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AN APPLICATION TO THE INTERNATIONAL POULTRY MARKET

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Since 1970 there has been a rapid expansion in world agricultural trade, its nominal value increasing from $52 billion to $230 billion in 1980. Analytical research on trade-related issues has increased commensurately, though with a predominant focus on changes in the trade in "low-valued" products (e.g., grains). Relatively little attention has been directed toward a consideration of trade in "high-valued" products, such as processed meat and dairy products and fruits and vegetables.[1] Attention to this area has been prompted by concerns that some exporters' market shares (e.g., the U.S.) have not increased in high-value product trade as they have in grains, for instance. On the importing side, the emergence of new, lucrative markets for high-value products, the OPEC nations in particular, has stimulated further interest in the international markets for these products, with implications for trade policy analysis.

Given the dynamic nature of agricultural trade generally and continuing market share changes for both low and high value products, the purpose of this paper is to compare the abilities of several market share models to explain variations in market shares over time. The application here is to the international poultry market, specifically, the Kuwaiti import market, although application to other markets and other internationally traded commodities is possible. A multinominal logit market share model is introduced as an alternative to traditional approaches such as the Markov model and the estimation of single market share equations. Given the relatively limited data available (a not uncommon problem in international agricultural trade), the relative

explanatory abilities of the estimated models under conditions of sparse data are emphasized. The paper concludes with a brief discussion of the implications of the results for trade policy.

International and Kuwaiti Poultry Markets

World imports of poultry increased substantially from 502,000 metric tons in 1970 to 1.64 million metric tons in 1983. The nominal value of these imports increased from $337 million to $2,098 million in 1983. This growth was substantially greater than the average growth in world agricultural exports and was also characterized by large changes in the market share positions of major exporters, most notably, the decline in Dutch export share and the emergence of Brazil and France as major exporters.

While the expansion in intra-EC trade and Soviet imports comprised much of this growth, a large proportion has been attributable to increases in imports by the Middle Eastern market comprised of seven OPEC nations[2] plus Oman and Bahrain. Middle Eastern poultry imports increased from a negligible volume in 1970 to about 500,000 metric tons in the early 1980's. Although Saudi Arabia is the largest importer in the region, discontinuities in data preclude the possibility of meaningful estimation of market share behavior in that market. The Kuwaiti market, despite being of lesser importance, displays many of the same trends in shares as Saudi Arabia, and can thus be thought of as a characteristic Middle Eastern market. Kuwaiti imports increased substantially over the 1971-81 period, from 5,000 metric tons to 53,000 tons. During this period, the market shares of the major exporters changed considerably. The EC share fell from 70 percent in 1971 to a low of 30 percent in 1977, and since then has increased to about 40

percent. The Hungarian market share increased from nine percent in 1971 to 22 percent in 1975 but has since fallen to about one percent. Contrasted with these declines, the Brazilian market share rose from zero in 1974 to more than 45 percent in 1981. The residual share composed of other exporters reached a high of 36 percent in 1973, principally because of Chinese exports, but has since fallen to about 6 percent. US share increased from 2-3 percent in 1971 to 10 percent in 1979, falling to about 6 percent in 1981.

Model Selection

In explaining the behavior of these market shares over time, three alternative empirical models are evaluated: the Markov model, with constant transition probabilities; the market share equation approach; and a multinominal logit market share model (MNL).

The Markov Model

The use of the Markov model in agricultural economics research has been sufficiently widespread so as not to require a detailed explanation here.[3] Briefly, in the current application, the Markov approach involves the estimation of the transition probabilities of an importer repeating or switching product suppliers (exporters) over time. More formally, under the assumption that the transition probabilities remain constant through time, the model can be specified as:

$$MS_{jt} = MS_{it-1}P_{ij} \qquad (i,j=1,2.....n) \tag{1}$$

where: $\sum_{j} P_{ij} = 1$ for all i

$P_{ij} \geq 0$ for all i,j

and MS_{jt}, MS_{it-1} denote the market shares of the jth and ith exporter in time t and time t-1, respectively, P_{ij} denotes the ijth element of the (n x n) transition probability matrix, there are n exporters, and MS_{jt} is represented as the ratio of imports from exporter j to total imports.

The sole requirements of the model are observations on exporter market proportions or shares through time. The transition probability matrix is estimated here by a maximum likelihood estimator provided by the algorithm of Lee, Judge and Zellner (1977). This procedure yields estimates of the probabilities that lie in the permissible range and are asymptotically efficient.

The assumption that the transition probabilities are constant through time is problematic since it implies that the underlying economic system remains stable, an assumption which may be highly unrealistic in view of actual behavior in world commodity markets. Attempts to estimate Markov models with variable transition probabilities, however, are fraught with a variety of problems when using "macro-data" such as market shares in international trade.[4] One recent alternative proposed by Mellor begins by positing the probabilities as functions of explanatory variables:

$$P_{ij} = a_{ij} + b_{ij} Z_{ij} \qquad (2)$$

which, given appropriate restrictions on the a_{ij}, b_{ij}'s, in the case of four shares leads to estimation equations of the form:

$$MS_{jt} = a_{4j} + (a_{jj} - a_{4j})MS_{jt-1} + b_j Z_{jt} \qquad (j = 1,2,3) \qquad (3)$$

where Z_{jt} is an explanatory variable which influences the behavior of MS_{jt}. One of the interesting aspects of this formulation is that, since

market share is determined by lagged share (MS_{jt-1}) and an explanatory variable (Z_j), it is identical to the market share equation approach reviewed below, if the same Z_j variable is used in each. For the purposes of this analysis, the important point is that the variable probability relationships can be inferred directly from the market share equation estimates.

The Market Share Equation Approach

Ultimately, estimation of the constant or variable transition probabilities enables inferences to be drawn about the behavior of shares or proportions through time. Alternatively, it may be more appealing to directly estimate the market shares as a function of key explanatory variables. Following previous applications,[5] market share can be specified as function of relative prices:

$$MS_{it} = f(UVR_{it}) \tag{4}$$

where UVR_i is defined to be the ratio of exporter i's export price to all other exporters' prices. This is henceforth referred to as the unit value ratio. Generally, it is hypothesized that changes in market share do not respond immediately to changes in unit values. Therefore, the following adjustment process can be specified:

$$MS^*_{it} = f(UVR_{it}) \tag{5}$$

$$MS_{it} - MS_{it-1} = \lambda(MS^*_{it} - MS_{it-1}) \tag{6}$$

where the starred term denotes long-run value, and λ denotes the adjustment parameter that is logically expected to lie between zero and one. Substituting (4) into (5) and expressing long-run market share as

a simple function of the unit value ratio, we can derive the following estimation equations:

$$MS_{it} = a + \lambda b(UVR_{it}) + (1 - \lambda)MS_{it-1} \qquad (7)$$

Since market share is expressed as a function of lagged share and one explanatory variable, this is identical to the estimation equations specified assuming variable transition probabilities (equation (3)). The probability relationships can then be inferred from equation (6). These equations were estimated by OLS rather than Zellner's seemingly unrelated regression procedure (ZSUR) because the data available were for sample periods of unequal length.

Multinominal Logit Model

The third approach estimated was a multinominal logit model of market shares.[6] Taking market share as an exponential function:

$$MS_{it} = e^{f_{it}} \qquad (8)$$

where:

$$f_{it} = b_{i0} + b_{i1}X_{1t} + \ldots + b_{in}X_{nt} \qquad (9)$$

that is, where the f's denote functions of explanatory variables X_k, equation (7) can be respecified as:

$$MS_{it} = e^{f_{it}} / \sum_{j}^{n} e^{f_{it}} \qquad (i,j=1,2\ldots n.) \qquad (10)$$

We can transform the model by taking the nth share as the denominator, divide all other n-1 shares by this term, and take logarithms. This implies:

$$\log (MS_{it}/MS_{nt}) = f_{it} - f_{nt} \qquad (11)$$

Therefore, for n exporters, n-1 equations must be estimated. The appealing characteristic of this formulation is that it is extremely flexible. Different variables can be incorporated into each functional relationship. Further, we are guaranteed that the predicted market shares always sum to unity.

Since the individual equations all pertain to the same market, it is reasonable to assume the existence of contemporaneously correlated error terms across equations, and so it is statistically more efficient to use ZSUR. Once the ratio relationships have been estimated, we can derive n-1 predicted share ratios. By applying the antilog transformation to these, we can then derive the predicted share of the nth exporter as follows:

$$MS_{nt} = 1/(1 + \sum_{i} MS_{it}\hat{/}MS_{nt}) \qquad (i \neq n) \tag{12}$$

From this, it is simple to derive predictions of the other market shares:

$$\hat{MS}_{it} = \hat{MS}_{nt}(MS_{it}\hat{/}MS_{nt}) \tag{13}$$

Therefore, the multinominal logit model allows the prediction of all market shares simultaneously, which has great appeal to a market share analysis where shares are by definition interdependent. The approach also allows for the consideration of more explanatory variables than the traditional market share equation approach.

Data

Data on Kuwaiti import shares for EC, Brazilian and Hungarian exports, a residual "other" exporter, and unit values for these

exporters were taken from UN Trade Statistics SITC 011.4 from 1971 to 1981, the last available year. Additional data are from various other sources, including FAO Trade Yearbooks. In the case of EC share, the contention that much of EC performance is due to export subsidies is tested by the inclusion of export restitution (XREST) as a percent of unit value as an explanatory variable. Data pertaining to EC restitutions are available in Eurostat publications.

It is hypothesized that Hungarian market share fell partially because increased poultry imports from the Soviet Union decreased effective Hungarian excess supply. To test this, the volume of Soviet imports was included as an explanatory variable, the data drawn from FAO Trade Yearbooks.

A final consideration is the rapid expansion in Brazilian poultry production and exports. Numerous government inducements exist to increase both production and export, for example, income tax exemptions on export sales, credit loans at below market rates, etc. Since the primary effect of these schemes is on production and also because the mix of policy measures has only recently changed, the volume of Brazilian poultry production is used as a proxy variable for the effects of these various policies on the potential export capacity of Brazil.

Estimation Results

The estimated transition probability matrix for the Markov model over the sample period 1971-81 is presented in Table 1. The exporter on the left refers to the state in time t-1, while the exporter above refers to the state in time t. The diagonal elements of the probability matrix can be thought of as a measure of "brand loyalty" (Telser), while

the off-diagonal elements indicate the probabilities of switching suppliers.

Table 1: Kuwaiti Market Transition Probability Matrix

	EC	Hungary	Brazil	Other
EC	0.743	0.057	0.000	0.200
Hungary	0.000	0.480	0.015	0.505
Brazil	0.000	0.000	1.000	0.000
Other	0.635	0.000	0.000	0.365

Theil Coefficients:

EC = 0.93; Hungary = 0.79; Brazil = 0.92.

The results suggest that there is a strong repeat purchase probability for EC and, especially, Brazilian exports. The diagonal element of the matrix for Hungarian share suggests that this attachment is relatively weak. The Theil coefficients reported capture the explanatory power of the model by relating actual share to predicted share. All of the coefficients are less than unity but relatively high, suggesting a modest degree of explanatory ability. Overall, the results indicate that both the EC and Brazil should continue to dominate the Kuwaiti import market.

Although the Markov results are acceptable, the Markov model does not explicitly incorporate explanatory economic variables. The estimated market share equations, however, do incorporate lagged share ($LAGSHARE_i$) and unit value ratios (UVR_i). These equations, presented in Table 2, were estimated by ZSUR for Hungary and the EC and by OLS for Brazil. The sample period in the former case is 1971-81 and 1975-81 in the case of Brazil.

Table 2: Kuwaiti Market Share Equations

	Exporter		
	EC	Hungary	Brazil
Intercept	1.529 (0.42)	0.290 (0.26)	0.223 (0.39)
LAGSHARE	0.665* (0.18)	0.450 (0.33)	0.392* (0.13)
UVR_i	-1.343* (0.40)	-0.266 (0.28)	0.516 (0.40)
$\bar{R}^2$	0.68	0.05	0.63
Durbin h	-0.52	-	-2.07
Theil U_2	0.57	0.77	0.27

*Statistically significant at the .05 level.
Standard Errors in parentheses.

For the EC and Brazilian share equations the adjusted R^2 values are reasonably good and lagged market share is found to be an important determinant of market share behavior. This suggests the existence of a lag in share adjustment to relative price changes. However, the unit value ratio is found to be significant only in the EC equation. Indeed, the unit value term for Brazil has an incorrect sign (though it is not statistically significant). In the Hungarian equation, the R^2 value is poor and none of the coefficient estimates are found to be statistically significant.

The h statistic in the EC equation indicates that we cannot reject the hypothesis of zero serial correlation at the five percent level. This is not the case with the Brazilian equation, and for the Hungarian share equation the statistic is undefined. While the result for the

Brazil equation is worrisome, the relatively poor statistical quality of the estimates suggests that this market share equation may be mis-specified. All the Theil coefficients are less than unity, the value being especially low for Brazilian share.

Multinominal Logit Model

The MNL model was estimated by ZSUR for the EC and Hungarian equations over the period 1971-81, and OLS for Brazil over the period 1975-81. The estimates are presented in Table 3. In all cases, the unit value ratio coefficients (UVR_i) have the expected negative sign, although the estimate is not significant for the Brazilian equation.

Table 3: Multinominal Logit Market Share Model: Kuwaiti Imports

Variable	Exporter EC	Hungary	Brazil
Intercept	8.02 (0.91)	3.03 (1.82)	5.85 (5.24)
UVR_i	-7.20* (0.85)	-3.97* (1.92)	-8.41 (5.35)
XREST	0.015** (0.008)		
SOVIM		-0.051* (0.019)	
BRAZQ			0.031* (0.009)
R^2	0.90	0.46	0.67
D-W	1.61	1.39	2.20
Theil U_2	0.55	0.38	0.90

*Statistically significant at the .05 level.
**Significant at the .10 level.

The level of EC restitutions as a percentage of unit value (XREST) is found to have the expected positive effect on EC share, indicating that export restitutions have influenced EC market share in at least the Kuwaiti market. Brazilian poultry production (BRAZQ), used as a proxy for the effects of policy inducements on Brazil's export potential, is found to exert a positive effect on Brazilian share. Finally, increases in Soviet poultry imports (SOVIM) are found to depress Hungarian share, as expected.

All the Theil coefficients are found to be less than one. In the case of the EC and Hungarian equations, the values of the Theil coefficient are less than for the other two models. For Brazil, the Theil coefficient is less than the Markov model, but greater than the market share equation. While the results do not offer totally compelling evidence that the logit model is 'better', this application with limited data strongly suggests that it is at least as good empirically and certainly more desirable from the standpoint of system estimation.

Conclusions

From a methodological standpoint, the empirical results show that the multinominal logit approach to market share analysis offers considerable promise as a procedure for analyzing the simultaneous behavior of exporter shares in an import market. While the procedure is not unequivocally superior to more traditional approaches (at least when using sparse data), the MNL has several advantages. First, the procedure is appropriate to a system of market share equations, rather than a single equation. Second, unlike the single market share equation

approach, the mathematical formulation necessarily guarantees that predicted market shares sum to unity and can never be negative, regardless of the values of the explanatory variables. Finally, as opposed to the relatively naive Markov model, the MNL can explicitly incorporate economic determinants of market share behavior.

From a policy perspective, both the logit and market share equation results show that unit value (relative price) changes are important determinants of changes in market shares. Therefore, the performance of the EC and Brazil in the Kuwaiti poultry market can be attributed as much to relative price as to the other variables such as export restitutions. Given the appreciation of the dollar relative to other currencies in recent years, which implies a relative price increase for US and residual "other" exports, the implication is that there is little possibility of US share increasing, unless the dollar's current decline proves more than a short-run phenomenon. The overall implication is that the EC and Brazil will continue to dominate the Kuwaiti and Middle Eastern poultry import markets.

NOTES

[1]Notable exceptions include Blandford and Boisvert, Schluter and Clayton, and USDA (1983).

[2]Iran, Iraq, Kuwait, Libya, Qatar, Saudi Arabia and the United Arab Emirates.

[3]See Kemeny and Snell for a theoretical treatment, and Dent for an empirical application to agricultural trade.

[4]See Lee, Judge, and Zellner for a precise definition of "macro-data" and associated estimation problems.

[5]For example, Capel and Rigaux.

[6]The discussion below is drawn largely from Tyrell and Mount's model of household expenditures. For an application using micro-data, see Stavins and Stanton.

[7]Durbin h-statistics, rather than the Durbin-Watson statistic, are calculated to test for the presence of autocorrelated residuals where lagged endogenous variables are present as regressors.

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