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Trade Agreements and Trade Opportunities: A Flexible Approach for Modeling Australian Export and Import Elasticities

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Abstract

Patterns of trade have changed enormously over the last 30 years, particularly due to the economic emergence of several Asian countries. With the increasing international tendency for bilateral preferential trade agreements, it is important for countries to be aware of trade substitution possibilities. This paper estimates import and export price elasticities for Australia and its major trading partners in Europe and Asia, 1958 to 2002, using a fully flexible version of the Symmetric Normalized Quadratic aggregator function. Imports and exports are disaggregated into six regions, covering 17 countries. Our results illuminate the (changing) substitution and complementarity patterns for Australian foreign trade, highlighting trading opportunities in the face of a changing international environment.

1. Introduction

This paper models Australian demand for imports and supply of exports by regions of origin and destination. Examination of the substitution and complementarity possibilities for Australian foreign trade can help to shape foreign-trade policy in light of increasing European economic integration, the rapid development of the Asian economies and the growing trend for regional trade agreements. These changes may lead to trade diversion, barriers to trade, and new opportunities for importers and exporters.

Estimates of Australia's import and export elasticities for the period 1958 to 2002 are provided. This was a period of great change in Australian trade, particularly influenced by the "loss" of traditional European markets through preferential trading agreements as part of European integration, and the growth in trading opportunities in Asia. An examination of Australia's historical trade elasticities is very timely. While showing how trading opportunities have changed over time, it also gives insights into the possible impact on trade patterns of the recent Australia–US Free Trade Agreement; see e.g. Findlay (2002) and Garnaut (2002) for information and debate on the economic, legal, and political aspects of this trade agreement. In addition, the elasticities provide some guidance as to the likely directions of trade diversion when faced with increased international protectionism, such as from regional trade agreements or technical trade barriers to trade such as quarantine; see e.g. Krueger (1999) for some of the possible

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consequences of preferential trading agreements on trade patterns, and Hooker and Caswell (1999) on the use of quarantine arrangements as a barrier to trade.

We model import demand and export supply through a two-stage optimization model, with the focus on the first stage of the profit-maximization problem faced by importers and exporters, where they choose the optimal aggregate import and export levels, respectively. The theoretical model is implemented using a fully flexible version of the Symmetric Normalized Quadratic aggregator function proposed by Diewert and Wales (1987). Specifically, this is used to model the trade pattern between Australia, Europe, and Asia from 1958 through 2002. This approach allows the estimated elasticities of substitution for both imports and exports to vary between pairs of countries and over time. In addition, the system-of-equations estimation approach helps to exploit more information than would a single-equation estimation technique.

Some key results are as follows. Complementarity relationships are found in imports from, and exports to, Japan and Korea plus Hong Kong, which indicates that cooperation between these countries could strengthen their trading positions relative to Australia. New Zealand was found to be a potential candidate to replace the Asian countries as a source for Australian imports and North America as an outlet for its exports. Exports to Europe were found to be complements of those to North America, while imports from these regions were found to be substitutes.

2. Theoretical Framework

Following Kohli (1978, 1991) and Woodland (1982), we model imports as inputs and exports as outputs, where we have a large number of profit-maximizing firms. The firms determine their mix of inputs and outputs given prices and the available technology. Under constant returns to scale, the competitive equilibrium is then the solution to maximizing GNP subject to factor endowments for given output and variable input prices. The demand for imports and supply of exports are modeled as the result of a two-stage profit-maximization process. In the first stage, importers determine the optimum import mix by minimizing the cost of obtaining a certain quantity of aggregate imports, given import prices. Simultaneously, exporters choose their export mix by maximizing export revenues given export prices. The second stage involves the simultaneous optimization of the use of aggregate imports and exports by firms that maximize profits for given input and output prices, and their technologies; see e.g. Kohli (1978) and Lawrence (1989). The focus of this paper is on the first stage.

Following Kohli (1994), the import model assumes imports from $j = 1, \ldots, J$ different regions. The import aggregator function is defined as $y_M = f(x_M)$, for an aggregate import vector of $x_M \equiv [x_{M_j}]$ and an import price vector of $w_M \equiv [w_{M_j}]$. The aggregator function $f(\cdot)$ is an increasing, linearly homogeneous and concave function. The import aggregation technology can be described by the import cost function under the assumption of cost minimization:

$$C(y_M, w_M) \equiv \min_{x_M} \left\{ \sum_j w_{M_j} x_{M_j} : f(x_M) \geq y_M \right\}. \tag{1}$$

The cost function is linear homogeneous in import prices and the quantity of aggregate imports, which allows it to be rewritten as:

$$C(y_M, w_M) = c(w_M) y_M, \tag{2}$$

where $c(\cdot)$ is the unit cost function that equals p_M, the price of aggregate imports, under perfect competition.

By Shephard's lemma, the demand for import component j may be derived by differentiation, as follows:

$$x_{M_j} = \frac{\partial C(y_M, w_M)}{\partial w_{M_j}} = y_M \frac{\partial c(w_M)}{\partial w_{M_j}}. \tag{3}$$

Hence, the demand for import component j is conditional on the level of aggregate imports, y_M. Partial price elasticities of demand can then be obtained by differentiating the natural logarithm of equation (3) with respect to the logarithms of the input prices:

$$\xi_{jk} \equiv \frac{\partial \ln x_{M_j}(y_M, w_M)}{\partial \ln w_{M_k}}. \tag{4}$$

If two countries' imports are complements in the Allen–Uzawa sense, $\xi_{jk} < 0$; if the imports are substitutes, $\xi_{jk} > 0$. The price-homogeneity assumption of the cost function implies that for each country the partial price elasticities sum to zero:

$$\sum_k \xi_{jk} = 0. \tag{5}$$

These are partial elasticities, so they are conditional on the level of total imports (Kohli, 1994, fn. 5, p. 584).[1]

The export model assumes there are $i = 1, \ldots, I$ types of exports with vectors of export quantities and prices denoted $y_X \equiv [y_{X_i}]$ and $p_X \equiv [p_{X_i}]$, respectively. The export aggregator function is defined as $x_X = h(y_X)$, which is an increasing, linearly homogeneous and convex function. The export aggregation technology is described by the revenue function under the assumption of revenue maximization:

$$R(p_X, x_X) \equiv \max_{y_x} \left\{ \sum_i p_{X_i} y_{X_i} : h(y_X) \le x_X \right\}. \tag{6}$$

This is linearly homogeneous and convex in export prices and linearly homogeneous in the quantity of aggregate exports. The revenue function can then be rewritten as $r(p_x)x_x$, where $r(\cdot)$ is the unit revenue function that equals w_X, the price of aggregate exports, under perfect competition. By Hotelling's lemma, the supply of export component i can be derived by differentiating equation (6) with respect to the respective export prices:

$$y_{X_i} = \frac{\partial R(p_X, x_X)}{\partial p_{X_i}} = x_X \frac{\partial r(p_X)}{\partial p_{X_i}}. \tag{7}$$

Equation (7) implies that the supply of export component i is conditional on the level of aggregate exports, x_X. As above, partial price elasticities of exports (conditional on total exports) can be obtained from the following equation:

$$\psi_{ih} \equiv \frac{\partial \ln y_{X_i}(p_X, x_X)}{\partial \ln p_{X_h}}. \tag{8}$$

If two countries' exports are complements, $\psi_{ih} > 0$; if the exports are substitutes, $\psi_{ih} < 0$. As with the adding-up constraint in the import context in equation (5), the price-homogeneity assumption of the revenue function implies that for each country, these partial price elasticities sum to zero.

3. Functional Form for Import Cost and Export Revenue Functions

The Symmetric Normalized Quadratic (SNQ) functional form is used to approximate the import and export price aggregator functions (Diewert and Wales, 1987; Kohli, 1991, 1994). This functional form is "flexible" in the sense that it can at least provide a local second-order approximation to an arbitrary (true) twice-differentiable continuous function at a point. That is, flexible functional forms allow the approximation of quite general technologies relative to more restrictive traditional functional forms such as the Cobb–Douglas or the CES (Diewert, 1974).

A main advantage of the flexible functional forms is that they place fewer restrictions on the elasticities of substitution or transformation prior to estimation than do the conventional Leontief, Cobb–Douglas, and CES technologies; flexible functional forms allow estimates of the elasticity of size and elasticity of substitution to be unrestricted (Berndt and Christensen, 1973; Diewert, 1974). The use of flexible functional forms also helps to uncover complementarity relationships that may be ruled out when more restrictive functional forms are used.

The SNQ import and export price aggregator functions (or, unit cost and unit revenue functions) are specified, respectively, as follows:

$$p_M = \frac{1}{2}\frac{\sum\sum a_{jk} w_{M_j} w_{M_k}}{\sum \alpha_j w_{M_j}} + \sum c_j w_{M_j} + \sum w_{M_j} \gamma_j(t), \tag{9}$$

$$w_X = \frac{1}{2}\frac{\sum\sum b_{ih} p_{X_i} p_{X_h}}{\sum \beta_i p_{X_i}} + \sum d_i p_{X_i} + \sum p_{X_i} \delta_i(t). \tag{10}$$

In equation (9), $\Sigma a_{jk} = 0$ and $a_{jk} = a_{kj}$, while the α_j's are nonnegative and predetermined subject to the condition $\Sigma\alpha_j = 1$. Effectively, $\Sigma\alpha_j w_{M_j}$ is then a fixed-weight input price index. The effects of technological change are captured by $\gamma_j(t)$, for time periods $t = 1, \ldots, T$. The SNQ functional form treats all inputs symmetrically and is flexible at the point of normalization of the data. It is globally concave if and only if $A \equiv [a_{jk}]$ is negative semi-definite and it is homogeneous of degree one; A is at most rank of $J - 1$ given the condition $\Sigma_k a_{jk} = 0$. We use $\mathcal{A}$ to denote the matrix that results from deleting the last row and the last column of A.

In equation (10), $\Sigma b_{ih} = 0$ and $b_{ih} = b_{hi}$, $\delta_i(t)$ captures the effects of technological change, the β's are nonnegative and $\Sigma\beta_i = 1$. This function is linearly homogeneous and is convex if and only if B is positive semi-definite. B is at most of rank $I - 1$ and $\mathcal{B}$ denotes the matrix that results from deleting the last row and the last column of B.

From equations (3) and (7), the disaggregated import demand and export supply functions can be derived by differentiation. Expressing these as relative to aggregate imports and aggregate exports, respectively, we get the following estimating equations, for $j, k, n = 1, \ldots, J$ and $i, h, m = 1, \ldots, I$:

$$\frac{x_{M_j}}{y_M} = \frac{\sum a_{jk} w_{M_k}}{\sum \alpha_k w_{M_k}} - \frac{1}{2}\alpha_j \frac{\sum\sum a_{kn} w_{M_k} w_{M_n}}{(\sum \alpha_k w_{M_k})^2} + c_j + \gamma_j(t), \tag{11}$$

$$\frac{y_{X_i}}{x_X} = \frac{\sum b_{ih} p_{X_h}}{\sum \beta_h p_{X_h}} - \frac{1}{2}\beta_i \frac{\sum\sum b_{hm} p_{X_h} p_{X_m}}{(\sum \beta_h p_{X_h})^2} + d_i + \delta_i(t). \tag{12}$$

Despite its advantages, the SNQ functional form does not guarantee that the required curvature conditions implied by microeconomic theory are satisfied, and the number of parameters to be estimated grows very rapidly as the number of inputs increases. Fortunately, the required curvature conditions can be imposed globally on the SNQ functional form without losing flexibility. This can be done through a reparameterization of the estimating functions to ensure that the matrix A is negative semi-definite (for concavity of the unit-cost function (9)) and the matrix B is positive semi-definite (for convexity of the unit revenue function (10)).

Following Diewert and Wales (1987), we apply the technique proposed by Wiley et al. (1973). A necessary and sufficient condition for an $N \times N$ matrix Z to be positive semi-definite is that it can be written as the product of a lower triangular matrix T ($T \equiv [\tau_{mn}]$) and its transpose, i.e. $Z = TT'$. Similarly, writing $Z = -TT'$, where T is an upper triangular matrix, ensures that Z is negative semi-definite. Therefore, to ensure that the SNQ cost and revenue functions are concave and convex in prices, respectively, the above results on semi-definiteness are applied to the matrices $\mathcal{A}$ and $\mathcal{B}$. The curvature conditions are imposed *a priori*, as the resulting functional form is a valid flexible functional form in its own right, and correct curvature is required for the model to make economic sense. We limit our consideration of alternative functional forms to the different specifications of the time trend functions $\gamma_j(t)$ and $\delta_i(t)$, as discussed in the next section.

4. Data and Estimation Procedures

We consider Australian imports from and exports to 17 countries that represent Australia's major trading partners: the United States, Canada, Japan, Korea, Hong Kong, New Zealand, the United Kingdom, Germany, Italy, Greece, Ireland, the Netherlands, Spain, Finland, Norway, Sweden, and France. The period is restricted to 1958 to 2002 due to sketchy availability of data before 1958 and due to delays in the official publication of the data and potentially substantial data revisions that often follow initial publication. As Australian trade with some of these countries is quite small for some or all of the 1958–2002 sample period, some countries have been grouped into composite trading areas representing actual trading blocs. Thus, we have six "regions" representing the bulk of Australia's international trade with their imports and exports having been aggregated (using the Fisher ideal index number formula): (1) the United States plus Canada; (2) Japan; (3) Korea plus Hong Kong (Korea + HK); (4) New Zealand (NZ); (5) the United Kingdom (UK); and (6) other European countries (OEC) comprising the remaining countries. Among these regions, (1) to (4) belong to the APEC region, and (2) and (3) belong to North Asia. Regions (5) and (6) belong to the European Union (EU), with the exception of Norway.[2]

Import and export data are expressed in current US$, with import prices proxied by foreign export unit values, and export prices proxied by foreign import unit values. Both sets of prices are normalized to one for 1958.[3] These data are taken from the International Monetary Fund publications, *Direction of Trade Statistics* and *International Financial Statistics*, respectively. In the case of the aggregate regions 1, 3, and 6, the superlative Fisher price index formula has been used to obtain the aggregate price indices.

The restrictions $\Sigma\alpha_k = 1$ and $\Sigma\beta_h = 1$ are imposed in (11) and (12), respectively, by treating the goods symmetrically and thus setting each α_k and β_h equal to 1/6. Appending stochastic error terms to each of the estimating equations in (11) allows the estimation of the J import demand equations as a system of seemingly unrelated regressions.[4] The same procedure has been applied to the I export supply equations in (12).

The functions of time in equations (11) and (12), $\gamma_j(t)$ and $\delta_i(t)$, respectively, have been specified as linear spline functions, with four spline segments for each equation in each model. That is, the time trend enters the models in a piecewise linear fashion, allowing for the slope with respect to time to change between periods, with different coefficients for each estimating equation. This allows for the role of technological change to play a different role in different time periods (Diewert and Wales, 1992; Fox, 1998) and across regions. The use of spline functions is an innovation compared to the approach of Kohli (1994). The specification and placement of the break points was determined from an iterative process of examining residual plots and the convergence properties of the nonlinear algorithm. For the import-demand model, break points were placed at 1961, 1968, and 1988, with different coefficients on the time variables in each estimating equation. For the export-supply model, break points were placed at 1963, 1971, and 1976. It is not surprising that the break points work better at different points between the different models, as there does not seem to be any reason to expect technological change to impact on export supply or import demand at exactly the same time. It is also not surprising that the break points are relatively early in the sample, given the observed large changes in trade patterns through the 1960s and 1970s.

There are 45 years of data for each region and thus there are $6 \times 45 = 270$ observations for estimating both the import-demand and the export-supply models. With curvature restrictions imposed and four spline segments specified for the time trend, there are 45 parameters to be estimated in each model.

5. Results

Table 1 shows the estimated coefficients for the import and export aggregator functions from estimating equations (11) and (12); the results for the import model are in the first three columns, with the results for the export model in columns four to six. For the import model, the R_i^2 give the R^2 values between observed and predicted for each equation $i = 1, \ldots, 6$. We can see that the overall fit is very good, with four of the six R^2 values being over 0.90. The (asymptotic) t-values indicate that most estimates are statistically significant at standard significance levels. The c_{ij} are coefficients on the time trend for equation $i = 1, \ldots, 6$ and time segment $j = 1, \ldots, 4$, where the break points are as discussed in the previous section. The c_{ij} are individually *and* jointly statistically significant, with a likelihood ratio test value of more than 400 being well above the 5% critical value of 36.415 (24 degrees of freedom). Tests that the price terms are jointly statistically significant, and that price and time trend terms are also jointly statistically significant, similarly result in the respective null hypotheses being easily rejected.[5]

The degree of statistical significance of the estimates of the c_{ij} indicate the significant role that technological change (captured by the passage of time) has played. It is of particular interest to note that the estimates for the UK ($i = 5$) are negative for the first three time segments, the period over which there was a large reduction in the relative importance of Australian imports from the UK. This result indicates that there were factors other than price which were responsible for this reduction.

Turning to the export model, the last three columns of Table 1 show the estimation results for the export aggregator function of equation (12). We can see that the overall fit is good, with three of the six R^2 values being over 0.90 and the lowest being 0.70. The (asymptotic) t-values indicate that several estimates are very statistically significant at standard significance levels. As with the import model, the time trend coefficients d_{ij} are individually *and* jointly statistically significant, with a likelihood ratio test value of 365 being well above the 5% critical value of 36.415. The null hypothesis that the price

Table 1. Coefficient Estimates

Import aggregator function			*Export aggregator function*		
Coefficient	*Estimate*	t-*Value*	*Coefficient*	*Estimate*	t-*Value*
c_1	0.14686	4.4327	d_1	0.02075	6.7869
τ_{11}	0.48100	10.4690	τ_{11}	0.21465	7.0258
τ_{21}	–0.50088	–10.6290	τ_{21}	–0.08387	–3.0212
τ_{31}	–0.02857	–0.9757	τ_{31}	–0.10335	–3.8032
τ_{41}	0.04963	2.8804	τ_{41}	–0.13207	–5.8559
τ_{51}	0.11006	2.2294	τ_{51}	0.02137	0.5456
τ_{22}	0.18447	2.6436	τ_{22}	–0.00097	–0.0339
τ_{32}	0.16605	3.3361	τ_{32}	–0.01392	–0.4337
τ_{33}	0.08585	0.9917	τ_{33}	0.6×10^{-7}	0.0000
τ_{42}	–0.11067	–2.5279	τ_{42}	–0.01616	–0.4161
τ_{43}	–0.00948	–0.0714	τ_{43}	0.1×10^{-6}	0.0000
τ_{44}	–0.14513	–5.1975	τ_{44}	0.1×10^{-7}	0.0000
τ_{52}	–0.23520	–2.8379	τ_{52}	0.08775	1.1349
τ_{53}	0.21192	1.8159	τ_{53}	-0.4×10^{-6}	0.0000
τ_{54}	0.11078	0.4984	τ_{54}	-0.2×10^{-7}	0.0000
τ_{55}	0.4×10^{-5}	0.0000	τ_{55}	0.7×10^{-9}	0.0000
c_{11}	0.06047	4.4514	d_{11}	0.00409	5.0820
c_{12}	0.01057	3.9032	d_{12}	0.00064	1.8537
c_{13}	–0.00121	–1.7485	d_{13}	–0.00083	–1.7389
c_{14}	0.00015	0.1295	d_{14}	–0.00103	–5.7974
c_2	0.06360	1.7305	d_2	0.03814	8.4615
c_{21}	–0.01303	–0.8757	d_{21}	0.00239	2.0164
c_{22}	0.01237	3.9856	d_{22}	0.00439	8.5749
c_{23}	0.00920	11.6880	d_{23}	0.00322	5.0989
c_{24}	–0.01007	–7.1781	d_{24}	–0.00068	–4.6239
c_3	0.01136	1.0691	d_3	0.00393	1.4029
c_{31}	–0.00475	–1.0887	d_{31}	0.00048	0.6474
c_{32}	0.00047	0.5449	d_{32}	0.00028	0.8517
c_{33}	0.00229	9.7731	d_{33}	0.00064	1.4810
c_{34}	0.00408	9.5576	d_{34}	0.00235	16.9730
c_4	0.01944	5.0198	d_4	0.02052	9.9387
c_{41}	0.00291	1.7684	d_{41}	–0.00028	–0.5159
c_{42}	0.00093	2.6548	d_{42}	0.00005	0.1968
c_{43}	0.00184	18.3410	d_{43}	0.00010	0.3397
c_{44}	0.00087	4.2191	d_{44}	0.00076	7.0878
c_5	0.59798	31.8650	d_5	0.09902	38.6580
c_{51}	–0.05108	–6.5994	d_{51}	–0.00738	–10.6170
c_{52}	–0.02121	–13.6020	d_{52}	–0.00326	–10.5780
c_{53}	–0.00988	–24.4160	d_{53}	–0.00407	–10.9240
c_{54}	0.00128	1.8521	d_{54}	–0.00020	–1.2145
c_6	0.16607	10.2210	d_6	0.04920	18.4840
c_{61}	0.00132	0.2046	d_{61}	0.00073	1.0496
c_{62}	–0.00011	–0.0811	d_{62}	–0.00216	–7.3315
c_{63}	0.00142	4.1784	d_{63}	0.00100	2.4925
c_{64}	0.00479	7.5423	d_{64}	–0.00059	–4.5465
$R_1^2 = 0.50$	$R_3^2 = 0.95$	$R_5^2 = 0.99$	$R_1^2 = 0.72$	$R_3^2 = 0.97$	$R_5^2 = 0.98$
$R_2^2 = 0.91$	$R_4^2 = 0.98$	$R_6^2 = 0.86$	$R_2^2 = 0.91$	$R_4^2 = 0.70$	$R_6^2 = 0.80$

Notes: The R_i^2 values give the R^2 between observed and predicted for each equation *i*, and the d_{ij} are the incremental coefficients on the time trend for equation *i* and time segment *j*, so that e.g. the partial derivative of the function with respect to time for the import model, region 1 in time segment 3 is $c_{11} + c_{12} + c_{13} = 0.06047 + 0.01057 - 0.00121 = 0.06983$.

terms are jointly zero cannot be rejected, but the price and time trend terms are jointly statistically significant.[6] The degree of statistical significance of the estimates of the d_{ij} indicates the significant role that technological change has played. For the UK ($i = 5$) the estimates are negative for all four time segments. As with the case of imports, this result indicates that there were factors other than price which were responsible for this reduction in the relative importance of Australian exports to the UK.

Top panel of Table 2 shows the 2002 estimates of partial price elasticities of import demand, which are conditional on the level of total imports. Partial price elasticities indicate the degree to which a change in the price of the imports from region k will lead to a change in Australian demand for imports from region j, holding aggregate imports constant.

The standard errors suggest that the elasticities are generally determined with a high degree of precision. With elasticities, we are often interested in the null hypothesis of the estimates being 1 or –1. From the table, it is clear that either null hypothesis is

Table 2. Partial Price Elasticity Estimates, 2002

Import aggregator function	$k = 1$ (*US + Canada*)	$k = 2$ (*Japan*)	$k = 3$ (*Korea + HK*)	$k = 4$ (*NZ*)	$k = 5$ (*UK*)	$k = 6$ (*OEC*)
ξ_{1k}	–0.742	0.711	0.039	–0.040	–0.140	0.172
	(0.158)	(0.114)	(0.031)	(0.022)	(0.080)	(0.070)
ξ_{2k}	1.218	–1.392	–0.188	0.148	0.529	–0.315
	(0.167)	(0.190)	(0.052)	(0.037)	(0.118)	(0.101)
ξ_{3k}	0.167	–0.475	–0.226	0.142	0.278	0.115
	(0.131)	(0.124)	(0.096)	(0.060)	(0.148)	(0.109)
ξ_{4k}	–0.211	0.455	0.173	–0.419	–0.066	0.069
	(0.119)	(0.116)	(0.022)	(0.074)	(0.136)	(0.089)
ξ_{5k}	–0.588	1.298	0.270	–0.053	–1.917	0.990
	(0.357)	(0.359)	(0.152)	(0.108)	(0.410)	(0.229)
ξ_{6k}	0.227	–0.243	0.035	0.017	0.311	–0.348
	(0.879)	(0.074)	(0.330)	(0.022)	(0.066)	(0.070)
Export aggregator function	$h = 1$ (*US + Canada*)	$h = 2$ (*Japan*)	$h = 3$ (*Korea + HK*)	$h = 4$ (*NZ*)	$h = 5$ (*UK*)	$h = 6$ (*OEC*)
ψ_{1h}	1.658	–0.650	–0.576	–0.862	0.042	0.387
	(0.478)	(0.270)	(0.190)	(0.191)	(0.266)	(0.202)
ψ_{2h}	–0.337	0.133	0.118	0.177	–0.016	–0.074
	(0.140)	(0.077)	(0.049)	(0.054)	(0.069)	(0.054)
ψ_{3h}	–0.460	0.182	0.164	0.245	–0.039	–0.092
	(0.150)	(0.076)	(0.080)	(0.066)	(0.094)	(0.065)
ψ_{4h}	–1.325	0.525	0.472	0.705	–0.107	–0.270
	(0.300)	(0.162)	(0.128)	(0.227)	(0.261)	(0.172)
ψ_{5h}	0.117	–0.087	–0.136	–0.191	0.590	–0.293
	(0.730)	(0.365)	(0.325)	(0.468)	(1.039)	(0.600)
ψ_{6h}	0.618	–0.229	–0.184	–0.280	–0.170	0.245
	(0.321)	(0.166)	(0.130)	(0.179)	(0.345)	(0.238)

Notes: US = USA, HK = Hong Kong, NZ = New Zealand, UK = United Kingdom, and OEC = Other European Countries. Standard errors are in parentheses.

rejected in most cases. Considering the own price elasticities (ξ_{jj}) along the main diagonal of Table 2, imports from Japan and the UK were most price responsive, with own-price elasticities of –1.392 and –1.917, respectively, holding aggregate imports constant. These imply that when the price of Australian imports from Japan or the UK increase by 1%, the demand for their imports would fall by 1.392% and 1.917%, respectively. This indicates that although Japan is one of the most important suppliers of imports to Australia, the quantity of imports demanded are very price sensitive, or "price elastic." By contrast, imports from US + Canada, Korea + HK, NZ, and OEC are relatively price inelastic.

Regarding the cross-price elasticities (ξ_{ij}), strong complementarity was found between imports from US + Canada and the UK, and Japan and Korea + HK. For example, a 1% increase in the price of imports from US + Canada would lead to a 0.59% fall in Australian imports from the UK. Other complementarity relationships for imports include US + Canada and NZ, Japan and OEC, and NZ and the UK (relatively weak).[7]

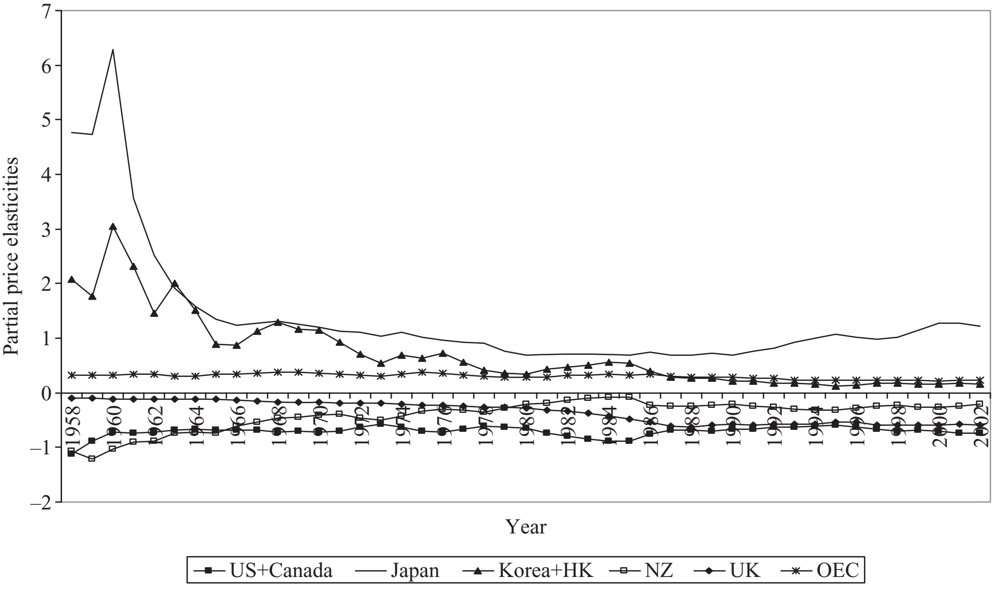
Strong substitution effects were found between imports from US + Canada and Japan, Japan and the UK, and OEC and the UK. This implies that although Japanese imports are very important to Australia, there is a possibility that they can be replaced relatively easily by imports from US + Canada and the UK.

To help convey more about the change of elasticities for the regions over the sample period, Figures 1 to 3 show the estimates of own- and cross-price elasticities of import demand from each of the regions considered, for 1958–2002. The figures reveal that there have been some quite large changes in elasticities over time, although no changes in sign. From Figure 1, it can be seen that imports from Japan were much more sensitive to changes in prices of goods from US + Canada early in the sample, with a strong substitution effect. Interestingly, from the figures the positive elasticities reveal that, over the sample, whenever the import prices of regions such as US + Canada, the UK, and NZ increased, imports from Japan and Korea + HK would also increase. In particular, from the top panel of Figure 3, Japanese imports are found to be strong substitutes for UK imports. This was especially so in the late 1950s until the mid-1960s; the price elasticity decreased thereafter. As noted, Japanese imports were strong substitutes for US + Canada imports, especially in the late 1950s until the mid-1970s, and again for the mid-1990s until the end of the sample. This implies that Japan has been a challenger to the UK and US + Canada in terms of exporting to Australia, consistent with anecdotal evidence.

NZ imports are seen to be substitutes for imports from Japan, Korea + HK, and OEC, but the substitution elasticities have been historically larger for the Asian countries. Imports from OEC, served as substitutes to imports from the regions other than Japan, but the substitution effect was not significant for Korea + HK and NZ.

Imports from Japan and Korea + HK were complements to each other over the sample period. The complementarity effect was extremely large in the late 1950s through the mid-1960s, with a general declining trend. Imports from US + Canada were complements to those from the UK and NZ. The complementarity effect was larger for the case of the UK and tended to increase slightly over time for both regions.

Table 2 also shows the 2002 estimates of partial price elasticities of export supply. The standard errors suggest that the elasticities are generally determined with a high degree of precision. As with the import elasticities, we are often interested in the null hypothesis of the estimate being 1 or –1. From the table, it is clear that either null hypothesis is rejected in most cases. Considering the own-price elasticities (ψ_{ii}), exports to US + Canada were most price responsive, with an own-price elasticity equal to 1.658.



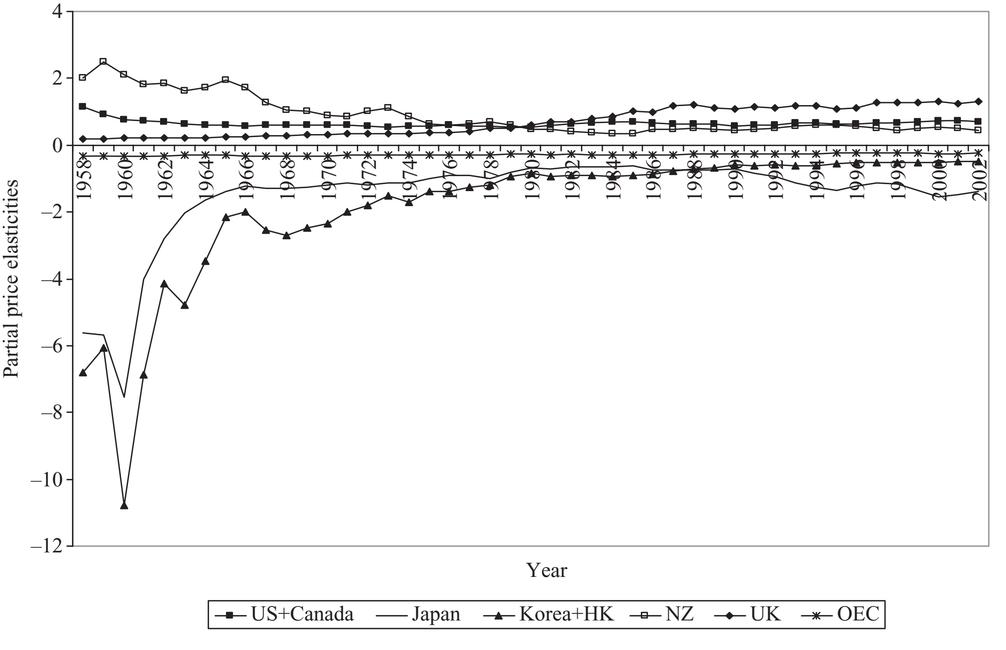


Figure 1. Partial Price Elasticities for Changes in Price of Imports from US + Canada (top) and Japan (bottom)

Exports to Japan, Korea + HK, and OEC were relatively price inelastic. For the case of Japan and Korea + HK, the price inelasticity is to some extent the result of the regions' large share of Australian exports.[8]

Regarding the cross-price elasticities (ψ_{ih}), strong complementarity was found between exports to US + Canada and OEC. Other complementarity relationships for exports include Japan and NZ, and Korea + HK and NZ. These results imply that due to the declining importance of exports to the European countries, exports to

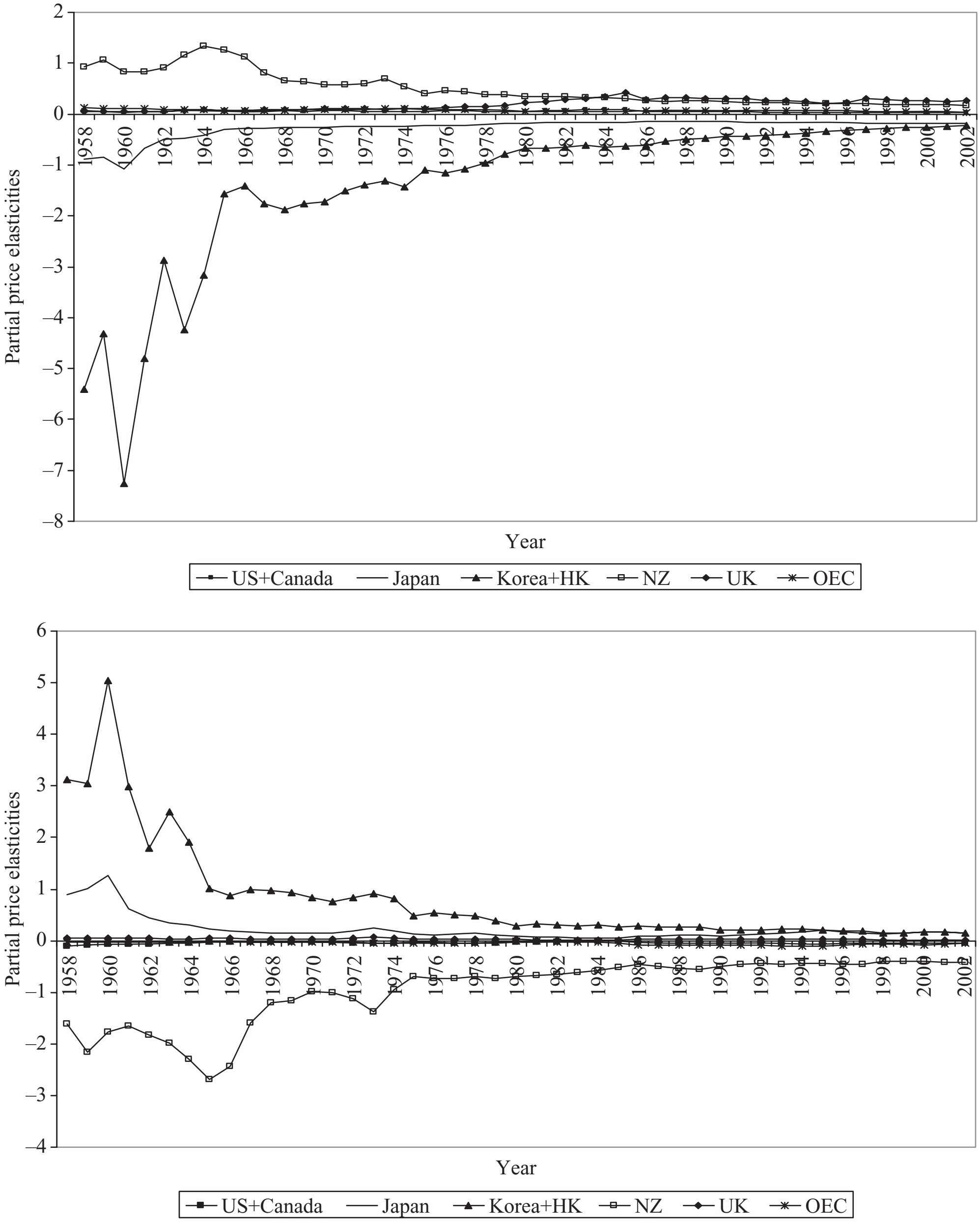


Figure 2. Partial Price Elasticities for Changes in Price of Imports from Korea + HK (top) and New Zealand (bottom)

US + Canada may also be adversely affected given the strong complementarity between these countries. Similarly, the results also imply that there is potential for more Australian exports to NZ, given that NZ exports show strong complementarity with those from the rising Asian market. Strong substitution effects were found between exports to US + Canada and NZ, which implies the existence of competitive relationship between exports to these two countries. Other substitution relationships include US + Canada and Japan, and US + Canada and Korea + HK. These results uncover

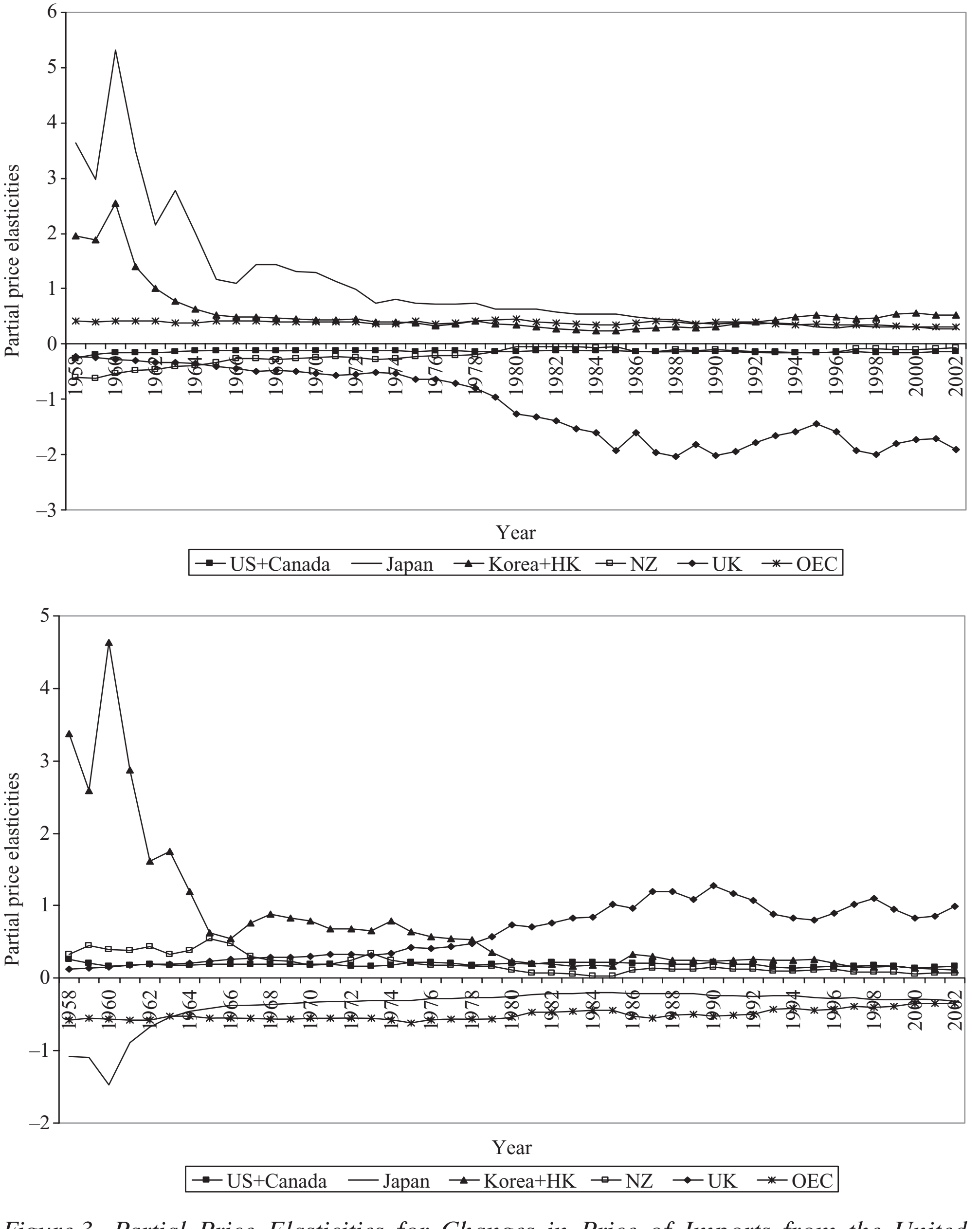


Figure 3. Partial Price Elasticities for Changes in Price of Imports from the United Kingdom (top) and Other European Countries (bottom)

the possibility of replacing of exports to Asian countries and NZ by exports to US + Canada. As with the import elasticities, to help convey more about the change of elasticities for the regions over the sample period, Figures 4 to 6 show the estimates of own- and cross-price elasticities of export supply to each of the regions considered, 1958–2002.

From the top panel of Figure 4, US + Canada had large (positive) own-price effects, as did Korea + HK (Figure 5), although the latter was declining, perhaps due to the

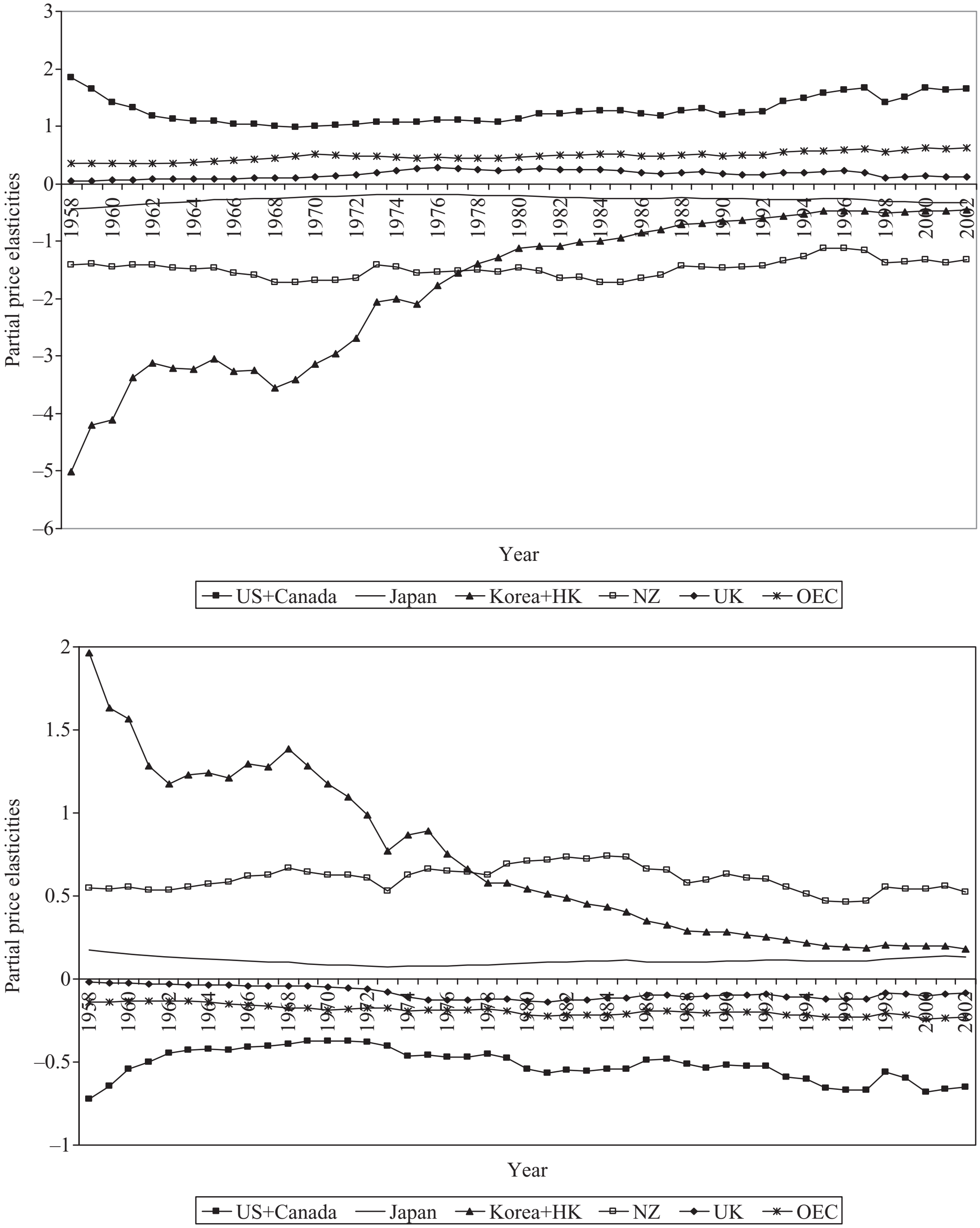


Figure 4. Partial Price Elasticities for Changes in Price of Exports to US + Canada (top) and Japan (bottom)

growing importance of the Asian region to Australian exports; Australian exporters are perhaps less sensitive to price changes now that they are established in these markets.

Over the whole sample period, exports to NZ were complementary to those of Japan and Korea + HK (Figures 4 and 5), while exports to these Asian countries were complementary to each other. Exports to US + Canada were complementary to exports of the

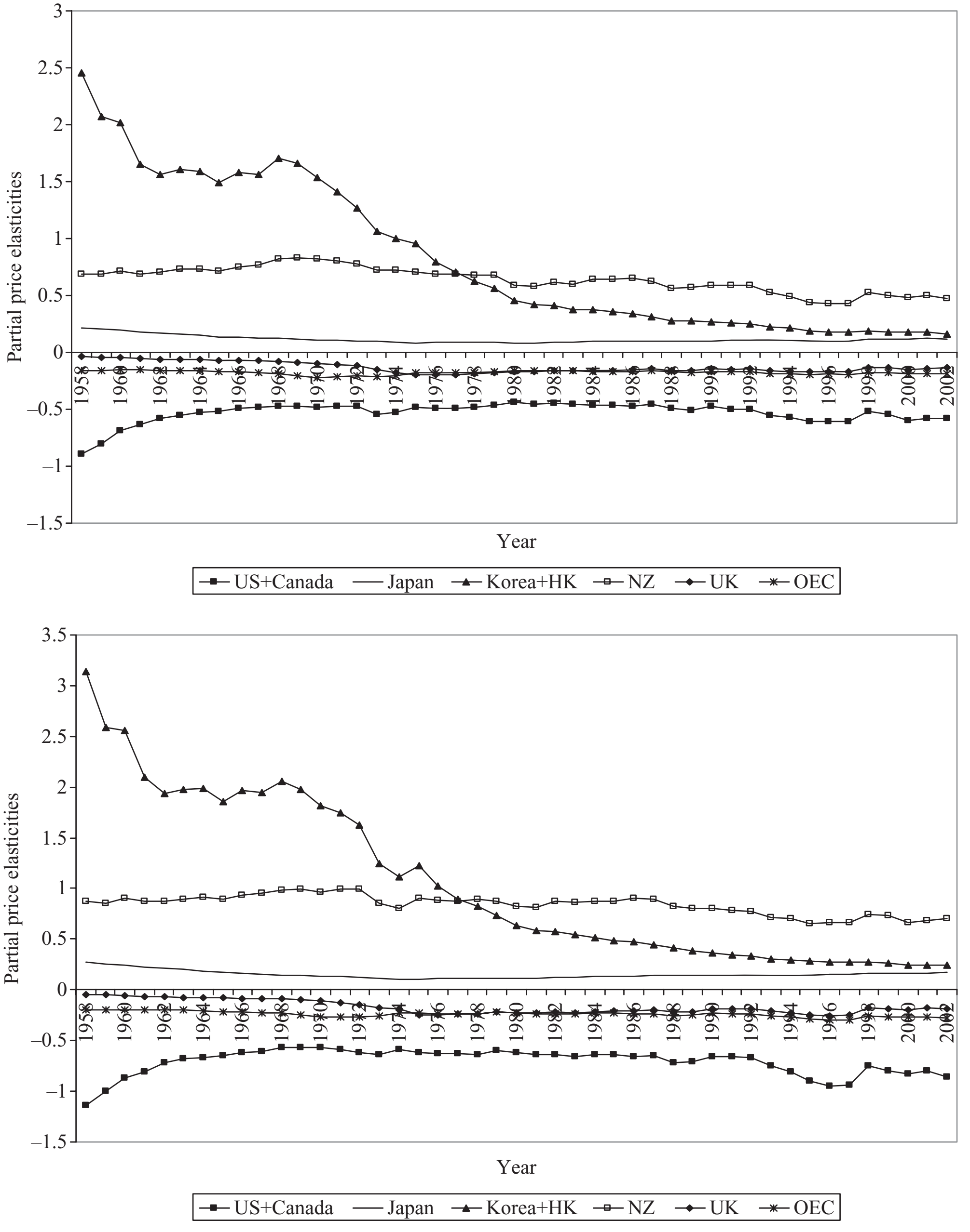


Figure 5. Partial Price Elasticities for Changes in Price of Exports to Korea + HK (top) and New Zealand (bottom)

UK and OEC (Figure 6). From Figure 5, exports to US + Canada have had a relatively large substitution elasticity with respect to prices of exports to Korea + HK over the sample. Exports to Asian countries are also substitutes for exports to the UK and OEC (Figure 6). Exports to NZ are substitutes for US + Canada (Figure 5), the UK and OEC (Figure 6).

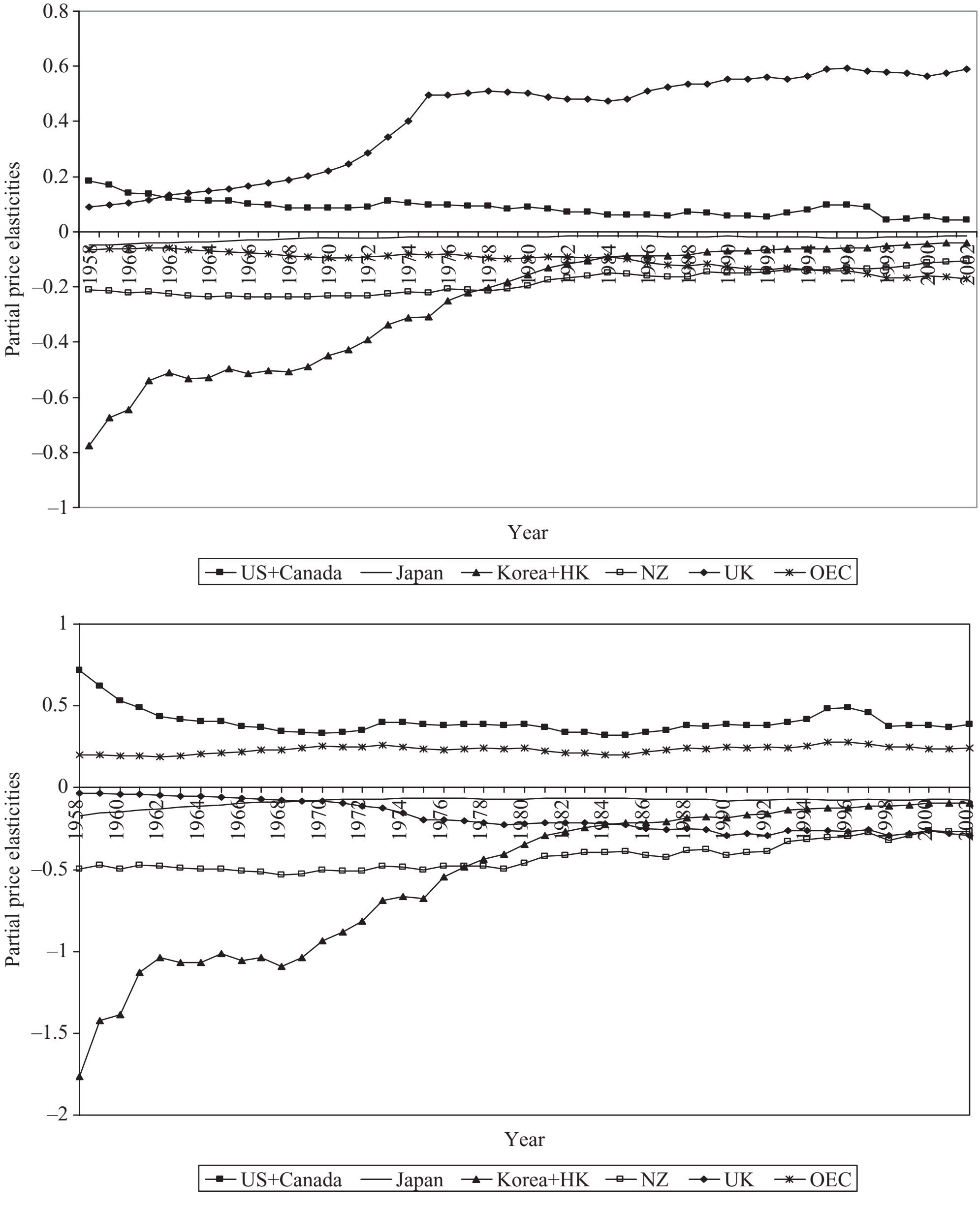


Figure 6. Partial Price Elasticities for Changes in Price of Exports to the United Kingdom (top) and Other European Countries (bottom)

6. Discussion and Conclusions

A fully-flexible version of the Symmetric Normalized Quadratic functional form has been used to model the Australian demand for imports and supply of exports by regions of origin and destination. Given the increasing importance of trade to the Australian economy, the strengthening of Asian countries, and the emergence of the European Union, it is profitable to identify the possible substitutability and complementarity relationships among Australia's trading partners. It is especially important for any reassessment of Australia's approach to entering into bilateral agreements with selected trading partners. Several important implications can be arrived at from the results of the paper.

The results for the import model suggest that despite a high dependency of Australian imports on the Asian regions of Japan, Korea + HK, the degree of dependency has decreased over time, with imports from New Zealand serving as substitutes. This is consistent with the fact that New Zealand is Australia's major trading partner under the Closer Economic Relations package, and for which Australia has established bilateral trade pacts with New Zealand since 1983.

Our results also show the interesting finding that imports from Japan and Korea + HK were complements to each other over the sample period. The complementary effect was extremely large from the late 1950s through the mid-1960s, but with a general declining trend that may be due to the changing of import mix of these regions. Given the dependency and complementarity of Australian imports from Asian regions, there is the possibility that certain countries in the Asia-Pacific region could, through regional trade agreements, gain a trade advantage relative to Australia. For example, China and Japan have already formulated their own bilateral or regional deals, such as the ASEAN–China Free-Trade Agreement (FTA). In addition, the key regional economic forum, the ASEAN-plus-Three, that includes the 10 ASEAN members plus China, Japan, and South Korea, has excluded Australia.

Imports from Other European Countries served as substitutes for imports from almost all of the regions other than Japan, and the substitution effect was significant for North America and the United Kingdom. This result suggests that while it is important for Australia to continue the development of relations with the Asia-Pacific region, Europe will remain a prime economic and trading partner for Australia.

Although exports to the United States, New Zealand, and the Asian countries have increased, our results suggest that these exports serve as substitutes for each other. Given Australia's recent trade policy of the pursuit of country-to-country trade agreements, this has implications for possible substitution among countries for the establishment of bilateral trading relationships. For example, more effort could be put into building bilateral trading relationships with the Asian countries instead of focusing on New Zealand and the United States. Early in 2005 Australia entered into a free-trade agreement with the United States to forge closer ties to the world's largest economy. Opponents of the agreement argued that it would create a gap between Australia and its key economic partners in Asia that account for about 60% of Australia's foreign trade (Stokes, 2003).

Exports to North America and to the European countries other than the United Kingdom are strongly complementary. Exports to New Zealand are complements to those to Japan and Korea and Hong Kong. Therefore, any tendency to neglect trade ties with Asia may also adversely affect its exports to New Zealand. Since our results indicate that trade ties with Asia are important, if the Asian countries are left to move towards sealing their own regional trade agreements without Australian participation, this may adversely affect Australian income growth.

Given the trend of a changing composition of world trade toward value-added manufactures and services, if imports and exports could be decomposed on a commodity basis in future research, it may help to further understand the above complementarity and substitution possibilities that our results indicate (Kohli, 1998). Finally, it should be noted that our results are limited to the theoretical trade model considered, and the available data. Factors that will broadly affect Australia's future trading environment include multilateral trade agreements, new regional arrangements and technical barriers to trade (such as emerging "biosecurity" requirements). Other changes such as the emergence of new technologies, WTO accessions, and unilateral trade liberalization also affect Australian trading patterns. Thus, our results should be seen as complementary to a broader policy analysis, rather than as a substitute.

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Notes

1. While these are the elasticities we are interested in for current purposes, it is also possible to calculate total elasticities; see Kohli (1994).

2. Our choice of aggregation is based on geographical considerations. For practical reasons we have had to group countries, and have chosen groupings which represent actual trade blocs. Alternative groups could be investigated using, for example, the aggregation test of Lewbel (1996). However, such approaches run into problems if there are changes in the composition of the aggregates over time; it would be difficult to interpret changes in elasticities between groups over time in this case. Also, there would be difficulties in interpretation if such aggregates combined geographically diverse countries, as we are interested here in cross-region trade and the related policy issues.

3. The linear homogeneity in prices of the cost and revenue functions means that the export supply and import demand functions are homogeneous of degree zero. The implication is that only relative prices matter, so there is no gain from putting the data into Australian dollars.

4. The default Davidon–Fletcher–Powell nonlinear estimation algorithm in the SHAZAM econometric package (White, 1978) was used. None of the estimation equations are omitted, as the equations are expressed in terms of quantity shares, rather than value shares, implying that there is no problem with linear dependency. The (unit) cost and revenue functions are omitted from the respective systems of estimating equations, because of some nonlinear dependency (Kohli, 1994, fn. 10, p. 590).

5. The likelihood ratio test that the price terms are jointly significant yields a test value of 97.39 with a critical value of 25 (15 degrees of freedom, 5% level of significance). The likelihood ratio test that the price and time trend terms are jointly significant yields a test value of 530.5 with a 5% critical value of 54.57 (39 degrees of freedom).

6. The likelihood ratio test that the price terms are jointly significant yields a test value of 16 with a critical value of 25 (15 degrees of freedom, 5% level of significance). The likelihood ratio test that the price and time trend terms are jointly significant yields a test value of 708 with a 5% critical value of 54.57 (39 degrees of freedom).

7. The results highlight the value of using a flexible functional form in the econometric modeling, a flexible functional form allows the identification of complementary.

8. Japan's share of total Australian merchandise exports was 18.8% in 2002–03, while its share of exports to Korea + HK was about 10.7% (The APEC Region, 2004). In 2002–03, Japan was Australia's largest export destination, whereas Korea was the third largest destination for Australian exports.