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Modeling Country Origin of Exported Soybeans in EC Destination Ports: A LOGIT Approach

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ABSTRACT

This study models country origins of exported soybeans at EC destination ports in a LOGIT framework, with quality characteristics as explanatory variables. Results indicate that shipments with low oil yield and high FM, have a greater probability of being of US origin than South American origin.

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Introduction and Problem Statement

Historically, the issue of the grain quality has generated considerable debate in the US (3). Recently, particular controversy has surrounded the question of whether the quality[1] of soybeans exported from the US is a key factor in the loss of US shares of European and Japanese soybean markets to South American exporters.

Those who believe that inferior quality of US exported soybeans accounts for US loss of market share in the EC and Japan argue that, all other things (**including prices**) equal, US soybeans arrive in destination ports with higher percentages of foreign material (FM)[2], splits, and damaged beans than soybeans arriving from Brazil or Argentina. Moreover, there is evidence

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[1] In this study, we use the Office of Technology Assessment's three-part definition of the term (soybean) "quality" (9); i.e., "...quality is defined in terms of physical, sanitary and intrinsic characteristics. Physical quality characteristics are associated with outward visible appearance of the kernel or measurement of the kernel. Included are kernel size, shape, and color, moisture, damage, and density. Sanitary quality characteristics refer to the cleanliness of the grain. They include the presence of foreign material, dust, [and] broken grain...These are essentially characteristics that detract from overall grain value. Intrinsic quality characteristics are critical to the end use of the grain. They are nonvisual and can only be determined by analytical tests. [In soybeans, for example, such characteristics refer to percentages of oil, protein, free fatty acids, phosphorus, and totox]."

[2] Foreign material is defined by the Federal Grain Inspection Service (FGIS) as, "All matter that passes through an 8/64 round-hole sieve and all matter other than soybeans remaining in the sieved sample after sieving according to procedures prescribed in FGIS instructions." (2)

to suggest that the intrinsic characteristics of US soybeans, i.e., oil and protein yields, are inferior to soybeans grown in South America (10).

The view of those who believe that quality factors account for loss of US market share in important export markets was summarized by a representative of the Japanese Oilseed Processors Association in a 1990 speech given to a group of US farmers, commodity groups and exporters (11):

> [A] comparison of oil and protein content and FM of US and Brazilian soybean imports into Japan...shows clearly that US soybeans are inferior in both respects. I am sure you are well aware that your soybeans have dual handicaps of poor nutrient contents and higher FM levels. As a result, US share of total Japanese crushing soybean imports have dropped.

In an attempt to gain understanding of how the quality of soybeans differ between exporting countries, the US Department of Agriculture conducted a study, from 1986 to 1989, to investigate the quality characteristics of soybeans originating from the US, Brazil, Argentina, Uruguay, and Paraguay. Shipments of soybeans from these exporting countries were sampled in five EC ports, and three Asian ports. Samples were graded, protein and oil yields were determined, and soybeans oil quality characteristics were assessed via laboratory procedures (8). The data set generated by the USDA study was recently released. The data set is unique in that it allows, for the first time, a direct comparison of quality characteristics of US and South American soybeans at their destination ports.

The purpose of this study was to model origin countries of

exported soybeans at destination European ports, using physical, sanitary, and intrinsic quality characteristics deemed important in recent surveys of European soybean processors. The results of this study will have the following implications:

1. The ability to model origin countries of imported soybeans at EC ports would lend direct support to the hypothesis that there exist significant quality differences between US and South American soybeans.

2. The ability to quantitatively differentiate country of origin of imported soybeans would, by implication, help US farmers, plant breeders, and grain handlers to identify quality characteristics deemed important by their foreign customers. Moreover, identification of important quality characteristics could serve to induce the development of a system of premia and discounts for identified quality characteristics.

3. An econometric model that predicts country of origin of exported soybeans, given quality characteristics, would serve as a foundation for subsequent research efforts to relate quality differences between US and South American soybeans to US losses of markets shares in EC and Japanese soybean markets.

The Model

The model explains country origin of exported soybeans in EC destination ports using physical, sanitary, and intrinsic characteristics of the sampled soybean shipments. The model is cast in a LOGIT framework, with country of origin as the

dependent variable and quality characteristics as explanatory variables. The LOGIT framework allows us to assign a probability to the event that a shipment of soybeans is of US origin, given a set of quality characteristics.

As mentioned above, data used in estimating the model was collected by the US Department of Agriculture, over a 42 month period between 1986 and 1989, in five European ports- Rotterdam, Amsterdam, Ghent, Hamburg, and Lisbon- from shipments of soybeans exported from the US, Brazil, Argentina, Uruguay, and Paraguay. The data set includes the following variables: Country of origin, destination port, test weight, moisture, damaged kernels, foreign material, splits, protein percentage, oil percentage, free fatty acid percentage, phosphorous content, and totox values.

Consistent with the LOGIT framework, country of origin functions as the dependent variable in the model. We assign a "1" to all shipments of US origin, and a "0" to soybean shipments originating from South America (i.e., from Brazil, Argentina, Uruguay, or Paraguay). We selected a subset of quality variables, from the set of variables for which data were collected, to function as explanatory variables.

Selection of the explanatory variables was based on recent surveys of European soybean processors. Two surveys reported in Bender and Hill (1) indicate that European processors' concerns are focused primarily on the oil yield and foreign material percentages of imported soybeans. This finding was reinforced in remarks by Vervaeke (12).

We estimated a LOGIT function, using oil yield and foreign material as explanatory variables, by solving the following log-likelihood function with the Newton-Raphson iterative procedure (6,5):

$$L = \sum_i [Y_i(\beta_0 + \beta X_i) - \log(1 + e^{\beta_0 + \beta X_i})] \qquad (1)$$

Results are as follows:

$$Y_i = 28.117 + \underset{(1.783)}{0.667}*\text{FOREIGN MATERIAL} - \underset{(-2.759)}{1.386}*\text{OIL} \qquad (2)$$

where,

$$Y_i = \begin{cases} 1 \text{ if soybean shipment is of US origin} \\ 0 \text{ if soybean shipment is of South American origin} \end{cases}$$

We used three criteria to evaluate the model: t-statistics, and what Judge, et al term the "chi-square statistic", and the "pseudo-R^2". Formulae and computed values for the chi-square statistic, and the pseudo-R^2 appear, respectively, below:

$$CSS = -2[\ln l(w) - \ln l(\Omega)] \qquad (3)$$

$$= 22.648$$

where,

$$\ln l(w) = n \ln(\bar{T}) + (T - n) \ln\left(\frac{T - n}{T}\right) \qquad (4)$$

$$= -38.968$$

and,

n = number of successes ($Y_i = 1$)

T = number of observations

$l(\Omega)$ = the value of the log-likelihood function evaluated at the maximum likelihood estimators

$$Row^2 = 1 - \frac{\ln l(\Omega)}{\ln l(w)} \qquad (5)$$

$$= .29$$

T-statistics computed for estimated coefficients, together with the Chi-square statistic, are each significant at acceptable levels of $(1 - \alpha)$. The pseudo-R^2 statistic suggests that oil yield and percent of foreign material explain almost 30 percent of the uncertainty associated with the probability that a shipment of soybeans imported into the EC originates from the US.

The signs on the estimated coefficients have interesting, if somewhat ominous, implications for the US soybean export industry. The positive sign on the foreign material coefficient indicates that a shipment of soybeans imported into the EC containing a high percentage of foreign material, has a greater probability of being US-origin soybeans, than South American-origin beans.

The negative sign on the oil yield coefficient suggests that a EC imported soybeans with a high oil yield have a greater probability of originating from a South American country, than from the US. Following Judge, et al, we determined that the estimated model coefficients indicate that a one percentage point increase in foreign material increases the probability that the

soybean shipment is of US origin, by 13 percent. Correspondingly, an increase of one percentage point in soybean oil yield decreases the probability that the soybean shipment was exported from the US by 27 percent.

On the assumption that soybean processors buy soybeans on the basis of oil content, we tried to estimate additional models that combine oil content with variables that are indicators of the quality of oil that a given shipment of beans is likely to yield. Specifically we attempted to model country origin by combining oil content with variables representing damaged kernels and free fatty acids.(12,8) In each of these instances, estimated coefficients for explanatory variables other than oil percentage were insignificant.

Mounts notes that, "It has generally been theorized that damaged kernels and splits content are more closely related to end-use quality, as these are indicators of pre- and post-harvest damage and the loss of seed coat integrity." We noted above that when a damaged kernels variable was included in the model, it did not enhance the explanatory power of the model in a significant way.[3] Inclusion of a splits variable, however, appears to be a significant factor in predicting the origin of EC soybean imports; i.e.,

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[3] Insignificance of coefficients estimated for damaged kernels and free fatty acids, may be attributable to the relatively high correlation between damaged kernels and oil content (0.44), and between free fatty acids and oil content (0.55).

$$Y_i = 53.282 - 0.251*SPLT - 2.377*OIL \quad (6)$$
$$\qquad\qquad (-2.313) \qquad (-3.197)$$

Chi-Square Statistic = 25.588
Pseudo-R^2 = 0.328

Results derived from modeling country origin of EC destination soybeans with splits and oil percentage suggests that oil percentage continues to be a characteristic that differentiates US soybeans from South American soybeans. In general the model associates beans with a high oil content with a South American-origin. EC shipments of soybeans with a high percentage of splits, however, reduces the probability of US origin. This finding may be due to better handling of export soybeans in the US, and/or US producer use of seed varieties that resist splitting.

The model results indicate that a one percentage point increase in splits induces a 6 percent decrease in the probability that the soybean shipment is of US origin. A one percentage point increase in the oil content of a bean shipment at an EC port decreases the probability of US origin by almost 55 percent.

$$Y_i = 45.538 + 0.642*FOREIGN\ MATERIAL - 0.241*SPLITS \quad (7)$$
$$\qquad\qquad (1.779) \qquad\qquad (-2.219)$$

$$- 2.068*OIL$$
$$(-2.802)$$

Chi-Square Statistic = 30.122
Pseudo-R^2 = 0.386

Equation (7) combines the variables of LOGIT models represented in equations (2) and (6). Note from the combined model that, again, bean shipments with high percentages of splits and oil content decrease the probability of US origin, as in earlier model results; shipments with high FM percentages increase the probability of US origin. Coefficients estimated in the combined model suggest that unit increases in splits, and oil content reduce the probability of US origin by 4 and by 37 percent, respectively. A unit increase in foreign material in a shipment of soybeans imported into the EC, increases the probability of US origin by almost 12 percent.

Summary and Conclusions

Results from the LOGIT models set out above contribute quantitative evidence to the hypothesis that quality differences exist between soybeans exported from the US and South America. Model results suggest that quality characteristics differentiating US and South American soybeans in EC destination ports include oil content, FM, and splits. Each of the three estimated models indicate that a greater probability of US origin is associated with soybean shipments with low oil yield and (/or) high FM.

The model results raise two questions with regard to the relatively low oil yield of US exported soybeans: First, whether there is a need for the US soybean industry to focus its attention on enhancing both public and private plant breeding programs; and second, what sort of policies could be instituted

to encourage the development of schedules of premia and discounts that would reward producers of beans with high oil yields.[4]

Model results provide evidence to what importers of US soybeans have been saying for a long time: that US soybeans have an FM problem. Domestic advocates of this point of view argue that FGIS grades and standards for soybeans need to be altered to reflect lower levels of allowable FM, in order for US soybeans to remain competitive with South American beans in world export markets (10). Others argue that the FM problem is not a grades and standards problem, but one that is merely exacerbated by US agricultural policies, and Brazilian export policies (4)(7).[5] We can say that the results of this study appear to confirm that US exported soybeans have an FM problem. We need additional research to identify both the nature of the problem and why it exists, and precisely what policy remedies might be available to alleviate it.

Additional research efforts could also be devoted to further examination of the USDA data set utilized in this study. Specifically, it would be interesting to determine whether the results generated in this study of EC destination ports, hold for the sampled Asian ports (i.e., Tokyo, Japan, Inchon, Korea, and

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[4] With the recently instituted FGIS requirement that oil and protein yields appear on inspections tickets of FGIS graded grain, it is likely that development of premium-discount schedules is already underway.

[5] The debate surrounding high levels of FM in US exported grain was intense enough to oblige the US Congress to mandate a study of the costs and benefits of cleaning grain in the Food, Agriculture, and Conservation and Trade Act of 1990.

Kaohsiung, Taiwan), as well. Additionally, this unique data set might be useful in trying to quantitatively establish a causality linkage between quality characteristics, and shares of export markets.

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