

**The Production Theory Approach to Import Demand Analysis: A Comparison of  
the Rotterdam Model and the Differential Production Approach**

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## **The Production Theory Approach to Import Demand Analysis: A Comparison of the Rotterdam Model and the Differential Production Approach**

The Rotterdam model application to import demand has been accomplished by a number of studies (Lee, Seale, and Jierwiriyanant; Seale, Sparks, and Buxton; and Zhang, Fletcher, and Carley). In past studies, imports are considered to be final goods that enter directly into the consumer's utility function and the resulting demand equations for imports are derived from consumer maximization theory. However, given the nature of international trade, where traded goods are either used in other production processes or go through a number of domestic channels before reaching the consumer, it is more appropriate to view imported goods as intermediate products than as final consumption goods even if no transformation takes place.

The primary objective of this paper is to present the differential approach to the theory of the firm and to present the methodology of how it can be applied to import demand analysis. Furthermore, this paper compares and contrasts the use of the differential production approach with the Rotterdam model. This approach is also applied to Japan's derived demand for imported wheat differentiated by source country of production.

The application of production theory to international trade is by no means a new concept. Past research that used a production theory approach to international trade include Burgess (1974a) and (1974b), Kohli (1978) and (1991), Diewert and Morrison (1989), and Truett and Truett (1998). However, these studies used production theory to estimate aggregate import demand and not the import demand for individual products or similar products from different sources. Each of these studies acknowledged that most goods entering into international trade require further processing before final demand delivery. They further acknowledged that even when a traded product is not physically altered, activities such as handling, insurance, transportation, storing, repackaging, and retailing still occur. This results in a significant amount

of domestic value added when the final product reaches the consumer. Therefore it is more appropriate to view imported products as inputs rather than as final goods even if goods are not transformed (Kohli, 1978; Diewert & Morrison, 1989).

The assumption of import decisions being made by profit maximizing firms and not by utility maximizing consumers has a number of advantages. One clear advantage is the correctness of this assumption in terms of how products are traded. Firms make import purchases and rarely do consumers purchase products directly from other countries. Another advantage relates to how traded products are typically reported. Traded commodities are typically reported in bulk quantities and values at dockside. Consumers almost never purchase commodities in such quantities or at the port. Therefore, assuming that import decisions are made by a profit-maximizing firm is more consistent with how trade data is typically reported.

Kohli (1991) notes that viewing imports as intermediate goods not only has its merits in correctness, but it also leads to substantial simplifications theoretically. One simplification is that the demand for imports can be derived from production theory and there is no need to model final demand. Second this approach allows for the avoidance of the difficulties that arise when we aggregate over individual consumers. To expound on this point, data that are typically reported are usually aggregate data. Therefore, if we are estimating demand, we are estimating aggregate demand, and if we are estimating derived demand it is aggregate or industry derived demand. The differences between aggregate demand and aggregate derived demand is that one is an aggregation over consumers and the latter is an aggregation over firms. When we consider optimizing behavior by both consumers and firms, do the properties derived from consumer and producer-maximizing behavior hold in the aggregate? Mas-Colell et al. (1995) indicates that when consumer preferences and wealth effects are identical across consumers, the aggregate

demand function satisfies all of the properties of an individual demand function.<sup>1</sup> However, if there is the slightest difference in preferences, and if these differences are independent across consumers, as one would expect, the property of symmetry, which is a common property tested in most empirical demand studies, will almost certainly not hold.<sup>2</sup>

When we aggregate across firms, there are no such conditions required for the properties of optimal firm behavior to hold in aggregation. This is because the aggregate profit obtained by each production unit maximizing profit separately, taking prices as given, is the same as that which would be obtained if they were to coordinate their actions in a joint profit maximizing decision (Mas-Colell et al., 1995)<sup>3</sup>. This result implies that the profit maximizing output arrived at if all firms coordinated their actions is the same as the sum of the individual output of each profit maximizing firm. It further implies that the total cost of production for the coordinated output is the same as the sum of total cost for each individual firm if firms are price takers in the input market (Mas-Colell et al., 1995). Therefore if we estimate input demand functions and output supply functions using aggregate data, the properties of the demand and supply functions for each individual firm will theoretically hold in aggregation.<sup>4</sup>

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<sup>1</sup> The properties of a system of demand equations for a utility maximizing consumer are adding up, homogeneity, and the symmetry and negative semi-definiteness of the matrix of price effects.

<sup>2</sup> The property of negative semi-definiteness holds in aggregation under less strict conditions. If each individual demand function satisfies the uncompensated law of demand then the aggregate demand function satisfies the weak axiom of reveal preference which implies a negative semi-definite price effect matrix.

<sup>3</sup> Prices are assumed as given even with coordination.

<sup>4</sup> The properties of the input demand function are the same as the properties of the consumer demand function. The properties of the supply function are that the matrix of price effects is symmetric and positive semidefinite. The author assumed that firms are still price takers even with coordination. Production technology can vary over firms.

## **The Differential Approach to the Theory of the Firm**

The differential approach to the theory of the firm is comparable to the differential approach to consumer theory proposed by Henri Theil and A.P. Barten in 1965. The empirical application of the differential approach to consumer demand resulted in the Rotterdam model, which has been used extensively in demand studies and to a lesser extent in import demand studies. The majority of import demand studies that used the Rotterdam model assumed that imported goods entered directly into the consumer's utility function and strong assumptions were made about how consumers view imported and domestic goods and how they grouped commodities. Furthermore, it was often assumed that these commodity groups were to some degree independent in terms of the consumer's utility function (For example, see Lee, Seale, and Jierwiryapant, 1990; Seale, Sparks, and Buxton, 1992; and Zhang, Fletcher, and Carley, 1994.). In these studies, the intermediate nature of imports was not considered.

In comparing the two differential approaches (consumption and production) to the demand for imports, advantages of the production approach become evident. First, in the production approach we need not assume that consumers view imports as separate from domestic goods. Furthermore, we need not assume that consumers group goods such that there is no good that belongs to two different groups and that those groups are separable. Instead we only need to make assumptions about the production possibilities of the firm in question and the input requirement set for a given production possibility set, which may be easier to argue intuitively.

Second, as mentioned before, optimization properties of the firm theoretically hold in aggregation while these same properties will more than likely not hold when we aggregate over consumers. Therefore, imposing economic restrictions in the production case is more justified. The difficulties that arise when aggregating over consumers are rooted in the ordinal nature of

the utility function. The value of a utility function for a given bundle of goods in and of itself is meaningless, it only has meaning when we compare it to the value of utility from another bundle. Therefore, if we aggregate across consumers, we are only concerned with the preserving of a rational preference ordering and not the aggregate value of the utility function. If there are differences in preferences across consumers then it is possible that aggregate data may violate the rationality assumptions yielding the properties of demand such as the weak axiom of reveal preference and transitivity (Mas-Colell et al., 1995). In contrast, the value of a production function is a physical quantity and in aggregation we get the aggregate quantity produced and as long as the individual firms are maximizing profits, this implies that the industry is operating at its optimal potential.

In estimating consumer demand, an advantage of the differential approach is that a functional form of the consumer's utility function need not be assumed. Furthermore, economic properties resulting from consumer maximization can be both tested and/or imposed as well as further demand restrictions such as strong and weak separability of individual commodities, and depending on the final version chosen this approach results in a linear system of equations. There are similar advantages to the differential production approach as well. Comparable to the consumer approach, a particular functional form of the production function, profit function, or cost function need not be assumed. The maximization properties in consumer demand (homogeneity, symmetry, etc.) also apply in production theory. These properties can also be tested and/or imposed in the production approach. Lastly, following a similar process as the derivation of the Rotterdam model, the differential production approach results in a linear system of input demand and output supply equations.

## Overview of Theory

In this section the multi-product firm is considered. This firm makes  $m$  products and utilizes  $n$  inputs in the production process. Letting  $\mathbf{q} = [q_1, \dots, q_m]$  represent the vector of  $m$  possible outputs and  $\mathbf{x} = [x_1, \dots, x_n]$  represent the vector of  $n$  inputs, the production of the firm is expressed implicitly as

$$h(\mathbf{q}, \mathbf{x}) = 0. \quad (1)$$

Equation (1) is twice differentiable, continuous and is expressed such that

$\partial h / \partial q_r < 0$  and  $\partial h / \partial x_i > 0$  for all  $r = 1, \dots, m$  and for all  $i = 1, \dots, n$ .<sup>5</sup> Without any loss in generality, we can conveniently use the output-homogeneous form of equation (1) which implies that this function satisfies

$$\sum_{r=1}^m \frac{\partial h}{\partial \log q_r} \equiv -1. \quad (2)$$

Selecting equation (1) such that it satisfies equation (2) amounts to representing the firm's technology by a unique production function (Laitinen and Theil, 1978; Laitinen, 1980; Theil, 1977). Note that equation (2) is automatically satisfied when the firm produces a single output and the production function is expressed implicitly in the form of equation (1) (Laitinen, 1980). This is not the case for every multi-product production function.

The objective of the firm is to maximize profits or minimize cost subject to the technology represented by equation (1). In this study it is assumed that firms maximize profits in a two step procedure which involves both profit maximization and cost minimization. The two step procedure to profit maximization assumes that within the firm there are two managers, a

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<sup>5</sup> When a production function is expressed in the form of equation (1) it is often referred to as a transformation function. For the single output firm this would be  $h(\mathbf{q}, \mathbf{x}) = h(\mathbf{x}) - q = 0$ .

production manager and an input manager. Given both input and output prices, the production manager decides on a profit-maximizing output mix and then informs the input manager of his decision. Next, the input manager having knowledge of the target output specified by the production manager acquires the inputs necessary to produce the target output such that costs are minimized (Laitinen, 1980; Theil, 1977). An alternative approach is to assume a direct or one step profit maximization procedure where there is one manager that chooses both outputs and inputs simultaneously, given input and output prices. Due to the duality of cost and profit, it can be shown that the resulting system of input demand equations from each procedure are equivalent (Mas-Colell et al., 1995). This is because profit maximization implies cost minimization at some optimal output level.

Although these two procedures yield equivalent input demand equations, there are advantages to assuming the two step procedure. The direct profit maximizing procedure yields a system of input demand and output supply equations for the firm both expressed in terms of output and input prices. As a result of this procedure, the error terms in the supply and demand equations are statistically dependent (Laitinen, 1980; Theil, 1977). Therefore if the interest is in derived demand equations only, as with this study, the estimation of input demand without the supply equations can not be justified. However, the two step procedure results in supply and demand equations where the errors of the supply equations are independent of the errors in the input demand equations. In this case input demand can be estimated independent of supply (Laitinen, 1980; Theil, 1977). A second advantage of the two step procedure is that, if one is only concerned about input demand, this procedure only requires that firms are price takers in the input market, but the output market can be perfectly competitive, monopolistic, etc. (Mas-Colell et al., 1995). In the one step profit-max approach, both the output and input markets must be



perfectly competitive, which may not always be the case. Additionally, if the interest is in input demand alone, the two step approach allows us to proceed directly to the cost minimization problem.

The differential production approach is comparable to the differential approach to the consumer. As mention, if we assume a cost minimizing firm that is subject to the technology given by equation (1), the result is a vector of input demand quantities that are a function of output and input prices expressed in general form as  $\mathbf{x} = \mathbf{x}(\mathbf{q}, \mathbf{w})$ . The basis of the differential approach is the total differentiation of the general input demand equation. However, before moving forward, a number of concepts resulting from the cost minimization problem must be defined (Laitinen, 1980; Theil, 1977; Laitinen & Theil, 1978).

The first concept to be considered is the elasticity of scale. The elasticity of scale is defined as the proportion by which output changes when all inputs change proportionately which is equal to  $\sum_i \partial h / \partial \log x_i$  for the multiproduct firm. However, if we consider the total differential of equation (1) in logarithmic form

$$\sum_{i=1}^n \frac{\partial h}{\partial \log x_i} d(\log x_i) + \sum_{r=1}^m \frac{\partial h}{\partial \log q_r} d(\log q_r) = 0, \quad (3)$$

and the result in equation (2), the elasticity of scale can be expressed as

$$\sum_{i=1}^n \frac{\partial h}{\partial \log x_i} = \sum_{i=1}^n \frac{w_i x_i}{\mathbf{I}} = \frac{C}{\mathbf{I}}. \quad (4)$$

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<sup>6</sup> Given that we are only concerned with proportional changes in input and output,  $d(\log x_i)$  and  $d(\log q_r)$  can be placed before the summation signs. This result also makes use of the first order condition in the cost minimization problem where  $\mathbf{I}$  is the Lagrange multiplier.

For convenience, we define the reciprocal of the elasticity of scale as  $\mathbf{g} = \mathbf{I}/C$  where  $C$  is the total cost,  $\mathbf{w}'\mathbf{x}$ . In addition to being the reciprocal of the elasticity of scale,  $\mathbf{g}$  is also equal to the elasticity of cost with respect to a proportionate output increase defined as

$$\mathbf{g} = \sum_{r=1}^m \frac{\partial \log C}{\partial \log q_r} . \quad (5)$$

This is verified in Laitinen (1980, pp. 11-14).

The next concepts to be defined are the factor and product shares. If we again define total cost as  $C$ , the factor share is defined as

$$f_i = \frac{w_i x_i}{C} . \quad (6)$$

Note that  $f_i > 0$  and  $\sum f_i = 1$ . Using the first order condition to the cost minimization problem it can be shown that

$$f_i = \mathbf{g} \frac{\partial h}{\partial \log x_i} \quad (7)$$

at the optimum. If we view  $q_r(\partial C / \partial q_r)$  as the dollar value of the  $r$ th output evaluated at its marginal cost and  $\sum_r q_r(\partial C / \partial q_r)$  as “total marginal cost”, then the share of the  $r$ th product in total marginal cost is defined as

$$g_r = \frac{q_r(\partial C / \partial q_r)}{\sum_{s=1}^m q_s(\partial C / \partial q_s)} . \quad (8)$$

By totally differentiating the factor share equation we can define the Divisia indexes.

Total differentiation of the factor share equation (6) is

$df_i = (x_i / C)dw_i + (w_i / C)dx_i - (w_i x_i / C^2)dC$  , which can also be expressed as

$$df_i = f_i d(\log w_i) + f_i d(\log x_i) - f_i d(\log C) . \quad (9)$$

If we sum equation (9) over  $i$ , we obtain

$$d(\log C) = d(\log W) + d(\log X) \quad (10)$$

Equation (10) is the Divisia decomposition of a logarithmic change in cost into the Divisia input price index and the Divisia input volume index, which are respectively defined as

$$d(\log W) = \sum_{i=1}^n f_i d(\log w_i) \quad (11a)$$

$$d(\log X) = \sum_{i=1}^n f_i d(\log x_i). \quad (11b)$$

We can also define an implied Divisia volume index of the outputs as

$$d(\log Q) = \sum_{r=1}^m g_r d(\log q_r). \quad (12)$$

Lastly, we define the marginal share of the  $i$ th input in the marginal cost of the  $r$ th product as

$$\mathbf{q}_i^r = \frac{\partial(w_i x_i) / \partial q_r}{\partial C / \partial q_r}, \quad (13)$$

and the Divisia mean of equation (14) as

$$\mathbf{q}_i = \sum_{r=1}^m g_r \mathbf{q}_i^r = \frac{1}{\mathbf{1}} \sum_{r=1}^m \frac{\partial(w_i x_i)}{\partial \log q_r}. \quad (14)$$

Equation (14) can also be regarded as the mean share of the  $i$ th input in the marginal cost of the firm.

As mention before, the basis of the differential production approach is the total differential of the general input demand equation resulting from the cost minimization problem.

If we put the general input demand equation in matrix form,  $\mathbf{x} = \mathbf{x}(\mathbf{q}, \mathbf{w})$ , the total differential is

$$d(\log \mathbf{x}) = \frac{\partial \log \mathbf{x}}{\partial \log \mathbf{q}'} d(\log \mathbf{q}) + \frac{\partial \log \mathbf{x}}{\partial \log \mathbf{w}'} d(\log \mathbf{w}). \quad (15)$$

If we premultiply equation (15) by  $\mathbf{F}$  equation (15) becomes

$$Fd(\log x) = \mathbf{g} \mathbf{K} \mathbf{G} d(\log q) + \mathbf{y}(\mathbf{Q} - \mathbf{q} \mathbf{q}') d(\log w). \quad (16)$$

where  $F \frac{\partial \log x}{\partial \log w'} = -\mathcal{O}(\mathbf{Q} - \mathbf{q} \mathbf{q}')$  and  $F \frac{\partial \log x}{\partial \log q'} = \mathbf{g} \mathbf{g}' - \mathbf{g} \mathcal{O}(\mathbf{Q} - \mathbf{q} \mathbf{q}') F^{-1} \mathbf{H}^* = \mathbf{g} \mathbf{K} \mathbf{G}$ <sup>7</sup>.

Equation (16) is the system of input demand equations in their final form expressed in vector notation where the demand for the  $i$ th input is expressed as

$$f_i d(\log x_i) = \mathbf{g} \sum_{r=1}^m \mathbf{q}_i^r g_r d(\log q_r) - \mathbf{y} \sum_{j=1}^n (\mathbf{q}_{ij} - \mathbf{q}_i \mathbf{q}_j) d(\log w_j). \quad (17)$$

This equation describes the change in demand for the  $i$ th input, measured by the quantity component of the change in the  $i$ th factor share, in terms of output changes and input price changes.

In addition to equation (17), we can also define the input allocation decision which is comparable to the allocation equation for the consumer. If we sum equation (17) over  $i$ , this results in the following equation

$$d(\log X) = \mathbf{g}' d(\log Q). \quad (18)$$

Equation (18) is the total input decision of the multiproduct firm, which says that the Divisia volume index of the inputs is proportional to the Divisia volume index of the outputs.

Substituting equation (18) into equation (17) results in the input allocation decision

$$f_i d(\log x_i) = \mathbf{q}_i d(\log X) + \mathbf{g} \sum_{r=1}^m g_r (\mathbf{q}_i^r - \mathbf{q}_i) d(\log q_r) - \mathbf{y} \sum_{j=1}^n (\mathbf{q}_{ij} - \mathbf{q}_i \mathbf{q}_j) d(\log w_j). \quad (19)$$

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<sup>7</sup>  $F$  is a diagonal matrix where the factor shares, equation (6), are along the diagonal.  $K$  is an  $n \times m$  matrix which has  $\mathbf{q}_i^r$  as its  $(i,r)$ th element.  $G$  is a diagonal matrix where the product shares, equation (8) are along the diagonal. Results are from Washington (2000).

Equation (19) indicates that changes in the decision to purchase the  $i$ th input is dependent upon the changes in the total amount of inputs obtained, changes in output, and changes in input prices. Equation (18) and (19) can be parameterized such that they are linear in estimation and the resulting parameters can be restricted such that economic properties can be tested.

Equation (18) or (19) also result in the following elasticities: The elasticity of the  $i$ th input with respect to the  $r$ th output for (18) and (19) respectively

$$\mathbf{e}_{x,q} = \frac{d(\log x_i)}{d(\log q_r)} = \frac{\mathbf{g}\mathbf{q}_i^r g_r}{f_i} \quad (20a)$$

$$\mathbf{e}_{xq} = \frac{d(\log x_i)}{d(\log q_r)} = \frac{\mathbf{g}_r(\mathbf{q}_i^r - \mathbf{q}_i)}{f_i}. \quad (20b)$$

The conditional own and cross price elasticity is

$$\mathbf{e}_{xw} = \frac{d(\log x_i)}{d(\log w_j)} = -\frac{\mathbf{y}(\mathbf{q}_{ij} - \mathbf{q}_i\mathbf{q}_j)}{f_i}. \quad (21)$$

The Divisia volume elasticity (equation (19) only) is

$$\mathbf{e}_{xX} = \frac{d(\log x_i)}{d(\log X)} = \frac{\mathbf{q}_i}{f_i}. \quad (22)$$

### **Application to the Derived Demand for Imported Whey in Japan**

As mentioned, this study also assess the competitiveness of whey imports into Japan from the U.S. compared to whey imported from other countries such as the EU, Australia, and New Zealand. Following Armington's (1969) specification, similar imported dairy products such as EU whey and US whey are both individual goods that are part of the product group whey, but different based on their source country of production. There are a number of reasons why similar products are viewed as different based on their source country of origin. Dairy products

from different sources may actually be physically different. Physical differences include quality, protein and fat content, and taste. There may also be perceived differences, such as a country's reputation for a quality product, trade history, reliability and consistency, and political issues tied to trade (Zhou & Novakovic, 1996). The crux of this assumption is that within an importing country, a particular dairy product imported from a given source is considered a substitute for that same product from another source. However, because of the physical and perceived differences attributed the product due to its origin, these products are imperfect substitutes.

In this paper it is assumed that dairy products are imported through firms that exclusively import. Although, there are firms within Japan that import whey as well as transform whey into other products, it is assumed that there is a separate entity within the firm that deals primarily with the procurement of imported dairy products. However, dairy imports through these type firms make up a smaller percentage of imports in Japan. In addition to providing imported products to other firms, these firms also provide the services that are associated with importing. These services include, search and acquisition, transportation, logistics, and storing.

The advantage of assuming this type of firm is that the outputs and the inputs are one and the same. Therefore we need not be concerned about all the possible products that could result from these imported inputs or the technological advancements in milk reconstitution, whey production, and other dairy products production processes.

A major characteristic of this type of firm is that it deals primarily in imported goods. This assumption suggests that the procurement of imported goods by firms is a unique process separate from the procurement of similar products produced domestically. Even if the firm is a subsidiary or branch of a larger firm that purchases domestic and foreign produced inputs, it is not unlikely that the subsidiary that is responsible for imported inputs deals primarily in this

activity. This is because the acquisition of foreign produced goods is more involved than purchasing domestically produced goods.

If we assume a production function for these firms, then the output of these firms is the imported goods that are sold to other firms and the inputs are the imported goods from the various exporting countries. If we minimize cost subject to this function, the system of input demand equations resulting from the optimization procedure will be a system of import demand equations. If we assume product differentiation across source countries, then each import demand equation represents the demand for a product from a particular source.

Assuming input independence and output independence the system of derived demand equations can be simplified into a system that is identical in structure to the Rotterdam model; however, since this approach is derived from production theory, parameters are interpreted differently. The resulting system, which will be referred to as the differential factor allocation model (DFAM) is specified as

$$\bar{f}_{it} D x_{it} = \mathbf{q}_i D X_t + \sum_{j=1}^n \mathbf{p}_{ij} D w_{jt} + \mathbf{e}_{it} \quad (23)$$

where  $\bar{f}_{it} = (f_{it} + f_{it-1})/2$  and  $f_i$  is the  $i$ th factor share of total cost;  $Dx_t = \log(x_t) - \log(x_{t-1})$  and  $Dw_t = \log(w_t) - \log(w_{t-1})$  are the log change in quantity and price respectively from period  $t-1$  to  $t$  and  $x_i$  and  $w_i$  are respectively the quantity and price of Japan's imported whey from source country  $i$ ;  $D(X)$  is the finite version of the Divisa input index, where  $DX_t = \sum_{i=1}^n \bar{f}_{it} D x_{it}$ .

$\mathbf{p}_{ij}$ 's are the price coefficients and  $\mathbf{q}_i$  is the marginal share of the  $i$ th input in marginal cost. Both are parameters to be estimated.<sup>8</sup>

A key feature of the DFAM is that production theory can be tested to determine if the data is consistent with theory. The properties of homogeneity and symmetry are imposed and tested, and negative semi-definiteness is checked by inspection of the eigenvalues of the price coefficient matrix. The homogeneity property in the DFAM model is satisfied when  $\sum_j \mathbf{p}_{ij} = 0$ . Symmetry is satisfied when  $\mathbf{p}_{ij} = \mathbf{p}_{ji}$ .

## Empirical Results

Using United Nations Commodity Trade Statistics the derived demand for imported whey into Japan was estimated. The exporting countries considered were the United States, European Union, Oceania (aggregation of Australia and New Zealand), and rest of the world (ROW) which was an aggregation of all other countries. The time period for the data set was 1976 to 1998. All values and quantities were reported through Japanese customs. Values were on a cost, insurance, and freight basis.

Table 1 displays the parameter estimates for the derived demand for imports of whey into Japan. All own-price coefficients are negative, and with the exception of the ROW, all are significant by at least the .05 significance level. The marginal factor shares estimates indicate a positive relationship between total imports and the imports from the individual sources; however, the marginal factor share estimate for the ROW indicate that as total imports increase, imports

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<sup>8</sup>  $\mathbf{p}_{ij} = \mathbf{y}(\mathbf{q}_{ij} - \mathbf{q}_i \mathbf{q}_j)$ . In equation (23) it is also assumed that the sum total of imported whey makes up a single product. With the added assumptions of input and output independence the single output case can be used.



Table 1 DFAM parameter estimates for Japan imports of whey

Exporting Country	Price Coefficients, $p_{ij}$				Marginal Factor Shares, $q$
	U.S.	Oceania <sup>a</sup>	EU	ROW <sup>b</sup>	
U.S.	-.3662 (.1250) <sup>c***</sup>	.3579 (.0685) <sup>***</sup>	.1029 (.0735)	-.0947 (.0877)	.3152 (.1707) <sup>**</sup>
Oceania		-.4953 (.0969) <sup>***</sup>	.0763 (.0426) <sup>*</sup>	.0612 (.0830)	.3859 (.0685) <sup>***</sup>
EU			-.2914 (.0625) <sup>***</sup>	.1122 (.0645) <sup>*</sup>	.4372 (.1149) <sup>***</sup>
ROW				-.0787 (.1274)	-.1384 (.1212)

System  $R^2 = .80$

<sup>a</sup> Australia and New Zealand aggregation.

<sup>b</sup> ROW= rest of the world.

<sup>c</sup> Asymptotic standard errors are in parentheses.

\*\*\* Significant level = .01

\*\* Significant level = .05

\* Significant level = .10

from all other sources will decrease. With the exception of the ROW all marginal factor shares are significant by at least the .05 significance level.<sup>9</sup>

Cross-price parameter estimates indicate that the U.S and Oceania whey imports, Oceania and EU imports, and EU and the ROW imports are substitutes. Although not significant, substitution exists between the U.S. and the EU, and Oceania and the ROW as well. The parameter estimate for the U.S. and the ROW indicate a possible complementary relationship; however this estimate is not significant from zero, indicating that imports from these sources may also be independent (Table 1).

Table 2 Japan Divisia and price elasticities of the derived demand for imported whey

Exporting Country	Divisia Import	Conditional Own-Price	Elasticities			
			Conditional Cross-Price			
			U.S.	Oceania <sup>a</sup>	EU	ROW <sup>b</sup>
U.S.	.889 <sup>c</sup> (.482) <sup>d</sup>	<i>-1.010</i> (.352)		<i>1.009</i> (.193)	.290 (.207)	-.267 (.248)
Oceania	2.286 (.559)	<i>-2.934</i> (.574)	2.120 (.406)		.452 (.253)	.362 (.492)
EU	2.352 (.618)	<i>-1.568</i> (.338)	.554 (.396)	.410 (.229)		.604 (.347)
ROW	-.476 (.416)	-.271 (.438)	-.325 (.302)	.210 (.285)	.386 (.222)	

<sup>a</sup> Australia and New Zealand aggregation.

<sup>b</sup> ROW = rest of the world.

<sup>c</sup> *Italics* indicate that the elasticity was significant by at least .10.

<sup>d</sup> Asymptotic standard errors are in parentheses.

The Divisia index elasticities for imports of whey into Japan are .889, 2.286, 2.352, and -.476 for the U.S., Oceania, EU, and the ROW respectively. These suggest that imports of whey from Oceania and the EU are superior to imports from the U.S. and the ROW. The negative Divisia elasticity for the ROW indicates that whey from all other sources are considered to be inferior inputs in further production processes (Table 2).

The own price elasticities are -1.010, -2.934, -1.568, and -.271 for the U.S., Oceania, EU, and the ROW respectively. With the exception of the ROW, these elasticities indicate that Japan's demand for imported whey is elastic; however, the demand for U.S. whey is close to unitary elastic. The own-price elasticity for imports from Oceania indicates that imports from this source have been highly sensitive to price changes (Table 2).

<sup>9</sup> Homogeneity and Symmetry are imposed on the parameters. AR(1) is also imposed because a likelihood ratio test rejected the hypothesis of no AR(1).

Cross-price elasticities of derived demand for whey in Japan indicate significant substitutional relationships between the imports from the exporting sources. The U.S./Oceania cross-price elasticity is 1.009, while the Oceania/U.S. elasticity is 2.120, again reflecting the higher value placed on Oceania whey that was indicated by the Divisia elasticity. The Oceania/EU and the EU/Oceania elasticities are .452 and .410 respectively, and the EU/ROW and the ROW/EU elasticities are .604 and .386 respectively. All other cross-price elasticities were not different from zero (Table 2).

## **Conclusions**

The purpose of this paper was to present a methodology of estimating the demand for similar imports differentiated by source country of production. In past studies, imports are considered to be final goods that enter directly into the consumer's utility function and the resulting demand equations for imports are derived from consumer maximization theory. However, given the nature of international trade, where traded goods are either used in other production processes or go through a number of domestic channels before reaching the consumer, it is more appropriate to view imported goods as intermediate products than as final consumption goods even if no transformation takes place.

Treating imports as intermediate goods rather than as final goods allows for the estimating of import demand using production theory rather than utility theory. As mentioned, viewing imports as intermediate goods not only has its merits in correctness, but also theoretical issues such as the aggregation over consumers can be avoided. Lastly, with a few assumption the DFAM results in a system that is exactly identical to the Rotterdam models; however, parameter estimates have different interpretations.

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