EXCHANGE RATE PASS-THROUGH: THE DIFFERENT RESPONSES OF IMPORTERS AND EXPORTERS

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ABSTRACT

This paper examines exchange rate pass-through for the prices of both imports and manufactured exports. It is found that, in the long run, exchange rate pass-through over the docks is complete for both classes of good. However, in the short run, responses to currency movements differ significantly. Differences occur with respect to the speed of pass-through and its pattern over time. Pass-through to import prices is found to be more rapid than that to manufactured export prices. However, evidence is presented of a recent and substantial increase in pass-through to manufactured export prices, in keeping with increased international integration. Conversely, existing patterns of exchange rate pass-through to import prices are found to accord with historical experience. The implications of this are discussed with respect to the balance of payments and inflation.

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1. INTRODUCTION

Devaluation increases the domestic price of traded goods and, other things being constant, increases the general price level. Thus, in the short run, currency depreciation is considered to be a source of inflationary pressure.[1] However, the latest episode of currency depreciation in Australia has had a less-than-expected impact on inflation. This suggests that the extent to which changes in the exchange rate are transmitted to changes in the domestic prices of traded goods might be less than it was, say, a decade ago. If so, there are important implications for both the balance of payments and inflation. First, currency depreciation may be less effective in inducing those changes in relative prices that assist improvement of the balance of payments. Second, currency depreciation may have a lagged and uncertain impact on inflation.

This paper reviews the process by which changes in the exchange rate impact upon the domestic price of traded goods - that is, the pass-through effect. The main purpose of the paper is to estimate the dynamics of exchange rate pass-through with respect to the prices of imports and manufactured exports in Australia.[2] It is hypothesised that there has been a change in the pass-through relationship during the 1980s. Furthermore, it is argued that the experience of exchange rate pass-through is significantly different for importers and exporters. The implications of this are discussed with respect to the balance of payments and inflation. In particular, an attempt is made to identify the inflationary consequences of the recent depreciation.

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1 Though it is generally accepted that, in the long run, inflation is a monetary phenomenon. See Blundell-Wignall (1992) for a discussion of this view.

2 That is, the pass-through relationship is being examined for similar classes of goods. The methodology for examining pass-through for commodities differs to that for manufactured goods (Heath 1991).

The paper is organised as follows. In section 2, recent trends in the exchange rate and inflation are discussed. In section 3, an analytical framework is developed which forms the basis of a model for testing the pass-through relationship. Features of the data required for estimation are discussed in section 4. Estimation and results are presented in section 5. In section 6, implications of the results are discussed. Finally, conclusions are drawn.

2. TRENDS IN EXCHANGE RATES AND PRICES

In Australia, since the mid 1970s, episodes of currency depreciation have tended to be accompanied by an increase in inflation.[3] The experience of the last decade is illustrated in Figure 1. The value of the Australian dollar on a trade-weighted basis is represented by the trade-weighted index (TWI). The TWI is inverted, so that an increase in the index represents depreciation, and is plotted against the annual rate of inflation.

From Figure 1 it is clear that the initial episode of currency depreciation in the early 1980s was accompanied by an increase in inflation. The record depreciation of the mid 1980s was also accompanied by an increase in inflation, although one which was less than proportionate. Conversely, the latest episode of currency depreciation has coincided with a *fall* in inflation.

The progress towards our present environment of low inflation has resulted in each peak in inflation being less than its predecessor. Many factors, monetary and non-monetary, have contributed to the nation's present inflation performance (Stevens 1992). However, for the first time, a major episode of currency depreciation has not been directly manifested in inflationary pressure, or at least not yet.

The apparent absence of inflationary pressure is reinforced in Figure 2 where the percentage point contribution of retail import prices to annual inflation is illustrated.[4]

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3 Prior to this time inflation tended to be associated with international shocks. See Stevens (1992) for an analysis of the determinants of Australia's inflation performance for the period 1950 to 1991.

4 Given the rural and resource based nature of the majority of Australia's exports, very few exportable prices are included in the CPI. Consequently, the inflationary impact of depreciation is largely captured by the contribution to changes in the CPI of items "wholly or predominantly imported".

Figure 1: TWI and Inflation

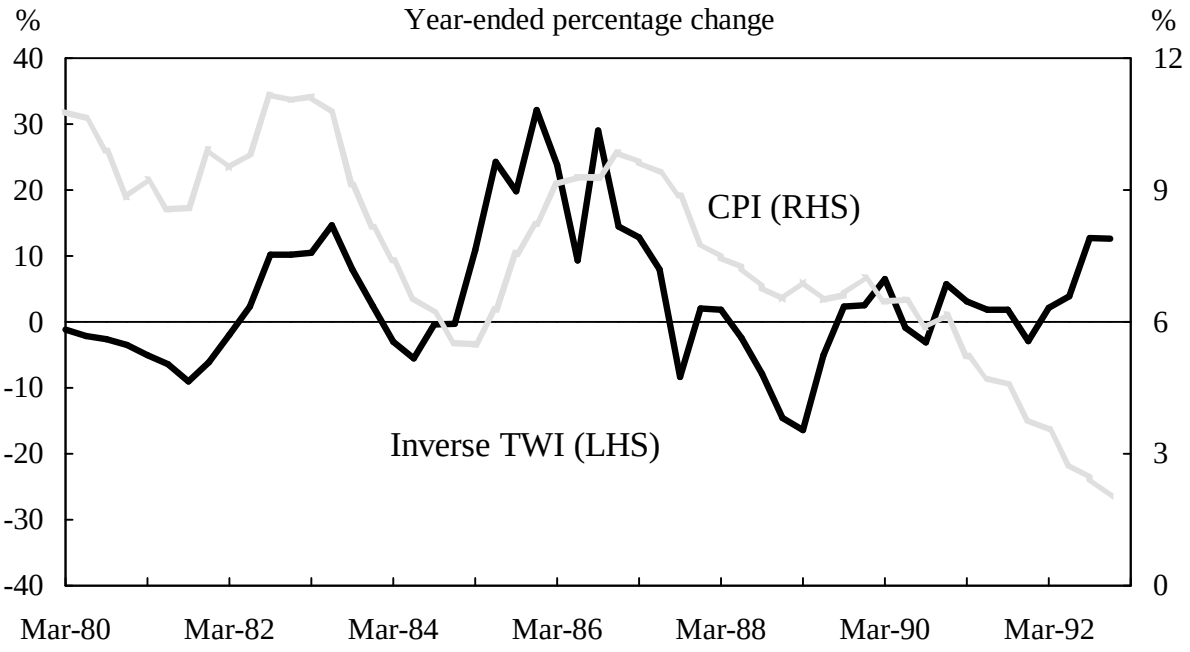
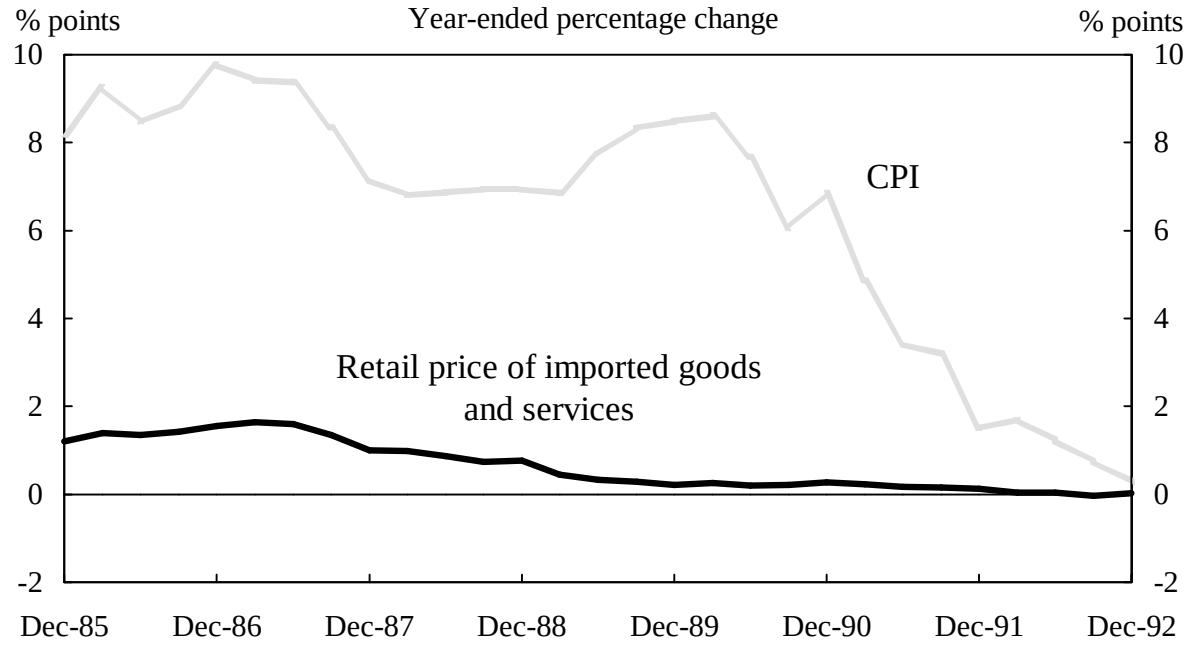


Figure 2: Contribution of Imported Items to the CPI



During the previous major depreciation of the mid 1980s, a substantial share of the annual inflation rate was directly attributable to higher retail prices of imports.[5] Conversely, during the recent depreciation, the retail prices of imported goods have not contributed to inflation.

Certainly, the world prices of Australia's imports have been subdued since 1989/90. Furthermore, the extent to which the collective forces of recession, wage restraint and microeconomic reform have offset the inflationary effects of depreciation is not known. In other words, the counterfactual is not known. Nonetheless, the impact of the recent depreciation on the general price level has been less than expected. Thus we commence with the testable proposition that price-setting agents have altered their responses to changes in the exchange rate. The framework for our analysis is outlined below.

3. THE ANALYTICAL FRAMEWORK

The starting point for analysis of exchange rate pass-through is "the law of one price".[6] In its absolute form, the law of one price states that the price of a traded good will be the same in both the domestic and foreign economies, when expressed in a common currency. The law can be expressed as follows:

$$P = P^{*}e \qquad (1)$$

where: P is the domestic price of the traded good; P^{*} is the corresponding foreign price; and e is the exchange rate in units of domestic currency per unit of foreign currency (so that an increase in e indicates depreciation).[7]

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5 Of course, currency depreciation also has an indirect effect on inflation (via the cost of imported inputs, inflationary expectations, wage outcomes, etc) which may be substantial and is not captured in Figure 2.

6 See Menon (1991a) for a comprehensive discussion of the relationship between the law of one price and exchange rate pass-through.

7 In its relative form, the law allows for a wedge factor of transactions costs (k) and can be expressed as $P_t = P_t^{*}e / k$. However, if k is constant, both the relative and absolute forms of the law of one price will be equivalent when expressed in log linear form or in proportional changes.

Departures from the law of one price occur when, for a given foreign price of a traded good, changes in its domestic price are not proportional to changes in the exchange rate. A departure from the law of one price, therefore, implies that exchange rate pass-through is incomplete. The pass-through relationship can be expressed most simply as:

$$\hat{P} = \hat{P}^* + \hat{e} \tag{2}$$

where: ^ denotes the proportional change. Clearly, if foreign prices do not change, $\hat{P}^*$ equals $\hat{e}$ and pass-through is complete. Alternatively, if foreign prices do not change but $\hat{P}^*$ is less than $\hat{e}$, there has been a departure from the law of one price and pass-through is incomplete.

However, this representation of exchange rate pass-through implicitly assumes perfect competition. If the assumption of perfect competition is relaxed, an allowance can be made for variations in the profit margins of price setting agents (Mann 1986; Hooper and Mann 1989). The price of a traded good can now be defined as the sum of the costs of producing the good (c) and a margin (m). For example:

$$\hat{P}^* = \hat{c}^* + \hat{m}^* \tag{3}$$

so that,

$$\hat{P} = (\hat{c}^* + \hat{m}^*) + \hat{e} \tag{4}$$

Thus it can be shown that the change in the domestic price of a traded good will be related not only to the exchange rate, but to the pricing policies of foreign agents. In this case, foreign suppliers may act to offset the effects of depreciation by lowering their margins so that exchange rate pass-through is incomplete.

In fact, as argued by Hooper and Mann (1989), presentation of the pass-through relationship should allow for the variation of margins of both domestic and foreign price setting agents. This permits the following expression:

$$(\hat{c} + \hat{m}) = (\hat{c}^* + \hat{m}^*) + \hat{e} \tag{5}$$

When the issue of margins is introduced, it is apparent that exchange rate pass-through occurs in two stages. In the first stage, foreign price-setting agents will choose either to maintain or change their margins in response to depreciation. In the second stage,

local distributors will, in turn, choose to maintain or change their margins when setting the price that they charge local customers. Thus, in an environment of imperfect competition, the final impact of an exchange rate depreciation on consumer prices is determined by the extent of combined pass-through.

The extent of exchange rate pass-through is governed by three main factors: the relative elasticities of demand for and supply of traded goods, macroeconomic conditions and the microeconomic environment (Phillips 1988).

First, in the absence of other shocks, the relative price elasticities of demand and supply are the principal determinants of exchange rate pass-through. For *exports*, the degree of pass-through will increase the greater is the elasticity of demand and the smaller is the elasticity of supply. Conversely, for *imports*, the degree of pass-through will increase the lower is the elasticity of demand and the greater is the elasticity of supply (Spitäller 1980; Bureau of Industry Economics 1987). From this it follows that pass-through will be complete in the case of a small open economy. In such a case, exporters are assumed to face perfect elasticity of demand while importers face perfect elasticity of supply, so that the country is a price taker in world markets.[8]

Second, macroeconomic shocks may operate either to reinforce or counteract the influence of demand and supply elasticities. For instance, when domestic demand is buoyant or capacity is constrained, the extent of exchange rate pass-through for imports is likely to be high irrespective of the relative elasticities of demand and supply (Piggot and Reinhart 1985; Phillips 1988). Alternatively, when domestic demand is weak or capacity utilisation is low, the margins of foreign suppliers may be squeezed so that pass-through for imports is incomplete. Again, this may occur irrespective of elasticities of demand and supply.[9] In fact, firms may face a

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[8] Specifically, when exporters face perfectly elastic demand, following a change in the exchange rate, the domestic price of the export must not deviate from the foreign price when expressed in common currency. This requires the domestic price of the export to move in exact proportion to the exchange rate: hence, pass-through will be complete. Importers, on the other hand, face perfect elasticity of supply. Since foreigners will not adjust the foreign currency price of the good following a change in the exchange rate, the domestic price of the import will move in exact proportion to the exchange rate: again, pass-through will be complete.

[9] That is, assuming such elasticities are neither infinite nor zero.

macroeconomic shock of sufficient magnitude to generate a permanent change in the volume of goods traded and the degree of pass-through (Baldwin 1988; Dixit 1989).[10]

Third, at the level of individual industries, the microeconomic environment will influence the strategies of price setting agents. When homogenous products are traded in an integrated world market, arbitrage eliminates differentials in the common currency price of goods. However, when markets are imperfectly competitive and segmented, a wide range of pricing responses is possible.[11] For example, if agents have power as price makers and seek to maximise profit, exchange rate pass-through is likely to be high regardless of other factors (Phillips 1988). Alternatively, if agents seek to maximise market share rather than profit, pass-through may be incomplete (Hooper and Mann 1989; Ohno 1990). Furthermore, if opportunities exist to discriminate between markets, "pricing to market" may occur, yielding different degrees of pass-through across a range of segmented markets (Krugman 1986; Gagnon and Knetter 1992). Finally, pricing strategies will be influenced by expectations about future currency price movements and the length of the corporate planning horizon (Froot and Klemperer 1988; Ohno 1990).

There is now an established body of empirical literature on exchange rate pass-through, most of which focuses on the American experience.[12] A body of Australian empirical literature has also emerged, largely in response to the price effects of currency movements in the mid to late 1980s. Australian studies have been almost entirely confined to the analysis of import price pass-through.[13]

It is timely to examine the responses of *both* importers and exporters to the latest episode of currency depreciation in Australia. In fact, Australia provides a test of the small country case. It is expected, *a priori*, that pass-through will be complete in the long run for imports and exports of manufactures. However, observed pricing behaviour suggests that, in the short run, pass-through will be incomplete.

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10 This possibility is most often considered with respect to large changes in the exchange rate. However, such shocks may also include domestic demand (Menzies and Heenan 1993).

11 Phillips (1988) explores the microeconomic aspects of pass-through.

12 Menon (1992a) provides an extensive review of the international literature.

13 Amongst the few examples of export price pass-through are those by Menon (1991b) and Heath (1991).

Equation (1) forms the basis of a simple model for testing exchange rate pass-through. It is applied to both imports and exports of Australian manufactures. However, before discussing its functional form and the estimation technique to be adopted, consider the data required to test the pass-through relationship.

4. THE DATA

Estimation of a pass-through relationship requires the domestic price of a traded good, its world price and an exchange rate. In principle, the distinction between these variables is simple. However, in practice, there are a number of measurement issues that require consideration. The data used in estimation of the pass-through relationship are listed below, with a comment on their features. All data are quarterly and are expressed as logarithms. Further details and sources are given in Appendix 1.

IPD^m implicit price deflator for endogenous imports, seasonally adjusted, excluding computers.

IPD^x implicit price deflator for manufactured exports, seasonally adjusted, excluding computers.

WP^m an index of world export prices, with weights proportional to import shares from the largest suppliers of non-oil imports to Australia.

WP^x an index of world export prices, with weights proportional to world trade shares of countries that are major exporters of manufactures.

TWI^m exchange rate measured by a TWI (expressed in units of domestic currency per unit of foreign currency), with weights proportional to import shares from the countries used in WP^m.

TWI^x TWI with weights proportional to manufactured export shares to the countries used in WP^x.

Using implicit price deflators to represent the domestic price of imports and exports facilitates the requisite time series for econometric analysis. However, use of these data has several implications. First, in recent years, these deflators have been affected

by rapidly falling computer prices. Thus, for the purpose of this paper, IPD^m and IPD^x have been adjusted to exclude computers. This is principally because the method employed by the Australian Bureau of Statistics to estimate computer prices differs to that adopted by other agencies and, therefore, detracts from the comparability of domestic and world prices.[14]

Second, implicit price deflators record prices "free on board" - that is, over the docks. Furthermore, where goods are invoiced in foreign currency, their value is converted to domestic currency at the exchange rate that prevails at the time of departure rather than receipt. Thus, for imports, a shipping lag is built into the price series. No adjustment for a shipping lag has been pursued here.[15]

Third, and perhaps most importantly, a free on board price is different to a final retail price of a traded good. In fact, use of a free on board price confines econometric analysis to the first stage of pass-through - that is, the response of price setting agents in the supplying country to exchange rate changes. However, identification of first stage pass-through is a pre-requisite for examination of price adjustment at the second stage in which local distributors may or may not pass on the full cost of the traded good.[16] Moreover, quantitative analysis of the second stage of price adjustment is beyond the scope of the present paper. In consequence, second stage pass-through will be dealt with in a qualitative way in this paper.

A world price index was constructed to represent the foreign currency price of manufactured goods imported by Australia. Given that endogenous imports are principally of manufactures, an average of the foreign currency price of exports from Australia's trading partners was thought to be a suitable proxy for the world price of these goods. WP^m is based on the world price index constructed by Richards and Stevens (1987).

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14 Problems associated with the measurement of computer prices are discussed in Appendix 2.

15 Phillips (1988) constructed import price series adjusted for the shipping lag, but found that it did not greatly influence estimates of exchange rate pass-through in the long run. It serves only to increase pass-through in the initial quarter.

16 In fact, even where attempts have been made to examine second stage pass-through using industry specific data, it has been assumed that pass-through was complete and instantaneous at the first stage. (See for example Andrew and Dollery (1990).)

Ideally, a world price index of the manufactures exported by Australia would comprise an average of the foreign currency price of manufactures imported by Australia's trading partners. However, appropriate data on foreign manufactured import prices are difficult to obtain. Consequently, WP^x is constructed to best represent that price faced by Australian exporters of manufactures when competing in world markets.[17]

Finally, a nominal effective exchange rate index was defined. The weight given to each country in an effective exchange rate index is most often based on its total trade with the domestic economy. However, for investigating import price pass-through, such weights should be proportional to import shares (TWI^m). Likewise, for investigating pass-through to manufactured export prices, weights should be proportional to shares of manufactured exports (TWI^x).[18] The different weights result in TWI^x depreciating by significantly less than TWI^m during the mid 1980s and in recent quarters.[19]

The data are graphed in Figures 3 and 4. Note the relative stability of world prices over the period. Further, IPD^m and TWI^m tend to move in line with each other, suggesting that pass-through may be complete in the long run. A direct relationship between IPD^x and TWI^x is, however, less apparent.

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17 That is, with a simplifying assumption: that those countries to which Australia exports manufactures also have access to a world market represented by the major sources of world manufactured exports.

18 Alternatively, Menon (1992b) advocates a contract-currency weighted exchange rate.

19 Whilst New Zealand is not a major source of Australia's imports, it is the nation's single largest destination for manufactured exports. In consequence, a substantial weight is attached to New Zealand in TWI^X. Given that the Australian dollar and the New Zealand dollar tend to move together, TWI^X has depreciated by significantly less than TWI^m.

Figure 3: Data for Import Price Pass-Through

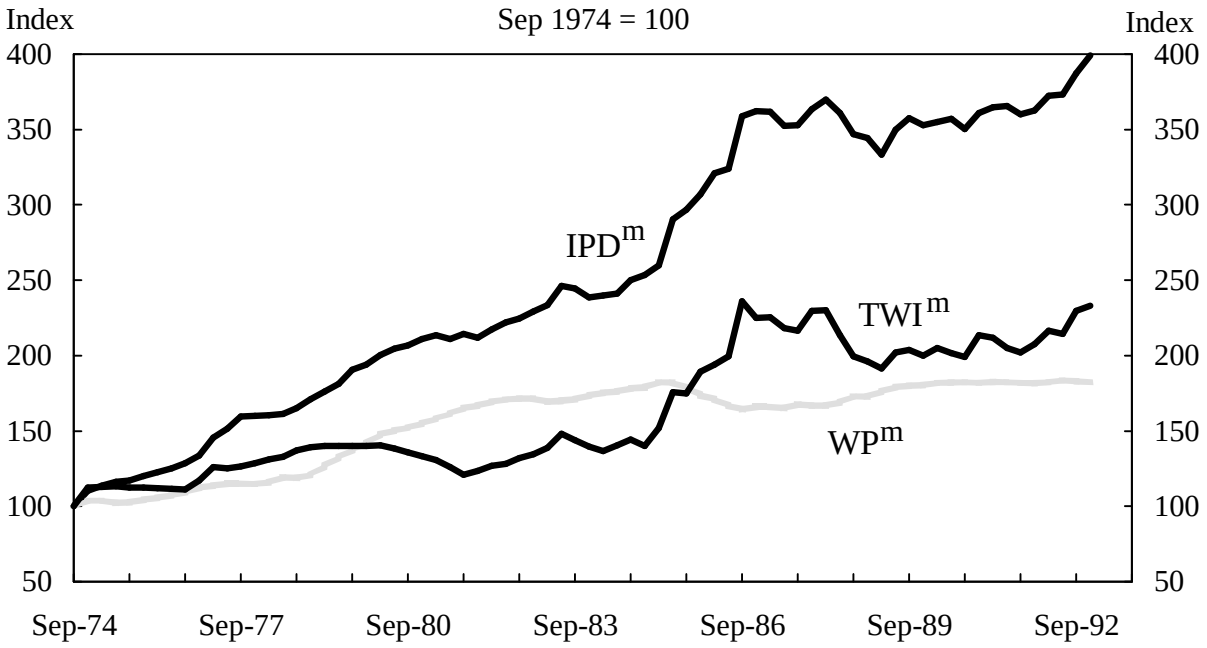
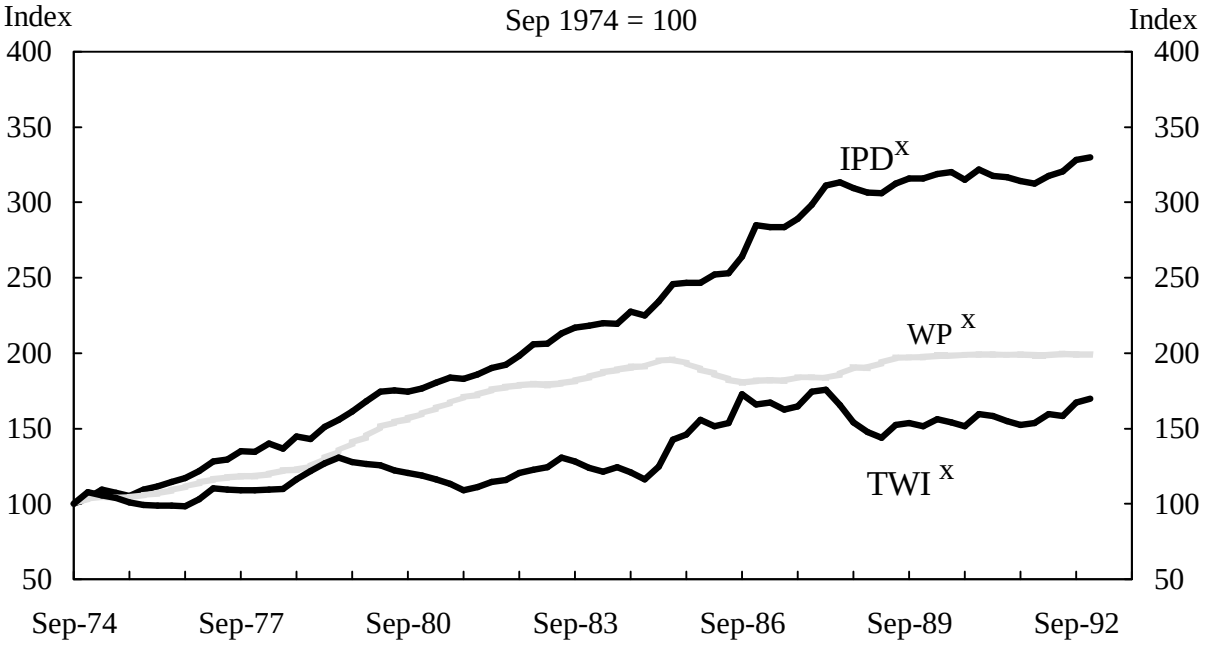


Figure 4: Data for Export Price Pass-Through



5. ESTIMATING THE PASS-THROUGH RELATIONSHIP

5.1 Econometric Method

Valid estimation requires that account be taken of the time series properties of the data to be employed. All data to be used in the estimation of the pass-through relationship are non-stationary.[20] When data are non-stationary, conventional estimation may lead to spurious regression results (Granger and Newbold 1974; Phillips 1986). An approach to dealing with non-stationary data which is increasingly employed in econometric estimation combines the concepts of cointegration and error correction.

In essence, if two series are non-stationary, but a linear combination of them is a stationary process, they are said to be cointegrated (Engle and Granger 1987). In this case, standard regression analysis can be usefully employed. Importantly, cointegration not only facilitates valid estimation, it also provides a framework with which to model the long-run equilibrium of an economic system. Furthermore, the presence of a cointegrating relationship implies the existence of an error-correction equation which can describe the short-run dynamics of adjustment towards equilibrium. Economic theory provides strong priors about the existence and possible nature of long-run relationships, but little information about the dynamics of adjustment. Thus the technique of cointegration can provide useful insights into the mechanics of reversion to a steady state. This is especially pertinent to exploring the process of exchange rate pass-through.

Most research on the Australian pass-through relationship was conducted prior to the convention of testing for stationarity. Important exceptions include the work by Menon (1991b, 1991c) and Heath (1991) where cointegration techniques were employed.[21] In this paper, the cointegrating relationship between the exchange rate and domestic prices is first tested and estimated using the Phillips and Hansen (1990) fully modified OLS estimator (P-H). To confirm that these results are robust,

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20 Details of the unit root tests are provided in Appendix 1.

21 Menon (1991b) was the first in the Australian pass-through literature to address the issue of non-stationarity by employing the Engle-Granger procedure to estimate a cointegrating relationship. Menon (1991c, 1992b) also tested for cointegration using the Johansen procedure. Previous studies had implicitly assumed that regressors were stationary or subject to a deterministic trend. For example, Phillips (1988) and Coppel, Simes and Horn (1987) estimated with log-levels, while Richards and Stevens (1987) used percentage changes. Lattimore (1989) performed a variety of estimation techniques and concluded that estimation with log levels minimised bias.

corresponding results from an unrestricted error correction model (UECM) are provided in Appendices 3 and 4. The two models produce broadly consistent results.

5.2 Import Price Pass-Through

(a) The Long-Run Relationship

To estimate the long-run pass-through relationship for import prices, a log linear form of equation (1) is used which allows for a constant so that:

$$IPD_t^m = a + bWP_t^m + lTWI_t^m \qquad (6)$$

The estimation period is from the September quarter 1974 to the December quarter 1992. Results from the P-H estimator confirm the existence of a cointegrating relationship between import prices, world prices and the import weighted TWI. The long-run elasticity estimates are shown in Table 1.

Table 1: Long-Run Import Price Elasticities

	Long-Run Elasticities	
	TWI^m	WP^m
IPD^m	0.93	0.96
standard errors	0.03	0.04

The exchange rate elasticity, whilst very high, is significantly different from unity at the 5 per cent significance level. It is not different from unity, however, at the 1 per cent level. Similarly, the world price elasticity is insignificantly different from unity at the 5 per cent level.[22] Thus, with respect to the long run, these results satisfy priors about Australia as a small open economy which is a price taker for imports so that exchange rate pass-through is complete (or at least very near complete).

[22] Note, however, that the UECM estimates suggest a slightly lower long-run elasticity for world prices. (See Appendix 3.) This would suggest that for world prices, pass-through is near complete rather than complete. A similar pattern is found for manufactured export prices and world prices. This could also reflect the fact that the world price index is an imperfect proxy.

(b) The Short-Run Dynamics

The residuals from the P-H estimation represent the deviations from long-run equilibrium. These are substituted into an error correction model (ECM) in order to analyse the dynamics of adjustment towards long-run equilibrium. The ECM specifies changes in import prices as a function of lagged residuals from the cointegrating regression (hence, error correction), and changes in other explanatory variables. Details of the lag structure adopted and diagnostics are presented in Appendix 4.

If adjustment to an exchange rate shock were instantaneous, import prices would follow their long-run equilibrium precisely. Figure 5 shows that import prices deviate from their long-run equilibrium for periods, on average, of about one year. This observation is confirmed by the impact elasticities derived from the estimated ECM. In Figure 6, the exchange rate impact elasticity shows the estimated dynamic response of import prices to a 1 per cent depreciation. Import prices are estimated to rise by around 0.5 per cent in the same quarter in which the depreciation occurs. After one quarter, import prices have risen by almost 0.8 per cent. It takes about one year before the depreciation is completely passed through. (Pass-through of world prices is complete after three quarters.)

Whilst impact elasticities are useful for the purpose of generalisations about the price effects of depreciation, they cannot provide information about changes in the pass-through relationship over time. In this paper, recursive estimation techniques are used to assess whether or not the pass-through relationship has altered with respect to the exchange rate.

The stability of the path of adjustment is tested by recursive estimation of the P-H ECM (in which the long-run equilibrium is fixed to that estimated using the full sample period). The P-H ECM is re-estimated up to the September quarter 1984 and then successively re-estimated by extending the sample period one quarter. The effect of a 1 per cent depreciation is analysed. The results are illustrated in Figure 7. Each line traces the extent to which pass-through is estimated to have occurred by the

Figure 5: Import Prices

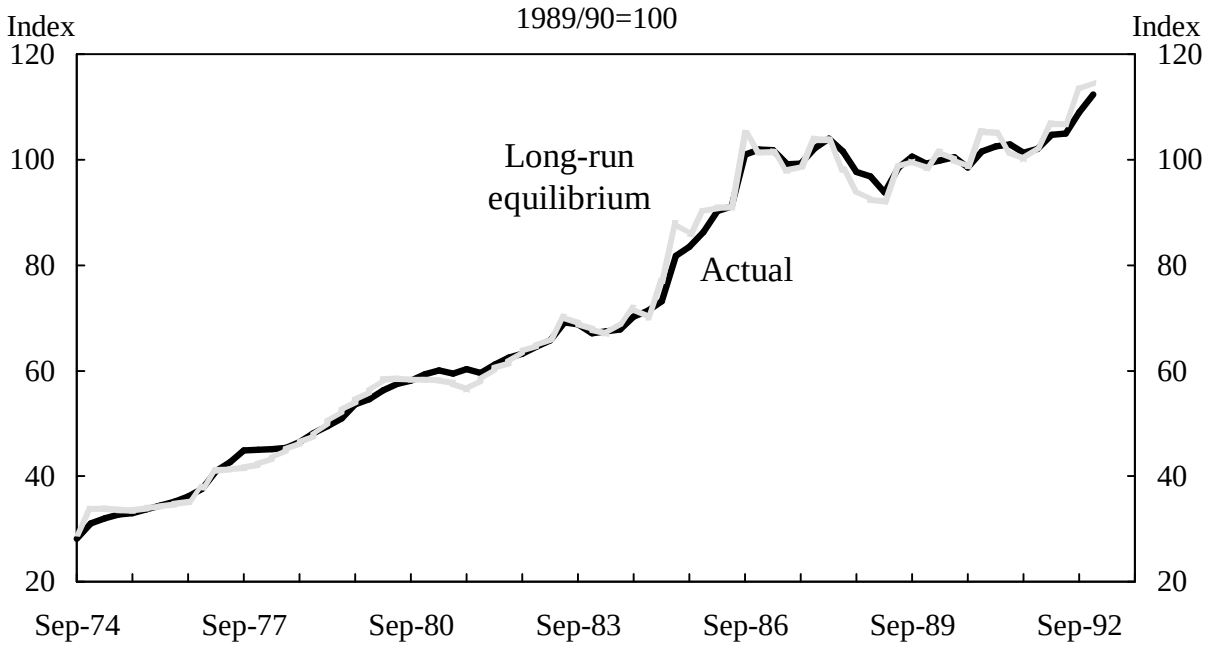
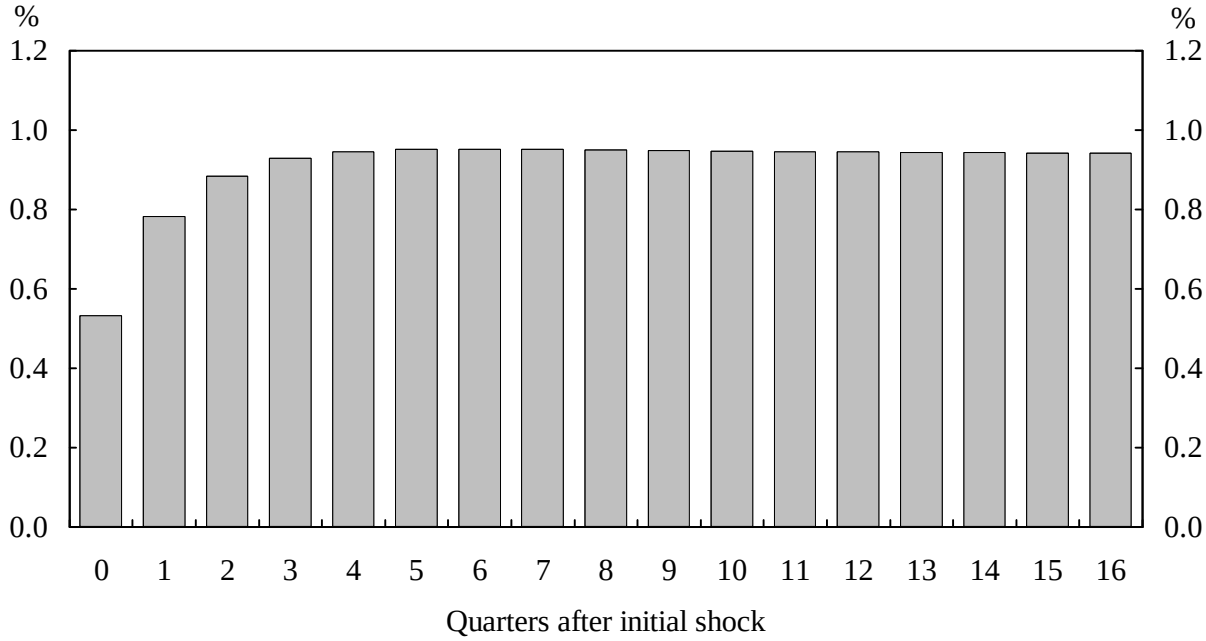


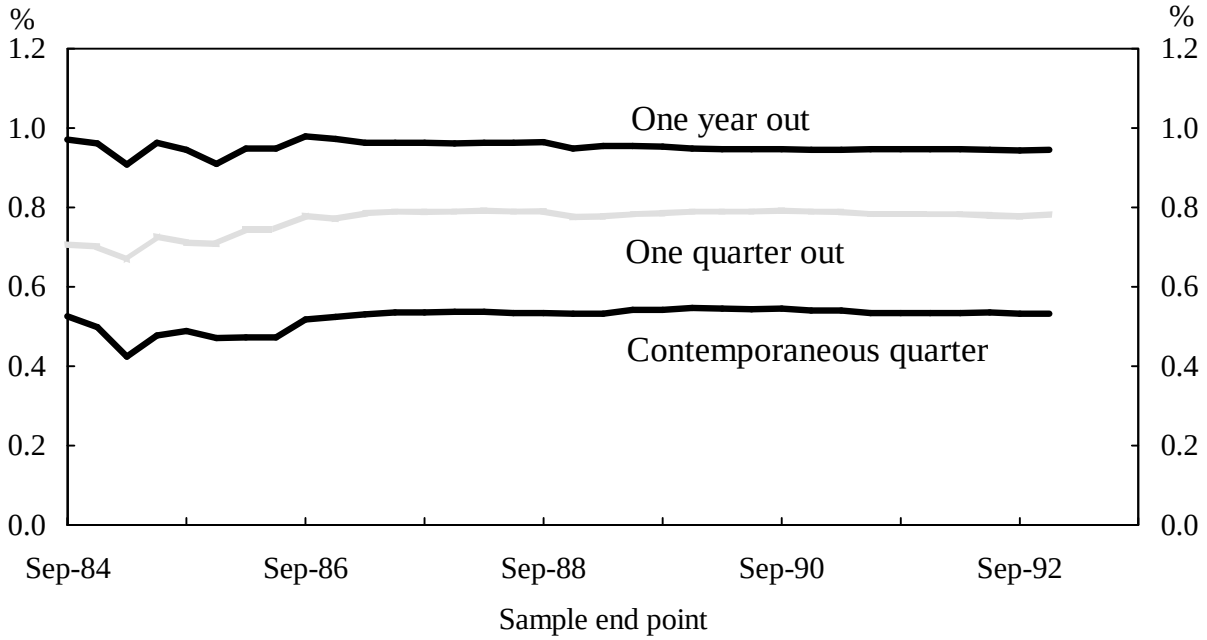
Figure 6: Import Prices -
Exchange Rate Impact Elasticity



quarter shown. Moving along each line shows how the path of adjustment alters with the extension of the sample. Clearly, the path of adjustment towards long-run equilibrium has remained remarkably stable.[23]

Such stability of the pass-through relationship is reinforced by out of sample forecasts. The P-H ECM is re-estimated over the period up to the September quarter 1991. It is then used to simulate import prices over the year to the December quarter 1992. Over this period, the TWI^m depreciated by 13.4 per cent. If this has been fully passed through, import prices would have risen by about 14.6 per cent in line with their long-run equilibrium. The out of sample forecast using the P-H ECM implies that import prices should have risen by 11.8 per cent to the December quarter 1992. Actual import prices have risen by 10.9 per cent. The current rise in import prices is, therefore, broadly consistent with historical experience.

Figure 7: Import Prices - Stability of Adjustment to Exchange Rate Shock



[23] A recursive estimation of the Bewley (1979) transformation of the UECM was conducted to ensure that the long-run equilibrium was itself unchanged. This generated long-run elasticities for each successive sample period. From this it could be concluded that the long-run relationship was also stable. Stability of the path of adjustment was confirmed by the results of a rolling regression (for which the sample length is held fixed, with the first quarter being removed from the sample as each new quarter is added).

5.3 Export Price Pass-Through

(a) The Long-Run Relationship

Similarly, to estimate the pass-through relationship for exports, a log linear form of equation (1) is used which allows for a constant so that:

$$IPD_t^x = a + bWP_t^x + lTWI_t^x \qquad (7)$$

However, contrary to the case for imports, the evidence of a cointegrating relationship is not as clear. Unit root tests from the residuals from the P-H estimation cannot reject the null hypothesis of no cointegration. Nevertheless, the coefficient on the error correction term is significant for both the P-H ECM and the UECM. This represents evidence of cointegration, as discussed in Appendix 3.

The paper proceeds on the basis that a cointegrating relationship does exist. First, theory suggests that there exists a long-run relationship between changes in the exchange rate and changes in domestic export prices. Furthermore, for a small country like Australia it is expected that pass-through will be complete in the long run. Second, inspection of the data reveals that manufactured export prices tend to deviate from their long-run equilibrium for longer periods than do import prices. This does not imply that there is no long-run relationship, but it does make it more difficult to establish a cointegrating relationship when the sample period is short, as in this case. Evidence in support of a cointegrating relationship is given in Appendix 3. The long-run elasticity estimates for manufactured export prices are shown in Table 2. As for imports, they are derived from the P-H estimators.[24]

Table 2: Long-Run Export Price Elasticities

	Long-Run Elasticities	
	TWI^x	WP^x
IPD^x	1.09	0.90
standard errors	0.12	0.09

[24] With corresponding elasticities derived from the UECM shown in Appendix 4.

These elasticities are insignificantly different from unity. They show that, in the long run, changes in the exchange rate will be completely passed through to manufactured export prices. Similarly, in the long run, changes in world prices are completely passed through.

(b) The Short-Run Dynamics

An ECM was estimated using residuals of the P-H estimator. (Features of the ECM and its diagnostics are presented in Appendix 4.)

Again, if the adjustment process were instantaneous, export prices would follow long-run equilibrium precisely. Figure 8 shows that manufactured export prices deviate from their long-run equilibrium for periods, on average, between two and three years; significantly longer than is the case for imports. As shown in Figure 9, following a 1 per cent depreciation, export prices are estimated to rise by around 0.3 per cent in the same quarter in which the depreciation occurs. After one year, export prices have risen by only about 0.65 per cent, and it takes two years before most of the depreciation is passed through. (For world prices, pass-through is estimated to be near complete in the contemporaneous quarter.)

Figure 8: Manufactured Export Prices

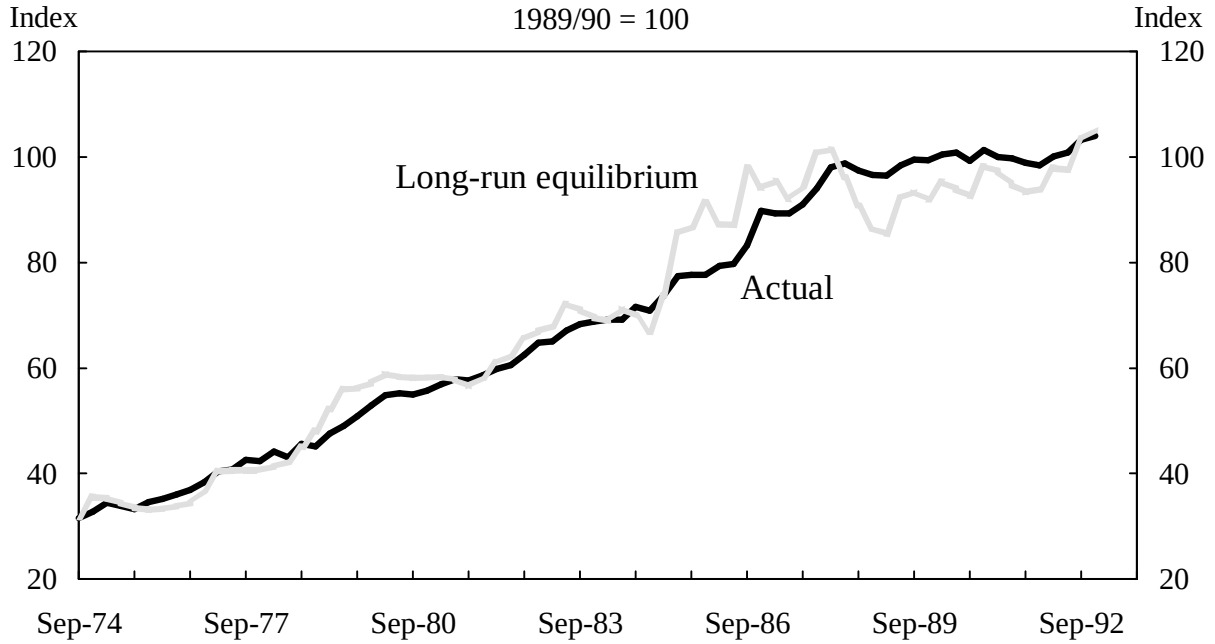
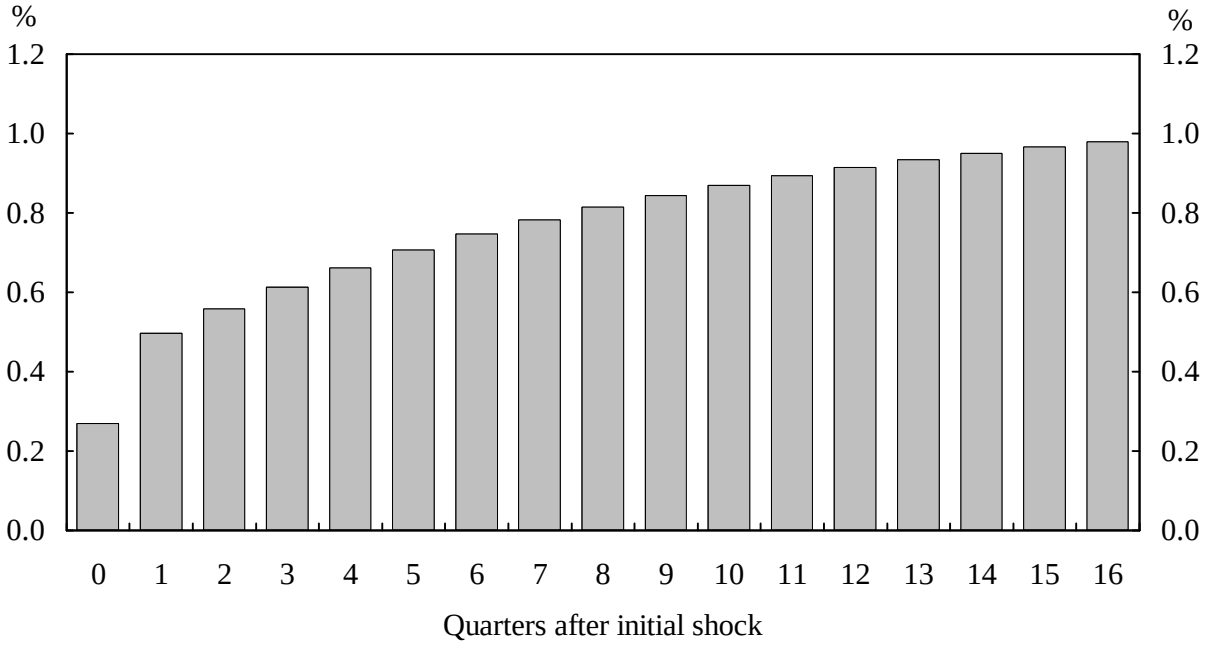


**Figure 9: Manufactured Export Prices -
Exchange Rate Impact Elasticity**



Recursive estimation is also conducted for exports to assess the stability of the pass-through relationship over time, with respect to the exchange rate.[25] Results indicate a structural break, with exchange rate pass-through becoming more rapid after 1986/87. The existence of the break is confirmed by the results of rolling regressions. The results of rolling regressions suggest that the current speed of pass-through is slightly greater than those based on the full sample period. The rolling regression results are illustrated in Figure 10, which shows the estimated effect of a 1 per cent depreciation. They indicate that up to the December quarter 1985, pass-through of the exchange rate is estimated to be only about 50 per cent complete after one year, and 60 per cent complete after two years. Conversely, for each sample period ending after the September quarter 1987, pass-through of the exchange rate is, on average, about 80 per cent complete after one year and 90 per cent complete after and two years. This suggests that since the mid 1980s, pass-through of the exchange rate to manufactured export prices has become more rapid.[26]

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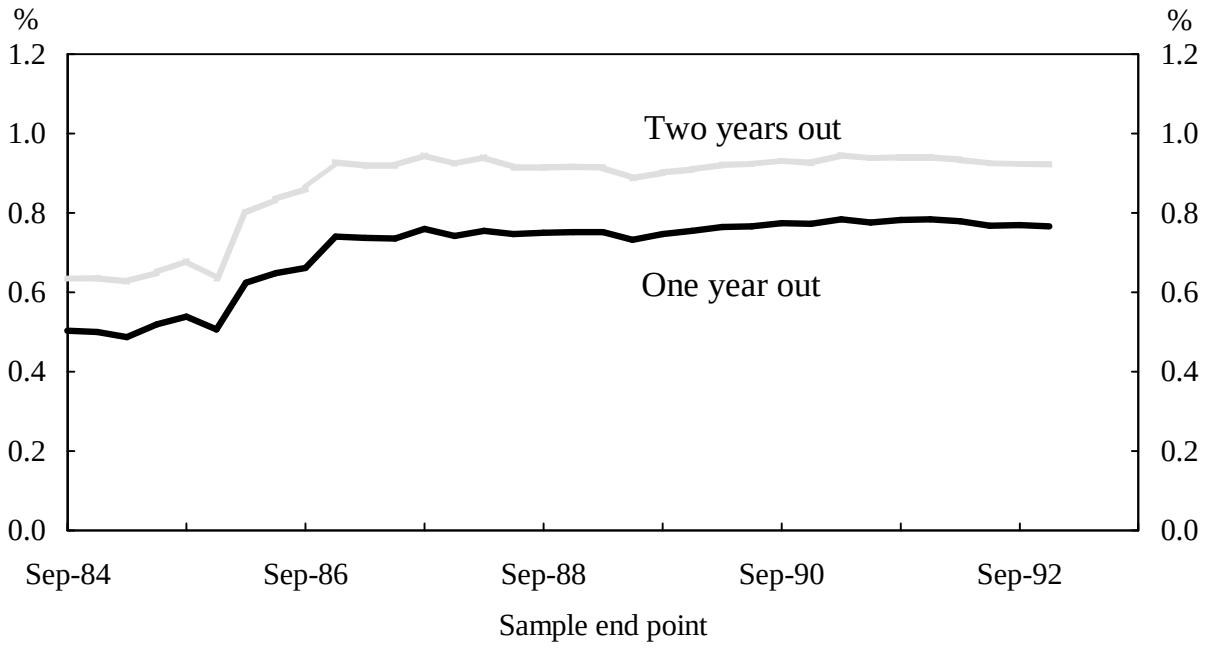
25 Again, the model is re-estimated up to the September quarter 1984 and then successively re-estimated by extending the sample period by one quarter.

26 However, it is not possible to draw conclusions regarding whether the long-run relationship has changed over time. Results from the recursive estimation of the Bewley transformation of the UECM fail to provide conclusive evidence of stability of the long-run equilibrium. Given that manufactured export prices deviate from their long-

Figure 10: Manufactured Export Prices - Stability of Adjustment to Exchange Rate Shock



6. ANALYSIS OF RESULTS

Estimation of the pass-through relationship for Australia has shown that first stage pass-through of changes in the exchange rate is complete in the long run for the prices of both imports and manufactured exports. This result satisfies priors about Australia as a small open economy. Nonetheless, a qualification needs to be made. In the pass-through literature, it is implicitly assumed that movements in the exchange rate are exogenous. Changes in the exchange rate may well be associated with changes in the domestic prices of traded goods relative to those abroad and thus be endogenous. In such a case, establishment of a cointegrating relationship may merely indicate that purchasing power parity (PPP) holds in the long run. If so, a result of complete pass-through would be found by default.[27]

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run equilibrium for extended periods, it is not feasible to estimate the long-run equilibrium over shorter sample periods.

27 In fact, proponents of the PPP doctrine would argue that, ultimately, complete pass-through will occur for any economy and so not be peculiar to the case of a small open economy.

However, it is well established that Australia has experienced exogenous shocks to the exchange rate. This is most apparent during the episode of exchange rate overshooting during the mid 1980s (O'Mara, Wallace and Meshios 1987). It has been shown that during such episodes of exchange rate movement, as well as generally, there has been a reversion of the domestic price of traded goods to their long-run equilibrium. Thus the issue of potential endogeneity of the exchange rate does not appear to detract from the finding of complete exchange rate pass-through.

Whilst it is concluded that exchange rate pass-through is complete in the long run, this is not so in the short run. The short-run dynamics of adjustment to long-run equilibrium contain important information about changes in relative prices. In particular, they illustrate the different responses of domestic import and export prices to exchange rate shocks.

6.1 Import Price Pass-Through

It was shown that following depreciation of the currency, adjustment of import prices is fairly rapid with most of the price effect passed on within two quarters and full pass-through occurring in about one year. Furthermore, this pattern of price adjustment appears to have been maintained throughout the estimation period. This is evidenced by the results of recursive regressions.

A stable pattern of pass-through indicates that there is symmetry in the response of import prices to exchange rate movements.[28] Furthermore, it indicates that the pattern of pass-through has not altered even during the recent recession: despite subdued domestic demand, foreign price-setting agents appear not to have altered their pricing policies.[29] The rate of pass-through being experienced during the latest episode of depreciation is, in fact, typical. Consequently, the hypothesis of a change in the response of foreign price-setting agents to Australia's latest episode of currency

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[28] That is, the extent to which domestic import prices rise when the currency depreciates equals the extent of their fall when the currency appreciates. This finding is contrary to reports that the pattern of pass-through was different during the episode of currency appreciation in the late 1980s (Prices Surveillance Authority 1989).

[29] Confirmation of this was provided by testing the speed of pass-through with respect to the effect of domestic demand pressures. This was done by including a measure of the output gap in the short-run dynamics of the P-H ECM and the UECM. However, this variable was found to be insignificant in both models. Whilst this does not imply that macroeconomic conditions are irrelevant to the speed of pass-through, there is no statistical indication that foreign suppliers consistently take account of Australian domestic conditions when setting the prices of their exports to Australia.

depreciation is rejected. Again, this may be expected to occur for a small open economy which is a price taker in world markets.

This finding has several implications. First, if the present rate of pass-through accords with historical experience, it follows that import prices over the docks will increase further as they move towards their long-run equilibrium value.

Second, if the current pattern of pass-through is typical, the exchange rate has not become less effective in inducing changes in the relative producer prices of imports and non-traded goods. Consequently, the lack of substitution in domestic production between importables and non-traded goods, as implied by high rates of import penetration, must be attributable to factors other than the exchange rate.

Third, if patterns of pass-through are normal with respect to the price of imports over the docks, the direct inflationary consequences of depreciation are being kept in check by other factors. These include developments in world prices and the second stage of price adjustment.

World prices of traded goods have been subdued since 1989/90. Thus low world prices have, in a sense, insulated the economy from the short-term inflationary stimulus provided by currency depreciation.

Furthermore, there appears to be significant price adjustment at the second stage: local distributors appear not to be passing on the full cost of an imported item to consumers. This is suggested in Figure 11 where it is shown that the final retail price of imports has moved by proportionately less than that over the docks.[30] The relative rates of change in the free on board and retail prices of imports contain information about the second stage of price adjustment. If it is assumed that cost structures remain stable, an increase in the free on board price of imports relative to their retail price represents a narrowing of the distributors' margin. On this basis, it can be inferred that there was considerable pressure on margins during the record currency depreciation of the mid 1980s. Subsequently, pressure on margins eased, especially as the currency

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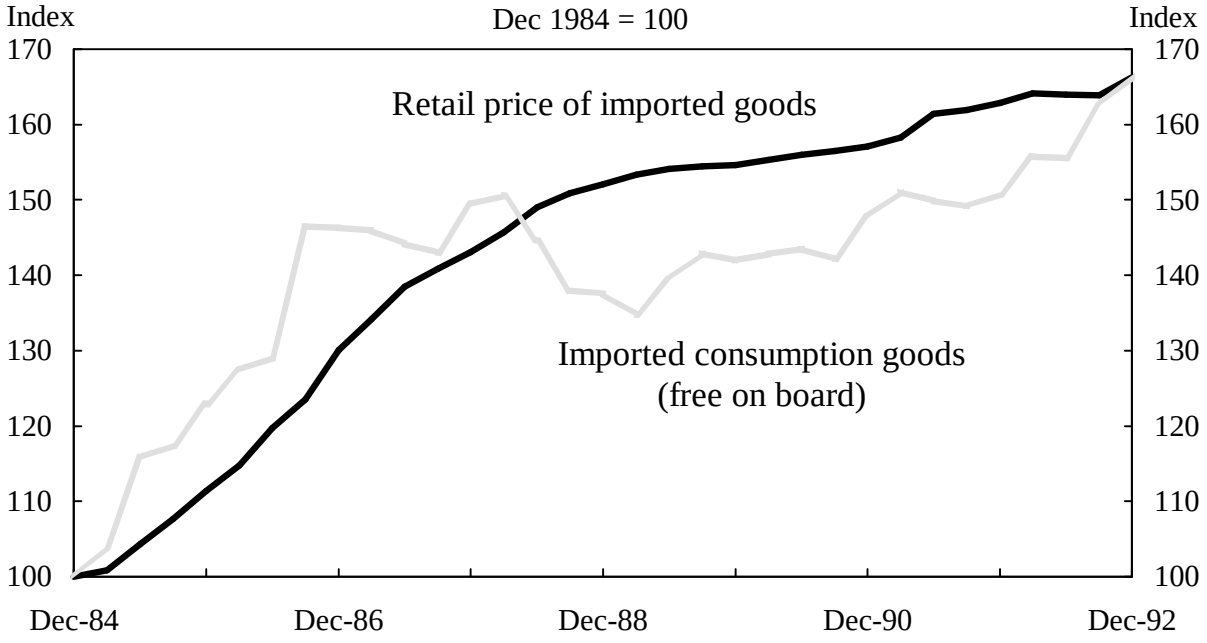
[30] The imported items component of the CPI and the implicit price deflator for imports are not strictly comparable due to compositional differences and alternative weighting systems. Thus the import price index for consumption goods is compared to the imported items component of the CPI. An attempt has been made to reconcile the basket of imported goods contained in the CPI and the index of free on board prices of imported consumption goods. Details are available on request.

appreciated.[31] During recent quarters, margins appear to have been squeezed again so that direct inflationary effects of depreciation are being absorbed, to some extent, at the second stage.

Figure 11: Import Prices at the Second Stage



One might speculate that an attempt will be made to "catch up" on lost margins which will generate inflationary pressure. However, the extent of pass-through at the second stage is governed by the scope for distributors to alter existing relative prices of final goods. Essentially, this is a function of the degree of substitutability between imports and domestically produced goods. Much of the record currency depreciation in the mid 1980s was absorbed at the second stage because market demand curves for final goods were sufficiently elastic for full pass-through to be sub-optimal with respect to profits. During the recent albeit less dramatic fall in the exchange rate, it appears that currency depreciation is again being absorbed at the second stage. This time, an environment of low inflation is imposing an additional constraint on pass-through: if the price of a domestic substitute has not changed, the scope for altering the retail price of an import is further limited. This increases the pressure for cost reduction in order to preserve viable margins. Thus second stage pass-through is essentially a

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[31] In fact, during the late 1980s margins appeared to recover to such an extent that the Prices Surveillance Authority (1989) conducted an inquiry into the issue of exchange rate pass-through.

microeconomic issue. The way in which it impacts on the macroeconomy is recommended for future research.

6.2 Export Price Pass-Through

It was shown that following depreciation of the currency, adjustment of manufactured export prices is significantly slower than that of imports. In fact, it takes almost two years for pass-through to be near complete. The slow adjustment of manufactured export prices relative to that for imports has a balance of payments implication. If import prices respond fairly rapidly to exchange rate movement, but manufactured export prices persist at levels below their long-run equilibrium, there results an effect on the current account balance analogous to that of the J-curve. This appeared to occur in the mid 1980s. Conversely, in the late 1980s, actual manufactured export prices remained above their long-run equilibrium, making a small positive contribution to the current account balance.[32] The differential rate of response of import and export prices to the exchange rate implies, other things being constant, that there is some degree of endogeneity in the nation's terms of trade.[33]

The response of manufactured export prices to exchange rate changes differs to that of import prices not only with respect to speed. Whereas a typical pattern of import price pass-through can be established, this is not so for manufactured exports. The results of recursive regressions indicate that since 1986/87 there has been a significant increase in the rate of pass-through. This suggests a change in the pricing behaviour of exporters.

This possible change in pricing policy is reinforced in Figure 12 in which it is shown that the export price of manufactures and the corresponding domestic price track each other closely until 1986/87. After this time, manufactured export prices deviate significantly from the domestic price. This break accords with the increase in the rate of exchange rate pass-through. It also accords with the increase in export orientation of the Australian manufacturing industry (Menzies and Heenan 1993; Reserve Bank of Australia 1992). Furthermore, the share of contracts invoiced in Australian dollars has

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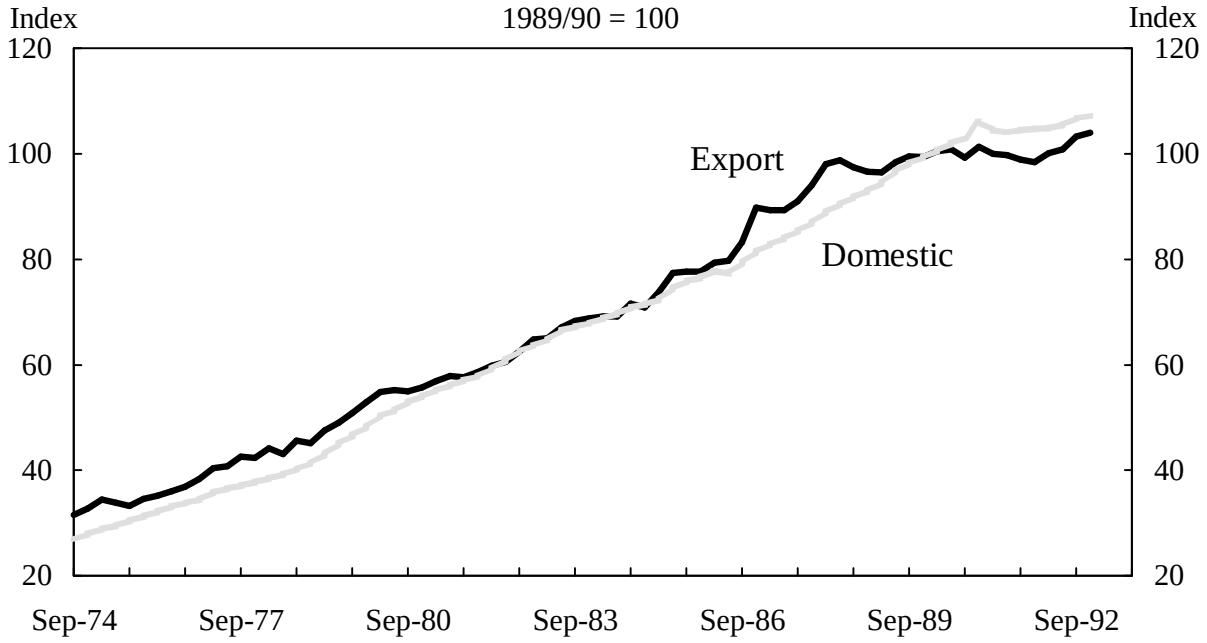
32 However, to the extent that manufactured exports are still a relatively small component of total export earnings, this effect is not likely to be very large.

33 This finding is consistent with that of Treasury Department (1986).

fallen considerably.[34] In combination, these factors suggest that there has been a shift in focus from pricing to the domestic market to parity with the world price. Certainly, such a result is consistent with the increase in international integration of the Australian economy.

Figure 12: Prices of Manufactures



If such a shift in pricing policy has occurred, it suggests that with continued international integration, the endogeneity in the nation's terms of trade that emerged during the mid 1980s will be dissipated, along with attendant effects on the balance of payments.

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[34] Unpublished ABS data indicate that the share of contracts for exports of manufactures invoiced in Australian dollars has fallen from around 73 per cent in 1984/85 to around 67 per cent in 1991/92. Conversely, in most years, around 37 per cent of contracts for total merchandise exports are invoiced in Australian dollars.

7. CONCLUSION

This paper has reviewed the process by which changes in the exchange rate impact upon the domestic prices of traded goods. It was found that there is a long-run relationship between the exchange rate and the domestic prices of traded goods which satisfies the small country case: in the long run, over the docks, exchange rate pass-through is complete for both imports and manufactured exports. However, in the short run, there are significant differences in the response of the prices of these goods to currency movements.

It was shown that import prices over the docks respond fairly quickly to changes in the exchange rate. This was contrary to the experience of manufactured export prices, where response to exchange rate change was considerably lagged, giving rise to some degree of endogeneity in the terms of trade.

The responses of import and manufactured export prices to currency movements differed not only with respect to the speed, but to the pattern of adjustment. Tentative evidence was presented of a recent change in the way manufactured export prices respond to currency movements. Conversely, domestic import prices over the docks have exhibited a consistent pattern of response over time, even during the recent recession.

This finding of a consistent pattern of first stage pass-through to import prices has an important implication. It implies that the present environment of low inflation has not been threatened by currency depreciation because other factors have been in operation. It was proposed that the first round price effects of depreciation have been partially offset by subdued world prices. Furthermore, it was argued that these price effects are being absorbed to some extent at the second stage. In part, this is a function of the present environment of low inflation limiting the scope for alteration of the relative prices of substitutable goods. Low inflation will continue to impose an exigency in this regard. This is not to say that the retail price of imports will not rise. In fact, further pressure will come to bear on retail prices as import prices over the docks gradually move towards their long-run equilibrium. However, the extent of the rise in the retail price of imports will be inhibited by stability of the prices of related goods. Understanding the microeconomics of the second stage of price adjustment is essential for identification of the full impact of currency movement on the general price level.

APPENDIX 1: DATA

All data series are quarterly from 1974:3 to 1992:4, seasonally adjusted (unless otherwise mentioned) and based in 1989/90 prices and period average where relevant.

(a) Domestic Prices - IPD^m and IPD^x

Implicit price deflators are used for the prices of endogenous imports and manufactured exports, both of which have computers excluded. Manufactured exports are defined as the three ABS categories: Machinery; Transport Equipment; and "Other Manufactures". Computer data are unpublished and non-seasonally adjusted ABS data (seasonal adjustment does not appear warranted). For computer imports, Standard Industrial Trade Classification categories 752 and 75997 are used. For computer exports, only the more general SITC division 75 was available and only from 1978:3.[35]

Source: ABS, Catalogue No. 5302.0

(b) Indices of World Traded Goods Prices - WP^m and WP^x

The WP^m is measured by creating an index of export prices of Australia's major non-oil trading partners. The weights are based on merchandise imports shares into Australia over the period 1980/81 to 1985/86. The index is calculated as:

$$\dot{WP}^{m}_{t} = \sum_{i} (w_i \times \dot{P}^{i}_{t}) \qquad (8)$$

where: $\dot{}$ denotes percentage change; w_i is the average share of goods imported into Australia from 1980/81 to 1985/86 from country *i* over all countries in the sample; and P^i_t is an index of export prices for country *i*. WP^x is calculated as in (8) but weights are replaced by the average share of goods exported to the world from 1980/81 to 1985/86 from country *i* over all countries in the sample.

The index is calculated as a weighted sum of the percentage changes in the foreign indices of export unit values. Percentage changes are used in order to minimise the error resulting from utilising weights based on the proportion of expenditure on

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[35] SITC division 75 is for Office Machines and Automatic Data Processing Equipment. SITC categories 752 and 75997 are for computer equipment and computer parts respectively.

imports, rather than the physical quantity of imports. The index is constructed using fixed weights because, for a similar reason, using variable weights would magnify the error in the index.[36]

The countries included in the world price indices and their weights are:[37]

	Weights (w_i)	
	WP^m	WP^x
USA	0.268	0.195
Japan	0.259	0.148
UK	0.088	0.089
Germany (western)	0.076	0.167
New Zealand	0.044	0.005
Taiwan	0.038	0.025
Italy	0.033	0.071
Singapore	0.031	0.020
Canada	0.027	0.074
Hong Kong	0.026	0.024
France	0.026	0.093
Sweden	0.019	0.027
South Korea	0.017	0.024
Netherlands	0.016	-
Switzerland	0.013	0.025
Malaysia	0.012	0.013
Belgium	0.008	-

The export price data are unit value data, with the method of construction varying across countries.[38] Lipsey, Molinari and Kravis (1991) and Alterman (1991) discuss the limitations of using unit value data in international studies. The most prominent drawback is that the unit value data generally do not account for quality changes. For most countries, however, the index of export unit values is the only price series available relating to external trade.

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[36] Applying the weights to the levels of the foreign index of export unit values results in an Laspeyres index of world prices in the current period multiplied by world prices in the base period.

[37] The weights vary slightly over the sample period as price data are not available for all countries over the whole period.

[38] Constructed variously as Laspeyre, Paasche, and Fisher Ideal indices.

These countries accounted for 81 per cent of total merchandise imports in 1991/92. Three countries which might have been included on the basis of trade importance, Saudi Arabia, Kuwait and Indonesia, were excluded because the majority of imports from these countries were petroleum related.

Source: IMF, *International Financial Statistics*; IMF, *Direction of Trade Statistics*; Hong Kong, *Monthly Digest of Statistics*; Taiwan, *Financial Statistics*; Council for Economic Planning and Development, Taiwan, *Industry of Free Choice*; and ABS, Catalogue No. 5437.0.

(c) Effective Exchange Rate Indices - TWI^m and TWI^x

The trade weighted indices are calculated as geometrically weighted averages of the bilateral exchange rates of the 17 countries included in the index of world traded goods prices. The index is calculated according to the formula:

$$TWI_t = 100 \times \prod_{j=1} \left[\frac{E_{jt}}{E_{j0}} \right]^{w_j} \qquad (9)$$

where: Π is the product operator; E_{jt} is the number of Australian dollars per unit of foreign currency at time t; E_{jo} is the number of Australian dollars per unit of foreign currency for country j in the base period; and w_j is the weight of country j.

For TWI^m the weights are based on the merchandise import shares of each country. Similarly, for TWI^x weights are based on each country's share of Australia's manufactured exports. The weights are calculated from annual trade data.

Source: Reserve Bank of Australia; ABS, Catalogue Nos. 5437.0 and 5410.0.

(d) Other series used

Published TWI. Source: Reserve Bank of Australia, *Bulletin*.

Annual Inflation Rate is based on the CPI All groups, weighted average of eight capital cities (non-seasonally adjusted). Source: ABS, Catalogue No. 6401.0.

The retail import price is the CPI for wholly or predominantly imported goods, non-seasonally adjusted, available from 1984:3. Source: ABS, Catalogue No. 6412.0.

The GDP gap is the ratio of real GDP to potential real GDP. Potential GDP is derived from the application of the Hodrick Prescott (1981) filter. Source: ABS, Catalogue No. 5206.0.

The domestic price of manufactures is the Price Index of Manufactured Articles Produced (non-seasonally adjusted, base year 1988/89). Source: ABS, Catalogue No. 6412.0.

Invoicing currency. Source: ABS, unpublished.

Import Price Index of Consumption goods. Source: ABS, Catalogue No. 6414.0.

(e) Time Series Properties of the Data

Each of the series used in estimating the cointegrating relationship was tested for non-stationarity using the Augmented Dickey-Fuller test (Said and Fuller 1984), and the Z_t test (Phillips and Perron 1988). The null hypothesis for both tests is non-stationarity.

Four lags on the differenced series were included initially in the ADF test. Lagrange multiplier tests were conducted to test for first, and joint first to fourth order autocorrelation. The test statistic was taken from the specification of the ADF test which was free from autocorrelation and had the smallest lag structure.

A time trend was initially included in the ADF tests on the log levels of the series. In each case the time trend was insignificant.[39] The results reported in table A2.1 are for the tests including a constant only. For the Z_t test 5 lags of the covariance were included.

Table A2.1 presents the results of the testing on the log-level and log-difference for each series. All series were found to possess one unit root.

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[39] The significance of the time-trend was tested using the critical values from Dickey and Fuller (1981).

Table A2.1: Results of Unit Root Tests

		ADF	Z_t
IPD^m	level	-0.50	-0.67
	1st difference	-4.18	-7.31
IPD^x	level	-0.55	-0.69
	1st difference	-4.49	-8.07
WP^m	level	-2.25	-1.96
	1st difference	-4.22	-4.45
WP^x	level	-2.17	-2.08
	1st difference	-3.97	-4.15
TWI^m	level	-1.21	-1.70
	1st difference	-3.83	-8.18
TWI^x	level	-1.14	-1.28
	1st difference	-4.65	-6.92

The critical values are taken from Fuller (1976):

- -3.51 at the 1 per cent level;
- -2.89 at the 5 per cent level; and
- -2.58 at the 10 per cent level.

Quite clearly, for every series the null hypothesis of non-stationarity is accepted at the 10 per cent level for log levels, and rejected at the 1 per cent level for first differences.

APPENDIX 2: COMPUTER PRICES

The rapid pace of advance in computer technology poses problems for the measurement of computer prices. In short, when estimating prices, it is difficult to adjust for quality differences over time. However, the approach undertaken by statistical agencies abroad differs to that adopted by the ABS. As a consequence, computers have been excluded from both the import and manufactured export price series.

The ABS make use of an hedonic computer price index estimated by the United States Bureau of Economic Analysis and IBM (Meade 1991; McCarthy 1989). In simple terms, the services provided by computers are attributed to a number of basic components, such as central processors, storage units, printers, screens, etc. Implicit price series are estimated for each of these components. The base period price for current computer models can then be estimated by 'reconstruction' from these basic components.

However, the effect of this methodology is to equate the dramatic rise in power of computers in recent years with a fall in the unit price of such power. In consequence, the *value* of computer imports as a share of GDP has risen little since the mid 1980s, while the *volume* of computer imports has risen significantly. This creates a downward bias in any series of which computer prices are a part. Thus failing to exclude computers would produce a significant downward bias in Australian import and manufactured export prices compared with those of foreign economies.

Since the mid 1980s, computers have become both a major import and manufactured export component. In the seven years to December 1992, the endogenous import implicit price deflator has risen about 22 per cent; excluding computers the rise is about 30 per cent. Over the same period, manufactured export prices have risen 26 per cent; excluding computers the rise is about 34 per cent.

APPENDIX 3: TESTING FOR COINTEGRATION

In this paper, two different procedures are used to test for a cointegrating relationship. First, the residuals from the P-H estimation are tested for stationarity. Second, the statistical significance of the error-correcting term in the dynamic equation is examined.

(a) Tests of Residuals

The residuals from the P-H estimation were tested for stationarity using the Augmented Dickey Fuller Test (ADF) and the Phillips Perron Z_t Test (Z_t). The results are presented in Table A3.1.

Table A3.1: Tests of Residuals from P-H Estimation

	ADF	Zt
Imports	-3.82	-3.82
Exports	-2.61	-2.79

The critical values for the null hypothesis of non-cointegration are -3.77 at the 5 per cent level, and -3.45 at the 10 per cent level (Phillips and Ouliaris 1990). Lagrange multiplier tests were conducted to remove unnecessary lags from the ADF test equation. The number of covariance lags included in the Z_t test was 5. The outcome of the test did not change when the number of covariances was varied.

For imports, non-cointegration can be rejected at the 5 per cent level using both the ADF and the Z_t tests. However, non-cointegration cannot be rejected for exports. An inspection of the autocorrelation function (ACF) for both series of residuals places some doubt on the finding of non-cointegration for export prices. If the sample autocorrelations die away rapidly as the lag length increases, the series is likely to be stationary.

The broken lines represent the approximate 95 per cent confidence bound for the sample autocorrelation function.[40] The sample autocorrelations from the imports equation become insignificant after one lag, strongly suggesting stationarity. For

[40] Bowerman and O'Connell (1979, p.343) provide a description of the estimated standard error of the sample autocorrelation function.

exports, the sample autocorrelations take only three to four quarters to die down, which is possible evidence of stationarity. The sample autocorrelation at lag 1 for the export equation is 0.82, and given the low power of the ADF and Z_t tests, may explain the conflicting results between these tests and the ACF.

Figure A3.1: Autocorrelation Function for Imports Equation

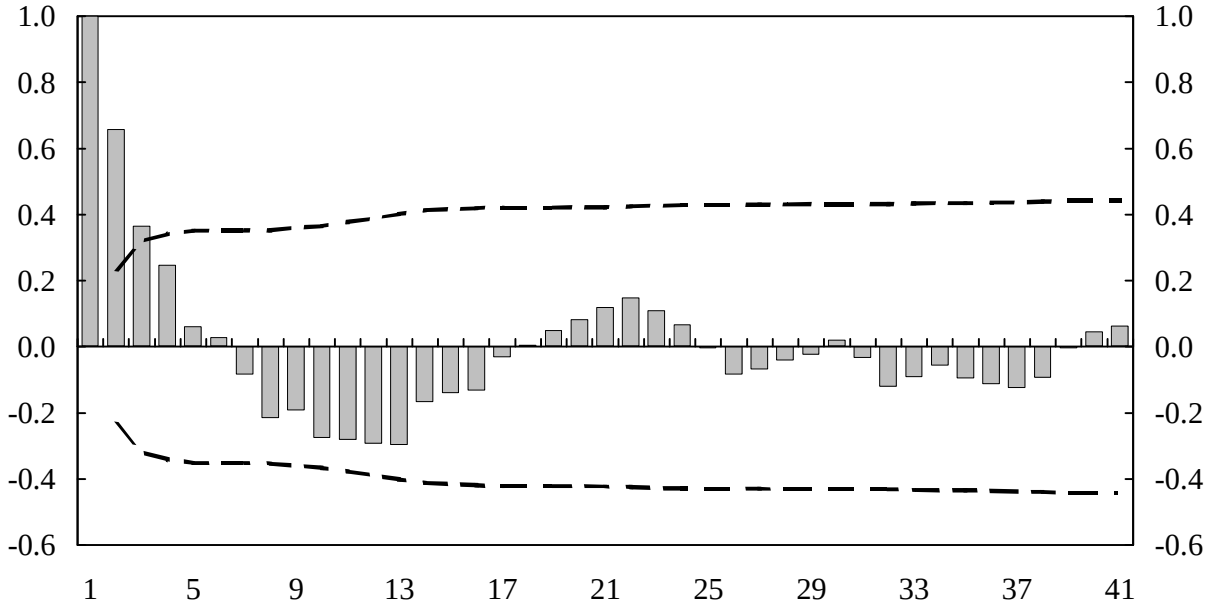
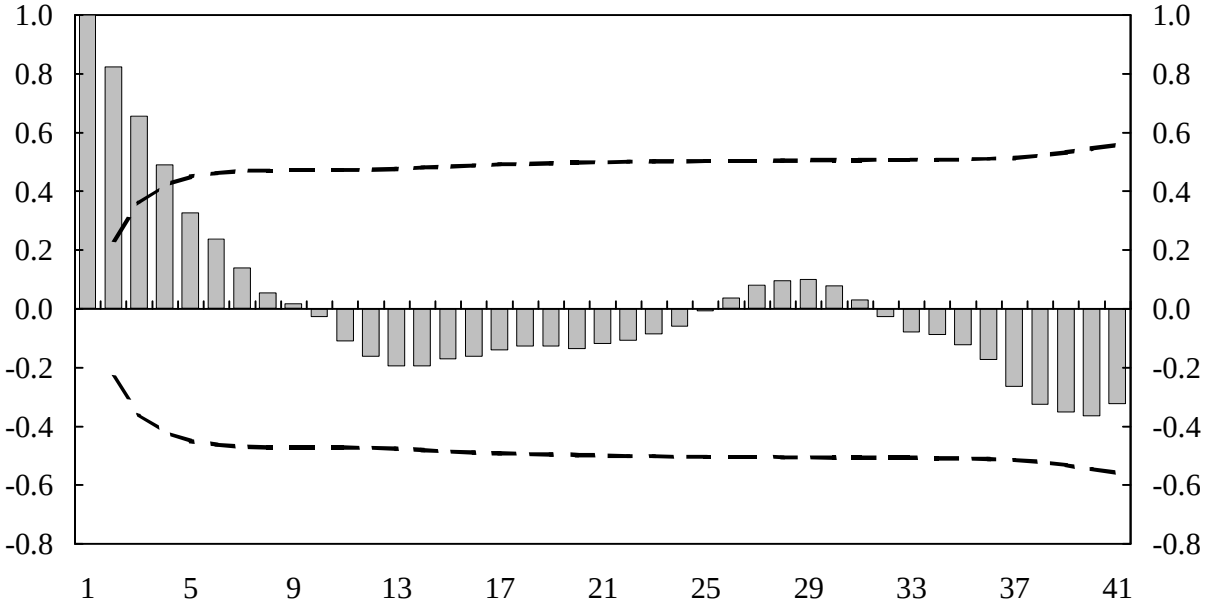


Figure A3.1: Autocorrelation Function for Exports Equation



(b) Significance of the Error-Correcting Term

Given the rejection of cointegration for exports from tests on the residuals, the significance of the error-correcting terms in the P-H ECM were tested. Kremers, Ericsson and Dolado (1992) demonstrate that this test for cointegration is, in fact, more powerful than the tests based on the residuals from the cointegrating relationship.[41] The coefficient estimates and t-statistics for the P-H ECM are shown in Table A3.2, with t-statistics in parentheses.

Table A3.2: P-H ECM Based Cointegration Test

	P-H ECM
Imports	-0.16
	(-2.3)
Exports	-0.10
	(-3.0)

For both export prices and import prices the null hypothesis of non-cointegration is clearly rejected.

In summary, there is unambiguous evidence of a cointegrating relationship for the import price equation. The null hypothesis of non-cointegration cannot be rejected for the export price equation using the Z_t and ADF tests. However, a plot of the autocorrelation function suggests that the finding of non-cointegration may be due to the low power of these tests. Further, tests based on the significance of the error-correcting term in the ECM indicate that non-cointegration can be rejected for the export price equation. Given the relative power of these tests, combined with the theoretical basis for the existence of a cointegrating relationship, it appears safe to reject non-cointegration for the export price equation.

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41 The loss of power arises because the residual based tests assume that the dynamics are error dynamics, rather than structural dynamics, causing them to ignore potentially relevant information. The power of a test is the probability of not committing a type II error - that is, it is the probability of not accepting the null hypothesis when it ought to be accepted.

APPENDIX 4: ERROR CORRECTION MODEL RESULTS [42]

(a) Import Prices

Model 1: Import Price P-H ECM

- dependent variable - ΔIPD^m
- period of estimation - 1975:1 to 1992:4

Variable	Lag	Coefficient	Standard error	t-statistic
RESIDUAL	t-1	-0.156	0.069	-2.259
ΔIPD^m	t-2	0.145	0.048	3.009
ΔTWI^m	t	0.528	0.038	13.779
ΔTWI^m	t-1	0.184	0.043	4.230
ΔWP^m	t	0.419	0.139	3.009
ΔWP^m	t-1	0.334	0.129	2.582

R^2	0.783
Adjusted R^2	0.767
Sum of squared residuals	0.011
Standard error of estimate	0.013

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi^2(1)=1.113$	0.291
First to fourth order	$\chi^2(4)=5.097$	0.277

[42] The full models contained four lags of all variables (including contemporaneous changes in world prices and exchange rates). Statistically insignificant variables were removed in order to obtain parsimonious models. All residuals were found to have insignificant degrees of heteroscedasticity, skewness and kurtosis at the 5 per cent level (unless otherwise specified).

Model 2: Import Price UECM

- dependent variable - ΔIPD^m
- period of estimation - 1975:3 to 1992:4

Variable	**Lag**	**Coefficient**	**Standard error**	**t-statistic**
IPD^m	t-1	-0.382	0.058	-6.579
TWI^m	t-1	0.343	0.054	6.386
WP^m	t-1	0.326	0.056	5.812
ΔIPD^m	t-4	-0.119	0.057	-2.107
ΔTWI^m	t	0.481	0.037	13.092
CONSTANT		1.844	0.272	6.773

R^2	0.798
Adjusted R^2	0.782
Sum of squared residuals	0.010
Standard error of estimate	0.013

Tests for autocorrelation:	**Test statistic**	**Significance level**
First order	$\chi^2(1)=1.271$	0.260
First to fourth order	$\chi^2(4)=8.680$	0.070

Long-run coefficients

Variable	**Coefficient**
TWI^m	0.899
WP^m	0.853

(b) Manufactured Export Prices

Model 3: Manufactured Export Price P-H ECM

- dependent variable - ΔIPD^x
- period of estimation - 1974:4 to 1992:4

Variable	Lag	Coefficient	Standard error*	t-statistic
RESIDUAL	t-1	-0.100	0.034	-2.959
ΔTWI^x	t	0.268	0.042	6.400
ΔTWI^x	t-1	0.142	0.074	1.933
ΔWP^x	t	0.882	0.129	6.850
R^2			0.384	
Adjusted R^2			0.357	
Sum of squared residuals			0.021	
Standard error of estimate			0.017	

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi^2(1)=1.423$	0.233
First to fourth order	$\chi^2(4)=12.102$	0.017*

* Standard error estimates were White corrected because of evidence of second order autocorrelation.

Model 4: Manufactured Export Price UECM

- dependent variable - ΔIPD^x
- period of estimation - 1975:2 to 1992:4

Variable	Lag	Coefficient	Standard error*	t-statistic
IPD^x	t-1	-0.111	0.030	-3.738
TWI^x	t-1	0.119	0.037	3.182
WP^x	t-1	0.085	0.030	2.817
ΔIPD^x	t-1	-0.336	0.104	-3.218
ΔTWI^x	t	0.222	0.049	4.553
ΔTWI^x	t-1	0.174	0.058	3.003
ΔWP^x	t	0.627	0.190	3.308
ΔWP^x	t-1	0.271	0.229	1.185
ΔWP^x	t-2	-0.441	0.217	-2.029
CONSTANT		0.673	0.207	3.254

R^2	0.559
Adjusted R^2	0.494
Sum of squared residuals	0.014
Standard error of estimate	0.015

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi^2(1)=0.109$	0.741
First to fourth order	$\chi^2(4)=5.901$	0.207

* Standard errors were corrected for heteroscedasticity (detected at a significance level of 3.3 per cent).

Long-run coefficients

Variable	Coefficient
TWI^m	1.072
WP^m	0.766

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