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TESTING DYNAMIC SPECIFICATION FOR IMPORT DEMAND MODELS: THE CASE OF COTTON+

by

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Abstract

Error correction models impose few prior restrictions on dynamic model specification and allow the data to determine model structure. Despite this obvious advantage, few applications have adopted the error correction model to explain trade flows. An error correction model of cotton import demand is estimated for France, Japan, and Hong Kong. A variety of tests are applied to determine the dynamic structure of the model. We find the most general models are those that best fit the data for cotton import demand. Long-run elasticities from these general models are significantly different than elasticities derived from a comparable static model.

**Testing Dynamic Specification for Import Demand Models:
The Case of Cotton**

Many recent studies have estimated import demand elasticities by using theoretically consistent demand models such as the Armington model (Abbott and Paarlberg, 1986; Babula, 1987; Figueroa and Webb, 1986; Grennes, Johnson, and Thursby, 1977; Johnson, Grennes, and Thursby, 1979; Penson and Babula; Sarris, 1983; Suryana, 1986; and others), the AIDS model (Haden, 1990; Heien and Pick, 1991), or the Rotterdam model (Seale et al., 1992). Information generated from these studies is potentially useful to trade liberalization policy analysis, for analyzing the effect of exchange rate fluctuations, and for explaining the basis for agricultural trade.

Despite convincing arguments favoring use of a dynamic specification, most studies have utilized a static import demand specification. Forcing a static specification on an import demand model will bias elasticity estimates, when the data generating process is inconsistent with instantaneous adjustment. Also, policy analysis based on these elasticities will be flawed and implies more rapid adjustment by importers to policy changes than could feasibly occur. For example, elasticities from a static model were used to formulate domestic policies during the 1985 debate over the U.S. Food Security Act (Thompson 1988). Based on the premise that import demands for U.S. products were price responsive, the U.S. government lowered loan rates to regain market shares in international markets (Alston et al. 1990).

This paper tests the static restrictions which are imposed by the traditional import demand models. This is done by nesting the AIDS model within a general dynamic specification -- namely, the error correction model. Long-run elasticities for the AIDS and the error correction model are then calculated to measure any potential bias in elasticity calculations.

The first section describes the econometric model used to test for both dynamic specification and economic hypotheses. The next section provides a summary of the empirical implementation of this model and its application to the international cotton market. Next is a summary of the econometric results. Conclusions and policy implications close the paper.

Modeling and Testing Dynamic Import Demand

Among model specifications which have been estimated for agricultural commodities, the Armington model is a popular choice. This model is appealing because of its simple linear (in logarithms) structure and because only a few parameters are estimated. However, this model imposes strong *a priori* restrictions which have been recently rejected by Alston et al. Keeping in line with recent studies, long-run importer behavior is approximated by an AIDS model, which is derived from a flexible functional form and, therefore, is less restrictive.

The AIDS Model

In the AIDS model, the share of imports from an exporter depends on the price charged by that exporter, prices of competing exporters, and real income of the importer. This model has many advantages: it is linear in parameters; the semi-logarithmic functional form is relatively easy to estimate; the symmetry and homogeneity restrictions are linear restrictions on fixed parameters; and, finally, the model can be derived from utility maximization. The share of the ith exporter in total imports is:

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} \log p_{jt} + \beta_i \log(\frac{M}{P})_t \tag{1}$$

where w_i is the share of imports from source i, p_j is the price charged by the jth exporter, M is total expenditure on imports, and P is a price deflator. The log of the price deflator is given by:

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln P_k + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \ln P_k \ln P_j \tag{2}$$

While the cost function for the AIDS demand model is a second-order approximation to the true cost function, the AIDS model is a first-order approximation to any demand function, much like the Rotterdam model.

Symmetry, adding up, and homogeneity restrictions on the AIDS demand model require respectively that,

$$\gamma_{ij}=\gamma_{ji} \;; \quad \sum_i \alpha_i=1, \quad \sum_i \gamma_{ij}=0, \quad and \; \sum_i \beta_i = 0 \;; \quad and \; \sum_j \gamma_{ij}=0. \tag{3}$$

Homogeneity restrictions ensure that the importer does not suffer from money illusion. A simplification adopted in this study involved use of Stone's geometric index as an approximation to the true AIDS price index, which is a second-order expansion in the logarithm of prices. This price index is:

$$\ln P^* = \sum_{k=1}^{n} w_k \ln P_k \tag{4}$$

Since Stone's geometric index is linear in logarithms, it is simpler to compute.

Short-Run Dynamics: The Error Correction Model

The data-based dynamics approach outlined in Hendry et al (1984) is used here to test the central hypothesis that the data generating process emulates dynamic behavior and to determine the structure of this dynamic process. This approach, originally developed by Anderson and Blundell (1982, 1983) to explain consumer demand, was recently applied by Friesen (1992) and Friesen, Capalbo, and Denny (1992) to data on the production sector. This approach is appropriate for the problem at hand because different countries are likely faced with different objective functions and constraints. Imposing a single dynamic structural equation on the data will likely lead to erroneous results.

Some recent studies have attempted to incorporate dynamic behavior in modelling import demand (Husted and Kollintzas, 1984, 1987; Haden, 1990; Heien and Pick, 1991). This paper contains the following innovations. First, the data-based dynamics approach allows testing for the validity of *both* dynamic specification and economic hypotheses. Second, a single dynamic specification is not imposed on the data. The most general estimated model is an error correction model which nests a richer set of lag patterns. Since a multiplicity of motives and decision rules determine different countries import demands, a general model, such as the error correction model, is an appealing vehicle for empirical work.

Actual shares w_i are assumed to slowly adjust to the long-run according to an error correction model, which can also be interpreted as a solution to an economic agent's intertemporal optimization problem (Domowitz and Hakkio, 1990). The error correction model decomposes share changes into two components: changes caused by exogenous variable movements and changes due to errors in the previous time period.

Denote the vector of shares at time t by W_t and the vector containing all prices and real income by X_t, then the error correction model is:

$$\Delta W_t = A \Delta X_t - C(W_{t-1} - BX_{t-1}) + \epsilon_t \tag{5}$$

A, C, and B are appropriately dimensioned matrices of coefficients. The matrix B contains parameters corresponding to the AIDS model. Adopting this notation, the ith share is $w_{it} = b_i X_t$, where $b_i = [\ \alpha_i\ \gamma_{i1}\ \gamma_{i2} \cdots \gamma_{im}\ \beta_i\ ]$ is the ith column of the matrix B. Independent and identically distributed additive random terms are appended to represent optimization errors. These error terms are assumed to be jointly normally distributed so that standard maximum likelihood estimation techniques can be applied. Since the error terms define a singular distribution, one equation must be deleted prior to estimation. Estimates obtained will be invariant to which equation is deleted (Anderson and Blundell, 1982).

The model as specified in equation (5) is appealing because it nests the partial adjustment and autoregressive models as special cases. For example, in the partial adjustment model no distinction is made between adjustments to changes in exogenous variables and response to errors. Therefore corresponding parameters in the A matrix and CB matrix are equivalent. The autoregressive model postulates that all share responses to price and real income changes are instantaneous; accordingly, corresponding parameters of the A and B matrix are equivalent. Maintaining the error correction model as the most general model permits testing for these two special cases. In addition, the hypothesis of instantaneous adjustment to the long-run can be tested.

Testing Economic Restrictions and Model Specification

From the previous discussion, two types of restrictions have been identified. These are: restrictions on the long-run model implied by economic theory and restrictions on model specification. Unfortunately, neither economic nor statistical theory provides any guidance on the order in which these restrictions should be tested. This problem is not unique to this study but occurs in other contexts (Mizon, 1977). Either the restrictions implied by economic theory can be maintained and then model specification restrictions tested or vice versa. Both approaches are pursued in this paper.

In the first stage of the analysis, economic restrictions are maintained and a test for model specifications nested within the error correction model is performed. Restrictions corresponding to each model specification are listed in detail elsewhere and are not repeated here to conserve space (Anderson and Blundell, 1982; Friesen, 1991; Friesen, Capalbo, and Denny, 1992). Economic restrictions, which are jointly imposed in the maintained model, are homogeneity and symmetry. While maintaining these restrictions, various tests of dynamic structure were performed on the model. Starting with the error correction model a sequence of tests were performed on successively more restrictive versions of the model.

At each successive stage of the hypothesis testing procedure, the likelihood ratio statistic is computed. This test statistic is asymptotically distributed as a chi-square with degrees of freedom equal to the number of independent restrictions. The level of significance changes at each stage of the hypothesis testing procedure. This standard practice is implied by the theory of sequential nested hypothesis testing (Friesen, 1992).

If the null hypothesis is rejected, the subsequent less general null hypothesis is tested until the null hypothesis cannot be rejected. The order maintained in this testing procedure is dynamic error correction, multivariate flexible accelerator (partial adjustment), univariate flexible accelerator (diagonal adjustment), and static in a decreasing order of generality. The multivariate flexible accelerator and autoregressive models were not nested within each other.

During the second stage of the testing procedure, the same sequence of tests of dynamic model structure were performed when no economic restrictions were maintained. This exhaustive test of economic restrictions provides a means of collating statistical evidence about these economic hypotheses.

Empirical Implementation and Data

The above model was estimated and tested using international trade data for cotton. We include three major importers in this study: Japan, France and Hong Kong. These countries import cotton from several sources including: the U.S., Nicaragua, Egypt, Turkey, Pakistan and the former Soviet Union. Data for the analysis (trade flows and export prices) were obtained from World Cotton Statistics published by the International Cotton Advisory Committee.

Dynamic behavior in cotton demand can occur for many reasons. First, the possibility of habit formation should be considered. This concept, which was introduced into the literature by Pollak and Wales (1969), implies that consumers develop consumption habits over time. Therefore, current consumption practices depend on past purchases. This may be true for cotton where, in addition to Agricultural Marketing Service standards, major exporting companies develop their own standard varieties. Cotton importers will often lock into purchasing firm-specific varieties, which is evidence of habit formation.

Search costs constitute a second justification for dynamic behavior. For example, purchasing a product of unproven quality from a new supplier may prove to be costly. When search costs are significant, an importing country may continue to buy from a particular exporter even when the price charged is increased.

A third reason is long-term contracting which is a common institutional feature of agricultural trade. Long-term contracts can explain incomplete import response to price changes in the short-run, especially when price changes are believed to be transitory. The former Soviet Union and the Peoples Republic of China have adopted long-term contracts with the United States for cotton. Finally, production, consumption, inventory, delivery, and transaction lags in agricultural trade can also justify a dynamic specification.

Empirical Results

The various specified models were estimated and the implied tests were performed using iterative techniques on the software package SHAZAM. The implied test statistics are reported in Tables 1-2. In France, when the economic restrictions were maintained, all nested model structures were rejected, including the static model. The statistical evidence favored the most general model specification -- namely, the error correction model. The chi-square statistics are reported in Table 1. The value corresponding to the multivariate flexible accelerator was 55.44, which exceeded the critical value. This hypothesis was accordingly rejected. The same conclusion applied to the autoregressive model. Since the diagonal adjustment and static models were nested within these models, the sequence of hypothesis testing was terminated.

When economic restrictions were imposed, results obtained for Japan reinforced those obtained for France. When restrictions corresponding to the partial adjustment model and the autoregressive model were imposed, the calculated value of the chi-square statistic exceeded the corresponding table values. These hypotheses were accordingly rejected and the sequence of hypothesis testing was terminated. Interestingly, the diagonal adjustment hypothesis (or univariate model) could not be rejected when the economic restrictions were imposed. Yet, the question is moot since models more general than the univariate model, namely the autoregressive and multivariate flexible accelerator models, were rejected. If the autoregressive or partial adjustment model were used as a maintained model rather than the error correction model, one would have falsely concluded that the appropriate adjustment structure was a univariate flexible accelerator.

Conclusions for Hong Kong were qualitatively similar to those obtained for Japan, when economic restrictions were imposed. However, there was one important difference. The error correction model was not rejected when the economic restrictions were not imposed for Japan and France. This was not true for Hong Kong where radically different results were obtained when the dynamic structure of the model was tested both in the presence of economic restrictions and in the absence of economic restrictions. When economic restrictions were dropped from the most general error correction model neither the partial adjustment nor the autoregressive model could be rejected. Furthermore, the more restrictive version, namely the diagonal adjustment model, was not rejected while the static model was rejected. Our results clearly suggest the importance of whether economic restrictions are maintained prior to sequential testing for dynamic structure. Previous studies on dynamic import demand functions have not conducted such an exhaustive battery of statistical tests.

Table 1 -- Tests of Dynamic Specification

	Economic Model		Unrestricted Model	
	Likelihood Ratio Statistic	D.F.	Likelihood Ratio Statistic	D.F.
FRANCE				
Static	62	3	106.8	3
Diagonal Adjustment	50.8	6	1.6	6
Partial Adjustment	55.44	15	38.8	15
Autoregressive	49.8	15	104.5	15
JAPAN				
Static	76.6	24	27.2	24
Diagonal Adjustment	5.0	3	18	3
Partial Adjustment	31.2	15	62.2	15
Autoregressive	54.2	15	132.8	15
HONG KONG				
Static	39.4	12	58.6	12
Diagonal Adjustment	5.0	2	0.14	2
Partial Adjustment	20.2	8	8.2	8
Autoregressive	30.6	8	9.1	8

Validity of Economic Restrictions

It is interesting to know whether the economic restrictions themselves are supported by the data. Joint statistical tests of the homogeneity and symmetry restrictions for the error correction model and the static model are reported in table 2. For France and Japan, these restrictions were overwhelmingly rejected since the calculated chi-square values exceeded the table values for nine degrees of freedom. Again, as before, the anomalous case was Hong Kong where the economic restrictions were not rejected for either the error correction or the static models. This observed consistency of results between the behavior of the static and error correction models for Hong Kong and other countries is comforting. If the hypothesis testing procedure first tested for the validity of economic restrictions in Hong Kong, then the accepted model would have been the error correction model. On the other hand, if the economic restrictions were not maintained, then the appropriate model structure would have been diagonal adjustment.

Table 2 -- Tests of Symmetry and Homogeneity Restrictions

COUNTRY	Static Model	Error Correction Model	
	Likelihood Ratio Statistic	Likelihood Ratio Statistic	D.F.
FRANCE	37.8	50.2	9
JAPAN	28.8	39.8	9
HONG KONG	7.4	2.0	4

In general, these statistical results suggest that the error correction model is an appropriate vehicle for analyzing dynamic import adjustments. This is in sharp contrast to the versions of the partial adjustment model which have dominated the literature.

Elasticities of Import Demand

Given the above results and the overwhelming rejection of the static model, we calculated import demand elasticities and cross-price elasticities for the traditional static model and the error correction dynamic model.

Table 3 lists the elasticities calculated from the estimation results of the dynamic model while those calculated from the estimated static model are listed in Table 4. Overall, the results yield some large elasticities. The size of the elasticities are not surprising given the competitive structure of the international cotton market. Importers in the cotton market have a choice of many exporters, thus the substitution opportunities among the different exporters are numerous and which is consistent with large own and cross elasticities.

The major thrust of this paper was to test the static restrictions which are imposed on many estimated demand models. Since those static restrictions were strongly rejected in favor of dynamic specification, it would be of interest to compare the calculated elasticities from the static model with those calculated from the dynamic model. A brief scan through these elasticities reveal that in some instances the difference in the calculated elasticities is striking. For example, in the Japanese import model, the own price elasticity for Nicaraguan cotton was -6.40 when calculated under the static model. However, when calculated under the dynamic specification, this elasticity is calculated to be -15.5. The French demand elasticity for Turkish cotton is -13.6 in the static model compared to -8.33 in the dynamic

Table 3: Long-Run Elasticities of Import Demand From Error Correction Model

JAPAN				
	Nicaragua	United States	Egypt	Soviet Union
Nicaragua	-15.5	-1.01	0.63	4.7
United States	5.09	-0.10	4.92	-2.55
Egypt	-3.39	1.96	-1.19	0.71
Soviet Union	13.10	0.63	-5.99	-2.44
FRANCE				
	Turkey	United States	Egypt	Soviet Union
Turkey	-8.33	7.75	2.17	0.58
United States	-0.07	-16.45	-1.59	3.40
Egypt	-1.05	-2.45	-0.73	1.7
Soviet Union	7.31	8.25	-1.76	-6.02
HONG KONG				
	United States	Pakistan	Soviet Union	
United States	-8.01	8.68	11.64	
Pakistan	9.96	-14.72	7.18	
Soviet Union	-3.96	17.95	-20.7	

Table 4: Long-Run Elasticities of Import Demand from Static Model

JAPAN				
	Nicaragua	United States	Egypt	Soviet Union
Nicaragua	-6.40	0.043	-1.70	3.61
United States	2.02	-0.87	3.08	-1.43
Egypt	-2.35	-0.44	-1.81	0.16
Soviet Union	7.59	-0.52	-0.75	-2.52
FRANCE				
	Turkey	United States	Egypt	Soviet Union
Turkey	-13.6	0.52	-2.25	2.19
United States	-0.89	-0.84	-1.59	0.009
Egypt	-1.70	-0.46	-1.29	0.47
Soviet Union	14.8	1.85	4.05	-4.06
HONG KONG				
	United States	Pakistan	Soviet Union	
United States	-2.68	1.09	2.81	
Pakistan	0.37	-2.01	1.53	
Soviet Union	0.735	0.645	-5.41	

model. The static demand elasticity for U.S. cotton in Hong Kong was calculated to be -2.68

compared to -8.01 using the dynamic results. Similar large differences can be observed for other direct and cross price elasticities.

Notice little can be said about any systematic change in the size or direction of the elasticities between the dynamic and static models. Twenty eight of the elasticities from the dynamic models are higher than those of the static models. All elasticities from dynamic models are significantly higher in Hong Kong than those from static models. Yet beyond this, little else can be said other than elasticities obtained from both models are different enough to warrant doubts concerning policy anlaysis based on elasticities obtained from static models.

Overall, the results point to the fact that calculating price elasticities using static estimates when dynamic estimates are appropriate, can lead to large bias in the estimates. Policy decisions based on elasticities calculated from an erroneous static model may be flawed.

Conclusions

Error correction models use data to determine model structure and thus impose few prior restrictions on the modeling process. Use of error correction models in trade have been limited despite the fact that the decision rule used to import agricultural goods lacks consistency across countries, time periods, and decision agents. An error correction model was used to model import demand for cotton from three countries. The choice to refrain from imposing prior restrictions on the model for three distinct countries proved to be worthwhile. Results obtained in this paper reinforce the pitfalls of using the partial adjustment model to represent dynamic importer behavior in the cotton market. The error correction model could not be rejected in most of the cases analyzed. The static model was rejected in all of the cases analyzed. This suggests that future research may benefit from taking a hard look at the validity of this model specification, especially when the model is used to derive elasticities for policy analysis.

A fruitful area of research for the future is deriving import demand functions corresponding to the error correction model from a consistent theoretical framework. The most general model maintained in this study did not impose restrictions implied by dynamic economic theory. While maintaining such restrictions would be against the spirit of the data-based dynamics approach, a case can be made to extend the role of economic theory in dynamic model specification.

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