The Elasticity of Substitution Between Imports from Different Sources – Estimates for New Zealand

by

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SALTER Working Paper No. 7

DECEMBER 1990

The author is grateful to Maureen Rimmer, Denis Lawrence, Grant Maclaine, Patrick Jomini, Alan Powell and John Zeitsch for their invaluable comments. He would also particularly like to thank Christine Hryhoriak, Roberta Wise and Andrea Versteegen for their typing and patience.

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Introduction

The demand for imported commodities in the SALTER model is determined by a two stage optimisation process. In the first stage the quantity which is to be sourced domestically and the aggregate level of imports is determined. In the second stage the composition of total imports by source is determined. The second stage assumes that the compensated, or Allen-Uzawa, elasticities of substitution are the same between all sources of imports; that is, a constant elasticity of substitution (CES) specification is assumed.

The purpose of this paper is to form estimates of the partial elasticities of substitution between different import sources using monthly import data for New Zealand from five sources, collected between July 1982 and December 1987. The five sources are: Asia, Australia, the European Community (EC), North America, and Other Countries. The Asian region comprises Indonesia, Singapore, Thailand, Malaysia and Japan, while the North American region includes the US and Canada.

Estimates of the substitutability between imports from the different sources were derived by treating New Zealand as a single producer combining imports of intermediate inputs with other factors such as capital and labour to produce finished goods for sale to consumers and for export. The production function is assumed to be homothetically separable between imported intermediate inputs and all other inputs. This permits the input demand equations to be derived via the minimisation of total costs over the different sources for a given quantity of total imports, in isolation from all other input decisions.

The import demand equations for New Zealand were derived from a CES import cost function. The CES import cost function is obtained through the minimisation of total import costs subject to importing a given quantity determined by a CES import function.

Previous work

Burgess (1974a, 1974b) develops a framework for modelling import demand by taking a production theoretic approach to the demand for imports. The justification for modelling import demand in this way is that most import decisions are made by firms who combine the imported commodities with other factors to produce the completed good for sale to consumers. The firms production function is assumed to be weakly separable between total imported commodities and all other factors. The firm then chooses its level of import demand from each source so as to minimise its total cost of importing subject to meeting the level of total imports required for the production process. Burgess uses a translog cost function to approximate the total cost of importing from all the sources. The translog cost function was inappropriate for this study since it permitted the elasticity of substitution to vary between pairs of import sources, whereas this study requires the elasticity of substitution between pairs of sources be the same.

Corado and de Melo (1983) derived constant elasticities of substitution for 26 groups of commodities, using annual import data for Portugal between 1962 and 1978. The two sources of imports were the EC and non-EC countries. The elasticity of substitution was estimated by regressing the logarithm of the ratio of EC to non-EC import values against the logarithm of non-EC to EC import prices. Where it was significant the logarithm of national income for Portugal was also included. The coefficient on the price term provides the elasticity of substitution since differentiating the import value term with respect to the price term is the elasticity of substitution by definition.

Kohli and Morey (1990) estimate the elasticity of substitution for US imports of crude oil between 8 regions using demand equations derived from a constant elasticity of substitution cost function. The justification for imposing a constant elasticity of substitution between the sources is that if all the characteristics of crude oil are accounted for in the model then there will be no reason for US importers to prefer oil from one region over another region. The characteristics they included in their equations are: the specific gravity (i.e., density) of the oil in each region, the sulphur content of the oil in each region, the shipping distance, the quantity of oil available in each region and the state of the political relationship between the US and the region. The authors make the same assumptions as Burgess in applying production theory to explain import demand behaviour.

A CES model of import demand

The demand for imports into New Zealand is modelled by assuming that New Zealand acts as a single producer minimising its total production costs by choosing the appropriate quantities of labour, capital and domestic or imported intermediate inputs. The production function is assumed to be homothetically separable between imported intermediate inputs and all other inputs and has constant returns to scale. This implies the producer minimises the total cost of importing over the different sources separately to the decisions concerning the level of aggregate imports and other inputs. Assuming all import decisions are made by producers is not unreasonable since even finished goods are not imported directly by consumers but have to go through distribution and retail channels before reaching the final consumer. The model is partial equilibrium in nature as all output and input prices are assumed to be exogenous. Since New Zealand is a small country in terms of international trade, its import decisions have negligible effects upon the world prices of the commodities it imports; consequently, import prices can reasonably be assumed exogenous.

This study is more specifically tailored to the parameter needs of the SALTER model. Within the SALTER model there are several effects that determine the level of commodity import demand by source. Firstly commodity demand is determined by the sum of consumer demand, intermediate usage, government demand and investment demand. Consumer demand is determined by a linear expenditure system whilst intermediate demand is determined by assuming firms have a Leontief technology. Government and investment demand both assume that imports are held in fixed proportions of their aggregates. In the next stage, the level of commodity demand that is to be satisfied domestically is determined while imports supply the remaining demand. This stage assumes a constant elasticity of substitution between demand for domestically produced and imported commodities. In the final stage, the model determines the level of commodities that will be imported from each of the five sources. The import substitution elasticities in SALTER for a particular commodity between the sources of imports is assumed to be the same, hence the need to estimate CES elasticities to be consistent with the specification of the model. The elasticity of substitution measures purely the effect of the responsiveness of the change in import mix as a consequence of a change in the price of one import in isolation of any expansion effect.

A change in the price of an imported commodity from one source will affect aggregate demand, total import demand and the level of demand for imports from each source. For example suppose the price of a commodity from one source fell, this would lower the aggregate import price for that commodity and thus in turn lower the price index of that commodity, increasing overall demand for that commodity by consumers and firms. In the SALTER model, there is both an expansion and a substitution effect at work in this case. Firstly the lower price index means that agents may increase their consumption of all commodities (as their budget now allows them to buy more of all products). Secondly, since one commodity is now cheaper relative to others, additional amounts of this commodity relative to others will now be consumed. This will raise demand for both the imported and domestically produced commodity, but there will be a change in preference for the imported commodity since it is relatively cheaper. In the final level the demand from all importing sources will increase but will favour the source which is now relatively cheaper.

For ease of exposition the import demand theory will be developed in terms of more familiar production input demand. It should be remembered that input prices are in fact imported prices inclusive of freight costs and duty. However, import duties will not affect the share of imports by source in total imports if the rate of duty on each source is the same ad valorem rate for all import sources.

A firm's cost function describes how a given level of output can be produced at least cost by employing a vector of inputs, x, given the vector of exogenously determined input prices ω. The cost function of a firm is linearly homogeneous, increasing, continuous and concave in input prices. Linear homogeneity requires that if all input prices are multiplied by the same non zero scalar then the firm's total costs must also increase by this amount. The intuition behind the concavity property is that increasing the price of one input will lead to higher costs but as the price continues to increase the firm substitutes towards other inputs, so that total cost increases but at a decreasing rate. Costs must increase in all input prices since if the firm were able to choose a cost minimising bundle that costs less as a consequence of the price of one input increasing it would have done so previously. Continuity of the cost function requires that for every positive input price there must exist a corresponding level of cost (see Varian 1984).

The cost function is obtained by minimising the firm's total costs subject to producing a given level of output q, to yield an equation which has as its arguments a vector of prices and output. Most empirical applications have also included a time trend to account for the effect of technological changes in total costs. The cost function may be represented as follows where Q(.) is the production function:

$$C(\omega, q) = \min_{x} \{\omega' x \text{ s.t. } q \in Q(x)\} \qquad (1)$$

where

- $C(\omega,q)$ is the cost function with arguments ω, a vector of input prices with elements ω_i, i=1,...,n and q is the level of production; and
- x is the vector of input quantities with elements x_i, i=1,...,n.

The firm's derived demand for inputs (x_i^*) may be obtained through Shephard's (1953) Lemma which states the first derivative of the cost function with respect to the i^{th} input price provides the i^{th} input demand equation as follows:

$$x_i^*(\omega,q) = \frac{\partial C(\omega,q)}{\partial \omega_i} \qquad (2)$$

Rimmer (1990) derives a CES cost function for the two-input case (capital and labour). This cost function extends easily to one in which the number of inputs is greater than two and is given as follows:

$$C(\omega,q) = q\left\{\sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{-1/\beta}}\right)^{\frac{\beta}{1+\beta}}\right\}^{\frac{1+\beta}{\beta}} \qquad (3)$$

$$A_j = \exp\{\psi_j t\},\ \sum_{j=1}^{n} b_j = 1$$

where ψ_j, β, and b_j, are the parameters to be estimated. The elasticity of substitution (σ) is given as; $\sigma = 1/(1+\beta)$.

Applying Shephard's Lemma to the cost function and multiplying both sides of the equation by ω_i / pq provides an expression for the share of input i in total costs:

$$S_i = \frac{\omega_i x_i}{pq} = \frac{\omega_i}{pq}\frac{\partial C}{\partial \omega_i}$$

In the case of the CES cost function (3) this share equals:

$$S_i = \frac{\omega_i}{p\left(A_i b_i^{\frac{-1}{\beta}}\right)}\left[\frac{\omega_i}{A_i b_i^{\frac{-1}{\beta}}}\right]^{\frac{-1}{1+\beta}}\left\{\sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{\frac{-1}{\beta}}}\right)^{\frac{\beta}{1+\beta}}\right\}^{\frac{1}{\beta}} \qquad (4)$$

Rearranging equation (3) we obtain:

$$\left(\frac{C}{q}\right)^{\frac{\beta}{1+\beta}} = \sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{\frac{-1}{\beta}}}\right)^{\frac{\beta}{1+\beta}} \qquad (5)$$

Substituting this term into equation (4) simplifies the equation for the share of input i in the total cost of inputs:

$$S_i = \frac{\omega_i}{pA_i b_i^{\frac{-1}{\beta}}} \left(\frac{\omega_i}{A_i b_i^{\frac{-1}{\beta}}} \right)^{\frac{-1}{1+\beta}} \left(\frac{C}{q} \right)^{\frac{1}{1+\beta}} \tag{6}$$

Further, by substituting into (6), the condition of perfect competition in the factor market (i.e. C=pq) provides a simple input share equation as follows:

$$S_i = b_i^{\frac{1}{1+\beta}} \left(\frac{\omega_i}{pA_i} \right)^{\frac{\beta}{1+\beta}} \tag{7}$$

It should be noted at this point that as the model is in fact to be used to describe import behaviour decisions, the price faced by importers from source i is $\omega_i(1+\tau)$, where τ is the ad valorem rate of duty. Assuming the rate applied to imports from all sources is the same then the price index of imports from all sources is $p(1+\tau)$. So the share equation is more appropriately given as:

$$S_i = b_i^{\frac{1}{1+\beta}} \left(\frac{\omega_i(1+\tau)}{p(1+\tau)A_i} \right)^{\frac{\beta}{1+\beta}} \tag{8}$$

However, it may be seen from the above that if the duty is ad valorem and applied without discrimination against any source then the duty will not affect the share of imports from each source. That is, the demand for inputs is assured to be homothetic.

Taking a logarithmic transformation of both sides of (7) and indexing it by time yields:

$$\ln(S_{it}) = \frac{1}{1+\beta}\ln(b_i) + \frac{\beta}{1+\beta}\left\{ \ln\left(\frac{\omega_{it}}{p_t} \right) - \ln(A_{it}) \right\} \tag{9}$$

While equation (9) could form the basis of an estimating system it is important to recognise that firms will form expectations on import prices from different sources. Thus if equation (9) is taken as the expected level of imports from source i then the error in forecasting import shares in the previous period is given by:

$$\ln(S_{i,t-1}) - \frac{1}{1+\beta}\ln(b_i) - \frac{\beta}{1+\beta}\left\{ \ln\left(\frac{\omega_{i,t-1}}{p_{t-1}} \right) - \ln(A_{i,t-1}) \right\} \tag{10}$$

Substituting $A_{it} = \exp\{\psi_i t\}$ into (9) and taking first differences provides:

$$d\ln(S_{it}) = \frac{\beta}{1+\beta}\left(d\ln\left(\frac{\omega_{it}}{p_t}\right) - \psi_i\right) \quad (11)$$

It is assumed that producers adjust current ordering patterns in response to past ordering errors. We shall assume that firms adjust inventories (excess or short fall) by some proportion of the error in the previous period. Thus the model includes a proportional change in shares plus some proportion of previous error which is known as an error correction mechanism:

$$\begin{aligned} d\ln(S_{it}) = {} & \frac{\beta}{1+\beta}\left(d\ln\left(\frac{\omega_{it}}{p_t}\right) - \psi_i\right) + \\ & (\alpha_i - 1)\left(\ln(S_{i,t-1}) + c_i - \frac{\beta}{1+\beta}\left\{\ln\left(\frac{\omega_{i,t-1}}{p_{t-1}}\right) - \psi_i(t-1)\right\}\right) \end{aligned} \quad (12)$$

where $-1 < (\alpha_i - 1) < 0$ is expected and $c_i = -\frac{1}{1+\beta}\ln(b_i)$.

To implement this model describing import demand behaviour for New Zealand, the total cost function $C(\omega,q)$ will be assumed to represent the total cost of importing a particular commodity. This function is therefore the minimum cost of importing a quantity of imports q from different sources, where ω_i is the price of an import from source i. Equation (12) is the system of equations to be estimated for each commodity. Each equation relates the share of a particular commodity that is imported from each of the import sources to the price of that commodity from each source.

Data and estimation

The quantity and value of imports (including freight costs) were obtained from the New Zealand Department of Statistics (External Trade Section). Data were monthly for the period July 1982 to December 1987. Import data were provided at the 5 digit Standard International Trade Classification (SITC).

Price and quantity series were formed by taking a divisia index of the prices and quantities of the components of aggregate commodity groups (Diewert 1978). The divisia index formula was chosen to aggregate the various components of each commodity group, because it is a weighted average of past and current prices and values. Alternative indices such as Laspeyres and Paasche, require base prices and thus do not take into account compositional changes in the share of each component within a commodity group.

The formula for the divisia index uses the logarithm of shares and prices. If either quantity or price is zero then the divisia index will be undefined. In order to remove the zeros from the data, the data were aggregated from the 5 digit SITC level to the 4 digit SITC level. In addition the data were aggregated from monthly data to quarterly data, to further remove the zeros. Details of the steps involved in aggregating the data are available in Maclaine and Wear (1990).

The percentage of each commodity imported from the different sources and the total value of imports are presented in tables 1 and 2 for the December quarters 1982 and 1987, respectively. The percentage of each source in total imports is provided in the final row, while the last column contains the percentage of each commodity in total imports.

There was little change in the composition of total imports over this period. Approximately one quarter of New Zealand's imports came from Asia. Australia is the second most important supplier of imports, supplying just over one fifth of New Zealand's imports. The most important commodity imported into New Zealand is Other Machinery and Equipment; its share of total imports increased over the five years from 21.6 per cent to 25.7 per cent. A significant shift is noticeable in the share of meat products by source between 1982 and 1987. In 1982 34.4 per cent were provided by Australia. However, by 1987 Australia was by far the most significant supplier providing 83.3 per cent of meat imports. Most of this increase occurred at

Table 1: **Percentage of commodity import value by source December quarter 1982** (per cent)

	Sources					
Commodity	*Asia*	*Australia*	*EC*	*Other Countries*	*North America*	*Proportion of commodity in imports*
Non-grain crops	14.3	12.0	2.5	42.1	29.1	3.8
Other minerals	1.8	10.0	1.1	30.0	57.1	2.2
Meat products	16.5	34.4	3.8	10.3	35.1	0.4
Other food	15.4	19.3	10.6	40.1	14.6	4.8
Tobacco and beverages	0.5	28.5	40.1	26.0	4.9	1.3
Spinning, weaving, dyeing, and other made-up textile goods	21.0	9.6	16.9	38.5	14.1	8.4
Wearing apparel	7.6	9.2	8.2	69.8	5.2	0.4
Leather fur and their products	3.2	26.4	34.4	26.2	9.8	0.6
Lumber and wood products	4.5	24.1	30.8	30.6	10.0	0.3
Pulp, paper and printing	22.2	12.3	37.0	19.1	9.4	2.0
Chemicals, plastics and rubber	14.1	16.0	21.3	18.0	30.7	13.4
Petroleum and coal products	25.6	40.5	1.0	18.0	15.0	11.5
Non-metallic mineral products	16.4	25.5	38.2	6.6	13.2	1.7
Primary iron and steel	51.4	26.9	10.9	7.6	3.2	9.3
Other metal and metal products	16.6	42.4	11.4	8.9	10.6	6.6
Transport equipment	30.7	29.7	15.6	2.2	21.8	11.1
Other machinery and equipment	33.2	11.0	26.2	9.3	20.2	21.6
Other manufactures	15.6	12.5	16.4	38.8	16.6	0.7
Aggregate imports	25.3	22.4	16.5	17.1	18.7	100.0

Source: New Zealand Department of Statistics, External Trade Section.

the expense of meat imports from North America.

During the period of the study there was a movement towards freer trade between Australia and New Zealand that might be reflected in the level of imports from Australia increasing not through changes in prices and this may cause some bias of the estimates. The free trade agreement between New Zealand and Australia has become known as Closer Economic Relations (CER). CER was implemented in the beginning of the first quarter of 1983. The agreement resulted in immediate removal of some restrictions to imports to New Zealand, while other commodities had the restrictions removed gradually. Within each SALTER group different commodities were affected in different ways. Some were never affected by trade restrictions, others were to have restrictions phased out gradually, while the remainders had restrictions removed immediately. Because immediate removal only occurred for a few commodities, CER was not considered to have much impact on the estimated demand for imports from Australia. Any impact could be expected to be negligible and accounted for in the time trend for imports from Australia.

Table 2: **Percentage of commodity import value by source December quarter 1987** (per cent)

	Sources					
Commodity	*Asia*	*Australia*	*EC*	*Other Countries*	*North America*	*Proportion of commodity in imports*
Non-grain crops	11.7	22.8	3.2	35.0	27.3	2.7
Other minerals	5.4	13.3	7.7	38.0	35.5	0.9
Meat products	1.7	83.2	3.3	8.0	3.8	0.6
Other food	19.4	37.5	11.0	20.1	12.0	5.1
Tobacco and beverages	0.3	51.0	31.7	13.1	3.9	1.3
Spinning, weaving, dyeing, and other made-up textile goods	15.3	14.7	18.5	43.1	8.4	6.5
Wearing apparel	5.2	16.8	11.2	64.4	2.4	0.6
Leather fur and their products	3.7	30.0	21.7	37.4	7.2	0.7
Lumber and wood products	8.8	37.0	13.3	36.0	4.8	0.8
Pulp, paper and printing	17.1	11.0	36.5	17.8	17.6	2.8
Chemicals, plastics and rubber	13.9	17.9	23.0	18.6	26.6	10.1
Petroleum and coal products	3.8	32.3	1.6	52.4	10.0	3.5
Non-metallic mineral products	9.8	19.0	42.6	15.5	13.2	2.4
Primary iron and steel	54.8	16.5	10.5	10.2	8.0	7.8
Other metal and metal products	9.6	58.3	11.6	14.4	6.1	6.6
Transport equipment	23.6	23.7	23.0	4.0	25.9	21.1
Other machinery and equipment	37.5	10.4	23.2	16.3	12.6	25.7
Other manufactures	18.1	15.9	26.4	26.5	13.0	0.9
Aggregate imports	24.4	22.0	19.7	17.8	16.1	100.0

Source: New Zealand Department of Statistics, External Trade Section.

The set of equations given by (12) is assumed to have an additive error term which has an independent normal distribution with mean zero and unknown covariance matrix. Any variation in the share of imports from one source will impact on the share of imports from other sources, consequently it is assumed that the errors are not independent across the equations. Zellner's (1962) technique of seemingly unrelated regressions was adapted to the non-linear setting of the present estimation.

The system of equations (12) consists of import shares which add up to total imports of a commodity. Including all the shares would result in a singular covariance matrix. The share of imports from the US was eliminated from the estimated system to avoid this. Since the critical

Table 3: **Estimated derived import demand equations by source**

	Estimated coefficient:								
Source:		*Asia*			*Australia*			*EC*	
SALTER Commodity:	α_1	c_1	ψ_1	α_2	c_2	ψ_2	α_3	c_3	ψ_3
Non-grain crops	-0.00	1.75	2.23	-0.23	2.55	-8.47	-0.42	3.70	-2.34
	(-0.01)	(15.77)	(1.64)	(-1.24)	(17.75)	(-1.59)	(-2.67)	(45.97)	(-1.12)
Other minerals	-0.15	3.97	-0.02	0.32	3.03	0.06	0.06	4.74	0.15
	(-0.64)	(19.36)	(-1.08)	(1.69)	(7.58)	(1.52)	(0.29)	(19.45)	(4.20)
Meat products	0.06	1.32	-0.55	-0.04	1.26	0.32	-0.21	3.15	0.30
	(0.24)	(3.48)	(-0.79)	(-0.19)	(11.40)	(0.96)	(-1.21)	(9.15)	(0.85)
Other food	0.02	2.12	0.04	-0.00	1.52	0.03	0.30	1.90	-0.00
	(0.08)	(19.81)	(4.10)	(-0.03)	(10.50)	(2.95)	(1.72)	(11.13)	(-0.03)
Tobacco & beverages	0.28	4.46	0.14	0.09	1.72	-0.06	0.31	0.55	0.04
	(1.72)	(9.49)	(2.19)	(0.69)	(8.71)	(-2.24)	(2.60)	(4.45)	(2.24)
Spinning, weaving, dyeing	0.38	1.28	0.49	0.18	2.75	-0.53	0.38	1.76	-0.16
other made-up textile goods	(2.45)	(14.72)	(0.20)	(1.27)	(31.09)	(-0.20)	(2.54)	(24.64)	(-0.19)
Wearing apparel	-0.21	2.61	0.06	-0.58	2.91	-0.14	-0.03	2.34	-0.01
	(-1.35)	(15.59)	(1.21)	(-3.03)	(19.01)	(-2.50)	(-0.18)	(13.85)	(-0.55)
Leather, fur & their products	0.35	3.13	0.28	-0.22	1.56	0.19	-0.15	0.85	-0.68
	(1.80)	(12.56)	(0.55)	(-1.52)	(26.07)	(0.92)	(-1.26)	(13.76)	(-0.87)
Lumber & wood products	0.16	2.76	-0.40	0.10	1.44	-0.24	0.16	1.07	0.43
	(0.80)	(12.15)	(-0.44)	(0.55)	(15.23)	(-0.42)	(0.79)	(10.68)	(0.42)
Pulp, paper & printing	-0.19	1.30	-0.02	0.58	2.30	0.02	-0.18	1.09	0.00
	(-0.81)	(17.17)	(-1.82)	(2.92)	(8.48)	(1.30)	(-0.88)	(17.63)	(0.45)
Chemicals, plastics & rubber	0.35	2.06	0.04	0.18	1.94	0.01	0.05	1.45	0.03
	(1.52)	(21.65)	(2.26)	(0.80)	(30.56)	(0.89)	(0.24)	(40.68)	(3.61)
Petroleum & coal products	0.05	1.30	0.00	0.00	0.37	-0.03	0.53	3.63	-0.00
	(0.26)	(6.11)	(0.22)	(0.00)	(2.36)	(-5.71)	(2.63)	(3.39)	(-0.11)
Non-metallic mineral products	0.17	1.69	-0.19	-0.23	1.43	-0.08	0.35	1.06	0.12
	(0.93)	(9.88)	(-0.40)	(-1.31)	(35.29)	(-0.59)	(1.37)	(10.59)	(0.43)
Primary iron & steel	0.00	0.52	0.00	-0.08	1.33	-0.01	-0.12	2.32	0.01
	(-0.03)	(13.74)	(0.27)	(-0.55)	(20.68)	(-1.14)	(-0.86)	(28.03)	(1.42)
Other metals and metal	0.36	1.78	-0.53	0.32	0.49	-0.01	0.25	2.11	-0.04
products	(2.49)	(11.22)	(-0.30)	(2.41)	(9.98)	(-0.12)	(1.53)	(24.81)	(-0.17)
Transport equipment	0.62	1.04	0.09	0.46	2.51	-0.05	0.79	4.44	-0.21
	(3.14)	(2.89)	(1.76)	(2.67)	(8.39)	(-1.24)	(4.61)	(2.67)	(-1.28)
Other machinery &	0.22	1.07	0.07	0.17	2.27	-0.03	0.11	1.21	-0.06
equipment	(1.30)	(16.23)	(1.87)	(0.99)	(18.03)	(-0.72)	(0.63)	(15.88)	(-1.58)
Other manufactures	0.43	1.61	0.04	0.10	2.15	-0.08	0.07	1.52	-0.01
	(2.77)	(10.68)	(1.30)	(0.60)	(18.99)	(-3.54)	(0.47)	(11.00)	(-0.40)

Note: t-statistics are in parenthesis

parameter to be estimated (the elasticity of substitution among imports) is constant across import sources, this does not affect the object of this research.

Results

For each of the 18 commodities considered, a system of 4 import share equations (12) was estimated. Each share is the share of imports from a particular source. As mentioned earlier, including all share equations in the system results in a singular system. Therefore the share of imports from North America was dropped from the estimating system. The resulting system of equations was estimated using Zellner's (1962) seemingly unrelated regression technique since

Table 3: *(continued)*

			Summary statistics for estimated demand equations							
Other Countries			*Asia*		*Australia*		*EC*		*Other Countries*	
α_4	c_4	ψ_4	R^2	*DW*	R^2	*DW*	R^2	*DW*	R^2	*DW*
-0.18	0.77	0.86	0.47	1.86	0.45	1.54	0.64	1.75	0.55	1.62
(-1.18)	(17.79)	(1.17)								
0.17	1.23	-0.03	0.75	2.32	0.20	1.78	0.49	1.85	0.44	1.85
(0.87)	(6.28)	(-1.37)								
-0.11	2.30	-0.01	0.36	1.61	0.57	1.89	0.66	2.06	0.49	1.80
(-0.51)	(11.80)	(-0.11)								
-0.14	1.26	-0.04	0.59	1.62	0.74	2.00	0.44	2.20	0.70	2.28
(-0.88)	(11.65)	(-4.65)								
0.34	1.57	0.02	0.41	2.02	0.36	1.37	0.09	1.24	0.65	2.35
(2.40)	(9.06)	(0.64)								
0.32	1.03	-0.20	0.25	1.36	0.43	2.02	0.37	2.06	0.21	1.09
(2.48)	(28.39)	(-0.21)								
-0.34	0.33	0.01	0.40	1.56	0.68	1.20	0.53	2.39	0.86	2.59
(-2.57)	(13.15)	(1.66)								
-0.23	1.44	0.49	0.41	2.38	0.53	1.77	0.47	1.59	0.58	1.68
(-1.67)	(25.52)	(0.82)								
-0.27	1.61	-0.34	0.41	1.87	0.37	1.43	0.23	1.32	0.58	1.65
(-1.51)	(25.87)	(-0.42)								
-0.09	1.74	-0.02	0.58	2.34	0.56	2.45	0.68	1.57	0.54	1.84
(-0.35)	(17.65)	(-2.09)								
-0.03	1.68	-0.03	0.46	2.37	0.59	2.26	0.61	1.23	0.58	2.05
(-0.15)	(25.98)	(-2.64)								
0.23	1.85	-0.08	0.43	1.02	0.60	1.52	0.44	1.89	0.68	1.74
(1.15)	(2.71)	(-3.55)								
-0.03	2.83	0.28	0.34	1.56	0.58	1.76	0.37	2.16	0.40	1.63
(-0.13)	(20.35)	(0.42)								
0.32	3.47	-0.01	0.60	2.17	0.44	1.70	0.72	2.26	0.53	2.07
(1.70)	(11.48)	(-0.33)								
0.43	3.26	1.20	0.31	1.75	0.31	1.85	0.44	2.05	0.29	1.58
(2.50)	(20.53)	(0.30)								
-0.18	4.92	-0.19	0.72	2.03	0.66	2.28	0.87	2.80	0.60	2.05
(-1.06)	(19.58)	(-5.01)								
0.25	2.46	0.08	0.28	1.64	0.27	1.20	0.39	1.66	0.20	1.36
(1.24)	(21.92)	(1.48)								
0.10	1.19	-0.02	0.53	1.81	0.29	1.41	0.45	1.78	0.82	2.73
(0.57)	(12.63)	(-1.18)								

variation in import shares from one source will impact on the shares of imported commodities from other sources; consequently it is expected that the errors are not independent across the equations. The estimation was performed using the non-linear regression algorithm within SHAZAM (White *et al* 1990). The elasticity of substitution was included in the estimation procedure by substituting $\beta=(1-\sigma)/\sigma$ in equations (12); thus the standard errors for the estimated elasticity of substitution are obtained directly.

Summary statistics and the estimated coefficients for each equation are provided in table 3, while table 4 contains the estimated elasticity of substitution and corresponding t-statistics. Table 5 contains the own price elasticities of demand from each source, computed for all commodities using the estimated elasticity of substitution and the import shares for the December quarter 1987.

The single equation coefficients of determination (R^2) imply the model fitted the data well. In 40 out of 70 equations estimated, more than 50 per cent of the variation in the data is accounted for by the model proposed. Kohli and Morey (1990) estimated their CES import demand equations using the seemingly unrelated regression equations technique. The model proposed by Kohli and Morey provided a superior explanation of the data compared to our results,

Table 4: **Estimated CES elasticity of substitution between import sources**

SALTER commodity	*Estimated elasticity of substitution:*	*SALTER commodity*	*Estimated elasticity SALTER commodity*
Non-grain crops	1.00 (283.37)	Paper, pulp & printing	2.18 (6.50)
Other minerals	1.81 (8.94)	Chemicals, plastics & rubber	1.44 (11.81)
Meat products	1.13 (7.58)	Petroleum & coal products	3.15 (9.99)
Other food products	2.02 (9.35)	Non-metallic mineral products	1.08 (5.79)
Tobacco & beverages	0.46 (7.37)	Primary, iron & steel	1.61 (7.40)
Spinning, weaving, dyeing and other made-up textiles goods	0.96 (4.36)	Other metal products	1.06 (7.40)
Wearing apparel	0.55 (2.61)	Transport equipment	0.52 (11.20)
Leather, fur & their products	1.05 (19.88)	Other machinery & equipment	1.23 (11.06)
Lumber and their products	0.94 (7.09)	Other manufactures	0.63 (5.35)

Note: t-statistics in parenthesis.

explaining almost all the variation of the data. It appears that the main difference between the model estimated here and that of Kohli and Morey is that their study provided additional variables to explain the difference in demand between the sources. Corado and de Melo (1983) estimate their model using OLS and obtain a similar range of coefficients of determination to those obtained in this appendix. Although the authors admit their data was of poor quality, their low R^2 were probably also due to the restrictive nature of their model.

Table 5: **Estimated own price elasticities of demand for each import source, December quarter 1987**

	Sources				
Commodity	*Asia*	*Australia*	*EC*	*Other Countries*	*North America*
Non-grain crops	-0.88	-0.77	-0.97	-0.65	-0.73
Other minerals	-1.71	-1.57	-1.67	-1.12	-1.17
Meat products	-1.11	-0.19	-1.09	-1.04	-1.09
Other food	-1.63	-1.26	-1.80	-1.61	-1.78
Tobacco and beverages	-0.46	-0.23	-0.31	-0.40	-0.44
Spinning, weaving, dyeing and other made-up textile goods	-0.81	-0.82	-0.78	-0.55	-0.88
Wearing apparel	-0.52	-0.46	-0.49	-0.20	-0.54
Leather, fur and their products	-1.01	-0.74	-0.82	-0.66	-0.97
Lumber and wood products	-0.86	-0.59	-0.81	-0.60	-0.89
Pulp, paper and printing	-1.81	-1.94	-1.38	-1.79	-1.80
Chemicals, plastics and rubber	-1.24	-1.18	-1.11	-1.17	-1.06
Petroleum and coal products	-3.03	-2.13	-3.10	-1.50	-2.84
Non-metallic mineral products	-0.97	-0.87	-0.62	-0.91	-0.94
Primary iron and steel	-0.73	-1.34	-1.44	-1.45	-1.48
Other metal and metal products	-0.96	-0.44	-0.94	-0.91	-1.00
Transport equipment	-0.40	-0.40	-0.40	-0.50	-0.39
Other machinery and equipment	-0.77	-1.10	-0.94	-1.03	-1.08
Other manufactures	-0.52	-0.53	-0.46	-0.46	-0.55

A Wald test (Amemiya 1986) was performed on the overall significance of the system regression by testing the joint hypothesis that all coefficients with the exception of the constant (or intercept) term are zero. The Wald test has an asymptotic chi squared distribution with degrees of freedom equal to the number of coefficients being tested, which in this case is 9. For all estimated import demand equations the Wald statistic exceeded the 5 per cent critical value of 16.9 with the lowest test value being 37.2 for Wearing apparel.

The Durbin Watson statistics indicate serial correlation is not present in most equations estimated. A Durbin Watson test statistic close to 2 reflects the absence of serial correlation. With few exceptions most Durbin Watson statistics were between 1.5 and 2.5. It was therefore not considered necessary to re-estimate the demand equations with corrections for any bias in the standard errors of the coefficients that arise when the errors are serially correlated.

From equation (7) it can be determined that a negative coefficient on the time trend ψ_i will result in the A_i term, which is an exponential function of time, decreasing during the period of the data. Since the A_i term appears in the denominator of the import share equation (7), a negative coefficient implies the share of imports from that source increases over time. Conversely a positive coefficient implies that the share falls over time. Individually the inclusion of the time trend appeared to make no significant contribution to the equations estimated with few of the coefficients being significantly different from zero at the 5 per cent level of significance.

Error correction terms α_i should fall between zero and one if forecasting errors are partially corrected for. If α_i equals zero then importers correct their errors instantaneously. If however α_i is less than zero then importers overcorrect their previous errors. An estimated α_i greater than one would be unreasonable as it would imply importers continually repeat their previous errors. This latter case does not appear in the results estimated.

Some of the estimated coefficients do however imply overcorrection by importers. In most cases however the α_i terms are not significantly different from zero, consequently we cannot reject the hypothesis that the error correction terms are not significantly different from negative one, which would indicate that in response to previous expectation errors, importers fully correct their error in the next period.

The estimated trend (ψ_i) coefficients indicate that there seems to have been some increase in the share of commodities imported from Australia at the expense of New Zealand's other Oceanic trading source Asia. For 12 of the estimated commodity import demand equations there was an increase in the share of imports from Australia while there was a fall in Asia's share of imports for 12 commodities, during the period of the data. There would therefore seem to be some evidence, however small, that there has been some increase in the demand for imports from Australia arising out of Closer Economic Relations between Australia and New Zealand. For EC and Other Countries the number of commodities for which demand for imports from these sources fell, was slightly outweighed by the number of commodities for which demand from these sources rose.

The term in (12) involving the coefficient b_i may alternatively be expressed as $C_i = \sigma \ln(b_i)$. Since the elasticity of substitution (σ) is positive for all commodities and the estimated constant is positive for all commodities and sources, then the coefficient b_i falls between zero and one in all cases. The effect of the constant term may best be interpreted from equation (9) with the demand share equations in logarithms. If the term in parenthesis is set to zero then the constant term represents some minimum level of import demand from each of the sources. That is the level that will always be imported regardless of what happens to prices. The estimated results indicate that for all imported commodities there will be some level of import demand by source that will be autonomous to the relative price levels. The inclusion of the constant term appears to be warranted since the corresponding t-statistic is relatively large, indicating it is significantly different from zero.

All elasticities of substitution are positive as expected, and are significantly different from zero at the 5 per cent level of significance, indicating that there is substitution between all sources. The large t-statistic implies that the coefficient is large relative to the standard error, therefore it is highly probable that the true elasticity of substitution falls within a very narrow interval around the estimated elasticity (assuming the model is correct). A negative elasticity of substitution would have implied complementarity between any pair of import sources for a similar commodity. It would be unreasonable to expect a rise in the price of a commodity from one source to be accompanied by an increase in demand when other sources may provide similar commodities at lower cost.

The estimated elasticity of substitution varies between 0.46 for Beverages and Tobacco and 3.15 for Petroleum and Coal Products. The magnitude reflects the degree with which the importing country may substitute between the different sources. A low value for the elasticity of substitution could be accounted for by the lack of homogeneity of the commodities comprising the SALTER commodity designation and the difference in quality of the commodity from each source. Quality may be the main reason for a relatively low elasticity of substitution for Lumber and Wood products, since the quality of wood depends upon the species of trees grown in each source. It would not be possible for New Zealand to obtain Australian Cedar or Tasmanian Huon Pine from Asia whereas Canadian Maple could not be imported from Australia. The estimate for Other Manufactures is relatively low since since this classification contains a wide variety of manufactures, that is the commodity designation is not very homogenous. Products within this designation range from buttons to jewellery to musical equipment. If some sources account for the bulk production of the individual goods then this will account for the low estimated elasticity of substitution since importers will not readily substitute between the different goods within the SALTER designation. The elasticity of substitution for Paper, Pulp and Printing is relatively large however, as this classification is relatively more homogeneous since it is less aggregated but more importantly there is less difference in quality between the sources of imports. New Zealand importers will therefore more readily switch between their sources of imported paper as the relative prices of paper imports vary.

The elasticity of substitution for US imports of crude oil estimated by Kohli and Morey of 3.37, with a t-statistic of 1091.14, is very close to the elasticity of substitution for Petroleum and Coal Products estimated by the model proposed here of 3.15. Corado and de Melo obtained an elasticity of substitution of 0.15, with a t-statistic of 0.19 significantly lower than the estimates obtained here and by Kohli and Morey. In addition a different aggregation for Corado and de Melo's commodity group, Petroleum and coal derivatives, may also explain some of the difference in the results of the two models.

The compensated demand elasticity measures the change in input demand once the income effect has been removed, that is, the compensated demand elasticity is measured with output held fixed and only the input combination allowed to vary. The compensated demand elasticity may be recovered from the elasticity of substitution between import sources i and j (σ_{ij}) by multiplying the elasticity of substitution by the share of imports from j. The matrix of compensated demand elasticities will therefore not be symmetric although the elasticity of substitution is constant. The own price elasticities may be obtained via the homogeneity property of the cost function which requires the compensated elasticity with respect to prices must sum to zero; alternatively the own price elasticity is equal to the negative of the sum of the compensated cross demand elasticities. Since the estimated elasticity of substitution is positive and the share of import values must sum to one then the cross compensated demand elasticities obtained from this model will all be positive. Through the homogeneity property, the derived own-elasticities of demand are therefore all negative as expected

Table 5 contains the own price import demand elasticities computed from the elasticity of substitution and the import shares of the December quarter for 1987. The own price elasticities were typically between zero and negative one indicating the demand for imported commodities from most sources was inelastic, that is the responsiveness of import demand from each source to a change in price was low. The most elastic demand for imports was for imports of Petroleum and Coal Products from the EC with an own price elasticity of -3.10, the most inelastic response being for imports of Pulp Paper and Printing from Other Countries which had an own price elasticity of demand of -0.20.

Conclusions

This study has found that the elasticities of substitution between import sources to be lower than those being used in some multicountry general equilibrium models. For example the substitution elasticity between import sources vary around 5 within the WALRAS model (See OECD 1990). It is important however to recognise that the estimates reflect short run. Long run estimates are expected to be higher, as firms will substitute between sources more if they believe price changes are to be sustained.

Further work may be necessary to estimate long-run elasticities. One possible route is to have prices generated by some expectations mechanism. Other work that may be fruitful is restricting the error correction term to be more plausible, in our case the error correction term should be restricted from implying overcorrection. Further consideration should be given to the choice of lagged variables. It may be more appropriate to lag by four quarters, to remove changes between successive quarters caused by seasonal effects. An alternative is the introduction of seasonal dummy variables to remove the seasonal effect.

The model proposed here assumed that the ad valorem rate of duty was the same for each source. Further investigation should be undertaken to see if the assumption was valid and there have been no changes during the sample period on the duty applied from each source.

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