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MODELLING MANUFACTURED IMPORTS: METHODOLOGICAL ISSUES WITH EVIDENCE FROM AUSTRALIA

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ABSTRACT

This paper investigates the relationship between manufactured import flows to Australia, and relative prices and domestic economic activity net of cyclical demand effects over the period 1981Q3 to 1991Q2. This is done through the estimation of import demand functions for total manufactured imports and nine major import categories using the general to specific modeling approach. We find that the homotheticity assumption on activity elasticity is met in most cases. The price elasticity estimates for individual categories range from 0.32 to 2.1, with a weighted-average of 0.52. We also find some evidence of upward bias in price elasticity estimates when an aggregate import function is employed in a context where a significant portion of imports are subject to quantitative restrictions (QRs).

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Modeling Manufactured Imports: Methodological Issues with Evidence from Australia*

by

Premachandra Athukorala and *Jayant Menon*

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 nine major import categories. The methodological issues considered include the choice of appropriate dynamic formulation of the import functions, the need for explicit treatment of cyclical demand effects in order to delineate pure activity effects, and the potential for aggregation bias in import price elasticity estimates in the presence of binding quantitative restrictions (QRs). Previous Australian studies (Gordon, 1986) as well as most studies for other OECD countries (Goldstein and Khan, 1985) have estimated activity elasticities at around 2 or higher. Our conjecture is that these high activity elasticity estimates may reflect the failure to appropriately allow for cyclical demand effects.

2. Model, Data and Method of Estimation

The general form of our import demand function is,

$$MQ_t = f(RP_t, AC_t, SS_t) \qquad (1)$$

$$f_1 \leq 0, \; f_2 \geq 0, \; f_3 \geq 0$$

where, MQ = real imports, RP = relative price derived by dividing the tariff augmented import price by the price of the domestic-competing commodity (DP), AC = a measure of related domestic economic activity, and SS = ratio of stocks

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(at period end) to average sales volume as a measure of the general scarcity of domestic supplies. The relative price and activity variables will identify pure demand effects on imports. The inventory-sales ratio is used as a control variable to capture any cyclical demand effect. The signs indicated for the partial derivatives are those customarily assumed in the literature (Goldstein and Khan, 1985).

It is necessary to allow for adjustment lags in implementing equation (1). In the existing literature on trade flow modeling, this has commonly been done by superimposing a predetermined lag structure, mostly the partial adjustment specification and, in a few cases, the Almon polynomial method (Goldstein and Khan, 1985). The problem with this approach is that the estimates may be subject to misspecification bias due to the (arbitrary) truncation of the lag structure. Moreover, these specifications, by their very nature, entail the use of variables in levels only. Given that time series data for most of the variables tend to be non-stationary, there is the potential danger of capturing spurious relations (Harvey, 1990).

In the light of recent advances in time-series econometrics, we began the estimation process by testing the time-series properties of the data using Dickey-Fuller and Phillips-Perron procedures.[2] The test results indicated that MQ, RP and AC are non-stationary processes of order 1 (or $I(1)$) in all cases. Guided by this finding, we tested for long-run equilibrium relations between these variables using the Engle-Granger and Johansen cointegration methods, but failed to find evidence of such a relationship in all cases. In theory, in the absence of cointegrating relationships between non-stationary series, the ideal choice is to model in differences of the variables. However, in small samples the bias in the cointegration tests can be substantial because the long-run or low-frequency properties of the data may only be dimly reflected (Harvey, 1990, p.256). Therefore, we were reluctant to simply ignore the long-run relations embodied in level variables. Our preferred strategy was to employ the general to specific modeling procedure which minimises the possibility of estimating spurious relationships while retaining long-run information.

(2) Results are available from the authors on request.

The autoregressive distributed lag representation of equation (1) which constitutes the "maintained hypothesis" of our specification search is:

$$mq_t = \delta + \sum_{j=0}^{n} [\alpha_j mq_{t-1-j} + \beta_j rp_{t-1-j} + \theta_j ac_{t-1-j} + \varepsilon_j ss_{t-1-j}] + \mu \quad (2)$$

where δ is the constant, μ is the error term and variable names in lower-case letters are measured in natural logarithms. The modeling strategy is to first estimate this unrestricted equation and then progressively simplify it by restricting statistically insignificant coefficients to zero and reformulating the lag patterns in terms of levels and differences to achieve orthogonality. The main advantage of this approach it that it provides for estimating lag effects without arbitrarily constraining the lag structure at the outset. Since we use seasonally unadjusted data, the length of the lags (n) is set at four periods. The chosen lag structure itself is usually expected to allow for seasonality in data series. However, if the dependent variable tends to exhibit persistent seasonal behaviour, seasonal effects may still be present (Harvey, 1990, p.266). On these grounds, quarterly dummies were added to the model.

The analysis covers "non-food non-oil manufactured imports" defined as goods classified to the Manufacturing Division (3) of the Australian Standard Industrial Classification (ASIC) less food, beverages and tobacco (ASIC 21) and petroleum products (ASIC 277 and 278). Import functions are estimated for total manufactures as well as for 9 subdivisions (2-digit items) included therein for the period 1981Q3 to 1991Q2. In this study we use, for the first time, the new Australian Bureau of Statistics (ABS) import price index. This index measures changes in prices of imports using prices of individual shipments obtained directly from importers, and is therefore free from the limitations of price proxies (see Lipsey *et al.*, 1991). The data sources are listed in the appendix.

3. Results

The final parsimonious import demand functions, together with a set of commonly used diagnostic statistics, are reported in Table 1. All regressions perform well in terms of these tests. The long-run price and activity elasticities derived from the estimated import functions are summarised in Table 2. The relative share in total sample imports and the share of competitive imports (i.e., the share of imports which directly compete with local products) are also reported in order to place the elasticity estimates in perspective. The competitive import shares are of particular relevance because the predominance of non-competitive imports in the Australian import structure has often been used to infer *a priori* low price elasticities (Gordon, 1986).

The long-run price elasticity estimates for clothing and footwear is not statistically different from zero. The coefficients for the remaining eight categories vary in the range 0.37 to 2.10, with the figure for total imports occupying a mid-way position (0.67). The result for clothing and footwear imports is not surprising when considering that competitive price-quantity relationship would have been distorted by the presence of binding QRs. The relatively low price elasticity for paper and paper product, non-metallic minerals and machinery is consistent with the nature of their commodity composition. The overwhelming share of imports in these categories are inputs to domestic production for which there are no close domestic substitutes. Thus, our results lend support to the Australian practice of making inferences as to the degree of price elasticity of imports on the basis of tariff-based "competitive/non-competitive" commodity disaggregation.

Table 1
Final Parsimonious Equations for Import Demand

(1) Textiles (ASIC 23)

$$\Delta_4 mq_t = \underset{(3.82)^{***}}{7.03} - \underset{(1.63)^{*}}{0.51\Delta_2 rp_t} + \underset{(1.29)}{0.25\Delta_4 ac_t} - \underset{(-4.58)^{***}}{0.97 mq_{t-4}}$$
$$- \underset{(2.91)^{***}}{0.62 rp_{t-2}} - \underset{(2.74)^{***}}{0.33 ac_{t-4}} - \underset{(-1.00)}{0.28 ss_{t-4}} + \underset{(2.69)^{**}}{0.30\Delta_4 mq_{t-1}}$$

R^2 = 0.79, SER = 0.08, F(10,24) = 9.26, FSP(10,12) = 0.97, DW = 1.53, LM4(4,20) = 1.64, RESET(1,23) = 2.70, JBN(2) = 1.60, HC(1,33) = 0.01, CHOW(11,13) = 2.27, PF(14,10) = 2.14

(2) Clothing and footwear (ASIC 24)

$$\Delta_4 mq_t = \underset{(2.70)^{***}}{4.23} - \underset{(-1.00)}{0.17 rp_{t-4}} - \underset{(-2.93)^{***}}{0.79 ss_{t-4}} - \underset{(-6.07)^{***}}{0.53(mq\text{-}ac)_{t-4}}$$
$$+ \underset{(1.97)^{*}}{0.23\Delta_4 mq_{t-1}}$$

R^2 = 0.70, SER = 0.08, F(7,27) = 8.93, FSP(12,12) = 1.36, DW = 1.94, LM4(4,23) = 0.33, RESET(1,24) = 0.04, JBN(2) = 0.89, HC(1,33) = 0.01, CHOW(8,19) = 0.78, PF(14,13) = 0.41

(3) Paper, paper products, printing and publishing (ASIC 26)

$$\Delta_4 mq_t = \underset{(1.55)}{1.74} - \underset{(-0.93)}{0.50\Delta rp_t} - \underset{(1.61)^{*}}{0.39 rp_{t-3}} - \underset{(-4.35)^{***}}{0.99(mq\text{-}ac)_{t-4}}$$
$$+ \underset{(3.34)^{***}}{0.52\Delta_4 mq_{t-1}}$$

R^2 = 0.56, SER = 0.07, F(7,27) = 5.00, FSP(11,12) = 2.38, DW = 1.51, LM4(4,23) = 0.83, RESET(1,26) = 0.11, JBN(2) = 1.02, HC(1,33) = 0.94, CHOW(9,19) = 0.95, PF(9,13) = 2.34

(4) Chemical products (ASIC 27 excluding petroleum products)

$$\Delta_4 mq_t = \underset{(2.67)^{**}}{9.94} - \underset{(-2.32)^{**}}{0.83\Delta rp_t} - \underset{(1.80)^{*}}{0.68\Delta_4 ac_t} - \underset{(-3.95)^{***}}{0.66 mq_{t-4}}$$
$$- \underset{(-3.98)^{***}}{1.39 rp_{t-2}} + \underset{(1.87)^{*}}{1.03 ac_{t-4}} - \underset{(3.05)^{***}}{1.16 ss_{t-3}}$$

R^2 = 0.70, SER = 0.08, F(10,25) = 5.79, FSP(10,12) = 1.07, DW = 1.36, LM4(4,21) = 0.66, RESET(1,24) = 1.33, JBN(2) = 0.45, HC(1,34) = 0.01, CHOW(11,14) = 0.79, PF(14,11) = 0.56

Table 1 (Cont.)

(5) Non-metallic mineral products (ASIC 28)

$$\Delta_4 mq_t = \underset{(3.39)^{***}}{3.15} - \underset{(-1.61)^{*}}{0.25\Delta_2 rp_t} - \underset{(-3.28)^{***}}{0.87\Delta_4 ss_t} - \underset{(-2.82)^{***}}{0.86 rp_{t-3}}$$

$$- \underset{(-3.48)^{***}}{0.70 ss_{t-3}} - \underset{(-4.76)^{***}}{0.79(mq\text{-}ac)_{t-4}} + \underset{(6.03)^{***}}{0.49\Delta_4 mq_{t-1}}$$

$R^2 = 0.93$, SER = 0.06, F(9,25) = 36.97, FSP(10, 12) = 0.70, DW = 1.64, LM4(4,21) = 0.89, RESET(1,24) = 1.57, JBN(2) = 2.79, HC(1,33) = 0.59, CHOW(10,15) = 0.41, PF(14,10) = 1.01

(6) Basic metal products (ASIC 29)

$$\Delta_4 mq_t = \underset{(4.43)^{***}}{6.23} - \underset{(-2.00)^{*}}{0.62\Delta_2 rp_t} + \underset{(3.70)^{***}}{0.59\Delta_4 ac_t} - \underset{(-3.56)^{***}}{0.84 rp_{t-2}}$$

$$- \underset{(-4.26)^{***}}{0.50 ss_{t-3}} - \underset{(-4.67)^{***}}{0.88(mq\text{-}ac)_{t-4}} + \underset{(1.50)}{0.16\Delta_4 mq_{t-1}}$$

$R^2 = 0.86$, SER = 0.09, F(9,25) = 17.68, FSP(6,15) = 0.43, DW = 1.39, LM4(4,21) = 1.97, RESET(1,24) = 0.45, JBN(2) = 0.48, HC(1,33) = 1.57, CHOW(10,15) = 1.48, PF(14,11) = 2.69

(7) Fabricated metal products (ASIC 31)

$$\Delta_4 mq_t = \underset{(2.62)^{**}}{2.40} - \underset{(-1.12)}{0.31\Delta_2 rp_t} + \underset{(4.51)^{***}}{0.87\Delta_3 ac_t} - \underset{(-1.95)^{*}}{0.39 rp_{t-2}}$$

$$- \underset{(-2.28)^{**}}{0.61 ss_{t-4}} - \underset{(-5.75)^{***}}{0.99(mq\text{-}ac)_{t-4}} + \underset{(2.64)^{**}}{0.24\Delta_4 mq_{t-1}}$$

$R^2 = 0.86$, SER = 0.09, F(7,25) = 21.05, FSP(11,12) = 0.65, DW = 2.32, LM4(4,21) = 0.60, RESET(1,24) = 0.28, JBN(2) = 3.46, HC(1,33) = 0.03, CHOW(14,10) = 1.53, PF(11,13) = 1.80

(8) Transport equipment (ASIC 32)

$$\Delta_4 mq_t = \underset{(3.56)^{***}}{4.83} + \underset{(3.31)^{***}}{0.92\Delta_4 ac_t} - \underset{(-1.19)}{0.003\Delta_4 ss_t} - \underset{(-3.58)^{***}}{1.07 rp_{t-4}}$$

$$- \underset{(-5.07)^{***}}{0.84(mq\text{-}ac)_{t-4}} + \underset{(3.54)^{***}}{0.35\Delta_4 mq_{t-1}}$$

$R^2 = 0.86$, SER = 0.09, F(8,26) = 19.38, FSP(10,13) = 1.72, DW = 1.76, LM4(4,22) = 2.40, RESET(1,25) = 1.11, JBN(2) = 0.28, HC(1,33) = 1.40, CHOW(9,17) = 1.39, PF(14,12) = 1.82

Table 1 (Cont.)

(9) Machinery and equipment (ASIC 33)

$$\Delta_4 mq_t = \underset{(2.11)^{**}}{1.14} + \underset{(6.69)^{***}}{0.76\Delta_4 ac_t} - \underset{(-2.14)^{**}}{0.28\Delta ss_{t-3}} - \underset{(-2.19)^{**}}{0.26rp_{t-4}}$$

$$- \underset{(-4.83)^{***}}{0.70(mq-ac)_{t-4}} + \underset{(4.09)^{***}}{0.33\Delta_4 mq_{t-1}}$$

R^2 = 0.91, SER = 0.05, F(8,26) = 34.39, FSP(10,13) = 1.49, DW = 1.79, LM4(4,22) = 0.99, RESET(1,25) = 0.99, JBN(2) = 2.07, HC(1,33) = 0.02, CHOW(7,17) = 2.30, PF(14,12) = 1.54

(10) Total manufacturing

$$\Delta_4 mq_t = \underset{(5.06)^{***}}{6.72} + \underset{(1.03)}{0.88\Delta ac_{t-3}} - \underset{(-3.80)^{***}}{0.56rp_{t-4}} - \underset{(-5.26)^{***}}{0.92ss_t}$$

$$- \underset{(-8.13)^{***}}{0.93(mq-ac)_{t-4}} + \underset{(4.50)^{***}}{0.39\Delta_4 mq_{t-1}}$$

R_2 = 0.91, SER = 0.06, F(8,26) = 31.04, FSP(10,12) = 0.45, DW = 2.26, LM4(4,22) = 0.64, RESET(1,25) = 0.06, JBN(2) = 0.55, HC(1,33) = 0.02, CHOW(14,12) = 0.94, PF(9,17) = 0.65

Notes:
Figures in parentheses below coefficient estimates denote t-ratios, with the significance levels denoted as; *** = 1%, ** = 5%, * = 10%. FSP = F-test for the validity of the restrictions in the reported equations relative to the Equation 2 (the maintained hypothesis); LM4 = Lagrange multiplier test for first and fourth order serial correlation; RESET = Ramsey's test for functional form misspecification using the square of the fitted values; JBN = Jarque-Bera test for the normality of residuals; HC= Engle's autoregressive conditional heteroscedasticity test of residuals; CHOW = Chow test of stability of the regression coefficients; PF = A test of adequacy of predictions (Chow's second test). CHOW and PF were calculated by rerunning the regressions for the subperiod 1981Q3 - 1987Q4 and using the remaining twelve observations for the purpose of these tests. For each test statistic, the degrees of freedom is indicated in parentheses. All test statistics except JBN relate to the F-distribution. JBN is based on the chi-square distribution.

Table 2
Estimates of Long-run Price and Activity Elasticities of Import Demand and Related Data

ASIC	Industry	Sample import share[1] (%) (1985-87)	Competitive imports (%) (1985-86)	Long-run price elasticity[2]	Long-run activity elasticity[2]	F^3
23	Textiles	6.6	39.0	0.64 (3.70)***	0.34 (4.13)***	20.40***
24	Clothing and footwear	3.1	89.4	0.32 (1.02)	1.00 (6.07)***	2.09
26	Paper, paper products	5.8	23.5	0.39 (1.52)*	1.00 (4.35)***	1.67
27	Chemicals	4.7	12.3	2.10 (2.62)**	1.56 (3.00)***	5.27***
28	Non-metallic minerals	1.8	56.5	0.43 (3.14)***	1.00 (4.76)***	0.05
29	Basic metal products	3.6	41.7	0.95 (3.53)***	1.00 (4.16)***	0.25
31	Fabricated metal products	3.1	61.2	0.39 (1.94)**	1.00 (5.74)***	0.17
32	Transport equipment	17.2	43.6	1.27 (4.28)***	1.00 (5.07)***	1.78
33	Other machinery	45.3	31.9	0.37 (2.04)**	1.00 (4.82)***	2.31
-	Total manufacturing	100	38.3	0.60 (4.54)***	1.00 (8.13)***	2.31

Notes:
1) The difference between the sum of individual shares and the total represents miscellaneous manufactures (8.4 percent).
2) The t-ratios are reported in parentheses with the significance levels denoted as; *** = 1%, ** = 5%, * = 10%.
3) The F ratio for the joint test of unit restriction on the activity elasticity.
Source: Columns 1 and 2: Industries Assistance Commission, *Australian Trade Classified by Industry: 1968/69 - 1981/82*, Working Paper, March 1985; Columns 3 and 4: Table 1.

Interestingly, demand for transport equipment is price elastic despite 20-25 percent of imports being subject to QRs during most of the period under study. This is, however, not surprising because relative price increases brought about by the massive Australian dollar depreciation in the mid-1980s pushed import levels below quota limits. Moreover, possibilities for the substitution of domestic supplies for imports, as measured by the competitive import share, is higher than for many other commodities (Table 2). The considerable variation in price elasticities across commodity categories raises the possibility of bias in the price elasticity estimate obtained from the aggregate import function. To shed light on this issue, we estimated a weighted-average price elasticity (using average import weights for 1981-87). This estimate is 0.52, as compared with the elasticity of 0.60 given by the aggregate function. This suggests some upward aggregation bias.[3]

The homotheticity assumption on the activity elasticity is met for seven commodity categories (which account for about 70 percent of total sample imports) as well as for total manufactured imports (Table 2, Column 4). This finding is in line with *a priori* theoretical expectations, and vindicates the use of Armington elasticities in applied general equilibrium models (see Dixon *et al.*, 1992).

As regards import demand dynamics, a comparison of long-run price and activity elasticities (Table 2) with respective short-run elasticities (coefficients attached to the difference terms in Table 1) suggests that most of the relative price and activity

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(3) Since our import-demand functions are log linear, the aggregate elasticity, derived simply as import-value weighted average of individual elasticities, would involve a bias. The appropriate procedure, as suggested by Magee (1975, pp.235-39) is to apply the formula:

$$\epsilon \quad = \quad \Sigma e_i \, (M_i/M) \beta_i \qquad (1)$$

where ϵ is the weighted price elasticity for total imports; e the individual price elasticity of commodity i; M_i the individual value of imports; M the total value of imports, and β the "distribution elasticity" or the ratio of percentage change in the price of a given commodity category (P_i) to that of total imports (P) obtained from the time series regression:

$$\log P_i \quad = \quad \alpha + \beta \log P + \mu \qquad (2)$$

where α is the constant term and μ is the stochastic error term.

Note that for proportional price changes, the distribution elasticities (β) is equal to 1, and equation (1) is reduced to a simple value-weighted sum of the individual elasticities. Menon (1993) corrects for these distribution effects using data at the 2-digit level of the Australian Import Commodity Classification.

adjustments take place within a one-year period. However, the activity effect seems to work much more quickly than the price effect. This finding is in line with most previous work for other developed countries (Goldstein and Khan, 1985).

5. Concluding Remarks

This paper reports estimates of aggregate and disaggregate demand functions for Australian manufactured imports. The results suggest that the dominance of non-competitive commodities in the import mix makes demand for manufactures generally price inelastic. With respect to methodology, the results highlight the importance of allowing for cyclical demand effects in order to obtain meaningful activity elasticity estimates. There is also evidence of some bias in price elasticity estimates based on an aggregate import function when a significant portion of imports are subject to QRs.

DATA APPENDIX

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 (6414.0), *Import Price Index*, (quarterly).
Domestic (producer) prices: ABS (6412.0), *Price Index for Articles Produced by Manufacturing Industry*, (monthly).
Stock-sales ratios: ABS (5629.0) *Stocks and Manufacturers' Sales*, (quarterly).
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).

Activity Variables in Import Demand Functions

Equation	Activity Variable
(1) Textiles	Private consumption of clothing, footwear and drapery
(2) Clothing and footwear	Private consumption of clothing, footwear and drapery
(3) Paper, paper products	GDP
(4) Chemical products	GDP
(5) Non-metallic minerals	GDP
(6) Basic metal products	Gross fixed capital formation
(7) Fabricated metal products	Gross fixed capital formation
(8) Transport equipment	Gross fixed capital formation plus private expenditure on motor vehicles
(9) Other machinery, equipment	Gross fixed capital formation plus private expenditure on household appliances
(10) Total manufacturing	GDP

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