Testing the Validity of Standard Representative Agent Import Demand Systems

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Introduction

The standard representative agent import demand system (hereafter called the standard approach) is a popular way to model the aggregate demand for agricultural imports (Alston *et al.*). The Armington version or later versions (i.e. Rotterdam or LA-AIDS model) have been used to estimate demand parameters useful in structuring government agricultural programs and competing strategically for global market share of goods and commodities. The key assumption of the standard approach is that certain factors cause product differention by characteristics unique to the country of origin. Paradoxically, nothing is done explicitly to include or explain these differentiating characteristics in the model. Although the results can be interesting and intuitive, the obvious unanswered question remains "is the country of origin sufficient to explain why a product is more or less preferred?"

Research designed to explicitly test for product differentiation consistantly looks to the theory by Lancaster and Ladd (hereafter called LL approach) in contructing their models. Certainly, the ability to use the LL approach requires data on characteristics which are not always available for agricultural products or commodities. This is especially true at import terminals where critical comparative analysis of prices, quality and quantity can be performed. However, given greater concerns over quality and improved testing technology, these analyses could be more widely performed in the near future.

Davis brought several enlightening points forward in comparing the two approaches. First, the assumption of product differentiation alone does not generate either the standard or the LL demand system. Second, under certain conditions about the form of the product differentiation (see below), we do get the LL system. Third, the standard system is a nested version of the LL system and will be observationally equivelent if two conditions are met. This raises the question, is the standard approach valid and if it is a valid approach when is it valid for modeling international agricultural trade? Davis recommended separate statistical procedures to test if the two condition for a standard system are met. A critique of this test is that the results may not be conclusive. A direct test using characteristic data would yield a more conclusive result.

The purpose of the research presented in this paper is to test the validity of the standard approach using characteristic data of Japanese wheat imports. Although the standard approach is used extensively, when it is a misspecified Lancaster-Ladd system, biased parameters can lead to erroneous policy recommendations. Conversely, the test can also help identify when the standard approach is appropriate eliminating the need for difficult to obtain characteristics data.

Background

The representative agent demand system is *a priori* a set of aggregate preference orderings that generate a demand for each variety of product as a function of product prices and total expenditure without using any specific aggregation scheme. The restrictions of individual demand theory, symmetry, homogeneity and Engel aggregation do not necessarily hold in the aggregate (Deaton and Muelbauer).

The theoretical linkage between the standard approach and LL approach is an important development in understanding when either approach can be appropriately used. We begin with the role of product differention, which is divided into two classes, (vertical and horizontal) and two forms: (combinable and noncombinable). Davis shows that only products defined as having combinable horizontal differentiation generate the LL demand system. As mentioned above, additional criteria need to be met in order to generate a standard system, which is a nested form of the LL system. Horizontal product differentiation occurs when all characteristics of the varieties differ but not consistently, and when agents have different preference rankings.[1] In such instances, each individual has an "ideal variety". Uniformly sized color computer monitors with varying other characteristics would be an example of horizontal product differentiation. However, these computer monitors would not have combinable product characteristics. Blendable commodities such as coffee or wheat would be horizontally combinable differentiated products, because the differentiated product can be combined to form new "ideal varieties."

To fully develop the relationship between the two approaches, we must first develop the formal structure of each. The Lancaster model is constructed using household production theory, which assumes that market quantities are used in a consumption technology to generate an intermediate input which becomes part of the utility function. Unlike the standard approach the

$$V(p,m,r) \;=\; \max_{q^{*} > 0} [\, u^{*}(q^{*}) : q^{*} = g(q,r) \Lambda p\_\, q = m]$$

household approach incorporates characteristics into its utility function as well as quantities: *V(p,m,r)* is the conditional indirect utility function obtained from a conditional utility maximization

[1] Vertical differentiation occurs when the characteristics of the product varieties differ consistently and all agents have identical preference rankings. An example of vertical product differentiation is the preference of all agents (who are not severely color blind) of a similar sized color computer monitor over a black and white monitor. Vertically differentiated products cannot generate a representative agent demand system because as all the agents have the same preference ranking so they always choose the variety with the greatest absolute number of affordable characteristics (i.e. the highest quality).

problem with the normal properties.[2] P and q are n vectors of price and quantities. The vector can be represented as any variable(s) beyond the consumer's control that influences demand. By

$$q_i \;=\; D_i(p,m,r)\; i \;=\; 1,\ldots,n$$

using Roy's identity the r becomes a vector of characteristics in the demand system.

The LL demand system has two important features, a) it incorporates characteristics that differentiate varieties explicitly, and b) the LL system allows demand to be influenced by characteristics across and within countries, in addition to prices and expenditures. The standard approach produces a representative agent import demand system based on product differentiation approach developed by Armington. The theory assumes a representative agents first stage problem is weakly separable into desired partitions of like products. It assumes the products in the second stage are differentiated by country of origin. The second stage of the optimization

$$V(p^*,m^*) = \max_{q^* > 0} [u^* \;=\; u^*(q^*): p^* \bullet q^* \;=\; m^*]$$

problem is:

$V(p^*,m^*)$ represents the conditional indirect utility function with the normal properties. Prices and quantities of the differentiated products are represented by the n^* vectors p^* and q^*. The function $u^*(q^*)$ is the sub-utility function of this problem and m^* is the total expenditure for the product. Utilizing Roy's identity produces the Marshallian demand system:

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[2]This is a second stage optimization problem and as Davis and Jensen show it can be

$$q_i^* = D_i^*(M^*, p^*) \quad i = 1, \ldots, n^*$$

Equation 4 represents the conditional Marshallian demand system. Unlike the LL method, product differentiation is not specified in the standard approach. The differences between the two models implies that both cannot be consistent with the product differentiation assumption. The LL model in (2) includes a characteristics vector which is not present in (4). Ommission of characteristics in the standard approach denies the importance of characteristics and violates the product differentiation assumption.

As already pointed out, assuming product differentiation does not automatically lead to a representative agent demand system. Only horizontal combinable product differentiation allows a representative agent model to generate a system of demands for each variety without additional distribution assumptions. This is the LL representation in equation 2, directly implies that equation equation 4 is misspecified without auxiliary assumptions.

The relationship between the standard and Lancaster-Ladd system is established by referring to Lewbel's modifying function technique. The r vector in this paper represents characteristics. This allows Lewbel's analysis to be extended to provide the theoretical foundation MacClaren states is missing. If the expenditure function related to the standard conditional utility is in equation 3 is $C^*(u, p^*)$ and if $p^* = h(p,r)$ the f function allows interactions between expenditures and r to occur. All f and h_i functions allow interactions to occur between r and p. Lewbel links the Lancaster-Ladd demands to the original Marshallian demands by:

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generated from an aggregate profit function or utility function.

$$D_i(m,p,r) \;=\; \frac{\partial f(m^*,p,r)}{\partial m^*} \sum_{j=1}^{n^*} \frac{\partial h_j(p,r)}{\partial p_i} D^*_j(m^*,\; p^*) \;+\; \frac{\partial f(m^*,p,r)}{\partial p^*} \quad i \;=\; 1, \ldots, n$$

where m^* = F(m,p,r). The properties of f and h are such that D_i(m,p,r) retains the properties of a Marshallian demand function. D_i(m,p,r) is derived from the LL theory while D_j(m,p,r) is derived from the standard theory. Lewbel observes the original demand system D^* is nested within the modified system in a demographic variables context. If r represents a characteristics vector the standard system can be nested within the LL system D.

The two systems are observationally equivalent if the characteristics vector r is consistent over the sample. This is a consequence of the r vector being subsumed in the mapping D_i causing the two systems to be observationally equivalent. The two systems are also observationally equivalent if the utility function u(q,r) in eq. 1 is recursively separable with respect to the elements of r. This is known as J-separability (Triplett). J-separability implies the marginal rate of substitution between any pair of q_i and q_j is independent of r. If J-separability exists, the r vector falls out of the LL model and the two models become observationally equivalent.

The standard demand system is identical to the LL demand system if and only if there is characteristics constancy or J-separability. The standard approach is a misspecification of the LL demand system if these conditions do not hold because it omits the r vector. This ommission influences D^* by correlating the error term with the regressors.

Davis' suggests a test to determine if the two systems are observationally equivalent that requires characteristics data. The problem with such a test Ladd concludes is obtaining time-series data on characteristics especially for international data. Consequently he used a more indirect test that indicates the standard approach may be appropriate to model Japanese wheat imports with the standard model. This study extends that research by using characteristics data to make the direct comparison between the two systems.

Data Requirements and Empirical Procedures

Wheat Characteristics

All wheat shipments to Japan are tested by the Japanese Food Agency (Stiegert and Blanc). Protein prior to 1988 is recorded at observed moisture contents. After 1988 protein is recorded at the moisture level for each country of origin. All protein is adjusted to a dry matter basis. The data is the volume-weighted average data of all quality tests for a financial year (FY, April 1 to March 31). The data set covers the years 1984 to 1992 inclusive.

Wheat prices are represented by the ratio of the price per ton of an imported wheat class

$$Pj = \frac{CF_{xt}}{PBAR_t}$$

and the world wheat index:

Cf_{xt} is the landed price in U.S. dollars per ton for wheat class x in financial year t. $PBAR_t$ is an index of the world wheat price (International Wheat Council) used to deflate each price series to common year (1992=100). This also adjusts for year to year quality changes as well as supply and demand shocks to the international market.

This study concentrates on Japan's hard wheat imports from Australia, Canada, and the United States and Dark Northern Spring. Protein is included because it represents the key characteristic for describing end-use performance. Protein quantity and quality is a function of weather, farming practices, variety choice and wheat class (Stiegert and Blanc). This characteristic should reflect differences, if any, in wheat caused by country of origin. Wheat from the United States is aggregated to reflect a "United States" hard wheat. The quantity data used in this study is obtained from a data set compiled by Koo at the University of North Dakota.

Empirical Procedures

$$w_i \, d \ln q_i = b_i \, d \ln M + \sum_j c_{ij} \ln p_j + \sum_j k_{ij} \, d \ln pr_j$$

The estimating model is specified following the conceptual framework of equation 2: where, following the Rotterdam model (Barten; Theil) w_i is wheat prices, q_i are import quantities, M is income, p_js are prices, and pr_j is protein content. The logged difference of the protein characteristics rather than levels is modeled to address possible trends in the data. The characteristics observations available are limited. Only protein is included to ensure the model is identified. An iterated seemingly unrelated regression estimator is used to obtain the parameters.

Results and Discussion

The parameters in the unrestricted system have the expected signs except for Canadian protein in the Japanese imports of Canadian wheat. All U.S. unrestricted parameters (table 1) are insignificant at the 10% level except for the Canadian price parameter. The parameters in the equation representing imports of Canadian wheat are significant at the 10% level except for the Canadian protein and price parameters in the unrestricted model. The Canadian protein parameter in the unrestricted model for imports of Canadian wheat is almost significant at the 10% level. Its sign is negative which is unexpected. In table 2 all prices are insignificant but the expenditure parameters for both the U.S. and the Canadian demand equations are highly significant.

The log likelihood ratio test equals 39.89. We reject the null hypothesis that there is J-separability. In addition tests of the log of likelihood functions of the restricted and unrestricted Canadian and American equations as single equations (Table 3). The results of table 3 also confirm that the restricted and unrestricted equations appear to be significantly different. The parameters from the single equations follow the same pattern as those found in the system. The significant difference between the restricted and unrestricted models indicates that the characteristics are not constant nor J-separable. This implies the standard demand system approach (i.e. one not including characteristics) is unsuitable for modeling Japanese wheat imports. In contrast to Davis' results from the indirect test he performed. His test covers an earlier period that may have been less sensitive to characteristics. Wilson concludes wheat characteristics are an increasingly important factor in determining the demand for wheat classes. He concludes characteristics had less relevance in earlier periods.

It is worthwhile to examine the output further particularly the assymetry between the Canadian and U.S. unrestricted parameters. It would appear that characteristics and prices affect the demand for Canadian wheat but not United States wheat. An explanation may be that Japan's policy of managing imports (Love, Murniningtyas) includes treating the United States as a preferred trading partner for wheat regardless of the prevailing prices and protein characteristics (Alston, Carter and Jarvis). Increases in Canadian protein may allow Japanese importers to purchase more U.S. wheat of a lower protein and blend it to maintain the same quality of baked product. Characteristics appear to influence the demand for Canadian wheat which further reinforces the possibility that some factor other than prices, income and quantities are influencing the demand for U.S. wheat in the Japanese market.

The differences in the size of the parameters of prices between the restricted and unrestricted models has potential implications for policy makers. The price parameters in the restricted equations appear to be more inelastic than those in the unrestricted models. Estimates of the effects on sales of wheat of policies that do not consider the effects of characteristics may underestimate their actual impact. Again this should be tested on a larger data set.

Conclusion:

The purpose of the research presented in this paper is to test the validity of standard demand systems such as the Rotterdam in estimating in estimating import demand parameters. Although the standard approach is used extensively, when it is a misspecified Lancaster-Ladd system, biased parameters can lead to erroneous policy recommendations.

The model is applied to wheat imported by Japan from three countries: U.S., Canada, and Australia. Following Davis, a test was performed to see if characteristics data should be included. Specifically, we tested for J-separability and characteristics constancy in the standard representative agent import demand system. The test rejects the hypothesis of J-separability implying the standard representative agent import demand system is inappropriate for modeling the Japanese wheat trade. This is the key result of our paper and an important step in the process of improving our measurement techniques on key policy-relevant import demand parameters.

Table 1 Unrestricted Model Parameters Without Constant

Variable	United States	P-Value	Canada	P-Value
M	-0.02377 (-.10706)	0.920	0.92953 (10.00)	0.001
Price-US	-0.47007 (-1.329*)	0.254	0.45966 (2.908)	0.044
Price-Canada	0.45966 (2.908)	0.044	-0.23800 (-1.482)	0.212
Protein-US	0.10099 (0.2303)	0.829	-1.3908 (-7.609)	0.002
Protein-Australia	0.30113 (0.9089)	0.415	-0.80940 (-5.642)	0.005
Protein-Canada	0.36314 (0.8502)	0.443	-0.35691 (-2.010)	0.115

* T-statistic

D-W	2.1076	1.5232
R^2	0.9990	
Log of Likelihood function	58.2251	

Table 2 Restricted Model Parameters Without Constant

Variable	United States	P-Value	Canada	P-Value
M	0.21754 (24.98*)	0.000	0.14922 (8.566)	0.000
Price-US	-0.033857 (-0.1190)	0.909	0.13320 (0.3345)	0.748
Price-Canada	0.1332 (0.3345)	0.748	-0.82881 ((-1.105)	0.306

* T-statistic

D-W	2.5559		1.9528	
R^2	0.9986			
Log of Likelihood function	38.2855			

Table 3. Log Likelihood Ratio and Chi - Squared Statistics For the Individual Restricted and Unrestricted Equations

Source of Imports	Likelihood Ratio Test	Chi-Square$_{d.f.3, 5\%}$
United States	9.40	7.82
Canada	36.5	7.82

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