AN ANALYSIS OF THE DETERMINANTS OF IMPORTS

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ABSTRACT

The econometric technique of cointegration is used to model the aggregate demand for imports in Australia over the period from September 1974 to September 1989. We find that movements in total and endogenous imports are well explained by movements in domestic demand, the relative price of imports, the relative price of exports, and the level of overtime. The demand for imports is found to be more responsive to changes in demand than to changes in prices, although movements in prices have an impact on import demand over a longer period of time. Our models explain almost all of the rapid growth of imports over the period from September 1986 to September 1989, and over this period we find that the contribution to growth in imports of relative prices outweighs that of demand.

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1. INTRODUCTION

In this paper the empirical relationship between import volumes, domestic activity and relative prices is examined. To date, most attempts to estimate this relationship have modelled the demand for imports as a function of domestic activity and a relative price term, using standard regression techniques. Such models have generally been unsuccessful in terms of their tracking performance, particularly in recent periods. Part of the problem may be the omission or inappropriate choice of explanatory variables. However, a major problem is that most previous studies of import demand in Australia have not taken explicit account of non-stationarities in the time series. The usual techniques of regression analysis may result in biased and inconsistent coefficient estimates when the variables in question are non-stationary. In this paper, however, we take explicit account of non-stationarities in the time series data by applying cointegrative techniques.[1]

Section 2 outlines the broad trends and major cycles in imports, activity and relative prices in the 1970s and 1980s. Section 3 discusses the appropriate choice of explanatory variables and looks at alternative relative price variables and demand variables (both trend and cyclical). Our choice of functional form is explained in Section 4, with an outline of the methodology used in Section 5. Section 6 presents the results of the preferred equations. Some conclusions are offered in Section 7.

2. TRENDS IN ENDOGENOUS IMPORTS, ACTIVITY AND PRICES

The two main influences on import growth are growth in domestic demand and changes in relative prices. Cyclical factors, such as the level of domestic capacity, also help to explain import growth particularly during periods when supply constraints are reached in the domestic economy.

Chart 1 shows growth in endogenous imports (that is, imports excluding "lumpy items" such as fuel, aircraft and defence equipment, which do not normally reflect the general level of demand), domestic demand, as measured

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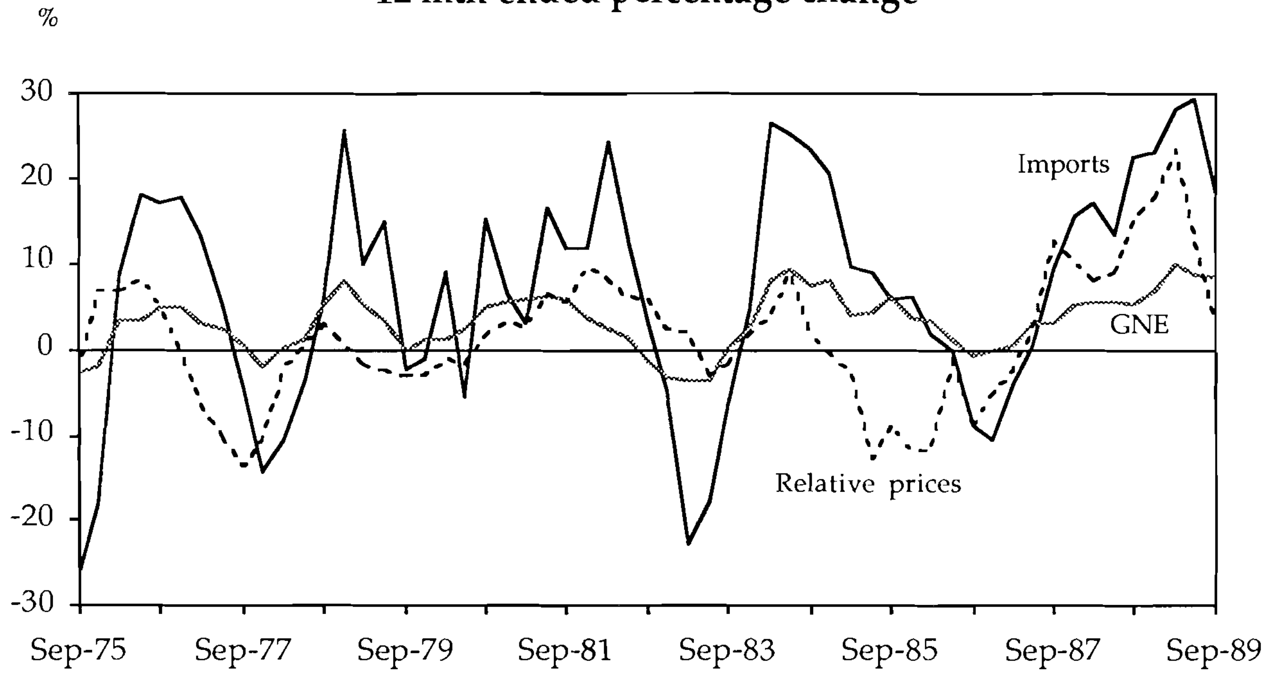
[1] Two papers which have used cointegrative techniques to model the demand for imports in Australia are Cairns (1989) and Hall et al. (1989). Preliminary work by Warwick McKibbin and Julie Cairns provided the initial impetus for this study.

Chart 1

ENDOGENOUS IMPORTS, DEMAND AND RELATIVE PRICES
12 mth ended percentage change



by gross national expenditure and relative prices (represented by the price of domestically produced goods relative to the price of endogenous imports). It can be seen from the chart that as growth in demand increases, growth in imports typically picks up more than proportionately. Imports also respond positively to an increase in the price of domestic goods relative to the price of imports. An interesting point to note from the chart is that movements in domestic activity and relative prices have tended to reinforce each other. Of course when the domestic economy is running more strongly than overseas economies, there will be inflationary pressures on domestic prices relative to import prices. In addition, at these times, monetary policy tends to be tightened to reduce domestic inflation. This, in turn, tends to push up the exchange rate, further increasing the price of domestically produced goods relative to the price of imports.

Over the period shown on the chart, there were a number of cycles in imports. After falling through 1975 imports increased sharply in 1976 largely reflecting increasing domestic demand. However, the rise was not sustained and imports fell through 1977 and 1978, reflecting favourable movements in relative prices together with some slowing in demand. Throughout the remainder of the 1970s, imports continued to grow (although there were some small falls at the end of 1979) despite the fact that import prices were increasing faster than domestic prices.

In the 1980s, there were two complete cycles in imports. One began in the early 1980s, when there was a surge in imports associated with the 'resources boom'. This was followed by a substantial fall in imports during the recession of 1982/83. Imports again grew very strongly in 1983 and 1984, reflecting the cyclical upswing of the economy, and slowed in 1985 and 1986 as domestic demand weakened and the exchange rate fell. However, the slowing in imports during this period was not as great as could have been expected given the extent of the fall in the exchange rate.

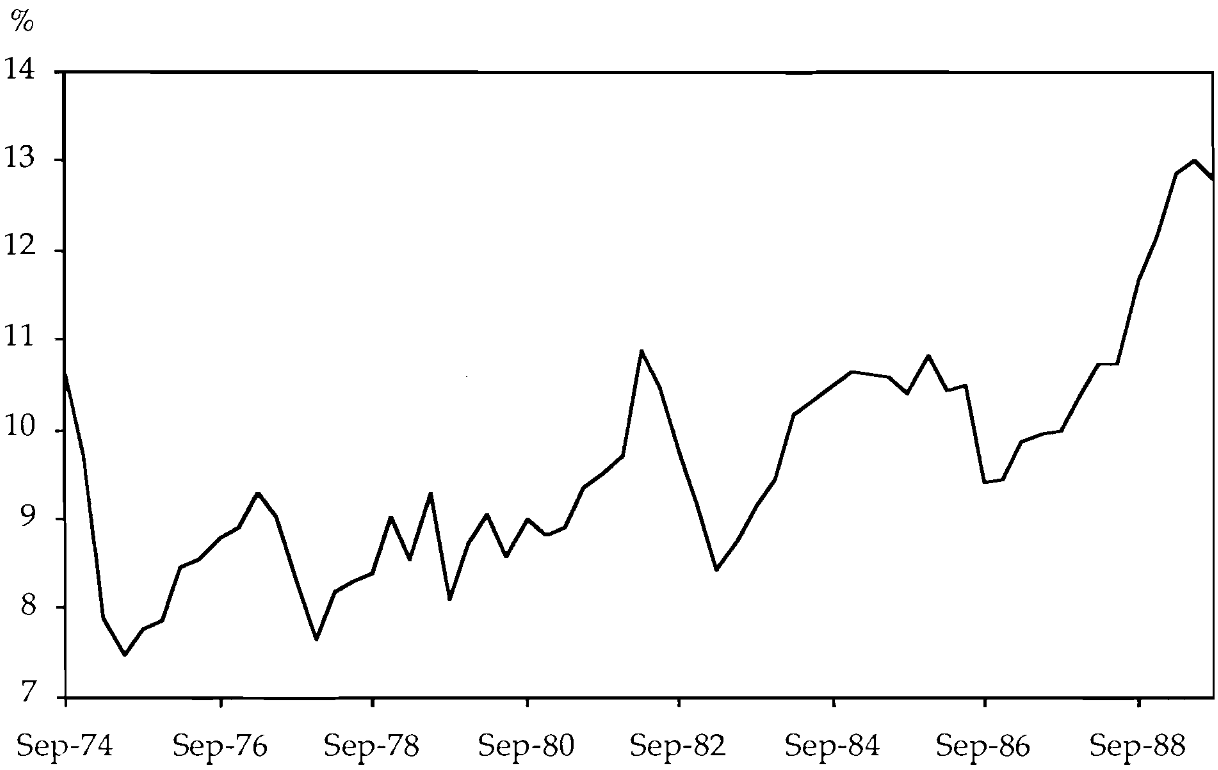
In the current cycle there has again been a strong rise in imports. Movements in domestic demand and relative prices have both acted to increase imports. Given the rapid rise in domestic demand, especially during late 1988 and early 1989, a general inability of supply to meet demand may also be an important factor in the recent growth of imports.

In fact, the increase in imports during the current cycle has been sharper and more sustained than in either of the previous two cycles. Most forecasters under-predicted this surge in imports. Some of this widespread under-prediction has recently been explained by special factors which underly the phenomenal growth in imports of motor vehicles (capacity constraints) and computers and other office machines (large falls in prices). These special factors would not be picked up by an aggregate demand-determined import volume equation.

While there is clearly cyclical behaviour in imports, it is also the case that the share of imports in total spending has shown a marked upward trend over time. Chart 2 shows the ratio of endogenous imports to non-farm sales. The increase has been particularly sharp at times of deteriorating competitiveness (for example, the early 1970s, the early 1980s and the late 1980s). One common explanation for the trend increase in the import penetration ratio is the decline in the Australian manufacturing sector, reducing the capacity for obtaining goods domestically. A trend increase in the import ratio would also be expected, however, given the worldwide trend toward increased specialisation and lower transportation costs.

Chart 2

ENDOGENOUS IMPORT PENETRATION RATIO



3. ANALYTICAL FRAMEWORK

In most studies of import demand, the quantity of imports is modelled as a function of the price of imports relative to domestic prices and of some activity variable. Many studies also attempt to incorporate cyclical influences on imports.

The demand model we estimate comes from simple production theory.[2] In this model there are assumed to be three sectors in the economy in which importables (m), exportables (x) and non-traded goods (n) are produced. The excess demand function for importables (d_m) - i.e. the demand function for imports - is thus the difference between domestic demand for (D_m) and supply of (S_m) importables. It is a function of three prices (p_m, p_x and p_n) and nominal income (Y), and is subject to a domestic production capacity constraint (CU), i.e.,

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[2] This framework is used in Hall et al.(1989).

$$d_m(p_m, p_x, p_n, Y, CU) = D_m(p_m, p_x, p_n, Y) - S_m(p_m, p_x, p_n, Y, CU)$$

Assuming this excess demand function is homogeneous of degree zero in income and prices, it follows that we can normalize it by any one, or an index, of these prices. Thus we define a new function d_m^* by:

$$d_m^*(p_m/p_n, p_x/p_n, Y/p_n, CU) = D_m^*(p_m/p_n, p_x/p_n, Y/p_n) - S_m^*(p_m/p_n, p_x/p_n, Y/p_n, CU)$$

In many studies, p_x/p_n is excluded from the estimation because it is claimed it is not a significant explanator. However, there are two reasons why we believe it may help explain import growth. First, it picks up the effect of terms of trade movements. When the price of our exports rises, our capacity to consume imports increases even though our actual GDP has not increased.[3] Secondly, we expect that movements in the price of exports could pick up sector specific demand effects. Since about 50 per cent of Australia's imports are intermediate goods, and a further 25 per cent are capital goods, we thought it likely that movements in the price of exports, which would make production in the exportable sector more profitable, would have a significant effect on the demand for imports.[4]

Explanatory Variables

From the evidence presented in Section 2 above, both relative prices and activity are very important determinants of the demand for imports. However, there are a variety of measures which may be used as a proxy for these variables. For this paper several alternatives were investigated for each variable before arriving at a preferred equation.

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[3] An alternative would be to use a measure of GDP adjusted for the terms of trade movements, however, this would make interpretation of the import price elasticities difficult.

[4] An alternative model of import demand, suggested by Goldstein et al. (1980), assumes that consumers first allocate their expenditure between tradeables and non-tradeables, and then allocate their expenditure between imports and domestically produced importables. It then follows that the demand for imports is independent of the price of non-tradeables and exportables. The relative price of imports to domestically produced importables is thus the sole relative price term entering the model. There are two problems with this approach. Firstly, the assumption of strong separability in preferences is very restrictive and whether it actually explains individuals' behaviour is subject to debate. Secondly, we do not have a reliable index of the price of domestically produced importables, making empirical estimation difficult.

Possible Demand Variables

The two main candidates for activity variables are gross national expenditure (GNE) and gross domestic product (GDP). There are valid reasons for choosing either measure: GNE may be preferred if it is thought that the demand for imports should be related to domestic spending on all goods rather than to the sum of domestic and foreign spending on domestic goods only. Alternatively, if imports are mainly intermediate goods used as an input to production, GDP may be a more appropriate measure as it may be more reasonable to treat imports as a function of domestic output rather than spending.

In a long run of data, GNE and GDP are highly correlated. We use both as potential demand explanators.

Possible Price Variables

The first of the relative price terms in our import demand function should compare the price of importables with the price of non-traded goods. However, reliable price indices for domestically produced importables and non-tradeables do not exist, therefore the price of all domestically produced goods is generally used as a proxy for the price of non-tradeables.[5] We use the GDP deflator.[6]

For the price of imports we use the endogenous import price deflator when modelling endogenous imports, and the merchandise import price deflator when modelling total merchandise imports. An alternative measure is the import price index. We did not use this measure for two reasons. First, it is only available in a consistent form since 1981/82 which reduces our sample period considerably. Secondly, the import price index is a fixed weight price index, weighted using the pattern of Australian imports during the three years to June 1981. We doubted the relevance in the late 1980s of those weights.

The price deflator for total merchandise exports was used to proxy for the price of exportables.

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[5] A consequence of this is that the elasticity of demand for imports with respect to the relative price of importables to non-traded goods is constrained to be the same as the elasticity of demand for imports with respect to the relative price of importables to domestically produced traded goods.

[6] An alternative is suggested by Dwyer (1988) - this involves removing movements in import prices from the CPI to isolate movements in non-traded goods prices. On preliminary estimation we found this series was not very different from the GDP deflator series.

Possible Capacity Variables

There is reason to believe that not all growth in imports can be explained by GNE and relative price movements. As the economy reaches full capacity, there is likely to be a spillover of excess demand into imports. Overtime is used to model capacity constraints.

4. FUNCTIONAL FORM

In most previous attempts to model imports it has been implicitly assumed that all variables used as explanators in the regression exhibit stationarity. That is, the distribution of each variable is assumed to be constant and thus its mean and variance do not change over time. This property ensures that any sample mean and variance gives a true representation of the population mean and variance for a series. In addition, errors from regressions involving only stationary variables must themselves be stationary. When variables are non-stationary, conventional econometric results must be interpreted with care as the classical assumptions about the behaviour of the random variables used in the regression no longer hold. Although the coefficient estimates from such regressions are consistent[7], the test statistics have non-standard distributions.

There are two ways of dealing with non-stationary variables in order to use standard regression techniques. The first is to manipulate the non-stationary data series in order to make them stationary. This may involve detrending or differencing the series, depending on the type (stochastic or deterministic) and order of non-stationarity. The major problem with manipulating data series in this manner is that information is lost - one cannot infer the long run steady state relationships between variables from the estimated model.

Until the mid 1980s this was the approach which economists tended to follow. However, following some important advances in econometrics, it became possible to test whether any of the non-stationary series are cointegrated with each other. Cointegration techniques attempt to model the long run steady state relationships. If variables are cointegrated it means that although the individual time series exhibit non-stationary properties, linear combinations of these variables exhibit stable properties. We would generally expect economic theory to explain why these variables move broadly together over time.

In this paper, when analysing the time series properties of our random variables, we look only at the first two moments of their distributions. A non-

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[7] That is, given a relationship $y_t = \alpha + \beta x_t + \varepsilon_t$, where ε_t has standard properties and x_t is stochastic, then the OLS estimate, $\hat{\beta}$, will be a consistent estimator of β as long as $E(x'\varepsilon)=0$.

stationary random variable is defined as one which does not have a constant mean and/or variance over time. If it is necessary to difference a series d times to make it stationary then the series is defined as being integrated of order d, denoted I(d). Stationary variables are therefore I(0).

If two variables, x_t and y_t, are cointegrated, then the residuals from a regression of x_t on y_t must be stationary, i.e. I(0). $\hat{A}$, the estimated coefficient on y_t from this regression, is known as a 'super consistent' estimate[8]. However, because x_t and y_t are I(1), $\hat{A}$'s standard error has an unknown distribution. Therefore $\hat{A}$'s t-statistic cannot be used as a test of significance.

If $\hat{A}$ is the estimated coefficient on y_t from a regression of x_t on y_t, then $x_t=\hat{A}*y_t$ is the estimated long run equilibrium relationship between x_t and y_t. In any period the residual, $z_t = x_t - \hat{A}*y_t$, measures the extent to which the system deviates from the estimated long run equilibrium in that period.

Engle and Granger (1987) showed that once a number of I(1) variables have been shown to be cointegrated, there always exists a system of equations having error-correcting form which represent the dynamics of the series. The error-correction representation implies that changes in the dependent variable are a function of the level of disequilibrium in the cointegrating relationship – that is the departure from the long run equilibrium – as well as changes in other explanatory variables.

More formally, assuming once again that two variables x_t and y_t are both integrated of order 1 and assuming they are cointegrated, so that $z_t = x_t - \hat{A}*y_t$ is I(0), then Engle and Granger proved that it must be the case that:

$$\Delta x_t = \alpha_1 * z_{t-1} + \beta_1 * \text{lagged}(\Delta x_t, \Delta y_t) + \gamma_1(L) * e_{1t}$$

and

$$\Delta y_t = \alpha_2 * z_{t-1} + \beta_2 * \text{lagged}(\Delta x_t, \Delta y_t) + \gamma_2(L) * e_{2t}$$

Within this system of equations, at least one of the coefficients on the cointegrating term, z_{t-1}, must be non-zero.

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[8] Super consistency refers to the fact that the estimate, $\hat{A}$, converges to its true value, A, at a rate faster than standard OLS estimates. This implies that one can be confident of the accuracy of coefficient estimates from cointegrated regressions. See Pagan and Wickens (1989).

The equation for Δx_t can be estimated by OLS, in isolation from the equation for Δy_t, because none of the explanatory variables in either equation are contemporaneous with the error terms. The standard t-tests of significance on the variables are also valid, since all of the regressors in this equation are I(0).

We can think of this equation as having both short run and long run components. The term z_{t-1}, measures the extent to which the system, that is x_{t-1} and y_{t-1}, deviates from its long run equilibrium relationship, i.e. $x_{t-1} = \hat{A} * y_{t-1}$. If the system is stable, α_1, the coefficient on z_{t-1}, will be negative.[9] Then, when z_{t-1} is non-zero – i.e. when x_{t-1} is different from $\hat{A} * y_{t-1}$ – the term $\alpha 1 * z_{t-1}$ acts to bring the system back towards its long run equilibrium. Thus, the size and sign of z_{t-1}, the previous equilibrium error, influences the magnitude and direction of movement in x_t.

The short run dynamics are captured in the full equation. Having imposed the cointegrating relationship, the coefficients on the lagged differenced series influence the path of adjustment back to equilibrium of the dependant variable.

5. METHODOLOGY

The estimation procedure involves a number of steps.

Firstly, all time series used in the estimation process are tested for stationarity[10]. They are each tested for a maximum of three unit roots down, using three different tests; the Dickey-Pantula, Stock-Watson, and Dickey-Fuller tests.

The next step in the estimation procedure involves estimating the long run, or cointegrating, relationships between the variables, noting the properties of the data suggested above. Thus the alternative measures of imports are regressed on each of the proposed demand variables and the price variables. An augmented Dickey-Fuller test (ADF) is used to test for stationarity of the residuals.

Finally, the full error correction models (ECM) are estimated. Initially four lags of each of the differenced explanators are included, and then the

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9 α_1 can be zero. This possibility is ignored because it complicates the argument without making any substantive difference.

10 Rob Trevor's "Unitroot" procedure was used to do these tests.

insignificant explanators are dropped from the equation to leave a preferred equation.

6. RESULTS

Properties of the Time Series

Eight time series were used in the estimation procedure:

M:	real total merchandise imports
EM:	real endogenous imports
Y:	real GDP
D:	real GNE
RPM:	ratio of the total imports deflator to the GDP deflator
RPEM:	ratio of the endogenous imports deflator to the GDP deflator
RPX:	ratio of the merchandise exports deflator to the GDP deflator
OT:	hours of overtime per employee

The natural logarithm of each series was used throughout the estimation. The base year for all price indices and real variables was 1984/85. All estimation was carried out using quarterly seasonally adjusted data over the period from September 1974 to September 1989.[11] (See Appendix 1 for further details.)

The results of the stationarity tests can be found in Appendix 2. For both total and endogenous imports, and GNE, these tests indicate clear evidence of one unit root at a 1 per cent significance level. GDP also appears to have a single unit root, although this could only be accepted at a 5 per cent level of significance. There is also evidence of a time trend in all of these variables.

The results for the relative price terms and overtime are less conclusive. There is evidence supporting the existence of both one and two unit roots. To an extent this ambiguity may be due to the relatively short estimation period used, as the statistical tests need long runs of data to differentiate between alternative models of the time series. Accordingly, these series were examined over a longer time period using the NIF data base for earlier periods; we found convincing support for the existence of one unit root. (These results are available on request from the authors.)

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[11] This sample period was chosen because the Australian Bureau of Statistics publishes and revises a consistent constant price series for imports over this period.

Table 1

COINTEGRATION REGRESSION RESULTS

M_t	= - 11.26	+ 1.85 Y_t	- 0.63 RPM_t	+ 0.49 RPX_t	ADF = -3.449	(1)
EM_t	= - 12.16	+ 1.92 Y_t	- 0.80 $RPEM_t$	+ 0.40 RPX_t	ADF = -3.638	(2)
M_t	= - 11.30	+ 1.85 D_t	- 0.39 RPM_t	+ 0.40 RPX_t	ADF = -4.122	(3)
EM_t	= - 12.44	+ 1.94 D_t	- 0.49 $RPEM_t$	+ 0.30 RPX_t	ADF = -3.974	(4)

Long Run Regression Results

The cointegrating relationships between imports and its explanators are estimated over the period from September 1974 to September 1989, and the results can be found in Table 1. At a 5 per cent significance level, –3.17 is the critical value for the ADF test, and at the 1 per cent level it is –3.77.[12] These results suggest that four cointegrative relationships have been identified.

Overtime is not included in any of the long run relationships, as it is not necessary for cointegration. This result is consistent with our model, as we include the overtime variable to capture short term cyclical demand effects, specifically, to identify times of demand spillover into imports.

The coefficients on each of the explanators in Table 1 can be interpreted as being estimates of the long run import demand elasticities of the respective explanators. Three important points emerge from an examination of this Table. First, all coefficients have the expected sign. Secondly, the demand elasticity appears to be insensitive to the choice of GNE or GDP as the activity explanator: it is around 1.9 for both endogenous and total imports. Thirdly, the choice of activity variable affects the import price elasticity. Using GDP as the demand explanator results in a price elasticity of 0.6 for total imports and 0.8 for endogenous imports. Alternatively using GNE as the demand explanator results in lower price elasticities of 0.4 and 0.5 for total and endogenous imports respectively.

We are not able to tell whether the relative price of exports is a significant explanator, because the standard errors have an unknown distribution. The inclusion of RPX_t increases the ADF statistic for total imports, and hence our

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[12] See Engle and Granger (1987), Table II, p. 269.

level of confidence that a cointegrating relationship exists. By contrast, the inclusion of RPX_t reduces the ADF statistic for endogenous imports. Nevertheless, in both cases, cointegrative relationships are found with RPX_t included.

It is worth briefly comparing these results with the results of other studies. Macfarlane (1979) compares elasticity estimates from a number of Australian import demand models which are estimated over the 1960s and early 1970s. Broadly the income elasticity estimates are lower than ours, ranging from 0.7 to 1.2, although in 3 of the 11 studies cited the income elasticity is constrained to 1. On the other hand, the significant relative price elasticities tend to be higher than our estimates, ranging from -0.5 to -1.6, although in 3 studies they are insignificant. These differences may reflect structural changes in the Australian economy or, alternatively, they may reflect differences in estimation techniques.

Our results can also be compared with estimates from other countries. Krugman (1988) estimates price and income elasticities for a number of countries between 1971 and 1986. Some of his income and relative price elasticities are, respectively: Canada 1.66 and -1.45, Germany 2.83 and -0.09, the US 1.31 and -0.93, Japan 0.8 and -0.42, Italy 1.31 and -0.68, Belgium 1.99 and -0.25, and the Netherlands 2.66 and -0.22.[13] Our income and price elasticities are clearly well within this range.

Error Correction Model Results

For each of the four cointegrated relationships discussed above, an error correction model is formed. This involves regressing the change in imports on the residual from the cointegration regression, one period lagged, and four lags of changes in imports, demand, relative prices and overtime. In order to improve the accuracy of the significant coefficient estimates, those variables whose coefficients were statistically insignificant were excluded from the regression. The results of these regressions can be found in Appendix 3.

In the following discussion, we concentrate on Models 1 and 2. These are the total and endogenous imports equations which use GDP as the demand explanator.

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[13] For each country Krugman estimates the model: $M_t = \alpha D_t + \beta RP_t + \lambda RP_{t-1}$. He does not test these series for their order of integration, nor these relationships for cointegration. To calculate his long run price elasticities we have summed the coefficient estimates β and λ. This is only strictly correct if true cointegrative relationships have been identified.

Table 2

IMPACT ELASTICITIES

LAGS	1	2	3	4	5	6	7	8
MODEL 1 – Total Imports								
Demand	1.41	0.34	0.08	0.02	0.01	0.00	0.00	0.00
Price-Imports	-0.07	-0.43	-0.51	-0.24	0.46	0.11	0.03	0.01
Price-Exports	-0.25	0.00	0.56	0.51	-0.26	-0.06	-0.02	0.00
MODEL 2 – Endogenous Imports								
Demand	2.14	-0.15	-0.05	-0.02	-0.46	0.34	0.09	0.02
Price-Imports	-0.53	-0.18	-0.06	-0.41	0.37	0.05	-0.01	0.07
Price-Exports	0.27	-0.29	0.28	0.51	-0.30	0.02	-0.12	-0.09

Some interesting observations can be made about these models. For both models the cointegrating term is statistically significant. In fact, around 70 per cent of the equilibrium error in the previous period feeds through into current period changes in imports. Changes in the relative prices both of imports and exports also significantly affect the short run dynamics of the system. And the overtime variables, although not individually significant, have the expected sign. For each model the null hypothesis of both overtime coefficients being zero is rejected at a 5 per cent level of significance.

The explanatory power of these error correction models is relatively high at around 60 per cent. The inclusion of both the relative price of exports and overtime as explanators increases the explanatory power by some 15 per cent.

Table 2 presents the impact demand and price elasticities which have been calculated from the reduced form of the error correction models.[14] From this Table it is interesting to note that while most of the impact of a change in demand occurs in the first 2 quarters, price effects have an impact over a much longer period.

The short run demand elasticities of the two models are quite different. In Model 1, the initial impact of a 1 per cent change in demand is a 1.4 per cent

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[14] These elasticities must be interpreted with care because the equation that we have estimated actually comes from a system of equations, as described in Section 4. To generate these short-run elasticities one is implicitly assuming that the 1 per cent change in demand (or price) is generated independently from the stochastic term in the imports equations. Although this may be an unrealistic assumption, these short run elasticities are useful for understanding the implied paths of adjustment of the model, which is important if the model is being used for single equation forecasting.

change in imports, and over the following quarters there are positive impacts which sum to the long run 1.9 per cent change. In the Model 2, however, 'overshooting' is evident. In the first period after a 1 per cent change in demand, the impact on imports is 2.1 per cent, and then this is partially reversed. These quite different paths to the new equilibrium in response to a demand shock can be explained by there being significant lagged changes in demand and imports in the ECM for Model 2, whereas there were none for Model 1.

The impact price elasticities are more variable over time much of which does not seem credible. However, the general trends which can be drawn from the table are that changes in the relative price of imports tend to have a negative impact on import demand in the first four quarters but they 'overshoot', and hence there is some correction in the following four quarters. Changes in the relative price of exports tend to have a positive impact on imports in the first four quarters but they too 'overshoot', and there is some correction in the following four quarters.

In Charts 3 and 5 the actual and fitted changes in the log of imports have been plotted for Models 1 and 2 respectively. Each chart shows changes in the actual series and two fitted series. The first of the fitted series is a static simulation – i.e. lags of actual imports are fed through the model – while the second shows a dynamic simulation – i.e. lags of the generated imports series are fed through the model.

In Charts 4 and 6, the changes in imports are converted into levels – only the dynamic simulation is shown.

From these charts it is interesting to note how well both simulated series track the actual series. For both models the large movements in imports in the early 1980s were not well tracked. However, in the most recent surge in imports, although the models have underpredicted the total growth, they have picked up a significant amount of the growth - even when using a dynamic simulation. Between September 1986 and June 1989 total imports increased by 52 per cent while Model 1 predicted (dynamically) growth of 47 per cent. Over this same period endogenous imports increased by 60 per cent while Model 2 predicted (dynamically) growth in imports of 55 per cent.

As Table 3 shows, in this recent period all of the explanators of import growth, other than the relative price of exports, moved in a direction to encourage growth in imports. Most dramatic were the falls in the relative prices of imports and the growth in activity.

Chart 3

MODEL 1 SIMULATION
First difference of log of total imports

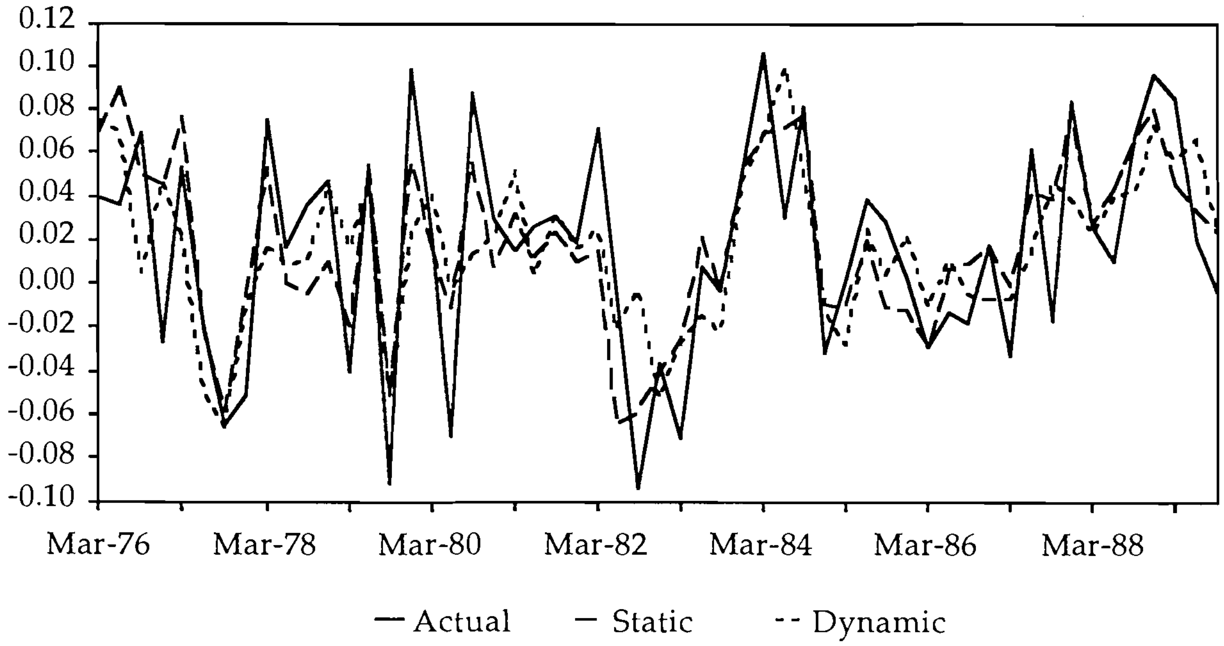

Chart 4

MODEL 1 SIMULATION
Total Imports

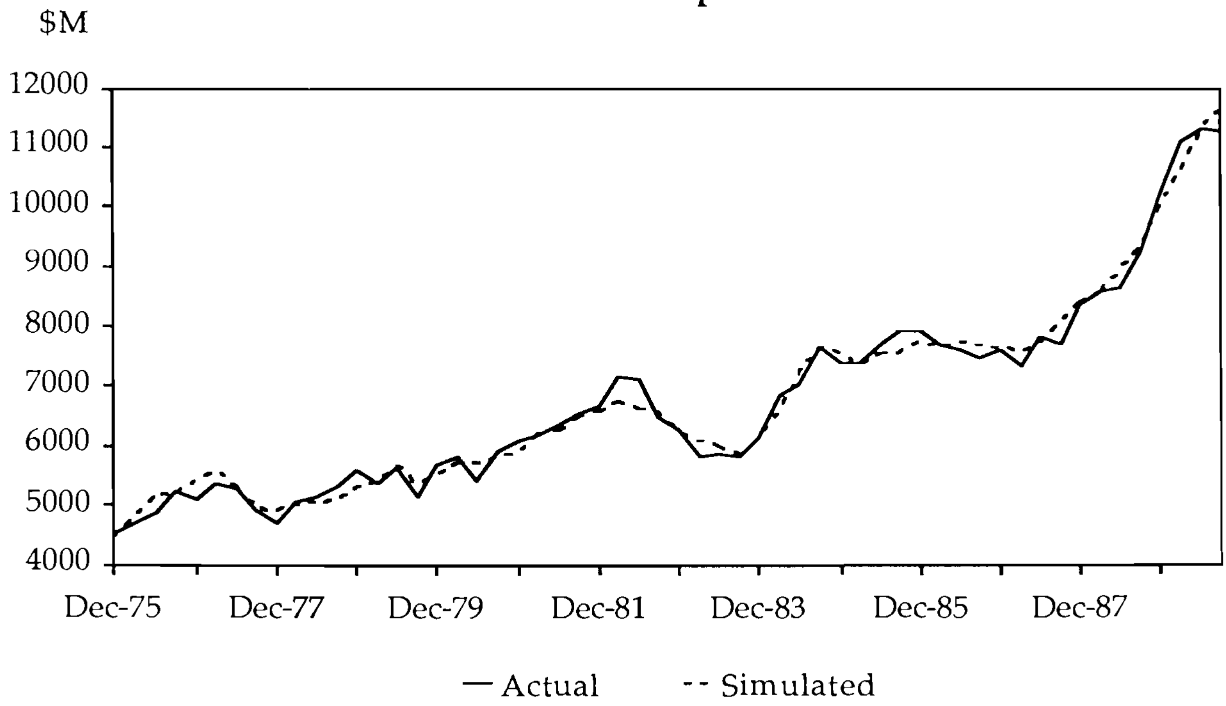

Chart 5

MODEL 2 SIMULATION
First difference of log of endogenous imports

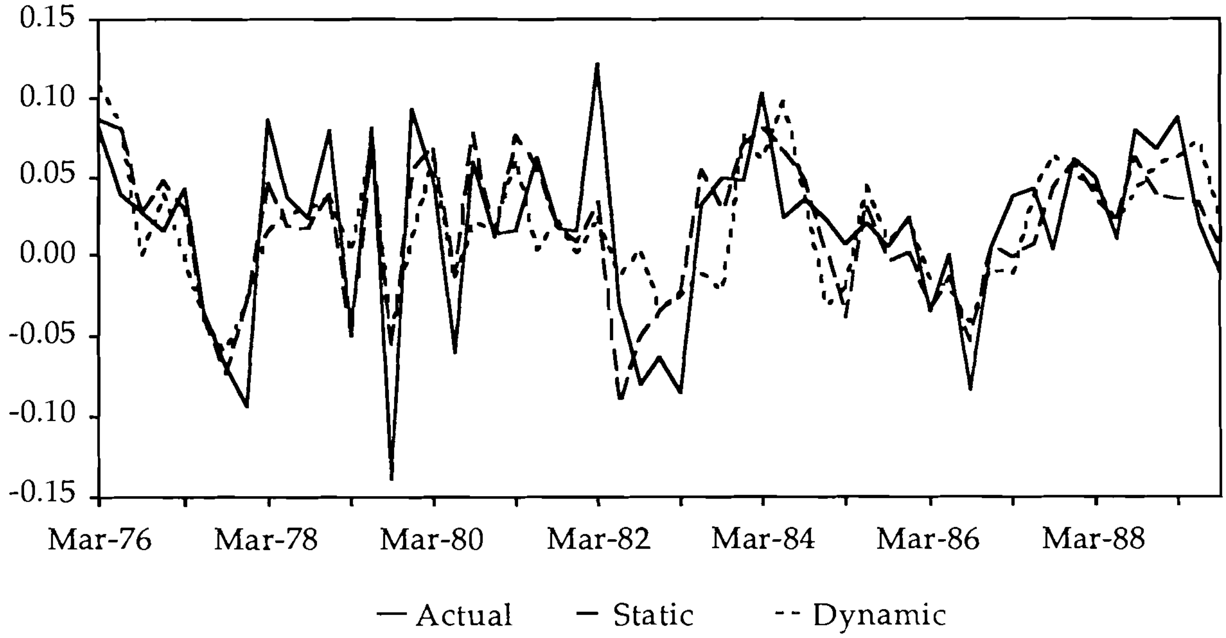

Chart 6

MODEL 2 SIMULATION
Endogenous Imports

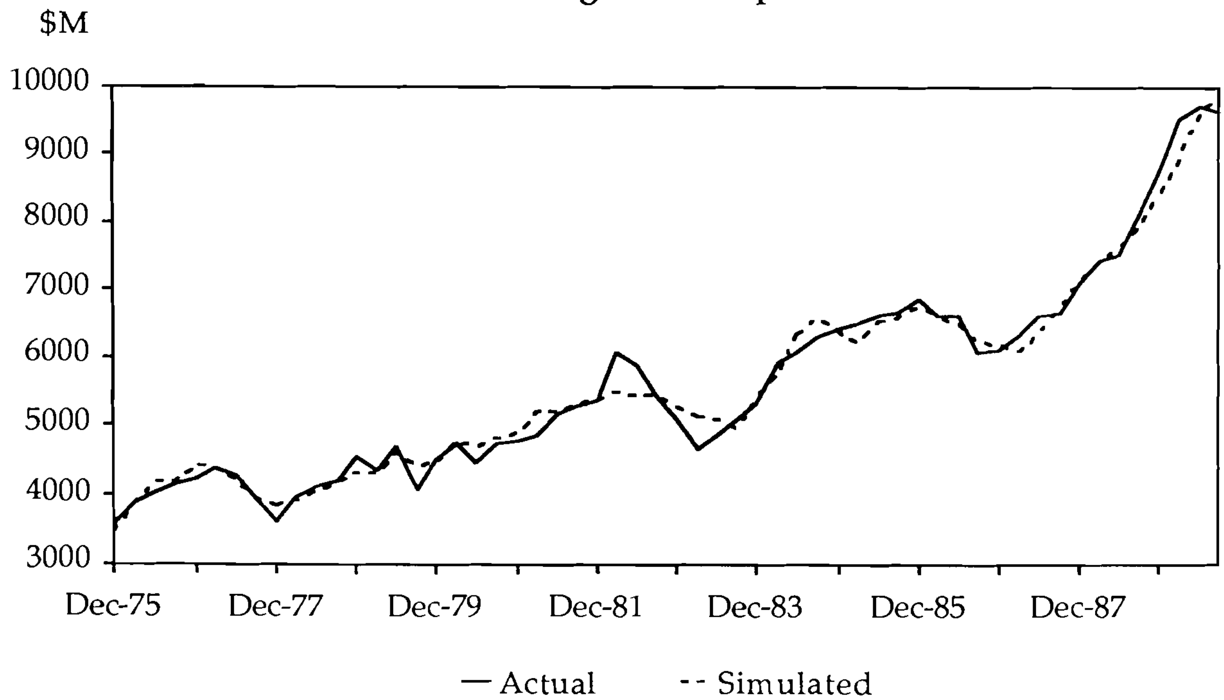

Table 3

ACTUAL PERCENTAGE CHANGE

Sept 86 to June 89

Total Imports	51.7
Endogenous Imports	59.9
GNE	17.6
GDP	12.2
Relative price of total imports	-26.9
Relative price of endogenous imports	-25.2
Relative price of exports	-2.1
Overtime	21.5

Table 4

CONTRIBUTIONS TO IMPORT GROWTH

Sept 86 to June 89

	Model 1	Model 2
Total growth predicted	47.4	54.7
Percentage points of import growth contributed by:		
Growth in GDP	24.9	28.3
Falls in the relative price of imports	31.1	37.1
Falls in the relative price of exports	-2.9	-2.2
Growth in overtime	0.4	0.2

An interesting question is which of these explanators made the largest contribution to this growth in imports? In Table 4 we use our models to dynamically simulate growth in imports while controlling for growth in the alternative explanators. Taking each explanator in turn, we impose no change in that explanator from September 1986 onwards, and then simulate our models to determine the level of import growth predicted. The difference between these predictions and the import growth predictions when all variables are changing, determine the percentage points of growth contributed by each explanator (as quoted in Table 4). Because our model is non-linear in levels, the sum of the individual contributions is not equal to the total amount of growth predicted by the respective models.

For both models a larger contribution to growth in imports was made by falls in the relative price of imports than by growth in activity. These two variables were the most significant contributors. The negative contribution of the relative price of exports was small because of its relative lack of movement.[15] Although overtime grew significantly over the period its contribution was also small. This is a consequence of the form of the models. First, because overtime is not included in the long run equations, it cannot have a long lasting impact on import demand. Secondly, our equations are estimated with all variables in logarithmic form. Because the coefficient on demand in the long run equation is greater than one, imports respond more than proportionately to surges in the level of demand. To an extent this reduces the need for a variable such as overtime and thus reduces its coefficient estimates.

Out of Sample Tracking Performance

There is valid concern that the performance of our models over the most recent period reflects primarily the fact that the models have been estimated over this period. To test the out of sample stability of our models we re-estimated both equations in their preferred forms (i.e. with the explanators from Appendix 2), between September 1974 and September 1986. We then simulated, using the new coefficient estimates, over the period from September 1986 to September 1989.

Charts 7 and 8 show the simulations for the total and endogenous import models respectively. These charts suggest there has not been a significant change in the relationship between imports and its explanators over the recent period. Further, they suggest that if, in September 1986, we had accurate forecasts of activity, overtime and price profiles for the next twelve quarters, the rise in imports could have been accurately predicted.

A post-sample predictive test developed by Davidson et. al. (1978) is used to test more formally the out of sample tracking performance of our models. This consists of estimating the model up to some date T, which we have taken to be September 1986, and then using the model to simulate for $\mathfrak{L}$ periods past T, in our case up to September 1989. Davidson et. al. (1978) developed a test statistic which tests whether the forecast residuals differ significantly from the residuals within sample. This test is based on the sum of squared residuals.[16]

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[15] The substantial increase in the foreign currency price of our exports since 1986 was partially offset by the appreciation of the $A, leading to the fall in the relative price of exports to the GDP deflator shown in Table 3.

[16] In a model of the form $y_t = x_t'\beta + \varepsilon_t$, $\varepsilon_t \sim (0, \sigma^2)$, estimated using T observations, and simulated using actual values for the periods $t=T+1, \ldots T+\mathfrak{L}$, under the null hypothesis of no change in the parameters β and σ^2, the test statistic is:

Table 5

STABILITY TESTS

Equation	Test Statistic	Critical Value	
		1%	5%
Model 1 - Static	12.86	26.22	23.34
Model 1 - Dynamic	9.87	26.22	23.34
Model 2 - Static	5.38	26.22	23.34
Model 2 - Dynamic	4.25	26.22	23.34

The results of our tests, reported in Table 5, lead us to convincingly accept the null hypotheses of stability in the coefficient estimates, confirming our conclusions from Charts 7 and 8.

$$\left(\sum_{t=T+1}^{T+\mathcal{L}} \hat{\varepsilon}_t^2\right) / \hat{\sigma}_T^2 \sim \chi^2_{\mathcal{L}}$$

where $\hat{\sigma}_T^2$ is the usual estimate of the variance of the error within the sample:

$$\hat{\sigma}_T^2 = \left(\sum_{t=1}^{T} \hat{\varepsilon}_t^2\right) / (T-k)$$

Chart 7

MODEL 1 SIMULATION
Estimated Sept-74 to Sept-86

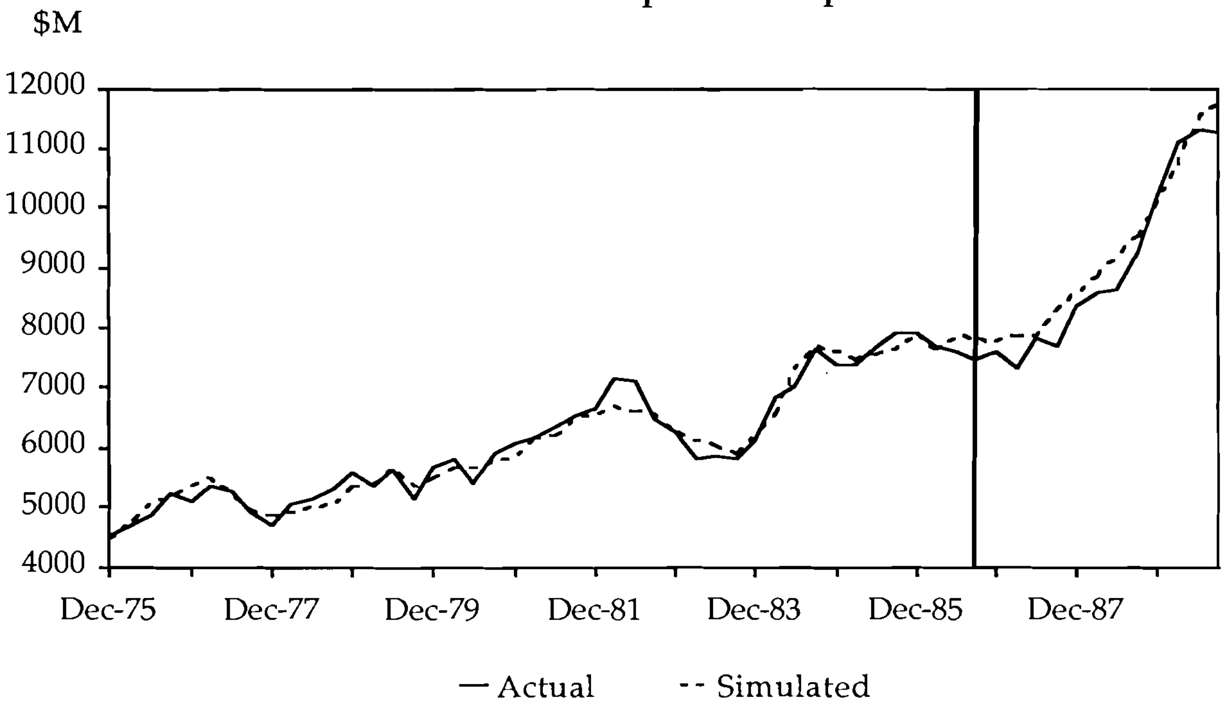
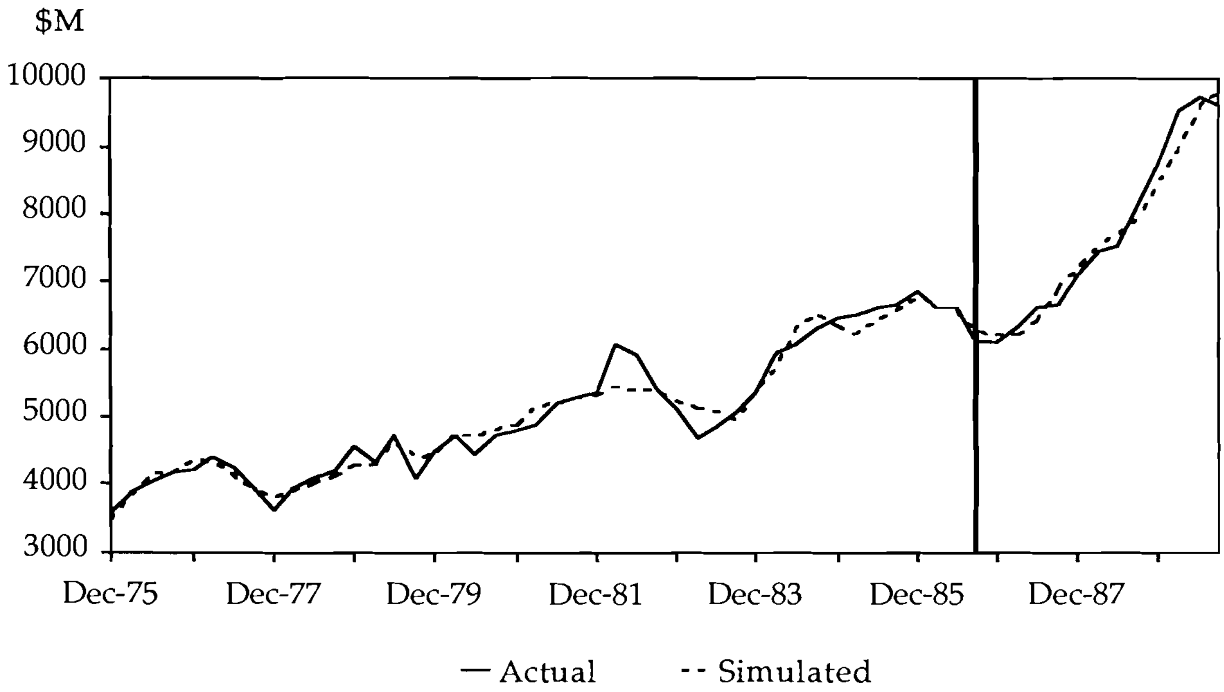


Chart 8

MODEL 2 SIMULATION
Estimated Sept-74 to Sept-86



7. CONCLUSION

Using simple aggregate models of imports which take explicit account of the non-stationarities in the data, movements in total and endogenous imports are well explained by movements in domestic demand, relative prices and overtime.

Our models confirm that imports respond more rapidly and to a greater extent to changes in demand than to changes in relative prices.

A notable feature of our models is that the relative price of exports is a significant explanator of import growth. We suggest two explanations for this. First, when the price of our exports rises, our capacity to consume imports increases even though our level of GDP at constant prices has not increased. Secondly, other things equal, an increase in the price of exports makes production and investment in the export sector more profitable. Because our export sector is relatively capital intensive, and since 75 per cent of Australia's imports are either capital or intermediate goods, an increase in the price of exports increases demand for these types of imports.

Finally, the rapid growth in imports over the past three years is almost entirely explained by our models of import demand. We find that movements in demand and the relative price of imports make the major contributions to this growth. Interestingly, the contribution of overtime to recent import growth is small. We also find that if in September 1986 we had accurate predictions of activity and relative price movements over the following three years, we could have predicted the surge in imports which has occurred.

APPENDIX 1

DATA DEFINITIONS AND SOURCES

Definitions:

M:	real total merchandise imports
EM:	real endogenous imports
Y:	real GDP
D:	real GNE
RPM:	ratio of the total imports deflator to the GDP deflator
RPEM:	ratio of the endogenous imports deflator to the GDP deflator
RPX:	ratio of the merchandise exports deflator to the GDP deflator
OT:	hours of overtime per employee

The data are quarterly and seasonally adjusted.

The sources for the data are the Australian Bureau of Statistics, Catalogue Nos. 5206.0 (GDP, GNE and GDP deflator), 5435.0 (total imports, endogenous imports, and implicit price deflators for imports and exports), 6354.0 and 6330.0 (overtime). The overtime variable has been seasonally adjusted using X11.

APPENDIX 2

UNIT ROOT AND TIME TREND TESTS

This appendix contains the results of sequentially testing for three unit roots, then two unit roots then one unit root in each series used in our estimation procedure. (The results for three unit roots are not shown below because they were always rejected.) In each case test statistics are presented which test firstly for a time trend or a constant, using standard t-tests, and then test the given hypothesis regarding the order of integration, using each of the three tests Dickey-Pantula (DP), Stock-Watson (SW) and Dickey-Fuller (DF). Four AR corrections have been made in testing each variable.

The following provides an example of how to read each section in each table. (e.g. lines 1 to 8 in Table 1.) Line 1 tests the null hypothesis of no time trend; line 5 tests the null hypothesis of no constant. The presence or absence of a time trend determines whether the tests in lines 2-4 or 6-8 are valid. If a time trend is detected (that is the null is rejected in line 5) then the three tests in lines 2-4 determine whether the hypothesis being tested in the section (in this case two unit roots versus at most one) can be accepted. If no time trend is detected then one uses the tests in lines 6-8.

For example, for Total Imports, at the 1% critical value we cannot reject the null hypotheses of no time trend and no constant. We can, however, reject the presence of two unit roots with each of the three tests (lines 6-8) and therefore accept that there is at most one unit root. Moving on to the second section of the table, we accept that a time trend exists and cannot reject the presence of one unit root for all three tests.

* indicates the null hypothesis is rejected at a 1% level of significance.
** indicates the null hypothesis is rejected at a 5% level of significance.

TABLE 1 : IMPORTS AND ACTIVITY

Test	Total Imports	Endog Imports	GDP	GNE	
H_0 : Two Unit Roots vs H_1 : at most One Unit Root					
time	0.872	0.991	1.250	1.164	(1)
DP:	-4.223*	-4.223*	-3.453**	-4.028*	(2)
SW:	-50.982*	-51.316*	-58.997*	-45.795*	(3)
DF:	-3.883**	-4.152*	-3.409	-3.846**	(4)
constant	2.040**	2.190**	3.316*	2.604*	(5)
DP:	-4.049*	-4.023*	-3.217**	-3.719*	(6)
SW:	-50.161*	-50.570*	-58.140*	-44.121*	(7)
DF:	-3.801*	-4.038*	-3.217**	-3.631*	(8)
H_0 : One Unit Root vs H_1 : No Unit Roots					
time	3.611*	4.022*	2.464**	3.020*	
DP:	-2.315	-2.689	-2.068	-2.174	
SW:	-13.992	-15.972	-9.363	-11.632	
DF:	-2.863	-2.891	-1.974	-2.792	
constant	0.024	0.021	-0.667	-0.656	
DP:	0.750	0.783	0.964	1.202	
SW:	0.431	0.581	0.566	0.733	
DF:	0.246	0.406	0.946	0.781	

TABLE 2 : RELATIVE PRICES AND OVERTIME

Test	RP Total Imports	RP Endog Imports	RP of Exports	Overtime
H_0 : Two Unit Roots vs H_1 : at most One Unit Root				
time	-1.536	-1.227	-0.207	0.565
DP:	-3.524**	-3.073	-4.048*	-2.688
SW:	-46.004*	-40.869*	-48.150*	-28.594**
DF:	-3.081	-2.576	-3.238	-2.913
constant	-0.275	-0.306	-0.741	1.691
DP:	-3.127**	-2.871**	-4.091*	-2.752
SW:	-44.409*	-40.245*	-48.039*	-28.714*
DF:	-2.677	-2.306	-3.265**	-2.989**
H_0 : One Unit Root vs H_1 : No Unit Roots				
time	-1.428	-1.759	-2.202**	1.662
DP:	-2.052	-3.030	-2.254	-2.140
SW:	-7.863	-8.935	-13.840	-7.734
DF:	-2.042	-2.422	-2.743	-1.528
constant	0.272	1.014	-0.403	1.453
DP:	-2.256	-2.539	-0.974	-0.562
SW:	-6.404	-6.524	-5.171	-0.847
DF:	-2.154	-2.063	-1.305	-0.343

APPENDIX 3

ERROR CORRECTION MODELS[17]

MODEL 1

- dependent variable - ΔM
- period of estimation - 1975:4 - 1989:3

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
$RESIDUAL_{t-1}$	-0.762	0.117	-6.513
ΔRPM_{t-1}	0.413	0.278	1.486
ΔRPM_{t-3}	-0.405	0.179	-2.263
ΔRPM_{t-4}	-0.519	0.263	-1.973
ΔRPX_{t-1}	-0.620	0.274	-2.263
ΔRPX_{t-2}	-0.559	0.160	-3.494
ΔRPX_{t-4}	0.379	0.232	1.634
ΔOT_{t-2}	0.150	0.100	1.500
ΔOT_{t-4}	0.145	0.087	1.667
CONSTANT	0.010	0.005	2.000

R^2	0.616
Adjusted R^2	0.512
DW	2.030
Sum of squared residuals	0.051
Standard error of estimate	0.035

F-tests of joint significance:

Variables	Test statistic	Significance level
$\Delta RPM_{t-1}, \Delta RPM_{t-3}, \Delta RPM_{t-4}$	$F(3,42) = 3.181$	0.034
$\Delta RPX_{t-1}, \Delta RPX_{t-4}$	$F(2,42) = 3.521$	0.039
$\Delta OT_{t-2}, \Delta OT_{t-4}$	$F(2,42) = 3.372$	0.044

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi_1^2 = 0.148$	0.700
Fourth order	$\chi_1^2 = 2.362$	0.124
First to fourth order	$\chi_4^2 = 2.491$	0.646

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[17] For all of these results the standard errors have been adjusted to take account of the additional 4 degrees of freedom lost in estimation of the cointegrating relationships.

MODEL 2

- dependent variable – ΔEM
- period of estimation – 1975:4 – 1989:3

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
$RESIDUAL_{t-1}$	-0.668	0.127	-5.260
ΔEM_{t-4}	-0.214	0.108	-1.981
ΔY_{t-1}	0.860	0.479	1.795
$\Delta RPEM_{t-4}$	-0.392	0.231	-1.697
ΔRPX_{t-2}	-0.380	0.174	-2.184
ΔRPX_{t-4}	0.416	0.230	1.809
ΔOT_{t-2}	0.196	0.114	1.719
ΔOT_{t-4}	0.178	0.097	1.835
CONSTANT	0.009	0.006	1.500

R^2	0.627
Adjusted R^2	0.523
DW	1.944
Sum of squared residuals	0.062
Standard error of estimate	0.038

F-tests of joint significance:

Variables	Test statistic	Significance level
ΔY_{t-1}, $\Delta RPEM_{t-4}$	$F(2,43) = 3.195$	0.051
ΔRPX_{t-2}, ΔRPX_{t-4}	$F(2,43) = 5.109$	0.010
ΔOT_{t-2}, ΔOT_{t-4}	$F(2,43) = 3.867$	0.029

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi_1^2 = 0.857$	0.354
Fourth order	$\chi_1^2 = 2.174$	0.140
First to fourth order	$\chi_4^2 = 3.079$	0.545

MODEL 3

- dependent variable - ΔM
- period of estimation - 1975:4 - 1989:3

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
$RESIDUAL_{t-1}$	-1.063	0.138	-7.703
ΔRPM_{t-3}	-0.300	0.149	-2.013
ΔRPX_{t-1}	-0.249	0.145	-1.717
ΔRPX_{t-2}	-0.495	0.143	-3.462
ΔOT_{t-2}	0.178	0.093	1.914
ΔOT_{t-4}	0.207	0.080	2.588
CONSTANT	0.009	0.004	2.250

R^2	0.637
Adjusted R^2	0.548
DW	2.210
Sum of squared residuals	0.048
Standard error of estimate	0.032

F-tests of joint significance:

Variables	Test statistic	Significance level
ΔRPX_{t-1}, ΔRPX_{t-2}	$F(2,45) = 8.609$	0.000
ΔOT_{t-2}, ΔOT_{t-4}	$F(2,45) = 7.134$	0.002

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi^2_1 = 1.426$	0.232
Fourth order	$\chi^2_1 = 2.289$	0.130
First to fourth order	$\chi^2_4 = 4.298$	0.367

MODEL 4

- dependent variable – ΔEM
- period of estimation – 1975:4 – 1989:3

VARIABLE	COEFFICIENT	STANDARD ERROR	T-STATISTIC
$RESIDUAL_{t-1}$	-0.903	0.156	-5.788
ΔEM_{t-4}	-0.200	0.101	-1.980
ΔD_{t-1}	0.536	0.401	1.337
ΔD_{t-3}	0.586	0.431	1.360
ΔRPX_{t-2}	-0.219	0.168	-1.304
ΔRPX_{t-4}	0.227	0.165	1.376
ΔOT_{t-2}	0.237	0.116	2.043
ΔOT_{t-4}	0.154	0.098	1.571
CONSTANT	0.006	0.006	1.000

R^2	0.624
R bar^2	0.510
DW	1.915
Sum of squared residuals	0.063
Standard error of estimate	0.038

F-tests of joint significance:

Variables	Test statistic	Significance level
ΔD_{t-1}, ΔD_{t-3}, ΔRPX_{t-2}, ΔRPX_{t-4}	F(4,43) = 2.468	0.059
ΔOT_{t-2}, ΔOT_{t-4}	F(2,43) = 3.715	0.032

Tests for autocorrelation:	Test statistic	Significance level
First order	$\chi_1^2 = 0.671$	0.413
Fourth order	$\chi_1^2 = 1.779$	0.182
First to fourth order	$\chi_4^2 = 3.456$	0.485

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