

# **MODELLING IMPORT PRICES IN THE TREASURY MACROECONOMETRIC (TRYM) MODEL**

**by**

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## **OVERVIEW**

The TRYM import price equation provides an important channel through which changes in the exchange rate and world price of imports affect the Australian economy. Dwyer et al (1993) note that the extent to which movements in the exchange rate are transmitted to changes in the domestic price of imports has important implications for both the balance of payments and inflation. They state that the rate of pass through firstly influences the effectiveness of a currency depreciation "...in inducing those changes in relative prices that assist improvement of the balance of payments" and secondly implies that currency depreciation may also "...have a lagged and uncertain impact on inflation".

A re-examination of the import price equation of the June 1993 TRYM conference model was motivated by the emergence, with recent updates, of unstable error terms towards the end of the sample period. This paper reports the improvements that have been made to address these problems and to derive a new TRYM import price equation. The new import price equation is a significant improvement on the previous equation. The equation is now estimated as an error correction model (as opposed to the partial adjustment equation estimated in the June 1993 conference TRYM model) and more accurate data have been used in its estimation. The overall fit of the equation is high and it does not appear to exhibit any serious problems of serial correlation, mis-specification, structural change or non-normality of errors. The diagnostics however do suggest some heteroscedasticity in the errors. The estimated coefficients are all plausible and are compatible to those found in other econometric studies on import prices. The speed of the pass through of exchange rate and world import price shock is also in accordance with the findings of these other studies.

The paper is arranged in the following manner: Section I begins with a review of both the theoretical and empirical literature on import price models; Section II follows with a discussion of the major changes in the data sources that have been used to estimate the current equation, namely an improved world price of imports series and a modified exchange rate series; Section III discusses the changes to the models specification; Section IV reports the equation's estimation results as well as the results of world price and exchange rate shocks; and Section V concludes by contrasting the results of this equation to those of other econometric studies.

## **SECTION I - THE THEORETICAL AND EMPIRICAL LITERATURE ON IMPORT PRICES**

### **Theoretical Literature**

Open economy macroeconomic theory states that, ignoring transportation costs, the price of any traded good will be equal across all economies when expressed in a common currency. This equality condition known as the "Law of One Price" emerges from international arbitrage and profit maximising behaviour by traders. If the price of a particular good differs between countries traders can make profits by buying the good in the countries with the lower relative price and selling the good in the countries with the higher relative price. The fall in supply of the good in the countries with the lower relative price puts upward pressure on this good's price while the increase in supply in the other countries puts downward pressure on the price. This process continues until all profitable opportunities are exhausted, which occurs when the prices of the good (excluding transportation costs) across all countries have been driven back to equality.

By aggregating the all foreign countries into one, namely the world economy, the "Law of One Price" can be interpreted as stating that the domestic price of imports is equal to the world price of imports expressed in domestic currency:

$$\text{Domestic Price of Imports} = \frac{\text{World Price of Imports}}{\text{Exchange Rate}}$$

While profit maximisation dictates that the "Law of One Price" must hold in the long run, a literature has emerged concerning reasons why the relationship between domestic import prices, and world import prices and exchange rates can, in the short run, depart from the "Law of One Price". Changes in the exchange rate and world import prices may not be passed on to domestic import prices immediately either because foreign suppliers perceive the movements as only temporary or because even changes perceived as permanent face delays in being passed through to domestic import prices. The literature is primarily concerned with the adjustment of domestic import prices to movements in the exchange rate, however in modelling import prices in the TRYM model the pass through of changes in world prices to domestic import prices is also of interest.

- There are two steps through which changes in the exchange rate are passed onto import prices. The first stage of pass through deals with how changes in the exchange rate are reflected in the domestic over-the-docks import price while the second stage of pass through is concerned with how movements in the over-the-docks import price results in changes in retail import prices. The TRYM import price equation is only concerned with the first stage of pass through while the second stage of pass through is examined in the TRYM relative price block.

Phillips (1988 & 1989) provides a useful summary of the economic theory behind the first stage of exchange rate pass through. He states that the degree and pace at which foreign suppliers pass on the effects of a change in exchange rates to the f.o.b. import price depends on the following factors:

- Revenue elasticities of the import supply and demand schedules. The greater the elasticity of import supply and the lower the elasticity of import demand, the greater the degree and more rapid the speed of exchange rate pass through. On this basis, we expect that the pass through for a small country, such as Australia, facing an almost perfectly elastic import supply curve, should be complete and rapid.
- The macroeconomic environment. This can reinforce or offset the influences of demand and supply elasticities. For example, foreign suppliers are more likely to pass on exchange rate depreciations to import prices when demand is strong since the threat of losing markets from higher prices is significantly less than when demand is weak. In the situation of weak demand foreign suppliers, fearful of losing markets from higher prices, are likely to postpone the pass through of the exchange rate depreciation and absorb the change in lower profits. Similarly if the currency appreciates when demand is strong foreign suppliers are more likely to expand their profits than to pass on lower import prices whereas when demand is weak exchange rate appreciations are more likely to be passed on as lower prices.
- Structural features of the foreign domestic markets. Industrial organisation models of pricing behaviour find that market concentration, product substitutability and the relative market shares of foreign and domestic producers all effect exchange rate pass through.

These notions form the basis of the import price equations estimated by Phillips (1988) and Dwyer et al (1993).

The nature of trade contracts between countries provides a institutional source of delay in the pass through of both exchange rate and world price changes.

The pace of exchange rate pass through can depend on the currency in which Australia's import contracts are written. If all contracts are written in Australian dollars then changes in the exchange rate have little instant effect on domestic import prices. It is only when contracts are rewritten that changes in exchange rates are reflected in domestic import prices. If all import contracts are written in the currency of the import sources then (in the absence of exchange rate hedging) any exchange rate changes are instantly passed through to domestic import prices. In between these extremes lies the possibility that some import contracts are written in foreign currency while the remainder are written in the domestic currency. The larger the proportion of import contracts written in the foreign currency the quicker the rate of exchange rate pass through, thus for a country like Australia which has the majority of its import contracts (90 per cent) written in foreign currency a quick exchange rate pass through is expected. In Australia, however, many import contracts between Australia and non-US countries are written in US\$, an arrangement which slows the rate of exchange rate pass through. For example, if Australia's contracts for imports from Korea are denominated in US\$ and the Won appreciates against both the AUS\$ and US\$ (leaving the exchange rate between AUS\$ and US\$ unchanged) then there will be no instant exchange rate pass through. When contracts are rewritten the US\$ denominated price will rise to reflect the US\$ depreciation against the Won and this will lead to the rise in domestic import prices which was implied by the depreciation of the AUS\$ against the Won.

Import contracts also slow the speed at which changes in the world price of imports are passed through to domestic import prices. If a price is agreed to in a contract which can only be changed on when the contract is rewritten then changes in the world price of imports are passed on to the domestic price of imports with some delay.

Confusion as to whether exchange rate movements are temporary or permanent also causes departures from the "Law of One Price" until the uncertainty is resolved. Foreign suppliers make exchange rate hedging arrangements to avoid passing on exchange rate movements which they perceive may be only temporary.

Firms may also be concerned with market share as a competing objective to firm profitability and Brain's (1986) IMP model takes this approach in modelling import prices. This model assumes that in the short run foreign suppliers are uncertain as to the permanency of the change in the exchange rate and are more concerned with maintaining market share. Consequently exchange rate changes only have a limited effect on import prices while domestic prices are a more important short run determinant. In the long run when exchange rate changes are perceived as permanent import prices will be adjusted back to the overseas price (denominated in domestic currency) to maintain profitability.

12. Hysteresis is another explanation for slow or incomplete exchange rate pass through. With differentiated products there may be some brand loyalty due to incomplete information of other brands as well as the accumulation of human capital with the known brand (eg computers). If a supplier reduces market share due to an exchange rate associated price change, it may face large

promotional costs when the exchange rate returns to its original level. Thus there is a trade off between losing profits today or facing large promotional costs in the future.

There are conflicting views, however, as to the importance of the market share objective for foreign imports to Australia.

- Brian (1986) states that in Australia there is a low cross price elasticity of substitution between imports and domestic goods, implying that foreign suppliers can adjust their import prices in response to exchange rate changes without too much threat of loss of market share. Furthermore, there is little incentive for foreign suppliers to maintain their market share in the Australian market given that it is fairly small by world standards.
- Phillips (1989) however notes that although Australia is a small country in terms of total world trade, it is a significant market for particular foreign exports and especially individual companies, such that full pass through can be either slow or incomplete.

### **Empirical Literature**

Most work on exchange rate pass through has been undertaken for either individual markets or only for manufactured imported and there appears to be very little work on the exchange rate pass through of aggregate import prices. In fact it appears that the view in the exchange rate pass through literature is not to analyse the issue at the macroeconomic level. For example, Melick (1990) believes that "...pass through at the macroeconomic level is a complicated amalgamation of disparate industrial structures that involves more than one long-run equilibrium relationship between the variables of interest." (p22) while Menon (1993) states that there are "many pit-falls associated with aggregative studies, especially the bias infused ... as a result of the aggregation of different classes of goods" (p93). Nonetheless, for the purposes of the TRYM import price equation we must undertake an aggregate estimation and the following findings are of some use to our analysis.

**Phillips, R. W. - *The Pass Through of Exchange Rate Changes to Prices of Imported Manufactures*, Centre for Economic Policy Research, A.N.U. Discussion Paper 197, December 1988**

Phillips estimates a model for non-oil aggregate imports for Australia over the period September 1981 to December 1986. He finds that in line with the small country assumption exchange rate pass through is virtually (approximately 90 to 95 per cent) complete in the **long run**.

In the **short run**, 70 per cent of the exchange rate pass through is reflected contemporaneously in f.o.b. import prices, while another 25 per cent is passed on in the next period.

- Phillips however believes that this apparent periodic absorption of exchange rate changes by foreign suppliers is a result of problems in the construction of the f.o.b. import price series (published in the ABS import price index). Import prices that are denominated in foreign currencies are converted to Australian dollars by using the exchange rate prevailing at the time of the goods' departure from the foreign port rather than when the transfer of property takes place. Consequently, depending on the shipping time, the f.o.b. price of imports reflects previous exchange rates. Phillips reconstructs the world price of imports series to account for this shipping lag and finds a coefficient of 90 per cent on the contemporaneous exchange rate. Accounting for the shipping lag will not change the long run pass through results.

Phillips other findings were that:

- The speed of exchange rate pass through was slower after the large depreciation in 1985, suggesting that following the depreciation foreign suppliers were less certain of the permanency of exchange rate changes.
- The result of overall pass through in the long run appears to be in part due to reversals in exchange rate movements. For example, while there is incomplete pass through on prices following a depreciation because this is matched by incomplete pass through following an appreciation so that full pass through results overall.

These above two findings are consistent with the hysteresis explanation of incomplete pass through.

**Dwyer, J. et al - *Exchange Rate Pass-Through: The Different Responses of Importers and Exporters*, RDP 9304, 1993, Reserve Bank of Australia**

Dwyer et al estimate exchange rate pass through to endogenous import prices in Australia over the period 1975(1) to 1992(4). They estimate an error correction equation using the Engel-Granger two step method. This method of error correction estimation is known to be unreliable, so the following results should be interpreted with some caution.

In the **long run** the level of f.o.b. import prices is a function of the world price level and the level of the TWI. The paper finds that 93 per cent of variations in the exchange rate is passed onto f.o.b. import prices in the long run. Their tests find that this is significantly different to complete pass through.

- Of changes in the world price of imports, 96 per cent are passed onto f.o.b. import prices. Their tests find that this is not significantly different to full pass through.

In the **short run** 53 per cent of movements in exchange rates are passed onto f.o.b. import prices in that quarter while a further 18 per cent is passed on in the subsequent quarter.

- When world import prices change, 42 per cent of the change is passed onto f.o.b. import prices in that quarter while another 33 per cent is passed on in the next quarter.
- The **coefficient on the long run residual** indicates that if the import price differs from its long run level the divergence will be corrected by 15 per cent every quarter.

**Brain P. J. - *The Microeconomic Structure of the Australian Economy*, Longman Cheshire, Australia 1986.**

This IMP model finds that in the **short run** the preservation of market share is of equal importance to profitability and foreign prices. While in the **long run** there is complete pass through of foreign prices and exchange rates while domestic prices have no effect.

## **SECTION II - DATA CHANGES TO THE EQUATION**

### **A World Price of Imports Series**

One deficiency with the June 1993 TRYM conference model's import price equation was the use of the world output index as a proxy for the world price of imports. The problem with this series is that the composition of goods in the world output price deflator differs from the composition of imports. The world price deflator contains non-tradeable goods and some tradeable goods that Australia does not import.

A more appropriate measure of the world price of imports has been constructed based on the idea of weighting the producer price of manufactures indices for the top 19 import sources (in 1993) by the contribution of each country to the total imports of this subset of countries. Manufactures account for about two thirds of Australia's imports so that this series would be a reasonable proxy for the world price of imports. However, producer price of manufactures data are only available for OECD countries. Proxy series, such as the wholesale price indices and consumer price indices were used for some countries.

- In general the use of the proxy series does not pose too much of a problem since all of the top five import sources are OECD countries for which we have manufacturing producer price data while the index used for China, our sixth largest import source, was the price of industrial goods index. Together these countries account for about two thirds of our imports. The implicit inclusion however of non-tradeable goods' prices in the series has lead to minor data problems which are discussed in Section II.

We believe that this series is the most sensible series given the available data. A more thorough explanation of the construction of this series is given in Appendix A.

### **An Import Share Weighted Exchange Rate Series**

The trade weighted exchange rate series in the June 1993 TRYM conference model was calculated as the sum of the exchange rates for the set of Australia's top 16 export destinations weighted by their contribution to the total exports of this subset of countries. The construction of the modified exchange rate series has changed in two ways.

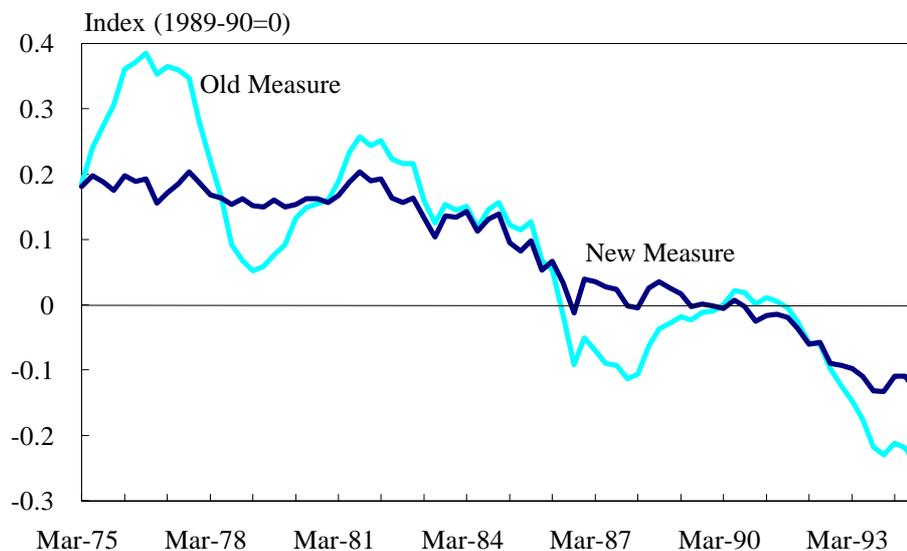
- Firstly, in order to establish consistency with the new world price of imports series, the sample of countries used to construct the new trade weighted exchange rate series is now the top 19 import sources.
- Secondly, the new exchange rate series is now calculated as the weighted sum of the change in each countries exchange rate rather than as the weighted sum of the log level of each countries exchange rate. As shown in Attachment B, merely weighting the exchange rate levels of each country by its contribution to imports can distort the data when country shares are changing.

A full discussion of the construction of the trade weighted exchange rate series, along with the data sources, is given in Appendix B.

## The Ratio of F.O.B. Import Prices and Australian Dollar World Price of Imports

As stated in the theoretical discussion, the ratio of f.o.b. import prices and the Australian dollar world price of imports is an important variable in modelling import prices. Chart 1 provides a comparison of the old and new measures of the ratio. The old measure uses the world output deflator and the exchange rate series which is simply the weighted sum of the level of each countries exchange rate. The new measure uses the manufacture price based world price of imports series and the weighted sum of the change in each countries exchange rate. The old measure is far more volatile than the new measure. Given that we would expect the ratio to remain reasonably steady over time, the new measure of the ratio seems more plausible .

**Chart 1 - The Logarithm of the Ratio of F.O.B. Import Prices and Australian Dollar World Price of Imports - Old Measure and New Measure**



## SECTION III - SPECIFICATION CHANGES TO THE IMPORT PRICE EQUATION

The import price equation is now estimated as an error correction model whereas the equation of the June 1993 conference TRYM model was estimated as a partial adjustment equation after previous unsuccessful attempts to estimate it using the error correction method.

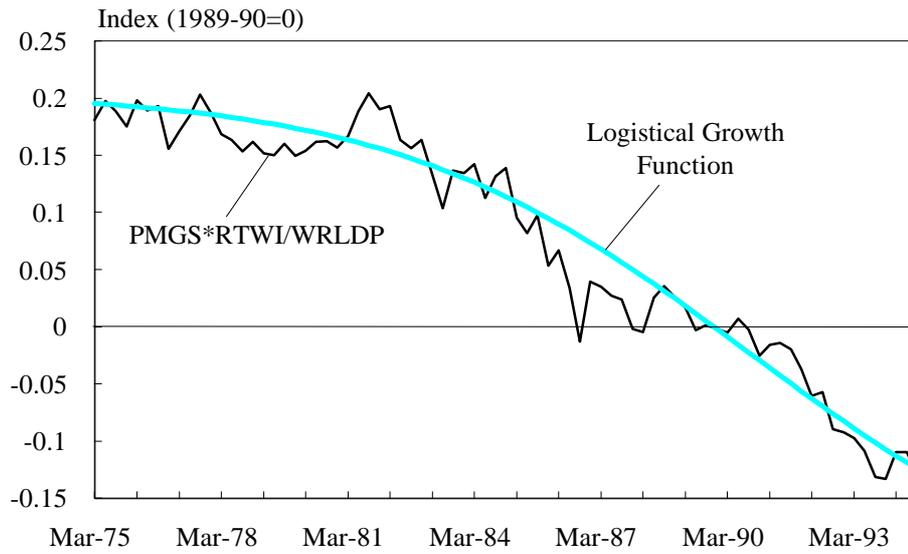
### The Long Run with a Logistic Growth Function

The long run part of the equation is centred around a constant and a logistic growth function. The "Law of One Price" states that in the long run the world price of imports, denominated in Australian dollars should equal the f.o.b. price of imports. However, the ratio of the two price series displays a distinct downward trend from about the early 1980s. Investigations into the series suggested that this trend was likely to be due to problems in the data.

In constructing the world price of imports series, the absence of any better data from Asian countries necessitated the use of wholesale price indices and in some cases consumer price indices. These price indices are an aggregation of both tradeable and non-tradeable good prices. Typically productivity improvements occur more rapidly in tradeable goods than in non-tradeable goods due to international competitive pressures and so prices are likely to grow more slowly for tradeable goods

than for non-tradeable goods. The growth in the wholesale or consumer price index, which is an aggregation of both types of goods' prices, therefore overestimates the growth in the price of tradeables (at an increasing rate through time) and also causes the growth in the world price of imports series to increasingly exceed its true value. The world price of imports when denominated in Australian dollars will therefore also be too large so that its ratio with the f.o.b. import price trends down through time. This problem only began to emerge from the early 1980s when imports from these Asian countries began to increase strongly. Previously the inclusion of non-tradeable in the import price did not lead to any distortions.

**Chart 2 - The Logarithm of the Ratio of F.O.B. Import Prices and Australian Dollar World Price of Imports and the Fitted Logistic Growth Function**



Another possible cause for the downward trend in the ratio of Australian dollar world import prices and f.o.b. import prices lies in the construction of conceptually inconsistent index series. For example the f.o.b. price of Australian imports is the price deflator that drops out from the ratio of the current price value of imports and the constant price value of imports. That is:

$$PMGS_t = \frac{MGS(\text{Current Prices})}{MGS(\text{Constant Prices})} = \frac{\sum_{n=1}^N P_t^n \cdot Q_t^n}{\sum_{n=1}^N P_{1989-90}^n Q_t^n}$$

where:  $P_t^n$  = f.o.b. price of import good n in period t

$Q_t^n$  = volume of import good n in period t

In contrast, the world price of imports series is calculated by weighting the changes in the price indexes for each country (denominated in its own currency) by its contribution to Australian imports. The series is indexed to equal 1 in 1989-90.

$$\Delta WRLDP_t = \left( \frac{1}{\sum_{n=1}^N (W_t^n * Q_t^n)} \right) \sum_{n=1}^N [(W_t^n * Q_t^n) * (\ln |W_t^n / W_{t-1}^n|)]$$

where:  $W_t^n$  = world price of import good n in period t

As can be seen from the above two equations the two index series are constructed using very different methodologies. A few experiments with the equations has shown that changes in data which should leave the ratio of f.o.b. import prices to the Australian dollar world price of imports constant can lead to movements in the series due to the different index constructions. These two series were chosen because it was believed that they reflected most accurately the prices of the goods that Australia has imported over the last 20 years. This feature would be lost if the series were to be constructed with more consistent methodology.

For the above reasons a logistic growth function was fitted to the long run part of the equation. This allows further reduction in the ratio over the projection period while at the same time ensuring a stable ratio in the long run.

$$\log(\text{PMGS}) = \log(\text{WRLDP}) - \log(\text{RWTI}) + A0\text{PM} + (A1\text{PM} / (1 + A2\text{PM} * \exp(-A3\text{PM} * \text{TREND})))$$

### The Short Run

The short run changes in import prices depend on the contemporaneous change in the world price of imports, the exchange rate, oil prices, domestic prices (as reflected in wages growth) and the adjustment to the long run desired level.

$$\begin{aligned} \log[\text{PMGS}/\text{PMGS}(-1)] = & [(A1\text{PM}/(1+A2\text{PM}*\exp[-A3\text{PM}*\text{TREND}])) \\ & -(A1\text{PM}/(1+A2\text{PM}*\exp[-A3\text{PM}*\text{TREND}(-1)]))] \\ & +A4\text{PM}*\text{LOG}[\text{WRLDP}/\text{WRLDP}(-1)] \\ & +A5\text{PM}*\text{LOG}[\text{WPMPE}/\text{WPMPE}(-1)] \\ & +(1-A4\text{PM}-A5\text{PM})*\text{LOG}([\text{WBH}/\text{WBH}(-1)]-\text{CLAM}/4) \\ & +A6\text{PM}*\text{LOG}[\text{RTWI}/\text{RTWI}(-1)] \\ & +A7\text{PM}*\{\text{LOG}[\text{PMGS}(-1)*\text{RTWI}(-1)/\text{WRLDP}(-1)] \\ & -[A0\text{PM}+(A1\text{PM}/(1+A2\text{PM}*\exp[-A3\text{PM}*\text{TREND}(-1)])]\} \end{aligned}$$

- The change in world prices and the change in the exchange rate are not constrained to have the same coefficient since in the short run import prices are likely to be more responsive to changes in the world price of imports than they are to changes in the exchange rate. Because exchange rates constantly fluctuate while world prices are more constant a change in world prices is more likely to be regarded as permanent than a similar movement in the exchange rate (which could be regarded as noise). Consequently foreign import suppliers are likely to pass on to f.o.b. import prices in the immediate period a greater proportion of a change in the world price of imports than they would for a similar change in the exchange rate.
- The change in wages reflects domestic price pressures and is included to account for the possibility, discussed by Brain (1986), that in the short run foreign suppliers may be more likely to adjust their prices in line with past, current or expected changes in world prices and exchange rates when other prices are also rising. Since when other prices are rising the fear of losing market share as a result of a price rise is greatly diminished.

- Oil prices are included in the short run as they appear to have a magnified effect on import prices. Oil prices are contained in the world price of imports series and so the effect of the change in the oil prices on f.o.b. import prices is above that which emerges from the change in oil prices affecting world import prices which in turn change in f.o.b. import prices. Given that oil prices are contained in the world price of imports series they do not appear separately in the long run part of the equation.

#### SECTION IV - MODEL ESTIMATION

The equation was estimated over the sample March 1975 to September 1994 and the coefficients are given below. In general the import price equation has been estimated with the import volume equation over the period from March 1978; however, the following results are only for the single estimation of the price equation. The estimated coefficients do not appear to change when estimated jointly and from March 1978.

Sample 75:1 to 94:3		R2 = 0.87		Standard Error = 1.16	
Diagnostics					
Auto-correlation		Box Pierce Q statistic= 7.40 $\sim \chi(8) = 15.15$			
Heteroscedasticity		Breusch-Pagan (yhat, t) statistic = 6.11 $\sim \chi(2) = 5.99^{(a)}$			
Normality		Jarque-Bera statistic = 1.79 $\sim \chi(2) = 5.99$			
Structural Change		Chow F-statistic = 0.637 $\sim F(4, 71) = 2.35$			
Mis-specification		Reset F-statistic = 0.113 $\sim F(1, 73) = 3.98$			
Current Estimate					
			June 1993 Conference Model (b)		
Parameter	Estimate	t-statistic	Estimate	t-statistic	
Long Run Constant (A0PM)	-0.253	-2.05	1.787	22.0	
LGC Coefficient (A1PM)	0.460	3.26	-	-	
LGC Coefficient (A2PM)	1.667	3.75	-	-	
LGC Coefficient (A3PM)	0.238	3.16	-	-	
$\Delta$ World Price of Imports (A4PM)	0.797	8.39	0.471	13.5	
$\Delta$ World Price of Oil (A5PM)	0.038	3.40	0.047	2.54	
$\Delta$ Wages (1-A4PM-A5PM)	0.165	-	-	-	
$\Delta$ Exchange Rate (A6PM)	-0.705	-20.09	-0.471	13.5	
Error Correction Coefficient (A7PM)	-0.288	-4.89	0.121	23.9	

(a) The null hypothesis of no heteroscedasticity is rejected at the 5 per cent significance level.

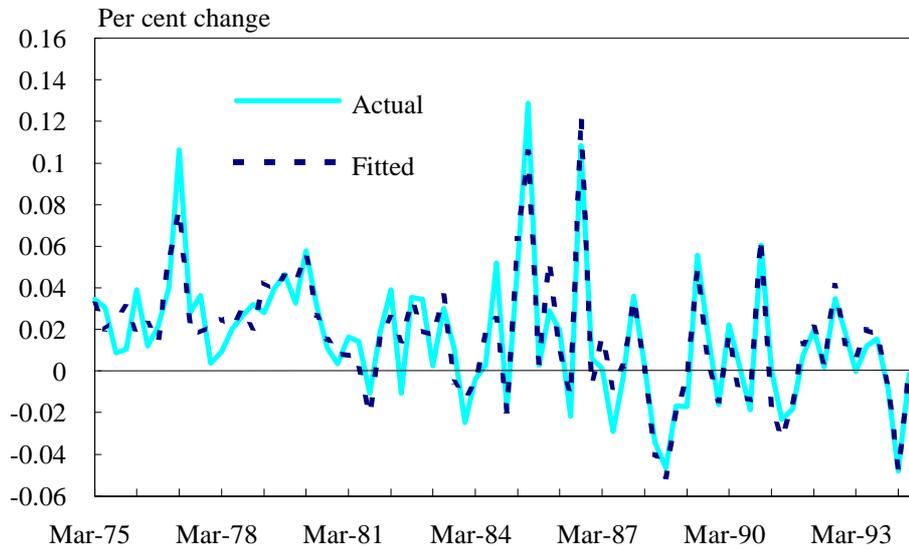
(b) The coefficients estimated in the June 1993 TRYM Conference Model are given for comparison.

When estimated using the September quarter 1994 database, the equation has an error correction coefficient of 29 per cent; that is, when import prices diverge from their long run equilibrium value the divergence is lessened by 29 per cent each quarter. The coefficients on the changes of the exchange rate and on the world price states that f.o.b. import prices jump by 0.71 per cent when the exchange rate falls by one per cent while a one per cent rise in the world price of imports leads to a 0.80 per cent jump in the f.o.b. price of imports in that period. All coefficients are plausible and the equation's goodness of fit is high. The diagnostic tests do not indicate problems of serial correlation,

mis-specification, structural change and non-normality of the errors. The Breusch-Pagan test suggests the presence of heteroscedasticity. There is however some ambiguity with this result since different constructions of the Breusch-Pagan test implied the absence of heteroscedasticity.

Chart 3 shows the actual and fitted values the change in import prices (the dependent variable). Chart 4 plots the actual and dynamic simulation of the level of import prices.

**Chart 3 - Change in the Price of Imports**



**Chart 4 - Price of Imports**

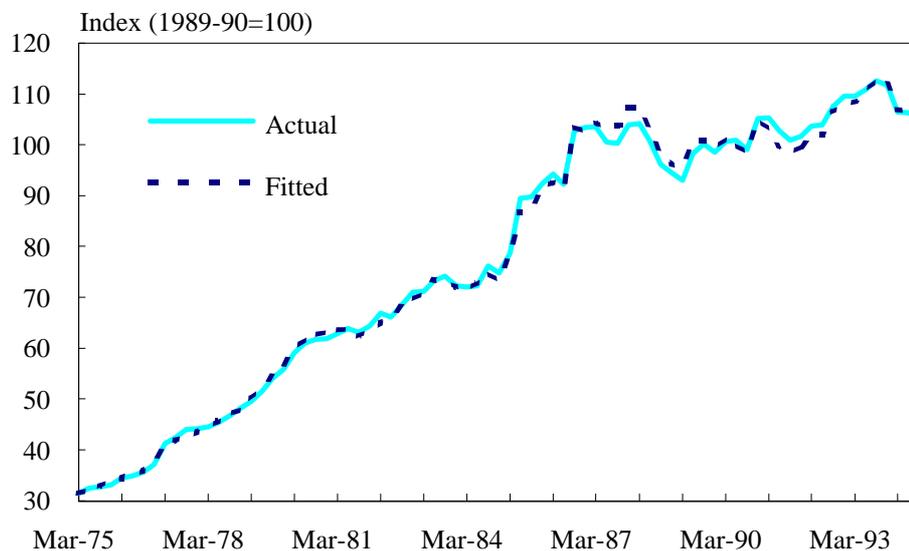
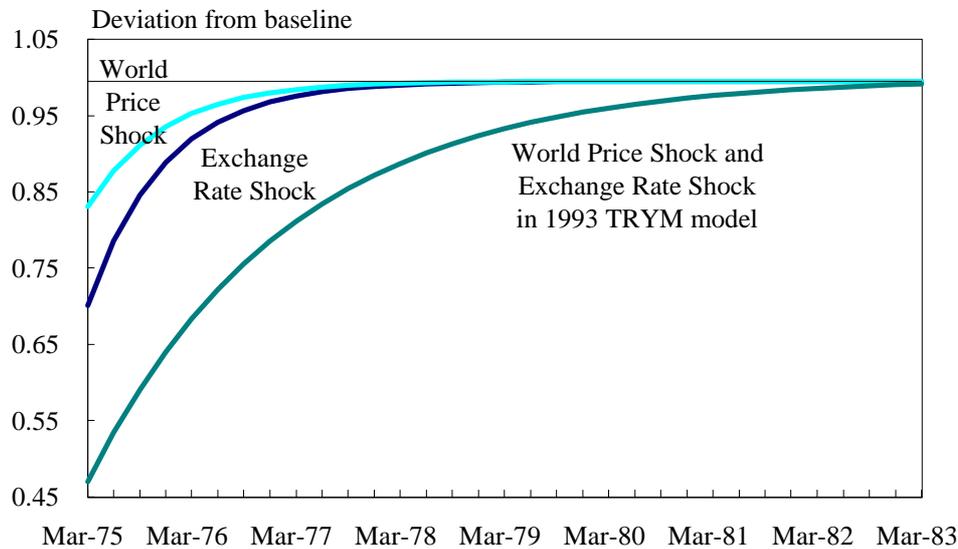


Chart 5 presents the long run changes in import prices that result from a one per cent fall in the exchange rate and a one per cent rise in world prices for both the newly estimated import price equation and the June 1993 TRYM Conference model equation. (The rate of world price and exchange rate pass through in the TRYM Conference model was constrained to be equal). The rate of both exchange rate and world price pass through is considerably quicker in the newly estimated equation. The effect of both exchange rate and world price shock are almost entirely passed through

to import prices within three years of the shock whereas in the TRYM Conference model these shocks took about seven years to be passed through.

**Chart 5 - Exchange Rate Shock and World Price Shock**



#### SECTION IV - COMPARISONS WITH OTHER STUDIES

This section of the note compares the results of our import price equation, in particular the degree and speed of exchange rate pass through, to those of the published articles discussed in Section I.

Phillips (1988) states that greater exchange rate pass through is expected the higher the elasticity of import supply and the lower the elasticity of import demand. Given Australia's small country assumption it is therefore reasonable to expect, and thus constrain, full pass through in the long run as is done in the TRYM import price equation. This constraint is further supported by the work of Phillips (1988), Dwyer et al (1993) and Brain (1986), all of whom find full or close to full pass through in the long run.

- Phillips (1989) notes that overseas empirical studies typically find full pass through for small open economies. He cites across country studies by Kremin (1977) and Spittaler (1980) which find full pass through for most developed economies excluding (West) Germany and Japan which are large enough to affect the terms of trade. Phillips however notes that studies for the US (Krugman & Baldwin (1987) and Helkie & Hooper (1988)) also find full exchange rate pass through.

The work by Phillips (1988) and Dwyer et al (1993) all suggest that the exchange rate pass through in Australia is fairly rapid. In Phillips' equation the exchange rate associated price change is 70 per cent in the current quarter and 25 per cent in the following quarter. In Dwyer et al's equation the contemporaneous pass through is 53 per cent followed by 18 per cent in the next quarter. Any lags greater than one period are found to be insignificant in both equations.

- The simple lag structure of Australian exchange rate pass through is in contrast to the conclusions of US studies which find protracted adjustment periods of often up to 5 years.

Phillips attributes this difference to currency invoicing. The bulk of US imports are denominated in US\$, the domestic currency while the majority of Australian imports (90 per cent) are denominated in foreign currency. As a result Australian import contracts respond more quickly to exchange rate changes than those of the US.

The rates of exchange rate and world price pass through estimated in the new import price equation are more consistent with the literature than the rates estimated in the June 1993 TRYM Conference model. The speed of the pass through of the newly estimated import price equation is slower than the rates estimated by Phillips (1988) but faster than those estimated by Dwyer et al (1993). The rates estimated in the June 1993 TRYM Conference model were however substantially slower the rates that would be expected given the theoretical or empirical literature.

Similar to the Brain (1986) model, the newly estimated TRYM import price equation also finds that the change in domestic prices is a significant short run explanatory variable.

The new TRYM import price equation compares favourably against those of other models of the Australian macroeconomy. Import prices in both the AMPS (1986) and Access Economics Murphy model (1992) are exogenous while the import price equation of the NIF-88 model (1988) is a distributed lag function of the exchange rate and a world competitiveness index.

Rochelle Edge  
Modelling Section

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## APPENDIX A

### Manufactured Producer Price Index Based World Imports Price Series

The world price of imports series that is now used in the TRYM import price equation is a weighted average of producer price of manufactures indices for Australia's top 19 import sources (in 1993). However, as noted earlier producer price of manufactures data is only available for OECD countries so that proxy series, such as the wholesale price indices and consumer price indices, were used for some countries.

#### *Producer Price of Manufactures Index Data*

The producer price of manufactures index was chosen as the conceptual base of our measure since manufactures represent a high proportion (about two thirds) of Australia's total imports. It was thus believed that weighting the series for each country by its contribution to total imports would provide a series that represents, reasonably accurately, the price that Australia faces for its imports.

The price series used in constructing the measure and their respective sources are listed below:

USA	Produce Price of Manufactures Index (whole sample/OECD)
Japan	Produce Price of Manufactures Index (whole sample/OECD)
UK	Produce Price of Manufactures Index (whole sample/OECD)
Germany	Produce Price of Manufactures Index (whole sample/OECD)
New Zealand	Produce Price of Manufactures Index (whole sample/OECD)
China	Growth of Hong Kong Consumer Prices (Mar-73 to Dec-75/IMF - IFS)(a) Consumer Price Index (Mar-76 to Dec-80/IMF - IFS) Price of Industrial Goods (Mar-81 to Dec-87/IMF - IFS) Consumer Price Index (Mar-88 to Dec-92/IMF - IFS)
Taiwan	Wholesale Price Index (whole sample/Industry of Free China)
ROK	Wholesale Price Index (whole sample/OECD)
Singapore	Wholesale Price Index (whole sample/OECD)
France	Consumer Price Index (Mar-73 to Dec-79/IMF - IFS) Produce Price of Manufactures Index (Mar-80 to Sep-94/OECD)
Italy	Wholesale Price Index (Mar-73 to Dec-80/IMF - IFS) Produce Price of Manufactures Index (Mar-81 to Sep-94/OECD)
Indonesia	Wholesale Price Index (whole sample/IMF - IFS)
PNG	Consumer Price Index (whole sample/IMF - IFS)
Sweden	Wholesale Price Index (Mar-73 to Dec-81/IMF - IFS) Produce Price of Manufactures Index (Mar-82 to Sep-94/OECD)
Canada	Produce Price of Manufactures Index (whole sample/OECD)
Malaysia	Consumer Price Index (whole sample/IMF - IFS)
Saudi Arabia	Unit Price of Exports (whole sample/IMF - IFS)(b)
Hong Kong	Consumer Price Index (whole sample/IMF - IFS)
Thailand	Wholesale Price Index (whole sample/IMF - IFS)

#### NOTES:

- (a) Given that most exports from China go through Hong Kong, Hong Kong prices give a reasonable indication of the prices that Australia faces for goods imported from China and is thus used where China data is unavailable.
- (b) The only available price series for Saudi Arabia is the Consumer Price Index. This is not a very accurate series to use to construct the world price of imports series given that Australia's main import from Saudi Arabia is oil which is very different to the commodities that are included in the Consumer Price Index basket of goods. The Unit Price of

Exports series is used as an alternative as oil accounts for a large proportion of Saudi Arabia's exports and thus gives a more accurate reflection of the price Australia faces for its imports from Saudi Arabia.

### ***The Country Set and Weightings***

The top 19 import sources in 1993 (given in order in the above list) were chosen as the country set as this set guaranteed that any country that has been one of the top ten import sources at any time in the last twenty years is included in the set. The above series were weighted according to the contribution of the imports from that country to the total imports of the set. Direction of Australian import data is available in the DFAT publication "Direction of Trade Time Series, 1973 to 1993".

### **Alternative World Price of Imports Series**

The RBA constructs a world price of imports series which weights the export price indices of our major import suppliers by their proportional contribution to our total imports. The idea is that the exports of our major import sources will be our imports. They expect that on average the larger the proportion of our imports a country accounts for the more likely it is that this country is a complementary trading partner, that is, the goods this country exports closely match our imports. Thus in weighting our import sources' export price indices by their contribution to our imports they are likely to end up with a measure of world prices that reflects an aggregation of those we actually import. This series is used in Dwyer et al (1993) which is discussed in Section I of the paper.

While conceptually sound such a series is likely to suffer from measurement errors. The error arises from the fact that the price of exports index for each country incorporates the prices of exports to countries other than Australia. It therefore incorporates goods that Australia does not import from these countries and if exporters can discriminate in the prices at which they export their goods then various prices for the same goods will also appear in the export price index. Consequently the export price index for any country will include the prices of goods that have no relevance to any trade that Australia has with this country.

A further problem arises with this measure from the way in which international trade contracts are written. Contracts for trade between most countries are written in US\$ (even when the US is not involved), but trade between Japan and all countries excluding the US are written in Yen, only when Japan trades with the US are contracts written in US\$. As a result if, for example, the US\$ depreciates against the Yen (with the exchange rate between the Yen and the AUS\$ remaining unchanged), then the US\$ price will remain constant (since the contract is written in this currency) but the price denominated in Yen will fall. This will be reflected as a fall in the export price index and if incorporated into the world price of imports series it will incorrectly suggest that price of imports that Australia is facing has also fallen. Including such a series in our import price model will result in incorrect parameter estimates. <sup>1</sup>

Basing the world price of imports measure on the producer price of manufactures index avoids this measurement problem and is the most sensible series given the available data.

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<sup>1</sup> A world price of imports series based on this methodology was used to estimate an import price equation and did indeed yield implausible estimates, particularly on the world price of imports variable. The pass through on world prices was very slow, considerably slower than for the exchange rate, an observation which is inconsistent to that suggested by the theoretical and empirical literature.

## APPENDIX B

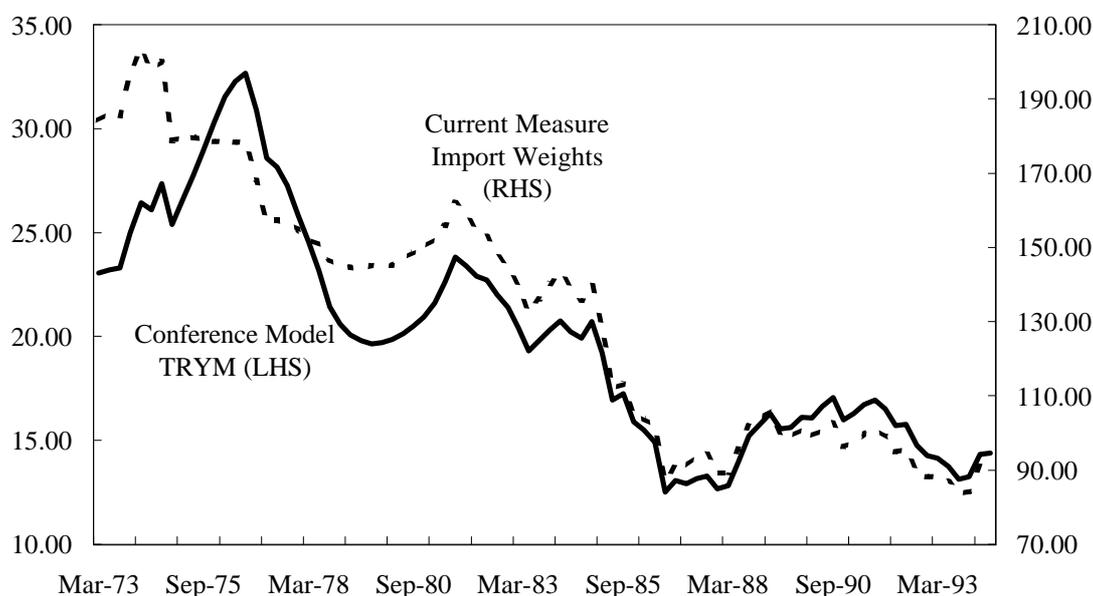
### The Import Share Weighted Exchange Rate

The exchange rate series used in June 1993 TRYM conference model was calculated as the sum of the exchange rates for the set of Australia's top 16 export destinations weighted by their contribution to the total exports to this set. The exchange rate series used in the estimation of the import price equation differs from the original series in two ways.

- Firstly, in order to establish consistency with the new world price of imports series, the sample of countries used to construct the new trade weighted exchange rate series is now the top 19 import sources.
- Secondly, the new exchange rate series is now calculated as the weighted sum of the change in each countries' exchange rate rather than as the weighted sum of the log level of each countries exchange rate.

This later difference was an important modification to the series as merely weighting the levels of the exchange rates can lead to distortions when changes country shares are occurring. This problem arises from vast differences between the denominations of various currencies. Consequently, even with no change in the exchange rates between the domestic country and its import sources, if there is a change in the country import shares the exchange rate series, calculated simply as the sum of the weighted exchange rate levels will change.

**Chart 6 - Trade Weighted Exchange Rates -  
TRYM Conference Model Measure and Current Measure**



- For example, Chart 6 shows the TRYM conference model measure (which weights the level of the exchange rate by export shares) and the modified measure (which weights the change in exchange rates by their import shares). Over the period December 1974 to September 1976 exchange rates were fixed and this is reflected in the modified measure which remains constant

over this period. In contrast, the TRYM conference model measure shows a sharp rise over this period. Investigations into the data revealed that this was because of a very strong rise in the share of Japanese exports from Australia (recall this measure was export share weighted but a similar trend was also happening in import shares). Over this period Japan had an exchange rate of about 390 Yen to an Australian Dollar, while the other major export destinations, US, New Zealand and UK (whose shares decreased slightly) had exchange rates of approximately 1.3 \$US to an \$A, 1.2 \$NZ to an \$A and 0.7 Pounds Sterling to an \$A respectively. Consequently while the Yen to \$A exchange rate (or for that matter any exchange rate) did not change over this period because the weight on the Yen to \$A exchange rate (which is denominated in fairly high units) grew strongly the overall exchange rate series also grew quickly.

- Weighting the change in the exchange rates of the various import sources by each countries import share is clearly the preferable method since it removes the distortions that may arise from the currency denominations.

The exchange rate data for all countries (excluding Taiwan) was the Average Exchange Rate (National Currency Unit/\$US) as found in the IMF IFS statistics. The exchange rate between the New Taiwan dollar and the Australian dollar was from the Reserve Bank Bulletin.

- Data on import shares was also taken from the DFAT publication "Direction of Trade Time Series, 1973 to 1993".

The method used by the RBA to calculate their TWI measure is similar to that used in the new TRYM exchange rate series, differing in the following factors:

- The RBA TWI measure uses constant weights for each country over the whole sample of the series where as the TRYM exchange rate measure uses weights that move through time. Moving weights were chosen to maintain consistency with the world price of imports series.
- The RBA TWI measure weights the exchange rates by according to that countries contribution to Australia's total trade rather than to just imports as is done in the TRYM exchange rate measure. The RBA also used the top 25 trading partners whereas that TRYM measure only uses the top 19 import sources.
- A discussion of the construction of the RBA TWI can be found in the October 1988 RBA Bulletin.