sales to the US. It is also this index, with the incomplete pass-through on sales to the US embedded in it, that is used to construct the world price index, since bilateral indexes for Japanese exports to Australia are not available. It is this process which not only distorts the world price index, but results in pass-through estimates that are almost certainly biased. In this context, a finding of full pass-through for Australia may represent nothing more than a confirmation of the pass-through rate (or an average thereof) found in overseas studies (Menon, 1992b). The fact that we use a foreign-producer cost of production index (which does not depend on the export market being targetted) instead of a world price index could be one factor that explains why pass-through is lower across products in this study.

5.2 Hysteresis in Import Prices

We performed recursive estimation of the equations over the period 1982q4 to 1991q2. The parameter estimates from the recursive estimation for the exchange rate (*er*) variable together with its two standard error (SE) bands are depicted in Figure 3 in Appendix B. It is clear that in all cases the parameters are remarkably stable, and do not display significant variation as more data is added to the estimating equation. As discussed in Section 4.5, we take advantage of the special properties of the recursive residuals to conduct a number of additional checks on this result. First, we examined plots of the standardised recursive residuals, checking for systematic departures from zero. These plots indicate only random fluctuations in the recursive residuals around zero in all cases. Second, we examined plots of the CUSUM and CUSUMSQ of recursive residuals. We found both to be remarkably stable for all products. At no point did either of these plots move outside the 5 percent critical lines. Finally, we employed the standardised recursive residuals to construct a series of one-period-ahead Chow tests. The hypothesis of a structural break was rejected in all cases[13]. In light of this, we can conclude that the "hysteresis" effect did not apply to import prices in Australia in the 1980s, and that exporters to Australia do not respond differently to appreciations and depreciations of the currency.

5.2 Determinants of Inter-Product Differences in Exchange Rate Pass-through

Before we began estimations, we examined the correlation matrix (Table 5) for possible inter-correlation among the variables to be included in the regression model. From Table 5, we find that a number of explanatory variables appear to be more closely correlated with each other than with the dependent variable. This is the case for the following pairs of variables: (i) total imports-domestic sales ratio

(13) The plots of the standardised recursive residuals, CUSUM and CUSUMSQ of recursive residuals and the sequential Chow tests are available from the author on request.

Table B1[1]
Results of Unit Root Tests for the Dependent and Independent Variables

(1) Organic chemicals (AICC 51)

	DF/ADF	JOHANSEN
pm	-0.6571	1.8997
Δ*pm*	-4.5320***	23.9988**
pd	-2.4692	0.0127
Δ*pd*	-4.5047***	23.1883**
er	-1.2092	3.1036
Δ*er*	-4.3093***	25.0541**
cp	-1.0982	0.5372
Δ*cp*	-4.2181***	15.2312**

(2) Inorganic chemicals (AICC 52)

	DF/ADF	JOHANSEN
pm	-1.9964	0.0041
Δ*pm*	-3.5090**	14.6020**
pd	-2.5188	2.8838
Δ*pd*	-4.8613***	25.0688**
er	-1.2049	2.6149
Δ*er*	-4.1624***	23.6812**
cp	-1.2545	0.0020
Δ*cp*	-4.1321***	15.3543**

(3) Dyeing, tanning and colouring materials (AICC 53)

	DF/ADF	JOHANSEN
pm	-1.8885	0.6190
Δ*pm*	-3.8565***	20.4557***
pd	-2.4692	0.0127
Δ*pd*	-5.4057***	23.1883**
er	-1.3836	2.5101
Δ*er*	-3.9650***	22.2084**
cp	-1.3266	0.1490
Δ*cp*	-3.8233***	21.9675**

(4) Medicinal and pharmaceutical products (AICC 54)

	DF/ADF	JOHANSEN
pm	-1.7589	2.8423
Δ*pm*	-3.5356**	19.0211**
pd	-1.9972	0.4110
Δ*pd*	-4.9540***	20.2188**
er	-1.4405	2.3793
er	-5.2571***	21.6145**
cp	-1.1911	0.0181
Δ*cp*	-4.1951***	15.1186**

APPENDIX B (RESULTS APPENDIX)

Results of the Unit Root and Cointegration Tests, and Detailed Econometric Results

This appendix reports the results of the unit root and cointegration tests, and the detailed econometric results. It contains 4 major tables. Table B1 reports the results of the unit root tests for the variables used in the time-series analysis. The results for total manufactures and the 50 product categories contained therein are reported. In conducting the DF and ADF tests, we paid careful attention to the performance of various diagnostic tests. The LM test for serial correlation suggested that augmenting the DF regression was unnecessary in most cases. When serial correlation was present in the DF regression, we found that a single augmentation (with the lagged dependent variable) was sufficient to ensure residual whiteness. The diagnostic statistics for normality and heterogeneity are insignificant in all cases, suggesting that the non-parametric adjustments suggested by Phillips (1987) and Phillips and Perron (1988) are unlikely to raise the power of these tests. A further concern relates to the possibility of structural breaks in the time series. Structural breaks can alter the apparent order of integration of time- series, so that a series that is $I(0)$, but with a structural break, may be mistaken for an $I(1)$ series (see Perron, 1989, 1990). To deal with this potential problem, we carefully inspect plots of all the data time-series, searching for possible breaks in the trend. This inspection revealed that a number of the *er* and *pm* series might have been subject to this problem. To test these suspicions, we employed recursive techniques to estimate the DF/ADF regressions for these series. The results do not support the view that there has been a structural break in any of these series.

Table B2 reports the results of the DF, ADF and CRDW tests applied to the cointegrating residuals of the Engle-Granger regression for total manufactures and the 50 product categories contained therein. Table B3 reports the results from the Johansen ML estimations. The parameter estimates have been normalised on *pm*, and are based on the largest eigenvalues of the estimated cointegrating vector. The test statistics for cointegration for the VAR with lag length equal to 1 are reported together with their 5 percent critical values. Results for total manufactures and the 12 product categories for which at least one cointegrating vector could be identified are reported. Finally, Table A4 reports the results for the parsimonious regressions of the difference models, together with a battery of diagnostic test statistics. The results for total manufactures and the 50 product categories contained therein are reported.

(*TIDS*) and competitive imports-domestic sales ratio (*CIDS*), and (ii) foreign control of imports (*FCM*) and foreign investment in turnover (*FIT*). If both pairs of these variables are retained in the regression model, this could result in serious multicollinearity problems. We decided to retain *TIDS* and *FCM* (and drop *CIDS* and *FIT*) since they were considered to be better proxies of market share of imports and multinational networking, respectively.

Table 5
Correlation Matrix of Variables in Cross-Section Analysis

	PT	*ES*	*TIDS*	*CON4*	*FCM*	*PDIF1*	*QR*	*FIT*
ES	0.3301							
TIDS	-0.4807	-0.3262						
CON4	-0.2582	-0.0538	0.0480					
FCM	-0.4437	-0.2072	0.5504	0.0812				
PDIF1	-0.0643	0.0619	-0.4322	0.3245	-0.0337			
QR	-0.5907	0.1093	-0.0309	0.3236	-0.5165	-0.0927		
FIT	-0.1710	-0.0815	0.0230	0.2444	0.6292	0.2031	-0.2862	
CIDS	-0.3051	-0.2985	0.6310	-0.1023	0.1182	-0.4331	0.3191	-0.1581

The cross-section regression is estimated using OLS. The coefficient estimates from the cross-section regression and the computed elasticities are reported in Table 6. The regression passes the *F*-test for overall statistical significance at the 1 percent level. The *t*-ratios are given in parentheses and have been corrected by White's heteroscedastic consistent covariance matrix. All the variables carry the correct sign, with *t*-ratios greater than 1. The basic assumptions relating to the OLS error process are overwhelmingly supported by the various diagnostic tests. Both the LM test for heteroscedasticity (HT) and the ARCH test are unable to reject the null hypothesis of a homoscedastic error at the 1 percent level. Furthermore, the absence of outliers is confirmed by the test for normality of the residuals (NORM). We attempted both linear and log-linear specifications of the model, and found the linear specification to be superior in terms of its ability to explain variation in the dependent variable.

Table 6
Inter-Product Determinants of Exchange Rate Pass-through

Variable	Coefficient	Elasticity
Constant	63.81 (4.81)***	
Quantitative Restrictions (*QR*)	-40.49 (-4.38)***	-0.16
Foreign Control of Imports (*FCM*)	-0.19 (-1.68)**	-0.12
Elasticity of Substitution (*ES*)	18.54 (1.92)**	0.28
4-Firm Concentration Ratio (*CON4*)	-0.24 (-1.12)	-0.11
Imports-Domestic Sales Ratio (*TIDS*)	-1.01 (-1.29)	-0.05
Product Differentiation Dummy (*PDIF1*)	-9.02 (-1.25)	-0.04
Test Statistics[1]		
Adjusted R^2	0.44	
SEE	18.00	
F(5,35)	5.02	
DW	2.28	
LM4(1,34)	0.82	
RESET(1,34)	0.64	
NORM(2)	1.55	
HT(1,35)	1.16	
ARCH(1)	1.98	

Notes:
1) Critical values for the diagnostic tests at the 5 percent level of significance (with degrees of freedom in parenthesis) are as follows. LM4(1,34) = 4.12; HT(1,35) = 4.13; RESET(1,34) = 4.12; NORM(2) = 5.99; ARCH(1) = 3.84. The LM4, RESET and HT statistics are based on the *F*-distribution. The NORM statistic is distributed as $\chi^2(2)$, while the ARCH statistic is distributed as $\chi^2(1)$. Critical values for the *t*-ratios for a sample of 40 are as follows: 10 percent = 1.303 (*), 5 percent = 1.684 (**) and 1 percent = 2.423 (***).

Product Differentiation Variables: Dichotomous Dummy Variable (PDIF1) and Advertising to Sales Ratio (PDIF2)

We employ two alternative measures to proxy for product differentiation. The first measure is a dichotomous dummy variable (*PDIF1*) with relatively differentiated products assigned a value of 1 and undifferentiated product assigned a value of 0. This approach involves judgementally allocating products into these categories based on the underlying source of differentiation (such as product complexity) and end-usage. As a general rule, we considered consumer and other finished goods as being relatively differentiated, and intermediate goods, materials and other inputs as being relatively undifferentiated. In pass-through analysis, a similar measure has been employed by Phillips (1988) to capture traits of product differentiation.

The second measure that we employ is advertising as a percentage of domestic sales (*PDIF2*). The data is based on survey results collected by the Commercial Economic Advisory Service of Australia (1985) and cover all advertising except retail, classified amusements and semi-display.

Source:
Commercial Economic Advisory Service of Australia, (1985), *Advertising Expenditure in Main Media*, Sydney.

Table A1
Import Weights for Trading Partner Countries: Total Manufactures

	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90
US	38.86	37.44	35.54	35.88	32.74	35.69	35.53	36.05	39.64
Japan	33.52	35.39	36.76	36.90	37.08	33.90	32.55	34.72	31.62
Germany	10.04	10.20	9.49	10.12	12.33	12.23	12.15	9.93	11.03
UK	12.21	11.52	11.91	10.95	11.31	11.90	12.54	12.29	10.75
New Zealand	5.37	5.45	6.31	6.16	6.54	6.29	7.22	7.07	6.96

Source: Computed using data from ABS, *Foreign Trade, Australia, Imports*, Cat. No. 5437, various issues.

Total Imports and Competitive Imports as a Proportion of Domestic Sales Ratios (TIDS, CIDS)

In 1985, the Industries Assistance Commission (IAC) published annual data on total imports and competitive imports as a proportion of domestic sales for all 4-digit ASIC categories covering the period 1968-69 to 1981-82. Competitive imports are defined as imports subject to duty rates at, or in excess of, 2.5 percent. Domestic sales is defined as sales and transfers out plus the duty paid value of imports (less re-exports) minus exports. The data used in this study apply to the period 1981-82.

Source:
Industries Assistance Commission, (1985), *Australian Trade Classified by Industry*, Canberra: Australian Government Publishing Service.

Elasticity of Substitution between Domestically Produced and Imported Goods (ES)

The estimates of the elasticity of substitution between domestically produced and imported goods are obtained from the ORANI data base (see Dixon *et al*, 1982). It provides estimates for more than 50 industries at the 4-digit level of ASIC. In this study, the majority of estimates were obtained by applying the following partial adjustment model:

$$ln\, Q_{it} = \lambda_i \alpha_i + \lambda_i \sigma_i \, ln\, P_{it} + (1 - \lambda_i)\, ln\, Q_{i(t-3/2)} + \delta_{i1} Z_{1it} + \delta_{i2} Z_{2it} \qquad (10)$$

where Q_{it} is the ratio of the quantity of imports of good i in period t to the anticipated use of good i in the import-ordering period (t - 3/2), i.e., it is assumed that import-ordering decisions are made one and a half quarters before import arrivals; P_{it} is the ratio of the anticipated domestic price of domestically produced good i in its ordering period (t - 1/2), as viewed in the import-ordering period (t-3/2), to the quoted price in (t - 3/2); and Z_{1it} and Z_{2it} are, respectively, proxies for excess domestic pressure of demand and below average pressure of demand. λ_i is the coefficient of adjustment in the partial adjustment model.

Source:
Dixon, P.B., Parmenter, B.R., Sutton, J. and Vincent, D.P., (1982), *ORANI: A Multisectoral Model of the Australian Economy*, Amsterdam: North-Holland.

The *QR* variable is significant at the 1 percent level. It is clear that this is our most convincing result, and relates to the role played by quantitative restrictions in limiting the pass-through of exchange rate changes to import prices. This finding can be viewed as a vindication of the "Bhagwati hypothesis" in the Australian context. That is, exchange rate changes have been prevented from being fully passed-through to import prices by the import premium pertaining to the quota (see Section 2.3). This finding is also in line with our hypothesis that not only is pass-through likely to be lower for quota-protected products relative to products that are not subject to QRs, but the degree of pass-through is inversely related to the extent of the QR. That is, the more binding is the quota, the lower is the pass-through. The reason lies in the fact that the more restrictive is the quota, the greater is the premium available to sellers to absorb the effects of exchange rate changes[14].

The coefficient of the *FCM* variable is statistically significant at the 5 percent level. This finding suggests that the presence of MNCs or its subsidiaries (as proxied here by foreign control of the importing sector) tends to result in a lower rate of pass-through across product categories. This finding is in line with the views presented in PSA (1989). If the subsidiaries act as either distribution outlets or purchasing agents that supply the manufacturing arm of the multinational, then the ability to deal with volatile exchange rates by manipulating the prices charged on intra-firm transfers is enhanced.

Apart from transfer pricing, intra-firm trade also enables the use of intra-corporate exchange rates, selective use of invoicing currencies, and manipulation of credit arrangements and the timing of payment on transfers so that the effects of a volatile exchange rate climate can be minimised. Given that our sample period is dominated, in terms of both magnitude and duration, by the depreciation of the AUD, it should not seem surprising that MNCs have employed these mechanisms to limit the pass-through of exchange rate changes to prices.

The coefficient of the *ES* variable attains statistical significance at the 5 percent level, suggesting that pass-through is higher (lower) for imported products that are close (weak) substitutes for the domestic-competing product. When the degree of

(14) There is evidence to suggest that the massive depreciation of the AUD during 1985-86 eroded significantly the tender sale premiums on quotas in manufacturing. In the case of motor vehicles for instance, the Industries Assistance Commission (IAC, 1986, pp.45-7) report that not only did tender premiums and unofficial transfer prices for quotas decline substantially over this period, but in 1986 the available quota pool was not cleared by tender. At the quota auction for 1987, 70 percent of 1 year licences were passed in (IAC, 1987, p.110). See also Menon (1992b).

substitutability is relatively low, the foreign exporter has more discretionary power in relation to pricing decisions. It allows the foreign exporter to manipulate the degree of pass-through of exchange rate changes to selling prices without jeopardising market share. On the other hand, if imports and domestic competing products are close substitutes, we would expect the law of one price to be a reasonable approximation in these cases, and pass-through to be close to complete.

The coefficients of the *TIDS*, *CON4* and *PDIF* variables all carry the correct sign with *t*-ratios greater than 1. Starting with *TIDS*, the results suggest that pass-through is generally lower for products where the import share of the domestic market is high. This finding accords with "sticky" price outcomes proposed by standard oligopoly theory and, more recently, "new Keynesian" theories of pricing (Rotemberg, 1982). The relatively low statistical significance of the estimate could be due to the fact that this relationship may also depend on foreign exporters' perceptions with regard to the permanency of the exchange rate change, and may be more sensitive to expected future than to current exchange rates (Froot and Klemperer, 1989). In the event that an appreciation, for instance, is viewed as temporary, Froot and Klemperer (1989) suggest that import prices could rise *or* fall depending on how aggressively exporters pursue market share.

In the case of the domestic seller concentration variable, the results point to pass-through being relatively lower for the more as opposed to less concentrated product categories. If the behavioural responses of firms in highly concentrated industries is in line with the well-known kinked-demand curve model, then this finding seems quite plausible. When exporters face only a small number of domestic rivals, the expectation is that any price increase that the exporters pass-through will not be matched by the domestic firms, thus resulting in possible loss of market share. This may limit the rate of pass-through in the case of an exchange rate depreciation.

Bearing in mind that the exchange rate affects only foreign exporters directly, the pass-through of an exchange rate appreciation will also be limited under the kinked-demand curve model. Since domestic rival firms are likely to match any price decrease that results from the foreign exporter passing-through the appreciation, the profit-maximising decision for the foreign exporter is to leave prices unchanged in domestic currency. As Domberger (1983, p. 52) puts it, "firms in concentrated industries with corresponding higher price-cost margins are more likely to behave as price leaders than those of fragmented industries".

Foreign Control of Imports (FCM) and Foreign Investment in Turnover (FIT)

We employ two alternative measures of foreign participation in Australian manufacturing. They are the share of foreign control of importing activities (*FCM*), and the share of foreign investment in turnover (*FIT*). The *FCM* and *FIT* data are obtained from the Survey of Shareholdings conducted by the ABS in 1985 and 1987, respectively. In the case of *FCM*, the survey covered all importing enterprises with an aggregate value of imports for 1984-85 of more than A$350,000. An enterprise was classified as foreign controlled or owned if it did not have naturalised or naturalising status and if it is connected to a foreign entity by an ownership link of 25 percent or more of the voting shares in the enterprise. *FCM* data is reported for all 2-digit AICC products for the period 1984-85, while *FIT* data is reported for all 3 and 4-digit ASIC industries for the period 1986-87.

Source:
Australian Bureau of Statistics, *Foreign Control and Ownership of the Manufacturing Industry, Australia*, Catalogue No. 5322.0, 1985-86.

Industry Concentration (CON4)

Estimates of industry concentration are prepared by the ABS based on manufacturing census data from time to time. The latest available data is for the period 1986-87, and are based on the share of turnover, value-added or employment controlled by the largest 4,8,12,16 and 20 firms in each of the 4-digit ASIC industries. A significant limitation of the ABS estimates is that they are calculated on the basis of domestic sales of producers, and thus represent producer concentration, and not seller concentration. For an open economy such as Australia, it is important that the concentration measure is adjusted to take into account the effects of exports and imports on domestic market power. A recent study by Madge *et al* (1989) estimates trade-adjusted concentration ratios using data for competitive imports, and including the cost of insurance, freight and transit exchange rate changes (i.e., on a c.i.f.e. basis). The turnover-based trade-adjusted concentration ratio (*CR*) for product category *i* is obtained as:

$$CR_{it} = UCR_{it} \{1 - [M_{it} / (T_{it} - X_{it} + M_{it})]\} \quad (9)$$

where UCR_{it} = unadjusted concentration ratio for product *i* in period *t*
M_{it} = Competitive imports of product *i* in period *t* (c.i.f.e. basis)
X_{it} = exports of product *i* in period *t*
and T_{it} = total turnover of product *i* in period *t*

In our study, industry concentration is represented by the 4-firm trade-adjusted turnover-based concentration ratio that obtained in 1986-87.

Source:
Madge , A., Bennett, R. and Robertson, P., (1989), "Concentration in Australian Manufacturing, 1972-73 to 1986-87", *Working Paper 57*, Canberra: Australian Government Publishing Service.

where j = foreign country, k = Australia,
W_{ijt} = cost of labor input in product i in country j in period t,
ME_{ijt} = cost of raw materials and energy inputs in product i in country j in period t,
ω_L, ω_M = input-output coefficients for labor and material and energy costs, respectively, and
$\Theta_{i(jk)t}$ = share of country j in the imports of country k of product i in period t.

In a small number of cases where wage and material costs series were unavailable, producer prices were used to proxy for foreign costs.

Sources:
Organisation for Economic Cooperation and Development, *Indicators of Industrial Activity*, Geneva (France, Germany, Italy, Netherlands, Sweden, UK)
Economic Planning Board, *Monthly Statistics of Korea*, (Korea).
Bank of Japan, *Price Indexes Annual*, (Japan).
Department of Statistics, *External Trade: Price and Volume Indexes*, (New Zealand).
Department of Statistics, *Cost of Production Indexes, unpublished*, (New Zealand).
Economic Research Department, Central Bank of China, *Financial Statistics Monthly, Taiwan District, The Republic of China*, (Taiwan).
Central Statistical Office, *Monthly Digest of Statistics*, (UK).
Central Statistical Office, *Economic Trends*, (UK).
Bureau of Labor Statistics, *Producer Price Indexes*, (USA).
Department of Labor and Bureau of Labor Statistics, *Monthly Labor Review*, (USA).
Bureau of Labor Statistics, *Handbook of Labor Statistics*, (USA).

Quantitative Restrictions (QRs)

In this study, we use estimates of quota assistance to manufacturing industries that have been carefully constructed from unpublished IC estimates. They are based on the observed clearing premiums for quota entitlements tendered at the auctions held in each financial year. A number of attributes of these data make them particularly useful for purpose. For instance, the motor vehicle industry is assisted by "local content provisions" specified under the Passenger Motor Vehicle Plan. To obtain reliable estimates of the assistance solely attributable to the QR, the local content assistance have been excluded from the data. Furthermore, price indexes for individual 4-digit ASIC industries, rather than an aggregate ASIC subdivision or industry group index, have been used to convert 1983-84 base year values to current prices to obtain the total figures for quota assistance. The data for *QR* used in this study relate to 1986-87.

Source:
Industries Commission, *unpublished estimates*

The limited significance of this variable may be due to the fact that the most concentrated industries are also usually the ones with the highest levels of foreign ownership (see Menon, 1992c, Chapter 4). It may be that the power of this relationship is reduced by the dominant role played by the foreign control variable.

The results for *PDIF1* supports the view that product differentiation provides the foreign exporter with more discretion to set prices, and to manipulate pass-through. This is as a result of the limited responsiveness in demand to changes in prices for goods that are relatively differentiated (Bourdet, 1988). Most of the products that are classified as undifferentiated in our dichotomous dummy are intermediate goods. The literature on the determinants of trade flows suggests that demand for these goods are driven mainly by the level of economic activity and production, rather than price competitiveness (see Goldstein and Khan, 1985). Furthermore, since the majority of Australian intermediate goods imports do not face competition from domestic suppliers, the finding of higher rates of pass-through for these products seems justified.

A possible explanation for the low level of statistical significance of the coefficient of *PDIF1* could lie with the fact that product characteristics are probably the most difficult to quantify accurately, thus making it difficult to capture this feature adequately. Given the crudeness of a proxy such as the product differentiation dummy, we attempted an alternative proxy of product differentiation in the form of the advertising to sales ratio (*PDIF2*). We failed to observe any significant change in the result, however.

It is clear that aspects of market structure and product characteristics generally possess less explanatory power than the protection and foreign control variables in accounting for the observed differences in pass-through across products. Previous researchers in this area, such as Phillips (1988), Kreinin *et al* (1987) and Fischer (1989b), have also found that industrial organisation variables tend to possess very weak explanatory power when it comes to explaining inter-industry differences in pass-through.

6.0 Major Findings and Policy Implications

This study has analysed the relationship between exchange rates and prices for Australian manufactured imports by applying an econometric procedure which avoids the pit-falls in previous studies to a carefully assembled data set. The analysis was conducted in two stages. In the first stage, exchange rate pass-through coefficients were estimated for total manufactured imports and 50 product categories contained therein. The results pointed to incomplete pass-through in most cases, with significant differences in rates of pass-through across products. We employed a number of tests to check on the structural stability of the pass-through relationship, namely recursive estimation, the CUSUM and CUSUMSQ tests, and a sequential Chow test. All tests rejected the hypotheses of the "hysteresis" effect in Australian import prices and the asymmetric pass-through of exchange rate depreciations and appreciations for all products. Our estimates are also generally much lower than those reported in previous Australian studies.

The second stage of the analysis sought to explain inter-product differences in pass-through by estimating a cross-section model that related the pass-through estimates to variables representing quantitative restrictions, foreign control and market structure and product characteristics. The results suggest that quantitative restrictions, foreign control, concentration, product differentiation and the import share of the domestic market are negatively related to pass-through, where as the substitutability between imported and domestically produced goods positively related to pass-through.

Our results point to a number of implications from a policy perspective[15]. Our finding of incomplete pass-through at the aggregate and disaggregate level suggests that the small-country assumption of international price taking behaviour is inappropriate for most of Australia's imports. Furthermore, the results imply that exchange rate changes are likely to lead to real effects in the economy operating through changes in the terms of trade.

Figure 4 plots the terms of trade (TOT) and the hypothetical full-pass-through terms of trade (FPTOT) for Australia for the period 1981q3 to 1991q2. The FPTOT is obtained by dividing export prices by the full-pass-through import price index (FPPM). The FPPM variable is the hypothetical import price that would obtain if exchange rate changes are fully passed-through to prices paid by Australian importers in AUDs. It is obtained by multiplying WP, an import-share weighted index of export prices of the major import-supplying countries by the exchange rate (ER), thus providing us with a "world" price index in domestic currency. By comparing the two series, it is clear that the deterioration in the TOT as a result of the collapse in commodity export prices during 1984-87 has been limited by the incomplete pass-through of exchange rate changes to import prices.

(15) This section draws freely on Menon (1993)

produce a quarterly series. In most cases, import shares of the five major source countries are used to average the exchange rate series into a weighted index. The weights used for total manufactures are presented in Table xxx. The weights for manufactured products disaggregated at the 2-digit level of the AICC covering the period 1981-82 to 1990-91 are available from the author on request.

The import weighted exchange rate index (*er*) for product *i* in period *t* is expressed as:

$$ER_{it} = \sum_{j} \Theta_{ij(k)t} \cdot ER_{(jk)t} \qquad (7)$$

where j = foreign country, k = Australia,
$ER_{(jk)t}$ = nominal exchange rate of country *j* in terms of country *k* in period *t*, and
$\Theta_{ij(k)t}$ = share of country *j* in the imports of country *k* of product *i* in period *t*.

We considered two alternative weighting schemes in constructing the exchange rate index: *fixed* weights and *variable* weights. With the fixed weight scheme, import shares for a representative year, or an average for all years, are applied to the entire time series. We considered two fixed weight schemes: the first was weighted using import shares for 1985-86, and the other using an average for the entire sample of 1981-82 to 1990-91. The variable weights series is constructed by weighting the exchange rate series by the import-shares that apply in individual years. The decision to consider alternative weighting schemes in constructing the exchange rate variables was encouraged by Feinberg (1991) who finds that pass-through estimates can vary quite widely depending on the way in which "effective" exchange rates are constructed.

Sources:
International Monetary Fund, *International Financial Statistics*, Washington, D.C., (all countries except Taiwan).
Economic Research Department, Central Bank of China, *Financial Statistics Monthly, Taiwan District, The Republic of China*, (Taiwan).

Foreign Cost of Production Variable (cp)

The foreign cost of production index in each product category is constructed as an import share weighted-average of foreign costs in the five major import supplying countries. The weights are based on import shares for 1985-86. In most cases, the cost of production index for a particular country is constructed as an input-output weighted-average of labor and raw material and energy costs. The import-weighted foreign cost of production index (*cp*) for product *i* in period *t* can be expressed as:

$$CP_{it} = \sum_{j} [\omega_L W + \omega_M ME]_{ijt} \cdot \Theta_{ij(k)t} \qquad (8)$$

APPENDIX A (DATA APPENDIX)

Variable Definitions, Data Sources and Method of Construction

Import Price Variable (pm)

In this study, we have been fortunate in that we have been able to utilise true price indexes rather than unit value proxies to measure import prices. Australia is among the few countries (along with Japan, Germany and the US) for which an import price index of adequate length is available. The ABS has been publishing quarterly import price indices based on surveys of importers since the September quarter of 1981. A large number of the import price series used in this study were obtained from unpublished sources of the ABS. The procedure used by the ABS is to obtain information on individual shipments of specific goods from major importers, in respect of goods which arrive in Australia in a particular quarter. Since this index is based on transaction prices, it is not subject to the deficiencies associated with price proxies.

Source:
Australian Bureau of Statistics, *unpublished series*.

Domestic Competing Price Variable (pd)

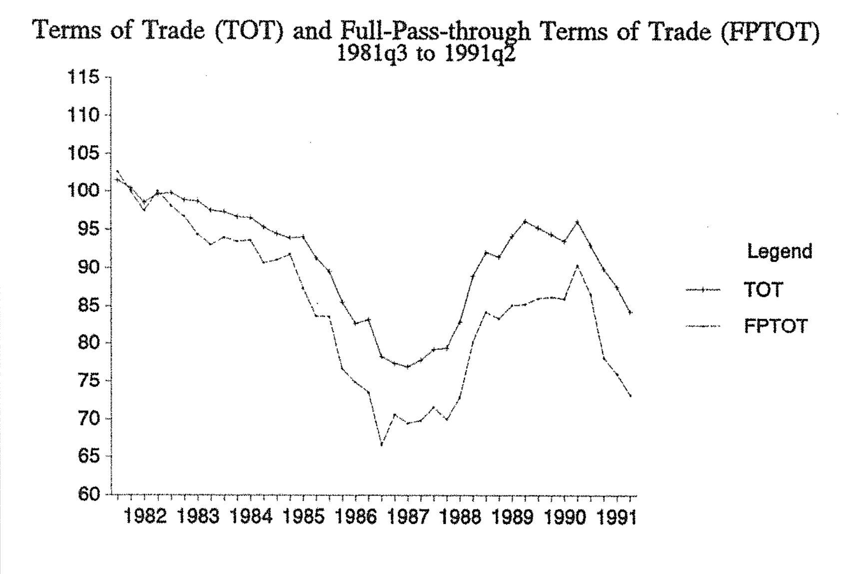
The published ABS prices of articles produced by manufacturing industry are available only at the 2-digit level of the ASIC. The 4-digit indices (which underlie the 2-digit indices) used in this study were obtained from unpublished sources of the ABS. Following a major review of the index in 1988, the series were re-weighted to reflect values of articles produced in 1986-87, instead of 1971-72 that pertained in the original series. We were able to use the re-weighted index in our study.

Source:
Australian Bureau of Statistics, *unpublished series*.

Exchange Rate Variable (er)

In constructing the exchange rate variable, it is necessary to capture the effects of differences that exist across products in terms of: (i) the range and relative importance of countries from which imports are sourced, and (ii) the magnitude of bilateral exchange rate changes across countries. To satisfy these criteria, we construct import-weighted (effective) exchange rate indices for each of the 50 product categories. All the nominal exchange rate series, except for Taiwan, are obtained from the IMF's International Financial Statistics (IFS), where daily exchange rates are aggregated to

Figure 4[1]



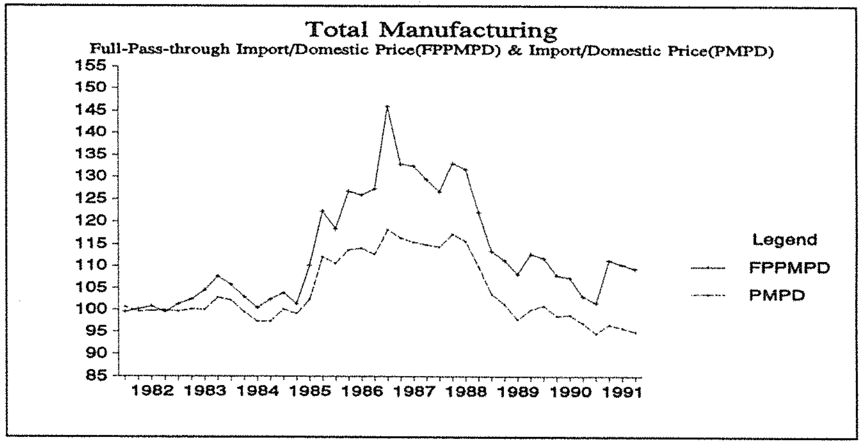
Notes:
1) 1981-82 = 100.
Sources: ABS, *Export Price Index, Australia*, Catalogue No. 6405.0, various issues.
ABS, *Import Price Index*, Catalogue No. 6414.0, various issues.

The terms of trade will remain unchanged following an exchange rate fluctuation *if and only if* the pass-through of exchange rate changes to exports prices is incomplete *and* equal to the pass-through to import prices. Given our finding of incomplete pass-through to import prices, an exchange rate depreciation, for instance, will lead to an improvement (deterioration) in the terms of trade if the pass-through to export prices is higher (lower) than the pass-through to import prices (see Menon, 1992a).

Our finding of incomplete pass-through has implications for the conduct of exchange rate policy. The effectiveness of exchange rate policy as a means to restoring external balance relies in part on exchange rate changes producing the relative price adjustments that underlie the expenditure-switching effects. The presence of incomplete pass-through implies that the extent of relative price changes will be limited.

Figure 5 depicts the movements in two versions of the relative import-domestic price ratio for total manufacturing in Australia for the period 1981q3 to 1991q2. The first series is the hypothetical full-pass-through import price (FPPM) divided by the domestic price (PD), which gives us the hypothetical relative price (FPPMPD) that would have obtained had exchange rate changes fully passed-through to import prices. The second series is the (actual) import price (PM) divided by the domestic price (PD), which gives us the relative price (PMPD) that was actually observed. The clear pattern that emerges from Figure 5 is that PMPD has displayed much less variability than FPPMPD throughout the period[16]. The coefficient of variation for PMPD is only 0.0718, but 0.1082 for FPPMPD. If we consider the period of sustained depreciation of the AUD between 1984-85 and 1986-87, we find that FPPMPD increased by 36.44 percent, while PMPD increased by only 17.63 percent. The limited variability in relative prices might go some way towards explaining why both nominal and real imports have remained stubbornly high following the depreciation in the mid-1980s despite a relatively high price elasticity of demand for imports.

Figure 5[1]



Notes:
1) 1981-82 = 100.
Sources: ABS, *Price Index for Articles Produced by Manufacturing Industry*, Catalogue No. 6412.0, various issues; ABS, *Import Price Index*, Catalogue No. 6414.0, various issues.

(16) It is important to qualify this by noting that the extent of the variability of FPPMPD is likely to be somewhat lower than depicted here if we allow for the increase in PD that would have occurred following from the full pass-through to import prices. Given the large divergence between the two series, however, it is unlikely that the overall pattern would be much affected by this.

Woo, Wing, "Exchange Rate Changes and the Prices of Non-food, Non-fuel Items", *Brookings Papers on Economic Activity*, Vol. 2, (1980) pp. 511-30.

Wu, D.M., "Alternative Tests of Independence between Stochastic Regressors and Disturbances", *Econometrica*, 41 (1973), pp. 733-50.

Nelson, Charles and Charles Plosser, "Trends and Random-Walks in Macroeconomic Time Series: Some Evidence and Implications", *Journal of Monetary Economics*, 10 (1982), pp. 139-62.

Perron, Pierre, "Trends and Walks in Macroeconomic Time Series: Further Evidence from a New Approach", *Journal of Economic Dynamics and Control*, 12 (June-September 1988), pp. 297-332.

Phillips, Peter C.B., "Time Series Regression with a Unit Root", *Econometrics*, 55 (March 1987), pp. 227-302.

Phillips, Robert, "The Pass-Through of Exchange Rate Changes to Prices of Imported Manufactures", *Discussion Paper No. 197*, Centre for Economic Policy Research, Australian National University, Canberra, 1988.

------, "Import Demand Patterns and Relative Prices During the 1980s", *Discussion Paper No. 218*, Centre for Economic Policy Research, Australian National University, Canberra, 1989.

Prices Surveillance Authority (PSA), "Inquiry Into Effects of Exchange Rate Appreciation on Prices of Consumer Goods, *Report No. 21*, Canberra, Australian Government Publishing Service, 1989.

Richardson, David, "Some Empirical Evidence on Commodity Arbitrage and the Law of One Price", *Journal of International Economics*, 8 (1978), pp. 341-51.

Salop, Steven, "Monopolistic Competition with Outside Goods", *Bell Journal of Economics*, 10 (Spring 1979), pp. 141-56.

Sargan, J.Denis, "Wages and prices in the UK: A Study in Econometric Methodology", in P. Hart, G. Mills and J. Whittaker, eds., *Econometric Analysis for National Planning*, London, Butterworths, 1964.

Sargan, J. Denis and Alok Bhargava, "Testing the Residuals from Least Squares Regression for Being Generated by the Gaussian Random Walk", *Econometrica*, 51 (January 1983), pp. 153-74.

Sawa, T., "Information Criteria for Discriminating Among Alternative Regression Models", *Econometrica*, 42 (1978), pp. 303-9.

Sibert, Anne, "Exchange Rates, Market Structure, Prices and Imports", *Economic Record*, 68 (1992), pp. 233-39.

Sims, Christopher, "Macroeconomics and Reality", *Econometrica*, 48 (January 1980), pp. 1-48.

Stock, James H., "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors", *Econometrica*, 55 (September 1987), pp. 381-6.

Venables, Anthony, "Microeconomic Implications of Exchange Rate Changes", *Oxford Review of Economic Policy*, 6 (September 1990), pp. 18-27.

The extent of the inflationary (deflationary) effects of exchange rate depreciation (appreciation) operating through changes in the prices of imported goods will be affected by the degree of pass-through. Changes in the prices of imported goods can affect the domestic price level through a number of channels. First, changes in the prices of imported consumer goods can feed directly into the CPI. Our results suggest that pass-through is incomplete for the majority of consumer goods (Tables 1 and 2). This suggests that the direct effects on the CPI from exchange rate changes will be limited.

Second, changes in the prices of intermediate imports will affect the cost of production of domestic industries, which could eventually be reflected in the prices of final goods. In 1984-85, intermediate imports made up 34.5 percent of the total cost of manufactured inputs used in the manufacturing sector[17]. Our finding of close to complete pass-through for imports of intermediate manufactured products suggests that we cannot rely on much slippage between exchange rate changes and import price changes as a moderating factor in the domestic price feedback effects of exchange rate changes. This view is in line with the survey-based findings of the Bureau of Industry Economics (BIE, 1987, pp.138-141) that the high pass-through of the depreciation to the prices of intermediate imports had significantly increased the costs of production of domestic producers. The study further notes that the higher prices of imported materials and components produced cost-push effects that were in turn passed on in higher domestic selling prices of domestically produced items.

Third, changes in the prices of imports that compete with domestically produced substitutes is likely to produce domestic price feedback effects that will vary directly with the degree of substitutability between them (Woo, 1984; Goldstein and Khan, 1985). In our cross-section analysis, we found that the degree of substitutability between imported and domestically produced goods was positively related to the degree of pass-through. This suggests that domestic-competing goods that are close substitutes for imports will undergo significant changes in price following exchange rate movements. This will tend to exacerbate the inflationary

(17) This information is obtained from ABS, *Price Index of Materials Used in Manufacturing Industries, Australia*, Catalogue No. 6411.0, December 1985.

(deflationary) effects of exchange rate depreciations (appreciations)[18].

There is a voluminous literature on the effects of exchange rate variability on international trade flows[19]. The basic argument put forward in these studies is that the increased risk and uncertainty associated with volatile exchange rates would lead to a reduction in the volume of international trade, and a retrenchment towards domestic activities. This uncertainty is said to affect both the demand for imports and the supply of exports. From the buyer's (importer's) point of view, the uncertainty resides in the price to be paid in domestic currency terms. The incomplete pass-through of exchange rate changes to import prices (in domestic currency) would reduce the variability of these prices, thus reducing the adverse effects of floating exchange rates.

From the foreign seller's (exporter's) point of view, the risk to which they are averse is ultimately about quantities, not prices (Dixit, 1990). The finding of incomplete pass-through may in fact confirm that the risk aversion is about quantities rather than prices, in that the motivation to limit pass-through resides with attempts to protect market share at the expense of variable foreign currency prices. In other words, the mere fact that pass-through is incomplete suggests that exporters are more willing to tolerate adjustments to the foreign currency prices that they receive than they are to the quantities that they sell. The pervasiveness of incomplete pass-through may also explain why a large number of studies have not been able to detect any significant link between exchange rate variability and international trade flows[20].

---

(18) These effects are described as the "first round" effects, and may induce a further round of effects depending on the response of wages. These "first-round" effects will be compounded if labour contracts have cost-of-living clauses built into them, or if indexation arrangements exist that tie wages in one way or another to the average level of prices. This compounding effect that is set-off by the "first round" effects of an exchange rate change serves to highlight the importance of the degree of pass-through in determining the extent of the inflationary (deflationary) consequences of exchange rate depreciation (appreciation).

(19) Surveys of this literature are provided in Farell *et al* (1983) and IMF (1984).

(20) For instance, the survey of this literature by the IMF (1984, p.36) concludes that "the large majority of empirical studies ... are unable to establish a systematically significant link between measured exchange rate variability and the volume of international trade, whether on an aggregated or bilateral basis".

Kreinin, Mordechai, S. Martin and E.J. Sheehey, "Differential Responses of U.S. Import Prices and Quantities to Exchange Rate Adjustments", *Weltwirtschaftliches Archiv*, 123 (September 1987), pp. 449-62.

Krugman, Paul and Richard Baldwin, "The Persistence of the U.S. Trade Deficit", *Brookings Papers on Economic Activity*, Vol. 1, 1987, pp. 1-43.

Krugman, Paul, *Exchange-Rate Instability*, Cambridge, Massachusetts, Massachusetts Institute of Technology Press, 1989.

Lattimore, Ralph, "Exchange Rate Changes and Competitiveness in Australian Manufacturing", *Working Paper No. 48*, Canberra, Australian Government Publishing Service, 1988.

Lawrence, Robert, "US Current Account Adjustment: An Appraisal", *Brookings Papers on Economic Activity*, Vol. 2, 1990, pp. 343-83.

Mackinnon, James, "Critical Values for Cointegration Tests" in Robert Engle and Clive Granger, *Long-run Economic Relationships: Readings in Cointegration*, Oxford, Oxford University Press, 1991.

Marston, Richard, "Pricing to Market in Japanese Manufacturing", *Journal of International Economics*, 29 (January 1990), pp. 217-36.

Menon, Jayant, "Exchange Rates and Prices of Australian Manufactured Exports", *Weltwirtschaftliches Archiv*, 128 (December 1992a), pp. 110-25.

------, "Exchange Rate Pass-through for Australian Imports of Motor Vehicles: An Application of the Engle-Granger Two-Step Procedure", *Discussion Paper D151*, Centre of Policy Studies, Monash University, Melbourne, 1992, forthcoming in *International Economic Journal*.

------, *Exchange Rates and Prices: The Case of Australian Manufactured Imports*, unpublished Ph.D. Dissertation, Institute of Applied Economic and Social Research, University of Melbourne, Melbourne, 1992c.

------, "Exchange Rate Pass-Through: Theory and Evidence", *IMPACT-COPS Discussion Paper*, Impact Research Centre and Centre of Policy Studies, Monash University, Melbourne, 1992d, forthcoming.

------, "Exchange Rates, Import Prices, and the Macroeconomy", *Economic Papers*, 12 (March 1993), pp. 37-48.

Mills, Terence, *Time Series Techniques for Economists*, Cambridge, Massachusetts, Cambridge University Press, 1990.

Mirus, R. and B. Yeung, "The Relevance of the Invoicing Currency in Intra-firm Trade Transactions", *Journal of International Money and Finance*, 6 (December 1987), pp. 449-64.

Helleiner, Gerald, "Comments on Efficiency, Equity and Transfer Pricing in LDCs", in Alan Rugman and Lorraine Eden, eds., *Multinationals and Transfer Pricing*, London, Croom Helm, 1985, pp. 240-4.

Hendry, David, "Econometric Modelling with Cointegrated Variables: An Overview", *Oxford Bulletin of Economics and Statistics*, 48 (September 1986), pp. 201-12.

Hendry, David and Grayham Mizon, "Serial Correlation as a Convenient Simplification not a Nuisance: A Comment on a Study of the Demand for Money of the Bank of England", *Economic Journal*, 88 (September 1978), pp. 349-363.

Holmes, P.M., *Industrial Pricing Behaviour and Devaluation*, London, Macmillan, 1978.

Hooper, Peter and Catherine Mann, "Exchange Rate Pass-Through in the 1980s: The Case of U.S. Imports of Manufactures", *Brookings Papers on Economic Activity*, Vol. 1, (1989a), 297-337.

Industries Assistance Commission (IAC), *Annual Report, 1985-86*, Canberra, Australian Government Publishing Service, 1986.

Industry Commission (IC), The Automotive Industry, *Report No. 5*, Canberra, Australian Government Publishing Service, 1990.

International Monetary Fund (IMF), "Exchange Rate Volatility and World Trade", *Occasional Paper No. 28*, Washington, D.C., July 1984.

Isard, Peter, "How Far Can We Push the Law of One Price", *American Economic Review*, 67 (December 1977), pp. 942-48.

Johansen, Soren, "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control*, 12 (June-September 1988), pp. 231-54.

Johansen, Soren and Katerina Juselius, "Maximum-Likelihood Estimation and Inference on Cointegration - With Applications to the Demand for Money", *Oxford Bulletin of Economics and Statistics*, 52 (May 1990), pp. 169-210.

Johnson, Harry, "International Trade Theory and Monopolistic Competition Theory", Chap. 9 in Richard Kuenne, ed., *Monopolistic Competition Theory: Studies in Impact*, New York, Wiley, 1967, pp. 203-18.

Kasa, Kenneth, "Adjustment Costs and Pricing to Market: Theory and Evidence", *Journal of International Economics*, 32 (January 1992), pp. 1-30.

Knetter, Michael, "Price Discrimination by U.S. and German Exporters, *American Economic Review*, 79 (March 1989), pp. 198-209.

Kravis, Irving and Robert Lipsey, "Price Behaviour in Light of Balance of Payments Theories", *Journal of International Economics*, 8 (May 1978), pp. 193-246.

References

Alterman, William, "Price Trends in US Trade: New Data, New Insights", in Peter Hooper and J. David Richardson, eds., *International Economic Transactions: Issues in Measurement and Empirical Research*, Chicago, University of Chicago Press for the National Bureau of Economic Research, 1991.

Athukorala, Premachandra and Jayant Menon, "Relative Prices, Economic Activity and Manufactured Imports: The Australian Experience", *Discussion Paper 20/88*, School of Economics, La Trobe University, Melbourne, 1988.

Baldwin, Richard, "Hysteresis in Import Prices: The Beachhead Effect", *American Economic Review*, 78 (September 1988), pp. 773-85.

Banerjee, Anindya, Juan Dolado, David Hendry and Gregor Smith, "Exploring Equilibrium Relationships in Econometrics through Static Models: Some Monte Carlo Evidence", *Oxford Bulletin of Economics and Statistics*, 48 (August 1986), pp. 253-77.

Bhagwati, Jagdish, "The Pass-Through Puzzle: The Missing Prince from Hamlet", *mimeo.*, Columbia University, December 1988.

Bourdet, Yves, *International Integration, Market Structure and Prices*, London: Routledge, 1988.

Branson, William, "Comment", on 'Exchange Rate Pass-Through in the 1980s: The Case of U.S. Imports of Manufactures' by Hooper and Mann (1989), *Brookings Papers on Economic Activity*, Vol. 1, 1988, pp. 330-3.

Brown, R.L., James Durbin and Evans, J.M., "Techniques for Testing the Constancy of Regression Relationships Over Time", *Journal of the Royal Statistical Society*, Series B, 37 (June 1975), pp. 149-92.

Bureau of Industry Economics (BIE), "Depreciation of the Australian Dollar: How do Mature Industries Fare?", *Research Report 24*, Canberra, Australian Government Publishing Service, 1987.

Carse, Stephen, John Williamson and Gerald E. Wood, *The Financing Procedures of British Foreign Trade*, Cambridge, Cambridge University Press, 1980.

Citrin, Daniel, "The Recent Behaviour of US Trade Prices", *IMF Staff Papers*, 36 (December 1989), pp. 934-49.

Corbane, Daniel and Stephen Ouliaris, "Robust Tests for Unit Roots in the Foreign Exchange Market", *Economic Letters*, 22 (1986), pp. 375-80.

Cuthbertson, Keith, Stephen G. Hall and Mark P. Taylor, *Applied Econometric Techniques*, London, Philip Allan, 1992.

Davidson, James, David Hendry, Frank Sbra and Steven Yeo, "Econometric Modelling of the Aggregate Time Series Relationship Between Consumers' Expenditure and Income in the United Kingdom", *Economic Journal*, 88 (December 1978), pp. 349-63.

Dickey, David and Wayne A. Fuller, "Distribution of Estimates of Autoregressive Time Series with Unit Root", *Journal of the American Statistical Association*, 74 (June 1979), pp. 27-31.

Dickey, David and S.G. Pantula, "Determining the Order of Differencing in Autoregressive Processes", *Journal of Business and Economic Statistics*, 5 (January 1988), pp. 455-61.

Dixit, Avinash, "Hysteresis, Import Penetration and Exchange Rate Pass-Through", *Quarterly Journal of Economics*, 104 (June 1989), pp. 205-228.

------, "Review" of 'Exchange Rate Instability' by Krugman (1989), *Journal of Economic Literature*, 28 (1990), pp. 705-7.

Dixit, Avinash and Joseph Stiglitz, "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*, 67 (June 1977), pp. 297-308.

Dixon, Peter, Brian Parmenter, John Sutton and David Vincent, *ORANI: A Multisectoral Model of the Australian Economy*, Amsterdam, North-Holland, 1982.

Dolado, Juan, Tim Jenkinson and Simon Sosvilla-Rivers, "Cointegration and Unit Roots: A Survey", *Journal of Economic Surveys*, 4 (September 1990), pp. 1-46.

Domberger, Simon, *Industrial Structure, Pricing and Inflation*, Oxford, Martin Robertson, 1983.

Dornbusch, Rudiger, "Exchange Rates and Prices", *American Economic Review*, 77 (March 1987), pp. 93-106.

Dunn, Richard, "Flexible Exchange Rates and Oligopoly Pricing", *Journal of Political Economy*, 78 (1970), pp.140-51.

Engle, Robert and Clive Granger, "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*, 55 (March 1987), pp. 251-76.

Farell, V.S., Daniel Derosa and T.A. McCown, "Effects of Exchange Rate Variability on International Trade and Other Variables: A Review of the Literature", *Staff Studies No. 130*, Board of Governors of the Federal Reserve System, December 1980.

Feenstra, Robert, "Symmetric Pass-Through of Tariffs and Exchange Rates Under Imperfect Competition: An Empirical Test", *Journal of International Economics*, 27 (August 1989), pp. 25-45.

Fischer, Eric, "A Model of Exchange Rate Pass-Through", *Journal of International Economics*, 26 (1989a), pp.119-37.

------, "Exchange Rate Pass-Through and the Relative Concentration of German and Japanese Manufacturing Industries", *Economics Letters*, 31 (1989b), pp. 81-5.

Friedman, Milton, "The Case for Flexible Exchange Rates", in Milton Friedman, ed., *Essays in Positive Economics*, Chicago, University of Chicago Press, 1953.

Froot, Kenneth and Paul Klemperer, "Exchange Rate Pass-Through When Market Share Matters", *American Economic Review*, 79 (December 1989), pp. 637-54.

Gilbert, Clive, "Professor Hendry's Econometric Methodology", *Oxford Bulletin of Economics and Statistics*, 48 (August 1986), pp. 283-307.

Goldstein, Morris and Mohsin Khan, "Income and Price Effects in Foreign Trade", in Ronald Jones and Peter Kenen, eds., *Handbook of International Economics*, Vol. II, 1985, pp. 1040-1105.

Gordon, J.M., "The J-Curve Effects", in Tom Nguyen and Robert Gregory, eds., *Exchange Rates and the Economy*, Supplement to *Economic Record*, pp. 82-8.

Granger, Clive, "Developments in the Study of Cointegrated Economic Variables", *Oxford Bulletin of Economics and Statistics*, 48 (August 1986), pp. 213-28.

Granger, Clive and Paul Newbold, "Spurious Regressions in Econometrics", *Journal of Econometrics*, 2 (July 1974), pp. 111-20.

Grassman, Sven, *Exchange Reserves and the Financial Structure of Foreign Trade*, Hants, England, Saxon House, 1973.

Greenaway, David and Chris Milner, *The Economics of Intra-Industry Trade*, Oxford, Basil Blackwell, 1986.

Hall, Stephen, "An Application of the Granger and Engle Two-Step Estimation Procedure to United Kingdom Aggregate Wage Data", *Oxford Bulletin of Economics and Statistics*, 48 (August 1986), pp. 229-39.

------, "Maximum Likelihood Estimation of Cointegration Vectors: An Example of the Johansen Procedure, *Oxford Bulletin of Economics and Statistics*, 51 (June 1989), pp. 213-8.

------, "The Effect of Varying Length VAR Models on the Maximum Likelihood Estimates of Cointegrating Vectors", *Scottish Journal of Political Economy*, 38 (December 1991), pp. 317-23.

Hausman, Jerry, "Specification Tests in Econometrics", *Econometrica*, 46 (1978), pp. 1251-72.

Harvey, Andrew, *The Econometric Analysis of Time Series*, 2nd Edition, London, Phillip Allan, 1990.

Helkie, William and Peter Hooper, "An Empirical Analysis of the External Deficit, 1980-86", Chap. 2 in Ralph Bryant, Gerald Holtham, and Peter Hooper, eds., *External Deficits and the Dollar: The Pit and the Pendulum*, Washington, D.C., Brookings Institution, 1988, pp. 10-56.