PRICE AND ACTIVITY EFFECTS IN INTERNATIONAL TRADE: COINTEGRATION, AGGREGATION AND PRICES*

JAYANT MENON

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. It overcomes a number of limitations which have marred previous contributions to this literature. For the first time in the literature, we provide disaggregated import price and activity elasticities based on the Johansen FIML procedure for estimating cointegration vectors. Second, we employ actual import prices for a new disaggregated data set covering 29 import products. Third, we check for possible aggregation bias in the aggregate import demand function by computing a value-weighted aggregate elasticity adjusted by "distribution" factors. The results point to price elasticities that are generally lower, ranging from 0.24 to 1.75. We also find evidence of upward bias in the aggregate import function.

I. Introduction

There is perhaps no other topic in international economics that has been subject to as much empirical investigation as the behaviour of foreign trade flows. One of the main reasons for this interest is the relevance of the estimated price and activity elasticities in analysing the impact of macroeconomic policy on a host of economic variables. These include the impact of exchange rate policy on the trade balance, the severity of the extarnal balance constraint on domestic policy choices, and the international transmission mechanism.

Despite the enduring interest in this topic, the available studies are subject to a number of 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.[1] Given that the data used to estimate these elasticities are usually trended (see Section 2), 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. Although much has been written since Orcutt's (1950) celebrated paper on the inaccuracies and estimation bias infused into international trade elasticity estimates by the use of price proxies, studies based on actual prices are still sparse. As Shiells et al. (1986, p.506) put it, this is because "such data are not available systematically on a disaggregated basis for any appreciable length of time".

Third, there is still very little in the literature by the way of a systematic analysis of trade flows disaggregated at levels finer than the 1-digit Standard International Trade Classification (SITC) or 2-digit SIC (Standard Industrial Classification). The aggregated nature of most previous studies raises the possibility of "aggregation bias" in the reported elasticity estimates. This point is of particular importance since variation in prices of component categories are usually negatively correlated with individual elasticities (see Appendix A). Furthermore, if the disaggregation does not permit separate treatment of products subject to binding non-price restraints, then the estimated elasticities will be distorted [see Barker (1970)].

This study overcomes these limitations. For the first time in the literature, we estimate disaggregated import price and activity elasticities using the Johansen Full-Information Maximum Likelihood (FIML) procedure for estimating cointegration vectors. The concerns relating to data first raised by Orcutt (1950) and reiterated by Shiells et al. (1986) is overcome by employing actual import prices (as opposed to price proxies such as unit values) for a new disaggregated Australian data set covering 29 import product categories defined at the 2-digit level of the SITC recently made available by the Australian Bureau of Statistics (ABS). This level of disaggregation is also sufficiently fine to separate out quota-restricted items in the Australian data. To check for aggregation bias in the aggregate import demand function, we compute a value-weighted aggregate elasticity adjusted by "distribution" factors.

Japan is Australia's most significant trading partner. In the 1990's, almost a quarter of Australia's manufactured imports have come from Japan. The share of imports sourced from Japan in a number of important import categories such as electrical appliances and motor vehicles are particularly high. Japanese enterprises have often tested new exportable products in the smaller and relatively more familiar Australian market prior to launching products in North America and Western Europe [Garnaut (1990, p.74)]. For these reasons, the results from this study should also shed some light on the extent of the competition that Japanese exports face in third-country markets.

The paper is in five sections. Section 2 discusses the import function specification and salient features of the data base. Econometric issues are discussed in Section 3, while Section 4 analyses the results. The last section of the paper summaries the major findings.

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[1] Exceptions in the Australian context are Wilkinson (1992) and Athukorala and Menon (1995). Only Athukorala and Menon (1995) consider imports at a disaggregated (2-digit Australian Standard Industrial Classification) level, however.

II. *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[2].

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. Furthermore, the data show 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. Our estimating equation for the *i*th product category is then given by:

$$LMQ_{it} = c_i + \varepsilon_{(RP)_i} LRP_{it} + \varepsilon_{(AC)_i} LAC_{it} \tag{2}$$

where c_i is the constant term, $\varepsilon_{(RP)_i}$ and $\varepsilon_{(AC)_i}$ 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 SITC) 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 of Australia's 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; Goldstein and Khan, 1985). 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 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

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

markets.

Import unit value indexes 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 compositon 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 constuct 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.[3]

These inaccuracies could have biased elasticity estimates reported in previous studies. In this study, we use the new ABS import price index. This (fixed-weight) 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 most of the limitations of price proxies. As an 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 SITC basis.

III. *Econometric Issues*

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, and the Johansen test for cointegration in one variable. The results from these tests clearly indicate that almost all series are integrated processes of order 1, or are $I(1)$[4]. In light of this, we proceeded to check if the level variables are able to form a cointegrating vector. There are two main approaches to

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[3] See also Orcutt (1950) and Magee (1975, p.205).

[4] The MQ variable for cork and wood manufactures (SITC 63), textile yarn and fabrics (SITC 65), iron and steel (SITC 67) and manufactures of metal (SITC 69) were found to be stationary in levels at the 10 percent level of significance, while apparel and clothing accessories (SITC 84) and footwear (SITC 85) were found to be stationary at the 1 percent level. These tests results are presented in Menon (1993a), or are available directly from the author on request.

testing for cointegration. They are the Engle-Granger (1987) two-step procedure and the Johansen (1988) 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.[5] 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.[6]

IV. Results

The estimated import price and activity elasticities are presented in Table 1.[7] The relative price elasticity for total manufactured imports is 0.66, while the activity elasticity is 1.87. 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.[8] The majority (73 percent) of price elasticities are less than 1, while the rest lie between 1 and 2. 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. The highest price elasticity of 1.75 is recorded for footwear (SITC 85), although a number of the other quota-protected industries that have a high share of competitive imports (see Menon 1993a) also record relatively high price elasticities.

An interesting exception is road vehicles (SITC 78), which records a low price elasticity of -0.48. As mentioned earlier, a significant portion of imports within this category (about 90 percent of motor vehicle imports) are sourced from Japan. There are two possible reasons for this finding. First, relative price increases brought about by the massive Australian dollar

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[5] The modification to the two-step procedure suggested by Phillips and Hansen (1990) overcomes this problem. The Phillips-Hansen fully-modified OLS procedure filters the data using a non-parametric correction for endogeniety and serial correlation, and takes short-run dynamics into account in estimating the cointegrating vector. However, unlike the Johansen procedure, it still fails when there is more than one cointegrating vector linking the variables together. For a practitioner's guide to recent advances in time-series econometrics, see Menon (1993b).

[6] Details of the Johansen FIML procedure are provided in Menon (1993a).

[7] The results of the Johansen cointegration tests are reported in Menon (1993a).

[8] We found that the activity elasticities were not sensitive to the choice of our measure of activity. For instance, the elasticities remained relatively unchanged when real GDP was used as the measure of activity for all import product categories.

TABLE 1. IMPORT PRICE AND ACTIVITY ELASTICITIES

SITC		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

depreciation in the mid-1980s, particularly against the Japanese yen, was substantial enough to push import levels below quota limits. In 1986, for instance, all available pool quota for motor vehicle imports was not cleared by tender (Industries Assistance Commission, 1986, pp.45-6). Second, despite relative price increases pushing imports below quota limits, the extent to which exchange rate changes were transmittted or "passed-through" to import prices of motor vehicles in the Australian market were less than complete (see Menon 1993c). Athukorala and Menon (1994) find evidence of substantial pricing to market behaviour in Japanese exports of motor vehicles, which maintained the relative competitiveness of Japanese exports in the face of the massive yen appreciation in the second half of the 1980s.

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 2, 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.

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 dis-aggregated price changes and elasticities is lost when the two are aggregated separately and then multiplied together.

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

$$\varepsilon_{(RP)} = \Sigma_i \varepsilon_{(RP)i}(MQ_i/MQ)\Omega_{(RP)i} \tag{3}$$

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 factors for each of the product categories presented in Table 2 (Column 5) clearly indicate that the value-weighted elasticity is in error. In particular, the distribution factors appear to be strongly negatively correlated with the price elasticities. For example, the lowest distribution factor of 0.53 is recorded for footwear (SITC 85), which is the most price elastic product in our sample. The aggregate weighted elasticity obtained after adjusting for the distribution factors 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.

With respect to the activity elasticities, we find that the majority of the estimates lie between 1 and 2. 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".[9] 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 between the 2 to 2.5 mark.

We tested the homotheticity assumption of unit activity elasticity using the Likelihood Ratio (LR) 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

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[9] A recent paper by Feenstra (1994) argues that high income elasticities reported in studies on US imports may be a result of omitting new product varieties from the import price index. While correcting for this omission tends to reduce the size of the income elasticities, they remain greater than one.

TABLE 2.   IMPORT WEIGHTS, DISTRIBUTION FACTORS AND RELATIVE
PRICE ELASTICITIES

SITC		LRP_i	ϕ_i[1]	$\phi_{(RP)i}$[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 products	-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
Menon, 1993a, 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) $\phi_{(RP)i} = LRP_i \cdot \phi_i$

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

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

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

price elasticity within the restricted equation are presented in Table 3[10].

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 elasticity estimates of 16 such

TABLE 3. LIKELIHOOD RATIO (LR) TEST RESULTS OF UNIT ACTIVITY ELASTICITY
HYPOTHESIS AND PRICE ELASTICITIES FROM THE RESTRICTED EQUATION

SITC		*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
hypothesesis is 7.88.

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 quantitative restrictions 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)[11]. 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.

V. *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 1992 Q2. We estimated import demand functions using actual import prices which covered total manufactured imports and 29 import product categories defined at the 2-digit level of the SITC. For the first time in the literature, we provide disaggregated price and activity elasticities employing the Johansen FIML procedure for estimating cointegration vectors. 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

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[10] Athukorala and Menon (1995) find that the homotheticity assumption of unit activity elasticity is accepted for 7 out of the 9 2-digit ISIC 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.

[11] For instance, this share declined from 47 percent in 1975-77 to 37 percent in 1980-82.

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 quantitative restrictions. The weighted price elasticity corrected for the distribution factors was 0.60, as compared with the elasticity of 0.66 from the aggregate import function, 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. The homotheticity assumption of unit activity elasticity was accepted for only ten product categories within our sample.

MONASH UNIVERSITY, AUSTRALIA

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:

$$LMQ = \varepsilon_{RP} LRP + \varepsilon_{AC} LAC \tag{1}$$

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:

$$LMQ_i = \varepsilon_{(RP)i} LRP_i + \varepsilon_{(AC)i} LAC_i \tag{2}$$

where $\varepsilon_{(RP)i}$ and $\varepsilon_{(AC)i}$ are the relevant component price and activity elasticities.
From the aggregate equation, we can show that the change in (aggregate) imports is:

$$(\Delta MQ/MQ) = \varepsilon_{RP} (\Delta RP/RP) + \varepsilon_{AC} (\Delta AC/AC) \tag{3}$$

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

$$
\begin{aligned}
(\Delta MQ/MQ) &= \Sigma (\Delta MQ_i/MQ) \\
&= \Sigma \varepsilon_{(RP)i} (\Delta RP_i/RP_i)(MQ_i/MQ) + \Sigma \varepsilon_{(AC)i} (\Delta AC_i/AC_i)(MQ_i/MQ)
\end{aligned}
\tag{4}
$$

For the results in (13) to be compatible with (14), 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:

$$\varepsilon_{RP} (\Delta RP/RP) = \Sigma \varepsilon_{(RP)i} (\Delta RP_i/RP_i)(MQ_i/MQ) \tag{5}$$

and

$$\varepsilon_{AC} (\Delta AC/AC) = \Sigma \varepsilon_{(AC)i} (\Delta AC_i/AC_i)(MQ_i/MQ) \tag{6}$$

From equations (15) and (16) above, we can write the total elasticity that will be consistent with the disaggregate data as:

$$\varepsilon_{RP} = \Sigma \varepsilon_{(RP)i}(MQ_i/MQ)\{(\varDelta RP_i/RP_i)/(\varDelta RP/RP)\} \qquad (7)$$
$$\varepsilon_{AC} = \Sigma \varepsilon_{(AC)i}(MQ_i/MQ)\{(\varDelta AC_i/AC_i)/(\varDelta AC/AC)\}$$

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

$$LRP_i = c_i + \Omega_{(RP)i}LRP \qquad (8)$$

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 IC (1988-1992) *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:

SITC 51	Organic chemicals
SITC 52	Inorganic chemicals
SITC 53	Dyeing, tanning materials
SITC 54	Medicinal and pharmaceutical products
SITC 55	Essential oils, perfumes etc.
SITC 58	Artificial resins, plastics etc.
SITC 59	Chemical materials and products
SITC 61	Leather, leather manufactures
SITC 62	Rubber manufactures
SITC 63	Cork and wood manufactures
SITC 64	Paper, articles of pulp paper
SITC 65	Textile yarn, fabrics
SITC 66	Non-metallic mineral manufactures
SITC 67	Iron and steel
SITC 69	Manufactures of metal
SITC 81	Sanitary, heating equipment
SITC 82	Furniture and parts thereof
SITC 87	Professional, scientific equipment
SITC 88	Photographic, optical goods
SITC 89	Miscellaneous manufactures

Gross Fixed Capital Formation:

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

Gross Fixed Capital Formation plus Private Expenditure on Motor Vehicles:

SITC 78   Road vehicles

Private Consumption of Clothing, Footwear and Drapery:

SITC 84   Apparel, clothing accessories
SITC 85   Footwear

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