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Import Price and Activity Elasticities for the MONASH Model: Johansen FIML Estimation of Cointegration Vectors

by

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Preliminary Working Paper No. IP-58 July 1993

ISSN 1031 9034

ISBN 0 642 10257 0

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ABSTRACT

This study investigates the relationship between manufactured import flows to Australia and relative prices and domestic economic activity over the period 1981Q3 to 1992Q2. This is done through the estimation of import demand functions for total manufactured imports and 29 import product categories defined at the 2-digit level of the AICC by employing the Johansen FIML procedure. The price and activity elasticities will form part of the elasticity files of the *MONASH* Model, currently being developed at the Centre of Policy Studies. The price elasticities range from 0.24 to 1.75, with a weighted-average of 0.60. We also find evidence of upward bias in price elasticity estimates when an aggregate import function is employed in a context where variation in prices of individual products are negatively correlated with their price elasticities, and when a significant portion of imports are subject to quantitative restrictions (QRs). The unit activity elasticity hypothesis was accepted for one third of our sample. The majority of activity elasticities are greater than one, and usually closer to two.

CONTENTS

1. Introduction	1
2. Manufactured Imports: An Overview	3
3. Model and Data	8
4. Econometric Procedure	10
5. Results	21
6. Conclusion	34
Appendix A	35
Appendix B	37
References	42

Tables

1. Percentage Share of Manufactured Imports in Total Imports, 81-82 to 90-91	3
2. Percentage Composition of Manufactured Imports, 81-82 to 90-91	4
3. Shares of Competitive Imports in Domestic Sales and Total Imports	5
4. Results of Unit Root Tests	10
5. Results of Johansen Estimation	19
6. Price and Activity Elasticities	21
7. Frequency Distribution of Price and Activity Elasticities	23
8. LR Test Results of Unit Activity Elasticity Hypothesis	24
9. Import Weights, Value-Weighted and Distribution Elasticities	26

Figure

1. Exchange Rate Pass-through in the Presence of Quantitative Restrictions	14

Import Price and Activity Elasticities for the *MONASH* Model: Johansen FIML Estimation of Cointegration Vectors

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1. Introduction

The object of this paper is to investigate the role of relative price and domestic economic activity in determining the volume of Australian manufactured imports. Towards this end, import demand functions are estimated for both total manufactured imports and 29 product categories defined at the 2-digit level of the Australian Import Commodity Classification (AICC).

The rationale for the study stems from the emphasis placed on the balance of payments adjustment process in Australian economic policy discussion following the rapid depreciation of the Australian dollar since early 1984. Much of this discussion has focused on the behaviour of manufactured imports (see Section 2). A major impediment to clear-headed thinking on this issue has been the lack of proper empirical evidence on the magnitude of import response to changes in relative prices and economic activity. The estimated price and activity elasticities will form part of the elasticities files of the *MONASH* Model currently being developed at the Centre of Policy Studies at Monash University.

The recent studies on the determinants of Australian imports have focussed on aggregate imports only (Hall *et al*, 1989; Meer and Heijdra, 1990; Wilkinson 1992). These studies do not provide guidance to policy formulation at the sectoral level. A much more serious concern, however, relates to possible "aggregation bias" in the reported elasticity estimates. This point is of particular importance in a context where a significant portion of import trade is subject to binding non-price restraints, and if variation in prices of component categories are correlated with individual elasticities (see Appendix A).

Previous studies that examine manufactured imports at the disaggregate level are now much dated[1]. Given many fundamental changes in international and national economic setting in the 1980s, the relevance for current policy discussion of trade elasticity estimates reported in these studies is highly questionable (Freebairn, 1986, p.109). This is particularly true for the estimates that are currently used by the antecedent of the *MONASH* Model, the *ORANI* Model (see Dixon *et al.*, 1982). **ORANI** contains detailed (4-digit ASIC) estimates of elasticities of substitution between imported and domestic substitute goods estimated by Alouze *et al.* (1977) using data covering the period 1968q2 to 1975q2. Moreover, these studies have other important limitations which mar the usefulness of their results. First, most previous researchers have ignored the time series properties of the data in conducting their estimations[2]. Given that the data used to estimate these elasticities are usually trended (Section 4), it is likely that previous estimates may have been biased as a result of the non-stationarity of the data. These estimates may be subject to the many problems of "spurious regressions" outlined in Granger and Newbold (1974).

Second, they are subject to the limitations imposed by inadequate data. In particular, there are reasons to suspect that the use of defective data with regard to both import and domestic prices could have biased estimated price elasticities (Section 3). Third, a common problem encountered in these studies is that there was little movement in the relative price and trade volume series (Gregory and Martin, 1976, p.14). Given this low data variability, it was often difficult to estimate relative price effects in trade with much confidence. The high volatility of the Australian dollar (and other key currencies) has generated plenty of variation in the data in the 1980s. In this context, we anticipate that our exercise would yield statistically more acceptable results.

The remainder of the paper is arranged as follows. As a preliminary to the statistical analysis, some basic facts about the role of manufactured imports in shaping Australia's balance of payments position and the pattern of such trade is reviewed in Section 2. Section 3 discusses the import function specification and salient features of the data base. The econometric procedure is discussed in

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(1) For a comprehensive listing of these works and useful summary presentations of their findings, see Macfarlane (1979) and Gordon (1986).

(2) Exceptions in the Australian context are Hall *et al* (1989), Wilkinson (1992) and Athukorala and Menon (1992). Only Athukorala and Menon (1992) consider imports at a disaggregated (2-digit Australian Standard Industrial Classification) level, however.

Section 4, while Section 5 analyses the results. The last section of the paper summaries the major findings.

2. Manufactured Imports: An Overview

In this study, manufactured goods are defined to cover non-resource based products belonging to Sections 5 to 8 of the AICC. This is in line with the most widely used definition of manufactures, which is the "Standard International Trade Classification (SITC) 5 through 8 less SITC 68 - non-ferrous metals". Table 1 provides annual percentage shares of total manufacturing in total nominal imports for the period 1981-82 to 1990-91. The most striking feature of the structure of Australian imports is the dominant share attributable to manufactured imports. From Table 1, we see that the share of manufactures in total Australian imports has varied in the range of 70 to 80 percent over the decade spanning the 1980s.

Table 1
Percentage Share of Manufactured Imports in Total Imports, 81/82 to 90/91

81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91
69.57	69.21	74.98	74.64	77.67	75.48	77.73	77.53	77.08	74.80

Source: ABS, *Imports by Commodity Division, Australia*, Cat. No. 5405.0, various issues.

Table 2 provides data on the shares of manufactured import products disaggregated at the 2-digit level of the AICC in total manufactured imports for the period 1981-82 to 1990-91. Imports of road vehicles (AICC 78) constitute the largest single item in manufactured imports, peaking in 1984-85 with a share of 14.24 percent. In 1985-86, its share in total nominal imports peaked at 10.87 percent, and 11.8 percent in total real imports. Imports of machinery and equipment items (AICC 71 - 78) make up the largest category of manufactured imports, with a share of 42.51 per cent in 1985-86.

Table 2
Percentage Composition of Manufactured Imports, 1981-82 to 1990-91

AICC	Product Description	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90	90-91
51	Organic chemicals	3.09	3.11	3.45	3.10	2.84	3.15	3.51	3.18	2.71	2.75
52	Inorganic chemicals	1.62	1.55	1.04	0.87	0.90	1.15	1.63	1.87	1.95	1.79
53	Dyeing, tanning materials	0.56	0.52	0.57	0.53	0.53	0.68	0.62	0.59	0.60	0.64
54	Medicinal,pharm. products	0.98	1.29	1.25	1.35	1.45	1.82	2.04	1.91	2.08	2.58
55	Essential oils,perfumes etc.	0.63	0.71	0.76	0.79	0.82	0.86	0.78	0.80	0.83	0.92
58	Artificial resins,plastics etc.	2.69	2.41	2.75	2.61	2.52	2.81	2.93	1.22	1.22	1.20
59	Chemical materials,products	1.38	1.56	1.59	1.55	1.53	1.42	1.43	1.59	1.58	1.71
61	Leather,leather manu.	0.27	0.30	0.47	0.51	0.46	0.54	0.53	0.41	0.35	0.33
62	Rubber manufactures	1.80	1.62	1.71	1.78	1.67	1.66	1.81	1.87	1.89	1.80
63	Cork,wood manufactures	0.66	0.62	0.67	0.70	0.62	0.61	0.60	0.64	0.57	0.59
64	Paper,articles of pulp paper	3.48	3.21	3.49	3.14	3.13	3.63	3.82	3.55	3.28	3.16
65	Textile yarn, fabrics etc.	6.84	6.70	7.38	6.66	6.23	6.56	6.11	5.48	4.94	4.97
66	Non-metallic mineral manu.	2.56	2.44	2.40	2.49	2.43	2.56	2.69	2.64	2.70	2.62
67	Iron and steel	3.61	3.64	2.47	2.52	2.26	2.28	2.65	2.95	2.62	2.42
69	Manufactures of metal	3.97	3.67	3.43	3.60	3.45	3.62	3.59	3.26	3.41	3.28
71	Power generating machinery	4.67	4.48	3.32	3.15	3.68	4.36	3.83	3.08	3.47	3.45
72	Machinery,specialised	9.26	7.15	6.52	7.62	7.62	6.21	6.30	6.47	6.97	5.87
74	General industrial machines	7.59	7.63	6.50	6.38	6.87	7.10	7.26	6.91	7.52	7.42
75	Office machines,ADP equip	4.59	5.43	6.47	7.69	8.07	9.17	8.39	9.12	8.99	9.22
76	Telecommunications equip.	4.44	5.36	5.47	5.39	5.45	5.37	4.79	4.71	4.57	4.75
77	Electrical machinery,parts	6.22	6.46	6.38	6.79	6.83	6.76	6.79	6.46	6.86	6.89
78	Road vehicles	12.30	12.00	13.04	14.24	13.99	9.74	9.94	13.17	12.79	12.18
81	Sanitary,heating etc. equip.	0.26	0.27	0.25	0.31	0.29	0.26	0.31	0.34	0.36	0.37
82	Furniture and parts thereof	0.80	0.75	0.81	0.90	0.89	0.85	0.81	0.79	0.86	0.79
84	Apparel,clothing accessories	2.46	2.59	2.41	2.49	2.11	2.36	2.29	2.08	2.30	2.61
85	Footwear	0.89	0.95	0.91	0.83	0.77	0.90	0.85	0.93	0.86	1.04
87	Professional,scientific equip	2.73	2.90	2.89	2.96	3.14	3.25	3.05	2.93	2.89	3.28
88	Photographic, optical equip.	2.44	2.47	2.28	2.36	2.35	2.58	2.26	2.14	1.98	2.13
89	Miscellaneous manufactures	6.30	7.59	7.50	7.37	7.23	7.74	7.50	7.91	7.61	8.18
	Total Manufactures	100	100	100	100	100	100	100	100	100	100

Source: ABS, *Imports by Commodity Division, Australia*, Cat. No. 5405.0, various issues.

Table 3
Shares of Competitive Imports in Domestic Sales (CIDS) and Total Imports (CITI)

AICC	Product Description	CIDS 81-82[1]	CITI 85-86[2]
51	Organic chemicals	3.3	7
52	Inorganic chemicals	2.5	3
53	Dyeing, tanning materials	5.7	37
54	Medicinal, pharmaceutical products	4.1	n.a.
55	Essential oils, perfume materials	19.2	50
58	Artificial resins, plastic materials	9.1	54
59	Chemical materials and products	9.4	n.a.
61	Leather, leather manufactures	22.4	51
62	Rubber manufactures	21.9	71
63	Cork and wood manufactures	7.3	n.a.
64	Paper, paperboard, articles of pulp paper	7.8	32
65	Textile yarn, fabrics, made-up articles	17.4	22
66	Non-metallic mineral manufactures	5.8	66
67	Iron and steel	6.0	63
69	Manufactures of metal	12.4	60
71	Power generating machinery and equipment	14.3	25
72	Machinery specialised for industries	16.4	25
74	General industrial machinery and equipment	17.5	25
75	Office machines and ADP equipment	15.3	20
76	Telecommunications, recording equipment	21.6	20
77	Electrical machinery and parts	17.2	45
78	Road vehicles	20.0	56
81	Sanitary, heating, lighting equipment	18.6	n.a.
82	Furniture and parts thereof	6.4	84
84	Apparel and clothing accessories	18.9	81
85	Footwear	-30.1	94
87	Professional, scientific equipment	3.7	12
88	Photographic equipment, optical goods	10.1	n.a.
89	Miscellaneous manufactured articles	18.3	n.a.
	Total Manufactures	9.6	n.a.

Notes:
1) CIDS = Competitive Imports as a proportion of Domestic Sales; *Source*: IAC (1985)
2) CITI = Competitive Imports as a proportion of Total Imports; *Source*: Phillips (1989)

Office machines and automatic data processing (ADP) equipment (AICC 75) record the highest growth over this period, with its share in manufactured imports more than doubling over this period, from 4.59 percent in 1981-82 to 9.22 in 1990-91. Its share in total imports increased from about 3 percent in 1981-82 to more than 7 percent in 1987-88. The increase is even more dramatic in terms of real imports, with its share rising from 3 percent to 15 percent over the same period. These features are also reflected on the global scene. In 1989, Australia was the 14th largest importer of automotive products, and the 15th largest importer of office machines and telecommunications equipment (GATT, 1991).

Table 3 contains data disaggregated at the 2-digit level of the AICC on the shares of competitive imports in domestic sales (CIDS) and total imports (CITI). Not surprisingly, the product categories that have the highest share of competitive imports are the quota-protected products. The highest share is for footwear (AICC 85), with a CIDS ratio of 30.1 percent and a CITI ratio of 94 percent. The lowest share is for inorganic chemicals (AICC 52), with a CIDS ratio of 2.5 percent and a TIDS ratio of 3 percent. The CIDS ratio for total manufacturing is very much on the low side, with less than 10 percent of domestic sales subject to competition from imports. This reflects the dominance of non-competitive imports in Australia's import structure, particularly in the form of imports of machinery and equipment that serve as inputs into the production process. In the context of analysing import flows, Gregory and Marsden (1979, p.36) argue that this structure would prevent changes in relative import prices (unless extremely large) from exerting a significant effect on the total flow of imports.

3. Model and Data

The general form of our import demand function is:

$$MQ_t = f(RP_t, AC_t) \tag{1}$$

$$f_1 \leq 0, \; f_2 \geq 0$$

where, MQ = real imports, RP = the relative price derived by dividing the tariff augmented import price (PM) by the price of the domestic-competing commodity (PD), AC = a measure of related domestic economic activity (see Appendix B). The signs indicated for the partial derivatives are those customarily assumed in the literature[3].

In studies on the determination of trade flows, the log-linear functional form (as against the linear form) is widely used mainly because it allows direct estimation of the desired elasticities. We have two additional reasons for preferring this form. Firstly, the data shows that manufactured imports to Australia has grown relative to GDP over time (as measured by the share of imports in GDP). For this data, a linear function with its constant marginal propensity to import implies a falling income elasticity of demand, which seems improbable. Secondly, tests for the appropriate functional form of import-demand equation using the Box-Cox transformation (Khan and Ross, 1977; Boylan *et al.*, 1980) favour the log-linear form. Our estimating equation for the *i*th product category is then given by:

$$LMQ_{it} = c_i + \epsilon_{(RP)i}\, LRP_{it} + \epsilon_{(AC)i}\, LAC_{it} \tag{2}$$

where c_i is the constant term, $\epsilon_{(RP)i}$ and $\epsilon_{(AC)i}$ are the relative price and activity elasticities for the *i*th product category respectively, and the letter L denotes variables measured in natural logarithms.

Import functions are estimated for the total as well as for 29 product categories (2-digit AICC) included therein for the period 1981Q3 to 1992Q2. We believe that our data series are, in important respects, more appropriate for the purpose than those used in previous studies. Here we discuss some salient features of the data base, leaving a complete listing of data sources and description of the method used in data transformations to Appendix B.

In the absence of a price index constructed using import prices, previous studies have used the Reserve Bank import "price" index which was based on production or wholesale price indexes of trading partners, or import unit values derived from customs import entries. Both these proxies suffer from a number of deficiencies which may result in spurious price movements being recorded between two given periods, even though actual import prices remain unchanged (Lipsey *et al.*, 1991). It is worthwhile reviewing some of these deficiencies, and the way in which our data overcomes these problems.

Wholesale prices are subject to three major limitations. First, the index usually includes some goods that are regarded as non-tradeables. Second, it is constructed

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(3) For a comprehensive survey of the related literature, see Goldstein and Khan (1985).

using domestic rather than international weights for the tradeable goods contained within the regimen. Finally, wholesale prices refer to list rather than transaction prices. List prices may not accurately record changes even in domestic transaction prices, let alone prices in international markets (see, for instance, Bushe *et al*, 1986; Goldstein and Khan, 1985).

Import unit value indices are calculated by dividing the value of imports by the physical quantities of imports for a given time period. This procedure is likely to yield an accurate price index only when it is applied to a single product. Since unit values are usually computed from observation units in which some aggregation has already taken place, they are accurate only if the composition of the unit, and the weights assigned to individual items within the unit, remain unchanged from one period to another.

For instance, changes in the commodity composition of the unit will result in the unit value index recording a change even if all "true" prices of component items remain unchanged. Similarly, because unit value indexes are not fixed-weight indexes, a price increase accompanied by a decrease in quantity demanded automatically reduces that good's weight in the index. Unit values are defective not only because of this ambiguity of computation but also because quantities used to compute unit values are usually available only for a limited number of categories at the four-digit SITC level of aggregation. Therefore unit values for aggregates such as total manufactures from a given country, or worse still for a group of countries, are highly unreliable.

Furthermore, since the data for import flows is published only in value terms, the appropriate price index must be used to deflate the value series to obtain the quantity series. Stone (1977) shows that when the unit value deflator is used to construct the import quantity series, the unit value errors will be inversely correlated with the quantity errors. Kemp (1962) points out that the OLS estimates of the price coefficient would be biased towards minus one as a result[4].

These inaccuracies could have biased elasticity estimates reported in previous studies. In this study, we use the new Australian Bureau of Statistics (ABS) import price index. This index measures changes in prices (expressed in Australian dollars) of imports using prices of individual shipments obtained directly from importers, and is therefore free from the limitations of price proxies. As an

(4) See also Orcutt (1950), Kakwani (1962), and Magee (1975, p.205).

outcome of significant improvements in the ABS trade and production data base since the late 1970s, import value, import price and producer price series are available for the sample period on a comparable AICC basis.

4. Econometric Procedure

In the light of recent advances in time-series econometrics, we began the estimation process by testing the time-series properties of the data. For this purpose, we employ the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests (see Dickey and Fuller, 1982), and the Johansen test for cointegration in one variable (see Taylor, 1991). The results from these tests are summarised in Table 4. These results clearly indicate that almost all series are integrated processes of order 1, or $I(1)$[5]. In light of this, we proceeded to check if the level variables are able to form a cointegrating vector. There are two different approaches to testing for cointegration. They are the Engle-Granger (1987) two-step procedure and the Johansen (1988) Full-Information Maximum Likelihood (FIML) procedure.

The Engle-Granger procedure has been frequently employed in the literature, but suffers from a number of problems. First, should a cointegrating relationship be identified, the assumption is made that the cointegrating vector is unique. This need not be true in the multivariate case; if we denote the number of variables as n, then there can be up to n - 1 cointegrating vectors (in our case, a maximum of 2). If there is more than one cointegrating vector, the estimates from the Engle-Granger will be invalid.

Second, there are concerns about the considerable small-sample bias in estimates from the Engle-Granger procedure. Stock (1987) shows that the bias in finite-samples will be in the order of $1/T$, where T is the sample size. Banerjee *et al* (1986) investigate this potential bias further, and show that it is related to $(1-R^2)$, and that this bias may decline much more slowly than the theoretical rate. Finally, the Engle-Granger procedure, unlike the Johansen procedure, is unable to accommodate dynamics in the cointegrating regression. Allowing short-run dynamics helps reduce biases and improve efficiency in the estimated cointegrating relationships. For these reasons, we employ the Johansen FIML procedure as the preferred test of cointegration and estimator.

(5) The *MQ* variable for cork and wood manufactures (AICC 63), textile yarn and fabrics (AICC 65), iron and steel (AICC 67) and manufactures of metal (AICC 69) were found to be stationary in levels at the 10 percent level of significance, while apparel and clothing accessories (AICC 84) and footwear (AICC 85) were found to be stationary at the 1 percent level.

Table 4
Results of Unit Root Tests

	AICC	DF/ADF	Johansen
51	Organic chemicals		
	LMQ	-1.16	4.63
	LRP	-0.56	0.35
	LAC	-1.16	5.32
	Δ*MQ*	-3.96***	53.34**
	Δ*RP*	-4.56***	26.99**
	Δ*AC*	-7.09***	50.29**
52	Inorganic chemicals		
	LMQ	-0.61	1.56
	LRP	-1.85	3.44
	LAC	-1.16	5.32
	Δ*MQ*	-8.94***	44.43**
	Δ*RP*	-4.28***	14.42**
	Δ*AC*	-7.09***	50.29**
53	Dyeing, tanning materials	-1.55	
	LMQ	-1.55	2.46
	LRP	-1.43	2.14
	LAC	-1.16	5.32
	Δ*MQ*	-5.72***	25.50***
	Δ*RP*	-3.40**	20.21***
	Δ*AC*	-7.09***	50.29***
54	Medicinal, pharmaceutical products		
	LMQ	-0.25	0.07
	LRP	-0.56	0.36
	LAC	-1.16	5.32
	Δ*MQ*	-5.49***	74.36**
	Δ*RP*	-3.84***	20.67**
	Δ*AC*	-7.09***	50.29**
55	Essential oils, perfumes etc.		
	LMQ	-1.01	1.06
	LRP	-1.40	2.02
	LAC	-1.61	5.32
	Δ*MQ*	-6.97***	32.49**
	Δ*RP*	-5.63***	24.03**
	Δ*AC*	-7.09***	50.29**

Table 4 (Cont.)
Results of Unit Root Tests

	AICC	DF/ADF	Johansen
58	Artificial resins, plastics etc.		
	LMQ	-0.13	0.56
	LRP	-1.50	2.31
	LAC	-1.16	5.32
	ΔMQ	-5.81^{***}	25.08^{**}
	ΔRP	-5.40^{***}	22.57^{**}
	ΔAC	-7.09^{***}	50.29^{**}
59	Chemical materials and products		
	LMQ	-1.05	4.13
	LRP	-2.04	4.88
	LAC	-1.16	5.32
	ΔMQ	-4.59^{***}	40.65^{**}
	ΔRP	-4.55^{***}	30.32^{**}
	ΔAC	-7.09^{***}	50.29^{**}
61	Leather, leather manufactures		
	LMQ	-1.68	2.85
	LRP	-0.74	0.57
	LAC	-1.16	5.32
	ΔMQ	-6.41^{***}	28.96^{**}
	ΔRP	-5.67^{***}	24.28^{**}
	ΔAC	-7.09^{***}	50.29^{**}
62	Rubber manufactures		
	LMQ	-1.15	1.39
	LRP	-1.31	1.77
	LAC	-1.16	5.32
	ΔMQ	-6.55^{***}	29.29^{**}
	ΔRP	-4.52^{***}	17.09^{**}
	ΔAC	-7.09^{***}	50.29^{**}
63	Cork and wood manufactures		
	LMQ	-2.74^{*}	7.26^{*}
	LRP	-2.40	6.57
	LAC	-1.16	5.32
	ΔMQ	-5.62^{***}	32.34^{**}
	ΔRP	-5.40^{***}	31.39^{**}
	ΔAC	-7.09^{***}	50.29^{**}

Table 4 (Cont.)
Results of Unit Root Tests

	AICC	DF/ADF	Johansen
64	Paper, articles of pulp paper		
	LMQ	-1.43	4.31
	LRP	-1.82	3.69
	LAC	-1.16	5.32
	ΔMQ	-4.89^{***}	39.45^{**}
	ΔRP	-5.31^{***}	29.57^{**}
	ΔAC	-7.09^{***}	50.29^{**}
65	Textile yarn, fabrics		
	LMQ	-2.85^{*}	7.78^{*}
	LRP	-1.17	1.44
	LAC	-1.16	5.32
	ΔMQ	-5.70^{***}	24.45^{**}
	ΔRP	-4.44^{***}	16.57^{**}
	ΔAC	-7.09^{***}	50.29^{**}
66	Non-metallic minerals		
	LMQ	-1.58	3.28
	LRP	-1.24	1.58
	LAC	-1.16	5.32
	ΔMQ	-3.45^{**}	39.92^{**}
	ΔRP	-4.79^{***}	18.74^{**}
	ΔAC	-7.09^{***}	50.29^{**}
67	Iron and steel		
	LMQ	-2.34^{*}	8.08^{*}
	LRP	-1.43	2.10
	LAC	-1.16	5.32
	ΔMQ	-7.93^{***}	38.41^{**}
	ΔRP	-5.97^{***}	26.15^{**}
	ΔAC	-7.09^{***}	50.29^{**}
69	Manufactures of metal		
	LMQ	-2.67^{*}	7.70^{*}
	LRP	-1.42	2.06
	LAC	-1.16	5.32
	ΔMQ	-6.97^{***}	32.49^{**}
	ΔRP	-4.54^{***}	17.19^{**}
	ΔAC	-7.09^{***}	50.29^{**}

Table 4 (Cont.)
Results of Unit Root Tests

	AICC	DF/ADF	Johansen
71	Power generating machinery		
	LMQ	-1.99	5.46
	LRP	-1.34	1.85
	LAC	-0.81	3.98
	ΔMQ	-4.63***	33.71**
	ΔRP	-4.69***	18.09**
	ΔAC	-4.15***	63.32**
72	Machinery, specialised		
	LMQ	-2.08	4.34
	LRP	-1.40	2.00
	LAC	-0.81	3.98
	ΔMQ	-5.79***	25.03**
	ΔRP	-5.30***	21.94**
	ΔAC	-4.15***	63.32**
74	General industrial machinery		
	LMQ	-1.42	2.06
	LRP	-1.66	2.10
	LAC	-0.81	3.98
	ΔMQ	-3.84***	26.37**
	ΔRP	-3.86***	18.38**
	ΔAC	-4.15***	63.32**
75	Office machines, ADP equipment		
	LMQ	-0.55	0.14
	LRP	-0.28	0.01
	LAC	-0.81	3.98
	ΔMQ	-4.45***	32.61**
	ΔRP	-4.47***	21.21**
	ΔAC	-4.15***	63.32**
76	Telecommunications equipment		
	LMQ	-1.68	4.91
	LRP	-1.08	0.28
	LAC	-0.81	3.98
	ΔMQ	-6.14***	38.63**
	ΔRP	-4.18***	15.02**
	ΔAC	-4.15***	63.32**

Table 4 (Cont.)
Results of Unit Root Tests

AICC		DF/ADF	Johansen
77	Electrical machinery and parts		
	LMQ	-0.70	0.46
	LRP	-1.38	1.21
	LAC	-0.81	3.98
	ΔMQ	-3.28**	21.41**
	ΔRP	-3.59***	19.23**
	ΔAC	-4.15***	63.32**
78	Road vehicles		
	LMQ	-1.61	2.65
	LRP	-1.56	2.50
	LAC	-0.81	3.98
	ΔMQ	-3.32**	17.80**
	ΔRP	-5.80***	25.08**
	ΔAC	-4.15***	63.32**
81	Sanitary, heating equipment		
	LMQ	-1.24	1.60
	LRP	-1.72	2.02
	LAC	-1.26	6.48
	ΔMQ	-5.84***	25.34**
	ΔRP	-3.43**	20.44**
	ΔAC	-4.91***	89.78**
82	Furniture and parts thereof		
	LMQ	-2.33	5.87
	LRP	-1.61	1.65
	LAC	-1.26	6.48
	ΔMQ	-6.64***	29.51**
	ΔRP	-3.88***	18.13**
	ΔAC	-4.91***	89.78**
84	Apparel, clothing accessories		
	LMQ	-3.87***	19.57**
	LRP	-0.23	0.13
	LAC	-1.26	6.48
	ΔMQ	-5.58***	91.35**
	ΔRP	-3.09**	23.82**
	ΔAC	-4.91***	89.78**

Table 4 (Cont.)
Results of Unit Root Tests

AICC		DF/ADF	Johansen
85	Footwear		
	LMQ	-8.18***	40.26**
	LRP	-1.94	3.79
	LAC	-1.26	6.48
	ΔMQ	-11.22***	134.43**
	ΔRP	-4.71***	27.10**
	ΔAC	-4.91***	89.78**
87	Professional, scientific equipment		
	LMQ	-1.15	3.11
	LRP	-1.62	2.46
	LAC	-1.16	5.32
	ΔMQ	-5.11***	39.22**
	ΔRP	-4.42***	25.71**
	ΔAC	-7.09***	50.29**
88	Photographic, optical goods		
	LMQ	-1.61	5.75
	LRP	-1.54	2.18
	LAC	-1.16	5.32
	ΔMQ	-7.69***	45.04**
	ΔRP	-4.20***	25.13**
	ΔAC	-7.09***	50.29**
89	Miscellaneous manufactures		
	LMQ	-2.23	5.01
	LRP	-1.96	3.24
	LAC	-1.16	5.32
	ΔMQ	-6.33***	28.42**
	ΔRP	-4.08***	22.29**
	ΔAC	-7.09***	50.29**
	Total Manufactured Imports		
	LMQ	-1.21	1.44
	LRP	-1.19	0.89
	LAC	-1.16	5.32
	ΔMQ	-3.68***	27.43**
	ΔRP	-3.51***	19.39**
	ΔAC	-7.09***	50.29**

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

To elucidate the Johansen procedure, suppose that the three variables in our study are individually $I(1)$[6] and follow a vector autoregressive process of order k:

$$X_t = \Pi_1 X_{t-1} + ... + \Pi_k X_{t-k} + \mu + \epsilon_t \qquad (3)$$

where $X_t = (LMQ_t, LRP_t, LAC_t)'$, μ is a vector of constants and ϵ_t is a 3-dimensional Gaussian error process.

Equation (2) can be re-written as:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \epsilon_t \qquad (4)$$

where

$$\Gamma_i = -(\mathbf{I} - \Pi_1 - .... - \Pi_i), \quad (i = 1 ,...., k - 1)$$

and

$$\Pi = -(\mathbf{I} - \Pi_1 - .... - \Pi_k).$$

Equation (2) represents an error-correction model in which the lagged level terms jointly form the error-correction term and indicate how disequilibrium is corrected. The level terms then capture the long-run steady state relations, while the difference terms estimate short-run dynamics.

The Johansen test generalises the error-correction model to a multivariate framework. It then examines the coefficient matrix Π of the lagged levels to extract information about long-run relationships. A long-run or cointegrating relationship is said to exist if $0 < \text{rank}(\Pi) = r < p$, where $p = 3$ = the number of variables in our system.

If there is no long-run relationship among the variables in our system, then the coefficient matrix Π will appear as a null matrix ($r = 0$). In this instance, our system is reduced to a vector autoregressive system in first differences. If on the other hand the coefficient matrix Π is of full rank, then the vector process X_t is stationary and the cointegrating relationship is undefined.

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(6) The fact that the *MQ* series for a number of the quota-protected product categories were found to be stationary in levels is not a serious problem as stationary variables tend to show up in estimated cointegrating relationships.

The Johansen procedure can also be used to construct likelihood-ratio tests of the number of truly distinct cointegrating vectors which link the variables in our system. The likelihood-ratio test of there being at most r cointegrating vectors in a set of p variables is obtained as the Trace Statistic (Trace) defined as:

$$Trace(r) = -T \sum_{i=r+1}^{p} \ln (1 - \hat{\lambda}_i) \tag{5}$$

where the $\hat{\lambda}_i$ are squared canonical correlations $(\hat{\lambda}_1 > \hat{\lambda}_2 > ... > \hat{\lambda}_p)$ between the two sets of residuals vectors, R_{ot} and R_{1t}, obtained in the following two regressions:

$$\Delta X_t = \sum_{i=1}^{k-1} A_{oi} \Delta X_{t-i} + \hat{\mu} + R_{ot} \tag{6}$$

$$X_{t-k} = \sum_{i=1}^{k-1} A_{1i} \Delta X_{t-i} + \hat{\mu} + R_{1t} \tag{7}$$

where the A_{ji} are matrices of coefficient estimates.

As a further check, likelihood-ratio statistics can be constructed for testing that there are r cointegrating vectors as opposed to $(r + 1)$ cointegrating vectors. This test is given by the Maximal Eigenvalue Statistics (LMax) defined as:

$$LMax(r) = - T \ln (1 - \hat{\lambda}_{r+1}) \tag{8}$$

The distribution of Trace(r) and LMax(r) are tabulated by Johansen and Juselius (1990).

Where there are r cointegrating relationships in p variables, the Π matrix is decomposed as:

$$\Pi = \alpha \beta' \tag{9}$$

where α and β are p x r matrices. β is the matrix of r cointegrating vectors corresponding to the r largest canonical correlations. The ijth element of α measures the weight with which the jth cointegrating relationship (β_j) enters the ith equation of the system. If $r = 1$ and all the elements of α_1 are zero except at the mth position, then the error-correction model for the mth equation provides the unique long-run relationship. If $r > 1$ however, then only the space spanned by the vectors in β is uniquely determined. In this instance, the application of OLS to a single equation model will provide only one possible linear combination of the cointegrating vectors. It is clear that the Johansen procedure overcomes this problem.

While the Johansen procedure overcomes a number of problems associated with conventional econometric estimators and the Engle-Granger procedure, it should be noted that it is not problem-free. The Johansen procedure is subject to two minor limitations. The first limitation is a general one, and besieges all VAR based procedures. The fact that the same regressors enter all equations with equal lag length may render the procedure inefficient. Second, and this is common when more than one cointegrating vector is identified, it may be difficult to find economically meaningful interpretations for some of the estimated cointegrating relationships.

5. Results

The results of the Johansen cointegration tests are reported in Table 5. In implementing the Johansen procedure, we need to select the length of the lag in the VAR. The likelihood ratio criterion was used to determine the lag length. We started with an eight lag system and tested down to the minimum number of significant lags using standard likelihood ratio tests[7]. Using this criterion the optimal lag length proved to be one in most cases, although the parameter estimates generally proved to be qualitatively unchanged for different lag lengths[8]. Table 5 also reports the non-normalised vectors of cointegrating coefficients (β_js) on $(LMQ_t, LRP_t, LAC_t)'$, and the (non-normalised) weight (α_j) with which the jth cointegrating relationship ($\beta'_j X_t$) enters each of the three equations of the system. It is clear from Table 5 that the hypothesis of one cointegrating vector linking the variables in our system is preferred in most cases. Two cointegrating vectors were identified for inorganic chemicals (AICC 52), power generating machinery (AICC 69) and road vehicles (AICC 78). In each of these cases, however, an economically meaningful vector could be isolated.

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

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

Table 5[1]
Results of the Johansen FIML Estimation

	AICC	*LMax*	Trace	α_1	α_2	β_1	β_2
51	Organic chemicals	35.16	37.87	-0.49		1.16	
	(VAR lag length = 1)	2.34	2.70	0.01		0.29	
		0.36	0.36	0.35		-1.56	
52	Inorganic chemicals	64.34	81.10	0.12	-0.26	2.52	1.08
	(VAR lag length = 8)	14.91	16.76	0.17	0.03	-5.08	1.83
		1.86	1.86	0.02	-0.01	-7.13	-1.46
53	Dyeing, tanning materials	35.80	40.31	-0.21		1.08	
	(VAR lag length = 1)	3.23	4.51	0.06		0.39	
		1.28	1.28	0.38		-1.99	
54	Medicinal,pharmaceutical prods.	44.74	47.83	-0.34		0.56	
	(VAR lag length = 1)	3.08	3.09	0.04		0.28	
		0.02	0.02	0.43		-2.57	
55	Essential oils, perfumes etc.	63.51	68.36	-0.09		1.10	
	(VAR lag length = 1)	4.43	4.85	0.06		0.31	
		0.42	0.42	0.46		-2.59	
58	Artificial resins,plastics etc.	42.07	46.21	-0.18		1.12	
	(VAR lag length = 1)	3.79	4.14	0.07		0.50	
		0.35	0.35	0.40		-2.56	
59	Chemical materials and products	29.31	39.69	-0.35		1.58	
	(VAR lag length = 1)	6.70	10.37	0.08		2.22	
		3.68	3.68	0.28		-2.05	
61	Leather, leather manufactures	29.31	35.09	0.15		-1.05	
	(VAR lag length = 1)	4.72	5.78	-0.03		-1.50	
		1.06	1.06	-0.31		2.35	
62	Rubber manufactures	27.42	35.05	0.17		-1.11	
	(VAR lag length = 1)	5.86	7.63	-0.01		-1.29	
		1.77	1.77	-0.35		2.26	
63	Cork and wood manufactures	21.07	32.95	0.29		-1.31	
	(VAR lag length = 1)	8.01	12.87	-0.05		-0.57	
		4.86	4.86	-0.23		1.37	
64	Paper, articles of pulp paper	26.30	41.72	-0.08		-1.02	
	(VAR lag length = 1)	13.29	15.40	0.05		4.06	
		2.12	2.12	0.32		-0.75	
65	Textile yarn, fabrics	21.17	29.98	0.23		-3.57	
	(VAR lag length = 4)	6.94	8.26	-0.06		-0.85	
		1.32	1.32	-0.01		1.16	

Table 5 (Cont.)
Results of the Johansen FIML Estimation

	AICC	*L*Max	Trace	α_1	α_2	β_1	β_2
66	Non-metallic minerals	29.14	32.72	-0.25		1.09	
	(VAR lag length = 1)	2.45	3.58	0.03		0.64	
		1.13	1.13	0.37		-1.96	
67	Iron and steel	21.78	29.96	-0.52		0.94	
	(VAR lag length = 1)	5.11	7.18	0.01		1.22	
		2.07	2.07	0.31		-1.22	
69	Manufactures of metal	31.29	34.76	-0.49		2.19	
	(VAR lag length = 4)	3.41	3.47	0.02		0.78	
		0.06	0.06	-0.08		-2.88	
71	Power generating machinery	35.57	51.35	-0.33	0.16	2.03	-0.73
	(VAR lag length = 1)	15.90	18.97	-0.02	0.02	-0.96	-0.78
		2.08	2.08	-0.21	-0.10	-1.20	1.40
72	Specialised machinery	21.08	29.90	0.44		-0.82	
	(VAR lag length = 1)	3.37	5.51	-0.08		-0.33	
		2.14	2.14	-0.15		1.04	
74	General industrial machinery	24.76	29.92	0.15		-1.11	
	(VAR lag length = 1)	2.81	4.54	-0.03		-1.08	
		1.73	1.73	-0.33		2.30	
75	Office machines, ADP equipment	24.68	31.71	-0.04		0.79	
	(VAR lag length = 4)	6.69	7.03	-0.03		1.07	
		0.07	0.07	0.18		-1.43	
76	Telecommunications equipment	31.63	38.30	-0.18		1.48	
	(VAR lag length = 1)	5.51	6.76	0.11		1.04	
		1.25	1.25	0.15		-2.10	
77	Electrical machinery and parts	31.47	34.47	-0.06		1.34	
	(VAR lag length = 1)	2.76	3.00	0.06		0.55	
		0.25	0.25	0.33		-2.48	
78	Road vehicles	26.20	43.66	0.03	0.20	-0.39	-1.24
	(VAR lag length = 4)	19.36	27.31	-0.01	-0.11	-2.46	-0.60
		2.10	2.10	-0.23	0.04	0.72	1.31
81	Sanitary, heating equipment	25.50	29.65	-0.32		0.78	
	(VAR lag length = 1)	3.37	4.15	0.05		0.74	
		0.78	0.78	0.33		-2.08	
82	Furniture and parts thereof	26.29	33.46	-0.28		0.96	
	(VAR lag length = 1)	5.95	7.17	0.12		0.42	
		1.22	1.22	0.26		-1.66	

Table 5 (Cont.)
Results of the Johansen FIML Estimation

	AICC	*LMax*	Trace	α_1	α_2	β_1	β_2
84	Apparel, clothing accessories	69.48	81.64	2.49		-0.55	
	(VAR lag length = 1)	11.87	12.17	-0.05		-0.55	
		0.29	0.29	-0.80		0.35	
85	Footwear	101.79	113.03	3.17		-0.51	
	(VAR lag length = 1)	9.59	11.24	-0.01		-0.90	
		1.64	1.64	-0.86		0.27	
87	Professional,scientific equipment	34.30	39.54	-0.24		1.13	
	(VAR lag length = 1)	3.81	5.24	0.01		0.64	
		1.43	1.43	0.37		-2.20	
88	Photographic, optical goods	36.91	39.34	-0.24		1.13	
	(VAR lag length = 1)	4.31	5.24	0.01		0.64	
		1.43	1.43	0.37		-2.20	
89	Miscellaneous manufactures	54.82	63.10	-0.13		1.56	
	(VAR lag length = 1)	5.44	8.28	0.01		0.93	
		2.84	2.84	0.38		-2.60	
	Total Manufactured Imports	32.41	35.87	-0.13		1.19	
	(VAR lag length = 1)	2.82	3.46	0.05		0.79	
		0.65	0.65	0.36		-2.23	

Notes:
(1) *LMax* and **Trace** are the maximal eigenvalue statistic and trace statistic for the Johansen multivariate cointegration test. The first, second and third rows of each statistic tests the null that there are 1, 2 and 3 cointegrating relationships, respectively. The critical values at the 5 percent level of significance are (20.96, 14.07, 3.76)' for *LMax* and (29.68, 15.41, 3.76)' for **Trace** (taken from Johansen and Jesulius, 1990). The β_js are non-normalised vectors of cointegrating coefficients on $(LMQ_t, LRP_t, LAC_t)'$. The α_js are the non-normalised weights with which the *j*th cointegrating relationship $(\beta'_j X_t)$ enters each of the three equations of the system.

The β vectors normalised by ***LMQ*** are reported in Table 6. There appears to be significant variation in both price and activity elasticities across product categories. The coefficient of variation for the price elasticities is 0.61, and 0.45 for the activity elasticities. The frequency distribution of price and activity elasticities provided in Table 7 highlights this point. The majority (73 percent) of price elasticities are less than one, while the rest lie between 1 and 2. The highest price elasticity of 1.75 is recorded for footwear (AICC 85), although a number of the other quota-protected industries that have a high share of competitive imports (see Table 2) also record relatively high price elasticities. The lower end of the scale as far as price elasticities are concerned appear to centre around the intermediate goods imports, particularly the machinery and equipment product categories.

Table 6
Price and Activity Elasticities (Normalised by *LMQ*)

AICC		*LRP*	*LAC*
51	Organic chemicals	-0.25	1.36
52	Inorganic chemicals	-1.69	1.34
53	Dyeing, tanning materials	-0.36	1.85
54	Medicinal, pharmaceutical products	-0.50	4.55
55	Essential oils, perfumes etc.	-0.28	2.35
58	Artificial resins, plastics etc.	-0.44	2.29
59	Chemical materials and products	-1.40	1.30
61	Leather, leather manufactures	-1.43	2.24
62	Rubber manufactures	-1.16	2.03
63	Cork and wood manufactures	-0.43	1.04
64	Paper, articles of pulp paper	-0.28	1.35
65	Textile yarn, fabrics	-0.24	0.33
66	Non-metallic minerals	-0.59	1.79
67	Iron and steel	-1.30	1.30
69	Manufactures of metal	-0.36	1.32
71	Power generating machinery	-1.06	1.91
72	Specialised machinery	-0.40	1.27
74	General industrial machinery	-0.96	2.07
75	Office machines, ADP equipment	-1.35	1.80
76	Telecommunications, equipment	-0.77	1.42
77	Electrical machinery and parts	-0.41	1.84
78	Road vehicles	-0.48	1.06
81	Sanitary, heating equipment	-0.94	2.65
82	Furniture and parts thereof	-0.43	1.74
84	Apparel, clothing accessories	-1.00	0.64
85	Footwear	-1.75	0.52
87	Professional, scientific equipment	-0.57	1.96
88	Photographic, optical goods	-0.36	1.56
89	Miscellaneous manufactures	-0.60	1.66
	Total Manufactured Imports	-0.66	1.87

Source: Table 5

Table 7
Frequency Distribution of Price and Activity Elasticities

	Number of Products	Percentage of Total
$LRP \leq 0.5$	14	47
$0 \leq LRP \leq 1$	22	73
$1 < LRP < 1$	8	27
$0 \leq LAC \leq 1$	3	10
$1 < LAC < 2$	20	67
$LAC \geq 2$	7	23

Source: Table 6

With respect to the activity elasticities, we find that the majority of the estimates lie between 1 and 2 (Table 7). This is in line with the findings of most previous studies in Australia (Gordon, 1986) and overseas (Goldstein and Khan, 1985). Krugman (1990, p. 180) provides the following explanation for this finding: "Import demand is generally estimated to rise more than proportionately to whatever activity variable the econometrician puts in, for fairly obvious reasons: goods, which are traded more than services, respond more to cyclical fluctuations in spending, and capacity constraints cause some of an increase in demand to spill over into imports". The lowest estimates are for the quota-protected categories, particularly the textile, clothing and footwear product categories. The highest activity elasticity of 4.55 for medicinal and pharmaceutical products appears to be an outlier, however, since the other estimates on the high side range around the 2 to 2.5 mark.

We also tested the unit activity elasticity hypothesis (the homogeneity assumption) using the likelihood ratio test provided within the Johansen procedure. We found that this hypothesis was accepted for about one third of our sample (10 product categories). The results of the tests for which the hypothesis could be accepted at the 5 percent level of significance, together with the price elasticity within the restricted equation are presented in Table 8[9].

Table 8
Likelihood Ratio (LR) Test Results of Unit Activity Elasticity Hypothesis and Price Elasticities from the Restricted Equation

AICC		*LRP*	*LAC*	*LR Test*[1]
51	Organic chemicals	-0.22	1.00	4.47
52	Inorganic chemicals	-1.55	1.00	4.04
59	Chemical materials and products	-1.49	1.00	3.96
63	Cork and wood manufactures	-0.39	1.00	0.02
67	Iron and steel	-1.01	1.00	0.98
69	Manufactures of metal	-0.23	1.00	0.04
72	Specialised machinery	-0.55	1.00	0.94
76	Telecommunications, equipment	-0.75	1.00	6.98
78	Road vehicles	-0.51	1.00	1.73
84	Apparel, clothing accessories	-0.66	1.00	6.13

Notes:
(1) The LR test statistic is distributed as χ^2 (1). The 5 percent critical value for rejection of the null hypothesis is 7.88.

The relative price elasticity for total manufactured imports is 0.66, while the activity elasticity is 1.87. A strict comparison of our import-elasticity estimates with those reported in previous Australian studies is obviously not possible given various differences among studies with regard to important aspects such as model specification and method of estimation, time coverage, data base and the level of disaggregation. However, an overall comparison based simply on the average order of magnitude would show that our elasticity estimates are somewhat lower than previous studies that use data from the mid-60s to early 70s. For instance, according to the survey by Gordon (1986, Table 3) the medium-run import-price

(9) Athukorala and Menon (1992) find that the unit activity elasticity hypothesis is accepted for 7 out of the 9 2-digit ASIC categories analysed. Their model, however, incorporates a domestic capacity constraint variable in the form of stock-sales ratio to capture short-run spill-over effects into imports. In our attempts to identify cointegrating relationships for imports, we found that the inclusion of a stock-sales ratio tended to distort the results because it only captures short-run behaviour.

elasticity estimates of 16 such studies range from 0.35 to 1.8 with an average of 1.3 and standard deviation of 1.2.

This period predates the imposition of QRs on some consumer-goods imports, in particular clothing, textiles and motor vehicles. Moreover, there is evidence that the share of competitive imports in total manufactured imports has declined since the mid 1970s mostly as an outcome of attempts by domestic manufacturers to restructure production in response to reduced international competitiveness (Krause, 1984)[10]. The fact that the estimated price elasticities are generally on the low side may also be a result of allowing for non-stationarity in the data in our estimation method. This is the conclusion arrived at by Asseery and Peel (1991) when they compare the estimates obtained from the application of conventional econometric procedures with those from the cointegration approach. The price and activity estimates of 0.71 and 1.96 obtained by Wilkinson (1992) employing the Johansen procedure for endogenous imports for the period 1974Q3 to 1989Q3 is much closer to ours.

Given the differences in price elasticities across product categories, and the fact that some products are subject to quantitative restrictions, the possibility arises as to potential aggregation bias in the aggregate import function. A straight-forward way of checking for aggregation bias is to calculate a value-weighted average price elasticity (using average import weights for 1981/82-90/91; Table 9, Column 3). The aggregate (weighted-average) price elasticity thus obtained is 0.68 as compared with 0.66, the elasticity coefficient given by the import demand function for total manufactured imports. This comparison would imply that there is some, *albeit* mild, downward aggregation bias in import price elasticity estimates obtained from aggregative analysis as far as the period under consideration is concerned.

The simple value-weighted aggregate price elasticity can be subject to error, however, as demonstrated by Magee (1975). A detailed description of how this problem may arise is presented in Appendix A. The crux of the argument revolves around the possibility that component product price changes may be negatively correlated with component product price elasticities. If this is true, then the actual aggregate quantity change will be less than the product of the aggregate elasticity and the aggregate price change. The products with large price changes should then receive smaller effective weights because their effect on aggregate imports operates through a small elasticity. The potential correlation between the disaggregated price changes and elasticities is lost when the two are aggregated separately and then multiplied together.

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(10) For instance, this share declined from 47 percent in 1975-77 to 37 percent in 1980-82.

Table 9
Import Weights, Value-Weighted and Distribution Elasticities

AICC	LRP_i	ϕ_i [1]	$\psi_{(RP)i}$ [2]	$\Omega_{(RP)i}$ [3]	$\eta_{(RP)i}$ [4]
51 Organic chemicals	-0.25	0.0309	-0.0077	0.87	-0.0067
52 Inorganic chemicals	-1.69	0.0144	-0.0243	0.58	-0.0141
53 Dyeing, tanning materials	-0.36	0.0058	-0.0021	0.98	-0.0021
54 Medicinal, pharmaceutical prods.	-0.50	0.0168	-0.0084	0.79	-0.0066
55 Essential oils, perfumes etc.	-0.28	0.0079	-0.0022	0.99	-0.0022
58 Artificial resins, plastics etc.	-0.44	0.0224	-0.0099	0.70	-0.0069
59 Chemical materials and products	-1.40	0.0153	-0.0214	1.04	-0.0223
61 Leather, leather manufactures	-1.43	0.0042	-0.0060	0.84	-0.0050
62 Rubber manufactures	-1.16	0.0176	-0.0204	0.47	-0.0096
63 Cork and wood manufactures	-0.43	0.0063	-0.0027	0.92	-0.0025
64 Paper, articles of pulp paper	-0.28	0.0339	-0.0095	0.63	-0.0060
65 Textile yarn, fabrics	-0.24	0.0619	-0.0149	1.00	-0.0149
66 Non-metallic minerals	-0.59	0.0255	-0.0150	1.04	-0.0156
67 Iron and steel	-1.30	0.0274	-0.0356	0.82	-0.0292
69 Manufactures of metal	-0.36	0.0353	-0.0127	0.78	-0.0099
71 Power generating machinery	-1.06	0.0375	-0.0398	1.05	-0.0418
72 Specialised machinery	-0.40	0.0699	-0.0280	1.09	-0.0305
74 General industrial machinery	-0.96	0.0712	-0.0684	1.13	-0.0773
75 Office machines, ADP equipment	-1.35	0.0771	-0.1041	1.06	-0.1103
76 Telecommunications, equipment	-0.77	0.0503	-0.0387	0.82	-0.0317
77 Electrical machinery and parts	-0.41	0.0664	-0.0272	0.93	-0.0253
78 Road vehicles	-0.48	0.1234	-0.0592	1.16	-0.0687
81 Sanitary, heating equipment	-0.94	0.0030	-0.0028	0.97	-0.0027
82 Furniture and parts thereof	-0.43	0.0083	-0.0036	0.99	-0.0036
84 Apparel, clothing accessories	-1.00	0.0237	-0.0237	0.60	-0.0142
85 Footwear	-1.75	0.0089	-0.0156	0.53	-0.0083
87 Professional, scientific equipment	-0.57	0.0300	-0.0171	1.11	-0.0190
88 Photographic, optical goods	-0.36	0.0230	-0.0083	1.09	-0.0090
89 Miscellaneous manufactures	-0.60	0.0749	-0.0449	0.79	-0.0355
Total Manufactured Imports	-0.66	1.0000	-0.6752	--	-0.6015 [5]

Notes: (1) The weights ($\phi_i = MQ_i/MQ$) are average imports shares covering the period 1981/82-90/91 (see Table 2). Since some of the component categories of total manufactured imports are not included in our analysis, the weights have been adjusted so that they sum to 1. *Source*: ABS, *Imports by Commodity Division, Australia*, Cat. No. 5405.0, various issues.

(2) $\Omega_{(RP)i} = \{(\Delta RP_i/RP_i)/(\Delta RP/RP)\}$

(3) $\psi_{(RP)i} = LRP_i \cdot \phi_i$

(4) $\eta_{(RP)i} = LRP_i \cdot \phi_i \cdot \Omega_{(RP)i}$

(5) $\epsilon_{(RP)} = \Sigma_i \eta_{(RP)i}$

A "true" aggregate price elasticity which overcomes these problems, and incorporates all the information that disaggregation can provide is given by the following formula:

$$\epsilon_{(RP)} \quad = \quad \Sigma_i \, \epsilon_{(RP)i} \, (MQ_i/MQ) \, \Omega_{(RP)i} \tag{10}$$

where $\Omega_{(RP)i} = (\Delta RP_i/RP_i)/(\Delta RP/RP)$ is the "distribution elasticity"; see Appendix A. Unless $\Omega_{(RP)i} = 1$ for all i, the simple value-weighted aggregate price elasticity will be biased. The distribution elasticities for each of the product categories presented in Table 9 (Column 5) clearly indicate that the value-weighted elasticity is seriously in error. In particular, the distribution elasticities appear to be strongly negatively correlated with the price elasticities. For example, the lowest distribution elasticity of 0.53 is recorded for footwear (AICC 85), which is the most price elastic product in our sample. The aggregate elasticity obtained after adjusting for the distribution elasticity is 0.60. This elasticity is significantly (more than 10 percent) lower than both the simple value-weighted elasticity and the elasticity obtained from the aggregate import equation.

6. Conclusion

This paper has investigated the relationship between manufactured import flows to Australia and relative prices and domestic economic activity over the period 1981Q3 to 1992Q2. We estimated import demand functions for total manufactured imports and 29 import product categories defined at the 2-digit level of the AICC employing the Johansen FIML procedure. The price elasticity estimates for individual categories ranged from 0.24 to 1.75. The fact that our price elasticities are generally lower than previous estimates might be a reflection of the fact that our estimation method accounts for non-stationarity in the data series. We also identified significant upward bias in price elasticity estimates when an aggregate import function is employed in a context where variation in prices of individual products are negatively correlated with their price elasticities, and when a significant portion of imports are subject to QRs. The weighted price elasticity corrected by the distribution elasticity was 0.60, as compared with the aggregate elasticity of 0.66 and 0.68 for the simple value-weighted elasticity. The majority of activity elasticities were found to be greater than one, and usually closer to two.

Appendix A

To elucidate the nature of the bias in simple value-weighted aggregate price elasticities, we write the Australian aggregate demand for imports as:

$$LMQ = \epsilon_{RP}\, LRP + \epsilon_{AC}\, LAC \tag{11}$$

where ϵ_{RP} and ϵ_{AC} are the aggregate price and activity elasticities.
The component equations for each (of the 29) subcategory *i* can be written as:

$$LMQ_i = \epsilon_{(RP)i}\, LRP_i + \epsilon_{(AC)i}\, LAC_i \tag{12}$$

where $\epsilon_{(RP)i}$ and $\epsilon_{(AC)i}$ are the relevant component price and activity elasticities.

From the aggregate equation, we can show that the change in (aggregate) imports is:

$$(\Delta MQ/MQ) = \epsilon_{RP}\, (\Delta RP/RP) + \epsilon_{AC}\, (\Delta AC/AC) \tag{13}$$

and, from the disaggregate equations, the change in imports can be re-written as:

$$\begin{aligned}(\Delta MQ/MQ) &= \Sigma\, (\Delta MQ_i/MQ) \\ &= \Sigma\, \epsilon_{(RP)i}\, (\Delta RP_i/RP_i)\, (MQ_i/MQ) + \Sigma\, \epsilon_{(AC)i}\, (\Delta AC_i/AC_i)\, (MQ_i/MQ)\end{aligned} \tag{14}$$

For the results in (4) to be compatible with (5), then the following two *sufficient* conditions must be met: (i) the first term in both equations must be equal, and (ii) the second term in both equations must be equal. That is:

$$\epsilon_{RP}\, (\Delta RP/RP) = \Sigma\, \epsilon_{(RP)i}\, (\Delta RP_i/RP_i)\, (MQ_i/MQ) \tag{15}$$

and

$$\epsilon_{AC}\, (\Delta AC/AC) = \Sigma\, \epsilon_{(AC)i}\, (\Delta AC_i/AC_i)\, (MQ_i/MQ) \tag{16}$$

From equations (6) and (7) above, we can write the total elasticity that will be consistent with the disaggregate data as:

$$\epsilon_{RP} = \Sigma\, \epsilon_{(RP)i}\, (MQ_i/MQ)\, \{(\Delta RP_i/RP_i)/(\Delta RP/RP)\} \tag{17}$$

$$\epsilon_{AC} = \Sigma\, \epsilon_{(AC)i}\, (MQ_i/MQ)\, \{(\Delta AC_i/AC_i)/(\Delta AC/AC)\} \tag{18}$$

Thus the aggregate price elasticity (ϵ_{RP}), for instance, is a function of three factors: the disaggregate (i) price elasticities ($\epsilon_{(RP)i}$), (ii) import shares (MQ_i/MQ), and (iii) variation of the component price i relative to the total price index $\{(\Delta RP_i/RP_i)/(\Delta RP/RP)\}$. This last term is called the "distribution elasticity", which we designate as $\Omega_{(RP)i}$. It is estimated from the following time-series regression:

$$LRP_i = c_i + \Omega_{(RP)i}\, LRP \tag{19}$$

Appendix B

Sources

Imports (f.o.b.): ABS (5433.0), *Imports, Australia: Monthly Summary Tables*, (monthly) and ABS (5406.0), *Imports Australia*, (monthly).
Import prices (f.o.b.): ABS, unpublished series.
Domestic (producer) prices: ABS, unpublished series.
Activity variables: ABS (5206.0), *Quarterly Estimates of Income and Expenditure*, Australia (quarterly) and ABS (5219.0) *ibid.*
Nominal protection rates: IAC (1987), *Assistance to Agricultural and Manufacturing Industries*, and IAC (1988, 1989) *Annual Report*, (annual data given in these reports were interpolated to provide quarterly rates).

Data transformations

In the absence of import quantity indexes at the required level of disaggregation, we derived the *MQ* series by deflating the import value series by the relevant import price index. An important issue relating to the derivation of the real import series in this manner is the comparability of the timing of price observations embodied in the import price index with the timing of import records. Any significant discrepancy in this regard may bias the timing of the import response captured in the lag structure of the import function. Fortunately, our data provides a more appropriate linking of the timing of import price and import value series. While the import price index measures the prices of commodities landed in a given quarter, import entries (on which the value series is based) for a given quarter cover at least 90 percent of imports landed in the same quarter.

To construct the *RP* series it was necessary to bring the original *PM* series (which is in f.o.b. terms) and the *PD* series on to a comparable basis. This was done by multiplying the former by $(1+\Theta)$, where Θ is the nominal protection coefficient which incorporates both the import duty and scarcity premium on quota-restricted imports. Ideally it should incorporate not only these two elements but also transport costs, insurance and all other charges which accounts for the difference between the price received by the foreign supplier and the price paid by the importer in Australia. These other elements are ignored here because of the lack of appropriate data. It is, however, unlikely that variations in these elements during the period under study would have been significantly large.

Finally, the activity variable used in the import function for total manufactured imports is real GDP. Much of Australia's imports take the form of intermediate products. To the extent that the import equation represents demand for intermediate goods, real GDP is clearly preferably to an aggregate domestic expenditure variable. In disaggregated functions, activity variables that relate more closely to the particular import category being considered is used. An aggregate output/expenditure measure or, where appropriate, an individual component of output/expenditure is selected as the appropriate variable. These variables are listed below.

Activity Variables in Import Demand Functions

GDP:

51	Organic chemicals
52	Inorganic chemicals
53	Dyeing, tanning materials
54	Medicinal and pharmaceutical products
55	Essential oils, perfumes etc.
58	Artificial resins, plastics etc.
59	Chemical materials and products
61	Leather, leather manufactures
62	Rubber manufactures
63	Cork and wood manufactures
64	Paper, articles of pulp paper
65	Textile yarn, fabrics
66	Non-metallic mineral manufactures
67	Iron and steel
69	Manufactures of metal
87	Professional, scientific equipment
88	Photographic, optical goods
89	Miscellaneous manufactures

Gross Fixed Capital Formation:

71	Power generating machinery
72	Specialised machinery
74	General industrial machinery
75	Office machines and ADP equipment
76	Telecommunications equipment
77	Electrical machinery and parts thereof

Gross Fixed Capital Formation plus Private Expenditure on Motor Vehicles:

78	Road vehicles

Private Consumption of Clothing, Footwear and Drapery:

81	Sanitary, heating equipment
82	Furniture and parts thereof
84	Apparel, clothing accessories
85	Footwear

REFERENCES

Akaike, H., (1974), "A New Look at the Statistical Model Identification", *IEEE Transactions on Automatic Control*, AC-19, 716-23.

Alouze, C.M., Marsden, J.S. and Zeitsch, J., (1977), "Estimates of Elasticity of Substitution between Imported and Domestically Produced Commodities at the $-Digit ASIC Level", *IMPACT Working Paper No. O-13*, The IMPACT Project, Melbourne.

Asseery, A. and Peel, D.A., (1991), "Estimates of a Traditional Aggregate Import Demand Model for Five Countries", *Economics Letters*, 35, 435-9.

Athukorala, P. and Menon, J., (1992), "Relative Price and Activity Effects in Australian Manufacturing Imports: A Disaggregate Analysis", Paper presented to the 1992 Australasian Meeting of the Econometric Society, Monash University, Melbourne.

Banerjee, A., Dolado, J.J., Hendry, D.F. and Smith, G.W., (1986), "Explaining Equilibrium Relationships in Econometrics Through Static Models: Some Monte Carlo Evidence", *Oxford Bulletin of Economics and Statistics*", 48 (3), 253-78.

Barker, T.S., (1970), "Aggregation Error and Elasticities of the UK Import Demand Function", Chapter 5 in K. Hilton and D.F. Heathfield (eds.), *The Econometric Study of the United Kingdom*, Macmillan, London, 115-45.

Bushe, D.M., Kravis, I.B. and Lipsey, R.E., (1986), "Prices, Activity, and Machinery Exports: An Analysis Based on New Price Data", *Review of Economics and Statistics*, 68 (2), 248-55.

Boylan, T.A., Cuddy, M.P. and Omuircheartaigh, I., (1980), "The Functional Form of the Aggregate Import Demand Function: A Comparison of Three European Economies", *Journal of International Economics*, 10 (4), 561-66.

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

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

Engle, R.F. and Granger, C.W.J., (1987), "Cointegration and Error Correction: Representation, Estimation and Testing", *Econometrica*, 55, 251-76.

Freebairn, J.W., (1986), "The Exchange Rate and the Trade Account: Comment", in T. Nguyen and R.G. Gregory (eds.), *Exchange Rates and the Economy*, Supplement to the Economic Record, Economic Society of Australia, 108-10.

General Agreement on Trade and Tariffs (GATT), (1991), *International Trade: 1989-90*, Vol.s 1 and 2, Geneva: GATT.

Goldstein, M. and Khan, M.S., (1985), "Income and Price Effects in Foreign Trade", in R.W. Jones and P.B. Kenen (eds.), *Handbook of International Economics*, North-Holland, Amsterdam, 1041-1105.

Gordon, J.M., (1986), "The J-Curve Effects", in T. Nguyen and R.G. Gregory (eds.), *Exchange Rates and the Economy*, Supplement to the Economic Record, Economic Society of Australia, 82-88.

Granger, C.W.J. and Newbold, P., (1974), "Spurious Regressions in Econometrics", *Journal of Econometrics*, 2 (2), 111-20.

Gregory, R.G. and Martin, L.D., (1976), "An Analysis of the Relationship Between Import Flows to Australia and Recent Exchange Rate and Tariff Changes", *Economic Record*, 53, 1-25.

Gregory, R.G. and Marsden, J.S., (1979), "Comment on McFarlane's Paper", *Proceedings of the Conference in Applied Economic Research*, Reserve Bank of Australia, Sydney.

Hall, A.D., Jankovic, C. and Pitchford, J.D., (1989), "Australia's Import Elasticities and Measures of Competitiveness", Paper presented at the 18th Conference of Economists, University of Adelaide, July.

Hall, S.G., (1991), "The Effect of Varying Length VAR Models on the Maximum Likelihood Estimates of Cointegrating Vectors", *Scottish Journal of Political Economy*, 38 (4), 317-23.

Industries Assistance Commission (IAC), (1985), "Australian Trade Classified by Industry: 1968-69 to 1981-82", *Working Paper*, March.

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

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

Kakwani, N.C., (1962), "On the Bias in Estimating Import Demand Parameters", *International Economic Review*, 13 (2), 239-44.

Kemp, M.C., (1962), "Errors of Measurement and Bias in Estimation of Import Demand Parameters", *Economic Record*, 38, 369-72.

Khan, M.S. and Ross, K.Z., (1977), "The Functional Form of the Aggregate Import Demand Equation", *Journal of International Economics*, 7 (2), 149-60.

Krause, L.B., (1984), "Australia's Comparative Advantage in International Trade", in R.E. Caves and L.B. Krause (eds.), *The Australian Economy: A View from the North*, George Allen and Unwin, Sydney, 275-312.

Krugman, P.R., (1990), "Equilibrium Exchange Rates", in W.H. Branson, J.A. Frankel and M. Goldstein (eds.), *International Policy Coordination and Exchange Rate Fluctuations*, University of Chicago Press, Chicago, 159-91.

Lipsey, R.E., Molinari, L. and Kravis, I.B., (1991), "Measures of Prices and Price Competitiveness in International Trade in Manufactured Goods", in P. Hooper and J.D. Richardson (eds.), *International Economic Transactions: Issues in Measurement and Empirical Research*, University of Chicago Press, Chicago, 144-95.

Macfarlane, I.J., (1979), "The Balance of Payments in the 1970s" *Proceedings of the Conference in Applied Economic Research*, Reserve Bank of Australia, Sydney, 2-29.

Mackinnon, J.G., (1991), "Critical Values for Cointegration Tests" in R.F. Engle and C.W.J. Granger (eds.), *Long-run Economic Relationships: Readings in Cointegration*, Oxford: Oxford University Press.

Magee, S.P., (1975), "Price, Income and Foreign Trade", in P.B. Kenen (ed.), *International Trade and Finance: Frontiers for Research*, Cambridge University Press, Cambridge, 175-222.

Meer, A.J. and Heijdra, B.J., (1990), An Econometric Analysis of the Australian Current Account Balance", *Australian Economic Papers*, 29 (55), 199-225.

Menon, J., (1992), *Exchange Rates and Prices: The Case of Australian Manufactured Imports*, unpublished Doctoral Dissertation, Institute of Applied Economic and Social Research, University of Melbourne, Melbourne.

Orcutt, G., (1950), "Measurement of Price Elasticities in International Trade", *Review of Economics and Statistics*, 32, 117-32.

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

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

Sims, C.A., (1980), "Macroeconomics and Reality", *Econometrica*, 48, 1-48.

Stone, J.A., (1979), "Price Elasticities of Demand for Imports and Exports: Industry Estimates for the US, EEC and Japan", *Review of Economics and Statistics*, 61, 302-312.

Taylor, M.P., (1991), "Modelling the Demand for UK Broad Money, 1871-1913", *Review of Economics and Statistics*, forthcoming.

Wilkinson, J., (1992), "Explaining Australia's Imports: 1974-1989", *Economic Record*, 68 (201), 151-164.