An Assessment of Soybean Imports from the United States by Japan

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This paper estimates the implicit prices of the physical and intrinsic characteristics of soybeans exported by the United States. It provides a couple of basic pieces of information. First, the U.S. grades and standards assigned to a shipment do provide information valued by the market. Second, in Japan there are two identifiable soybean markets - a premium food bean market and a crushing market. The soybeans going into the food market for processing can be identified by their lower oil content, lower percentage of split and damaged beans, and a lower amount of foreign material, as well as smaller shipment sizes. The soybeans which have characteristics which satisfy those demanded in the food bean market are bid into that market. (*JEL* Classification: Q17)

I. Introduction

Japan has a reputation as a quality conscious importer of agricultural commodities (Cramer 1993; Hayami 1990; Ito and Maruyama 1991). Coincident with quality concerns is the fact that Japan is the world's second largest importer of soybeans. In 1993, for example, Japan accounted for 4,600 thousand metric tons or 16 percent of total world soybean trade (Foreign Agricultural Service January 1994). Ninety percent of these soybeans are used by the soybean crushing industry to produce soybean oil and soybean meal, while the remaining 10 percent of the beans go directly for food uses. Since 1974, the United States

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[**Seoul Journal of Economics** 1995, Vol. 8, No. 4]

TABLE 1
JAPANESE SOYBEAN IMPORTS BY SUPPLIER

	U.S.	Brazil	China	Other	Total
1974	2923		231	89	3243
1975	3041		240	53	3334
1976	3287		133	134	3554
1977	3428		98	76	3602
1978	4143		80	37	4260
1979	3839		267	26	4132
1980	4226		100	75	4401
1981	4022	1	113	61	4197
1982	4196	0	112	36	4344
1983	4646	24	288	37	4995
1984	4181	9	308	26	4515
1985	4345	221	289	55	4910
1986	4331	128	323	35	4817
1987	4100	307	290	100	4797
1988	3657	576	297	155	4685
1989	3263	685	280	118	4346
1990	3456	857	284	84	4681
1991	3721	271	279	60	4331
1992	3960	300	280	60	4600

Source: Japan Oil and Fat Importers and Exporters Association (annual)

has supplied an average of 89 percent of Japan's imported soybeans (Table 1). Given these data and its penchant for agricultural commodity quality, it stands to reason that the Japanese are very much concerned about the quality of the soybeans they import. This study focuses on this issue.

Soybeans are a heterogenous product. Different shipments of soybeans have different levels of oil, protein, damaged beans, non-soybean material, and off-color soybeans. These differences affect the value of each shipment, and can affect the suitability of a soybean shipment for a specific use. Of particular interest is whether the soybean market accounts for these differences and, if so, just what soybean characteristics influence soybean shipment prices. In a properly functioning market, the price of soybeans would be expected to reflect the differentiation in the characteristics of a specific lot of soybeans. To investigate whether the market for soybeans is behaving as expected, this study looks at the relationship between the price and the soybeans characteristics for soybeans exported from the United States. Because of the different uses to which soybeans are put, the Japanese market must be examined closely for product differentiation for soybeans going into the food and crushing sectors.

Using shipload inspection data from the Federal Grain Inspection Service (FGIS) and shipload value and quantity data from the Department of Commerce, the relationship between soybean prices and characteristics of Japanese soybean imports will be examined. This examination identifies the soybean characteristics relevant to the Japanese market, estimates the premia and discounts associated with the various soybean characteristics, and explores the usefulness of U.S. Grades and Standards in explaining soybeans prices.

II. Background

A. An Overview of the Japanese Soybean Market

Soybeans in Japan are the primary input for two production processes which supply two distinct Japanese markets—the crushing market which produces soybean meal and soybean oil and the food market whereby soybeans are processed into products such as tofu and natto and sold in the food market. Each of these markets tends to value the physical and intrinsic characteristics of soybeans differently (Cramer 1993).

As noted, soybeans are heterogenous in nature, exhibiting differences in protein and oil content, color, and other intrinsic characteristics. Because of this, in general the oil and protein content as well as other soybean characteristics of soybeans exported from the United States vary from shipment to shipment. Theory suggests that the value of soybeans will change with changes in the amount of oil, protein, foreign material, and the percentage of split, damaged, and off-color soybeans because these characteristics are valued differently by different consumers. Additionally, the contribution of the soybean meal and oil components to the overall price of soybeans should vary as market conditions result in a change in the ratio of the soybean meal to oil price.

As noted, there are two distinct segments of the market for imported soybeans in Japan—the crushing market and the food market for beans. These are discussed in turn.

(i) Crushing Market—In the crushing market, soybeans are the raw ingredient for a process that yields the joint products of soybean meal and soybean oil. The market value of soybeans for crushing is characterized as the sum of the value of soybean oil and meal contained in the soybeans (Houck 1964a, 1964b). The value of soybean meal and soybean oil is derived from the value of the final products in which they are used. Soybean meal is a source of protein for livestock feed, being commercially prepared as well as being mixed in rations on the farm. Soybean meal serves as a major input into the production of meat, eggs, and dairy products. Soybean oil is one of the major components of the edible vegetable oil complex which also includes canola, corn, cottonseed, peanut, and sunflower oils.

(ii) Soybean Food Market—Each food product derived from soybeans requires specific soybean characteristics including protein content, size, color, and weight making the food market for soybeans more complex than the crushing market. In 1991, for example, the Japanese soybean food market used 930 thousand tons of soybeans, of which 500 thousand were processed into tofu (Webb 1994 and Japan Oil and Fat Importers and Exporters Association (JOPA) 1992). Other soybean based food products (in order of soybean use) include miso, natto, frozen tofu, soysauce, and soymilk.

Because different soybean characteristics are required for each of these foods, soybeans from different sources are used for each product.[1] Since 1986, the United States has supplied approximately 75 percent of the soybeans used for tofu and frozen tofu which requires a soybean with a relatively high protein content, China has supplied 85 to 91 percent of the soybeans for the miso market which requires a soybean with a consistent color, and China and the U.S. have combined to supply approximately 90 percent of the soybeans for natto processors who require soybeans with a consistent color and weight. The U.S. has supplied almost all of the soybeans processed into soysauce which requires beans with a relatively high oil and constant moisture content. Only Japanese grown soybeans are used for soymilk. (There are political reasons for this based on Japanese agricultural policy. (Webb 1994)

The contracts for U.S. produced soybeans going to the Japanese food market reflect the risk adverse nature of Japanese food processors of soybeans. These contracts typically specify U.S. soybeans must come from only three states, Indiana, Ohio, and Michigan because Japanese food processors have found soybeans from these states meet their

[1]See Gerrietts (1993) and Smith (1989) for a discussion of the soybean characteristics required for various food products.

requirements for specific characteristics (Webb 1994).

B. U.S. Grades and Standards

The primary characteristics which distinguish one shipment of soybeans from another and which ostensibly are reflected in the price are the protein and oil content of the soybeans and attributes which might limit the amount of crushable material in the shipment. An ancillary issue concerning the price of soybeans involves whether the information on other soybean characteristics provided by official U. S. inspection is incorporated into the price of soybeans for export. Currently all grain and oilseeds exported from the U.S. are inspected and issued a numerical grade by the Federal Grain Inspection Service (FGIS) using the U.S. grades and standards. The stated objective of these grades and standards is to facilitate the transmission of quality information to buyers and thereby aid in the determination of a price. Implicit in this assignment of quality grades is the presumption that participants in the market are unable to accurately determine the quality of the commodity, a form of market failure (Friedman 1984). Soybean characteristics measured during the official inspection include test weight, the percent moisture content, the percentage of split beans, the percentage of damaged kernels, the percentage of heat damaged kernels, and the percentage of soybeans of other colors (Federal Grain Inspection Service 1991). Soybean protein and oil content are measured only upon request.

Much of the debate over the U.S. position in the world soybean market has revolved around the quality of U.S. soybeans and the formulation of a set of grades and standards that are more rigid (i.e., stricter in terms characteristic requirements) and better reflect the information required by soybean purchasers. One argument often heard is that stricter standards for foreign material and split and damaged kernels would improve the U.S. world soybean market position (Anderson 1991; American Soybean Association 1990; U.S. Department of Agriculture 1991).[2] On the other hand, it is argued that the information conveyed by the current grades and standards is either irrelevant or insufficient and responsible for complaints about U.S. grain quality by foreign buyers (Hill 1990; Johnson and Wilson 1992; Marlenee

[2]Similar discussions have occurred for other commodities. See Hyberg *et al.* (1994) and Mercier (1989, 1994) for an examination of the importance of U.S. grades and standards for wheat.

1987; Wilson and Preszler 1992). An intermediate position holds that the information content of the current grades and standards is but one of many factors affecting the demand for U.S. soybeans (Office of Technology Assessment 1989; Gunset 1994).

The results of an empirical examination of the factors influencing the price of soybeans for export should provide some insight into the relevance of the current soybean grades and standards and this information can be of use in formulating new grades and standards.

C. Theoretical Constructs

In a competitive market, forces operate to assign a price to each lot of soybeans. This price reflects the presence and relative merits of all important attributes. Price differentials between lots of the same commodity with somewhat differing characteristics—referred to as differentiated products—represent the disparity in the value associated with these differences. For this reason, the price of a given shipment can be viewed as being determined by a combination of implicit prices associated with both desirable and undesirable attributes or characteristics of the commodity. For soybeans these characteristics include the amount of soybean oil and protein (Heinen and Pick 1991).

The theoretical development of the approach for understanding the markets for differentiated products relies on the work of Lancaster (1966), Griliches (1971), and Rosen (1974). There have been a number of applications of this approach to agricultural commodities including those Espinosa and Goodwin (1991), Ethridge and Davis (1982), Ladd and Martin (1976), Ladd and Suvannunt (1976), Larue (1991), Larue and Lapan (1990), Prescott and Puttock (1990), Stanley and Tschirhart (1991), Uri, *et al.* (1994), Veeman (1987), and Wilson (1984, 1989).

Each characteristic of soybeans, but particularly oil and protein content, is viewed as an input into a production process. Under this approach, a differentiated product like soybeans is demanded by processors because of the particular physical and intrinsic characteristics that it possesses. These characteristics are identifiable inputs into the production of soybean oil and meal. Thus, it is possible to express the implicit price associated with each characteristic.

Assume, as do Ladd and Martin (1976), a profit maximizing processor operating in a competitive environment. The production function is assumed to be composed of the soybean characteristics in addition to other factors of production used in crushing soybeans (e.g. capital, labor, etc.). Let this production function for output x be represented as

$f_x(z)$ where z is a vector of inputs including the physical and intrinsic characteristics of soybeans. The first-order conditions (developed in Ladd and Martin 1976) assuming profit maximization gives an implicit price for input v, p_v, as

$$p_v = p_o \sum_{k=1}^{m} (\partial f_x/\partial z_{kx})(\partial z_{kx}/\partial v_x), \tag{1}$$

where p_v is the price of input v (e.g., soybeans), p_o is the price of the output (e.g., soybean meal, soybean oil, etc.), m is the number of physical characteristics of the input, $\partial z_{kx}/\partial v_x$ is the marginal yield of the k^{th} characteristic in the production of x from input v, and p_o $(\partial f_x/\partial z_{kx})$ is the value of the marginal product of characteristic k used in the production of x. The term p_o $(\partial f_x/\partial z_{kx})$ is the implicit price of the k^{th} characteristic. Relationship (1) indicates that the price of each input is equal to the sum of the implicit prices of the characteristics possessed by the input multiplied by the marginal yield associated with each of those characteristics.

It is possible to simplify relationship (1) by assuming that only two products are being produced (e.g., oil and meal) and by letting p_o $(\partial f_x/\partial z_{kx}) = A_k$, and $\partial z_{kx}/\partial v_x = \gamma_{kv}$. Also assume that A_k and γ_{kv} are constant. That is, assume that each additional unit of input v contributes the same amount of the k^{th} characteristic to the production function and that the implicit price for characteristic k is constant (Ladd and Martin 1976). Given these considerations, relationship (1) can be rewritten as

$$p_v = \sum_{k=1}^{m} A_k \gamma_{kv}, \tag{2}$$

where A_k is the marginal value of physical characteristic k and γ_{kv} is the quantity of characteristic k contained in each unit of input v that goes into the production of x.[3]

[3]The development here has assumed that the relationship between the price of the input and the implicit value of the quality characteristics and the quantity of the characteristics is linear. This implies that each processor utilizes the input in the same fashion as every other processor so that they all have identical production functions. This, of course is not necessarily realistic. That is, different processors might have different preferences among characteristics (e.g., more protein content versus less oil content) for different uses. In this situation, the price relationship would not be linear. Whether the relationship is linear is an empirical issue that must be investigated.

D. Variables of Interest

As noted previously, one the concerns here is with the value Japanese importers place on the characteristics for which the FGIS collects and reports information. This value is expressed as an implicit price for each of these characteristics. For soybeans FGIS inspects and reports information on all soybeans exported from the United States.[4] This information is reported by grade ranging from 1 to 4. The grade is based on meeting limits for a number of characteristics including test weight per bushel, the percentage of foreign material, the percentage of heat damaged kernels, percentage of split beans (beans that have more than one quarter removed and are not damaged), percentage moisture content, percentage oil content, and percentage protein content.[5] The grade measure is a composite of factors and is based on quantitative limits (either a minimum or maximum) in place for each factor for each of the grades (Table 2).

Test weight (in pounds per bushel) measures the density of the soybean kernels. Although Hill (1990) and others have clearly demonstrated a poor relationship between test weight and crushing yield, some popular references continue to maintain that test weight is an indicator of crushing yield. If the market reflects this, then test weight will be positively related to price. Foreign material and moisture content, on the other hand, measure the amount of non-crushable material in a shipment. Consequently, the quantity of each of these factors should be negatively related to the price of soybeans.

Split soybeans and damaged kernels are two characteristics used to estimate the likelihood of increased free fatty acids (FFA) in soybean oil. Although these do not directly measure the amount of FFA in the soybeans, they are the proxies generally used to estimate FFA content in soybean shipments. Because FFA lowers the value of the oil by increasing processing costs, splits and damaged kernels are expected to have

[4]Until 1990, the FGIS also reported similar information by state on soybeans harvested. These reports could be used by importers of U.S. soybeans to make inferences regarding the quality of the overall soybean crop and/or soybeans from a specific region. These data are not examined in this study.

[5]Note that oil, protein, and moisture content are not determining factors in U.S. grades and standards. For convenience of exposition, however, they will be discussed with the factors that are FGIS designated as grade determining factors.

TABLE 2
U.S. STANDARDS FOR SOYBEANS

Grades	Minimum test weight per bushel	Maximum limits of: Damaged Kernels		Foreign material	Splits	Soybeans of other colors
		Heat-damaged	Total			
	Pounds	Percent				
U.S. No. 1	56.0	0.2	2.0	1.0	10.0	1.0
U.S. No. 2	54.0	0.5	3.0	2.0	20.0	2.0
U.S. No. 3[1]	52.0	1.0	5.0	3.0	30.0	5.0
U.S. No. 4[2]	49.0	3.0	8.0	5.0	40.0	10.0

U.S. Sample Grade shall be soybeans which:
(a) Do not meet the requirements for U.S. Nos. 1, 2, 3, or 4; or
(b) Contain 8 or more stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of broken glass, 3 or more crotalaria seeds, 2 or more castor beans, 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic foreign substance(s), 10 or more rodent pellets, bird droppings, or an equivalent quantity of other animal filth per 1,000 grams of soybeans; or
(c) Have a musty, sour, or commercially objectionable foreign odor (except garlic odor); or
(d) Are of otherwise distinctly low quality.

Note: 1. Soybeans which are purple mottled or stained shall be graded not higher than U.S. No. 3.
2. Soybeans which are materially weathered shall be graded not higher than U.S. No. 4.
3. From Federal Grain Inspection Service (1991).

a negative effect on soybean prices.

The percentage oil content of soybeans is an estimate of the yield of soybean oil that will be obtained during processing. By multiplying the price of soybean oil by the percentage oil content, a measure of the per unit (e.g., bushel) oil value is generated. One would expect a higher value for oil content to be positively related to the price of the soybeans.

Finally, the protein content percentage measure is used to indicate the quantity of soybean meal of a specific protein content that can be obtained from a shipment. A proxy variable for the value of soybean meal in a shipment can be obtained by multiplying the protein content per unit times the value of soybean meal. A higher protein value is obviously desirable,[6] and thus should be positively related to the price of soybeans (General Accounting Office 1987).

The preceding discussion examines soybean characteristics from the perspective of the crushing industry. Food processors may weigh the soybean attributes somewhat differently. In particular foreign material, heat damaged beans, total damaged soybeans, and split soybeans are likely to be considered less desirable by food processors where the visual characteristics of soybeans are relatively more important.

III. Data

The recent acquisition of soybean shipment data from the Department of Commerce permits an analysis of the implicit prices of the characteristics of soybeans produced in the U.S. and exported. The data used in the estimation were collected by the FGIS and represent transaction prices (FOB) for specific shiploads together with information on the specific FGIS grades and standards characteristics for each of these shiploads. This data set marks a substantial improvement over data used in most other studies which attempt to measure the implicit prices associated with grain characteristics because it uses actual transactions prices and the associated physical and intrinsic characteristics instead of some sort of average values for the various variables.[7]

[6]A higher protein content is also valued because it permits more hulls and other admixtures to be included with the meal increasing the yield of soybean meal for the shipment. One needs to exercise caution, however, when considering protein content because it is reported in several ways: a 13 percent moisture basis, a zero percent moisture basis, and a zero percent oil and moisture basis. FGIS reports on a 13 percent moisture basis.

[7]For example, in studying the price of Kansas wheat, Espinosa and Goodwin (1991) use seasonal averages of the price of wheat and wheat characteristics for nine crop-reporting districts in Kansas. Veeman (1987) and Larue (1991) use annual averages of the price of wheat and its characteristics, while Mercier and Young (1993) used annual state price averages to measure wheat price—characteristic relationships. It has been shown that the use of averages is not appropriate in the estimation of implicit price relationships (Brown and Rosen 1982; Griliches 1964; Triplett 1986). Aggregation tends to obfuscate the measurement of the impact of physical and intrinsic characteristics on the price of the good in question yielding implicit prices for those characteristics that, in general, can

The individual transactions for which the data were collected by the FGIS occurred over the period January 1990 through October 1991. A sample of 74 soybean shipments to Japan was used to examine the Japanese market. The observations in this data set represents nearly 20 percent of the U.S. soybeans shipped to Japan during this period. Three grades—U.S. number 1, U.S. number 2, and U.S. number 3—are represented in the sample.

IV. Estimation Considerations

A. Identification

The implicit price function for soybeans is exogenous as far as both consumers and producers are concerned. Rosen (1974) shows how the implicit price function in general is determined by demand and supply forces in the market and that, by itself, does not identify consumer preferences or producer costs. This is not a problem here since the focus of the study is on the overall market valuation of the various soybean quality characteristics and does not specifically concern itself with consumers' valuation nor producers' costs associated with growing and processing soybeans.

B. Nature of the Data

Estimation of empirical relationships which combine cross section and time series data frequently present unique estimation problems. For example, differences can exist among cross-sectional units (the different countries in the full sample). The problem of serial correlation (first order or, perhaps, higher orders given that the shipload data being used cover 22 months) might also be present in the time series structure of the data. Frequently used estimation techniques such as pooled cross section and time series estimation techniques (see, e.g., Judge, *et al.* 1985) are not appropriate here because there are many missing observations for various paired combinations.

Additionally, any dynamic effects associated with the time series must be captured. The dynamics can take the following form. Over the period January 1990 through October 1991 covered by the data, one sees relative changes in the price of soybeans due to fluctuation in

not capture the underlying price mechanisms for individual shipments.

quality characteristics between shiploads. Additionally, however, one might observe variations in the absolute price of soybeans due to variations in the underlying market conditions for soybeans (Griliches 1971). Whether in fact the market conditions changed is an empirical issue that needs to examined.

C. Model Specification

The two markets, soybean crushing and food processing, are considered. A basic question in this is whether the same soybeans are used in each market. That is, are the physical and intrinsic characteristics of the soybeans used in each of the markets the same in Japan?

This determination was made by plotting the data and examining the outliers. This effort revealed that Japan had a considerable number of outliers and influential observations. The data were examined for influential observations using the regression diagnostics of Belsley, Kuh and Welsch (1980). Upon close scrutiny it was clear that there were two separate types of soybean sales to Japan contained in the data set —one type of sales (59 observations) was similar to those observed for the other importing countries and another type (14 observations) had a relatively high price and low volume.

It was concluded (in consultation with some U.S. soybean exporters) that the two sets of observations represented soybeans for the two Japanese soybean markets. The observations associated with the relatively high price were in all likelihood shipments of soybeans destined for the food bean market and the shipments of soybeans in the larger set of observations were undoubtedly to be processed by soybean crushers.

The small size of the food sector sample limits the statistical analysis of Japanese soybean purchases for this market. Differences between soybeans for crushing and the food market can be determined but valuation of the specific physical and intrinsic soybean characteristics in the Japanese food market cannot be conducted with the data available because there are simply too few degrees of freedom to permit robust estimation.

This being the case, to make the estimation results compatible for inferential purposes, the complete data set consisting initially of 263 shiploads of soybeans exported by the United States during the sample period was purged of observations of soybeans destined for the food market based on shipment size, price, oil content, percentage of split and damaged beans, and amount of foreign material. This yielded a total of 213 shiploads of soybeans for the crushing market with 154 shiploads sent to countries other than Japan.

D. Other Considerations

There remain a few other considerations before turning to the estimation results. One has to do with heteroscedasticity. In the current analysis, this problem would occur if the regression results for, say, larger shiploads indicate a larger variation in the error term on the soybean price equation than one observes for smaller shiploads. Using the data for all of the shiploads, White's (1980) test for heteroscedasticity was performed on the price equation. The test statistic is distributed as chi-squared with 27 degrees of freedom. The computed value of the test statistic is 1.59. The critical value at the 5 percent level is 40.1. The tabulated value is less than the critical value so that the null hypothesis of homoscedasticity can not be rejected.

There are other factors besides physical and intrinsic characteristics and the temporal considerations that might impact the price of soybeans. For example, the processing margin of soybeans (the difference between the value of the soybean oil and soybean meal that can be extracted from a bushel of soybeans and the price paid for a bushel of soybeans) would be expected to offer a measure of the opportunities available to soybean processors. Evidence from Uri, Chomo, Hoskins, and Hyberg (1993) indicates that world markets for soybeans and soybean products are linked and extremely efficient. Thus, estimates of U.S. processing margins are used to capture changes in world markets of the relative price of soybeans and soybean products compared to processing costs. The processing margin is estimated on a monthly basis by the U.S. Department of Agriculture. The margin tends to range between 50 cents and one dollar per bushel.

V. Empirical Results

A. Soybean Characteristics in the Food and Crushing Markets

The mean and variance for price, quantity, oil and protein content, foreign material, moisture content and damaged soybeans were calculated for soybeans going into the crushing and food markets in Japan. Because the data used in the analysis are statistics possessing a random component, a statistical test was conducted to determine if the average (mean) characteristics of the soybeans going into the two markets differed. Of interest were the characteristics of the soybeans that distinguished the two uses.

The comparison revealed that besides having much lower shipment volumes and a price $60/metric ton (MT) higher than soybeans going to the crushing market, soybeans processed into food products had significantly lower amounts of split and damaged beans and lower average foreign material (Table 3). This result suggests that food processors place a higher premium on clean shipments of undamaged soybeans. A comparison of the oil and protein content of the soybeans shows that soybeans going to the food sector have, on average, a higher protein and lower oil content but that the difference is not statistically significant for protein. There is no significant difference in the test weight or the moisture content between soybean shipments going to the two different markets.

B. An Analysis of the Implicit Price of Soybean Characteristics in the Crushing Market

A linear-in-logarithms function for the U.S. export price for soybeans was estimated for (1) the major developed soybean importing countries, (2) the major developed soybean importing countries, Japan excluded (for convenience this will be referred to as the Rest of the World, or ROW), and (3) Japan (Table 4).[8] The price is measured in dollars per metric ton. The data, as noted previously, are a mix of cross section and time series observations. Because the time period is relatively short, no attempt is made to correct for inflation. This means that the implicit values of the soybean quality characteristics are in current dollar terms. The units on the explanatory variables are as previously indicated. A variable was retained in the final specification if the coefficient estimate exceeded its standard error.

In the first two models, country specific dummy variables (defined to equal one if the shipment was destined for a specific country and zero otherwise) are introduced to allow for possible effects common to individual countries represented in the cross section but not captured by the other variables used in the estimation. A zero restrictions test (Judge, *et al.* 1985) was employed to assess whether such factors have

[8]A Box-Cox transformation was used to test for the appropriateness of the functional form (Judge, *et al.* 1985). The linear-in-logarithms was deemed to be the appropriate functional specification. Complete details of the testing procedure and test results are available from the authors.

TABLE 3
CHARACTERISTICS OF SOYBEAN SHIPMENTS FROM THE U.S. TO JAPAN FOR THE FOOD AND CRUSHING MARKETS

	Food Market		Crushing Market		
	Mean	Std dev*	Mean	Std dev	*t*-stat**
Price ($/mt)	286.204	889.902	228.193	75.160	2.44***
Quantity (mt)	187.613	63.725	1959.003	1022.011	-13.21***
Foreign material (%)	0.393	0.532	1.742	0.309	-9.17***
Heat damage (%)	0.007	0.027	0.064	0.074	-4.79***
Damaged kernels (%)	0.436	0.413	1.102	0.316	-5.66***
Splits (%)	0.300	0.248	0.836	0.245	-7.28***
Percent oil	18.232	0.485	18.734	0.421	-3.75***
Percent protein	36.042	1.341	35.532	0.490	1.40
Test weight (lb)	56.691	0.679	56.391	0.362	1.61
Moisture (%)	12.014	0.789	11.993	0.699	0.06

Note: * : Standard deviation associated with the sample mean of the specific variable.
**: The computed *t*-statistic used to test the null hypothesis that the mean values of the specific variable between the two soybean markets are the same.
*** : Statistically significant at the 5 percent level or better.

a measurable effect on the price of soybeans sold to a country. If there was no indicated effect, the country variable was dropped from the final specification. The assumption is implicit in this specification that a varying intercept term captures any differences among the countries in the analysis and that each country shares common estimates of the implicit values of the soybeans physical and intrinsic characteristics.

To account for variations in the absolute price of soybeans due to changes in the underlying market conditions for soybeans and in the absence of a better measure, dummy variables are introduced for each month and defined to equal one if the shipment occurred in that month and zero otherwise. A zero restrictions test is used to determine whether there was any measurable change in the underlying market conditions for a given month. If there was none, the variable was dropped from the estimated relationship.

Finally, there is a relatively high degree of collinearity between the test weight and the meal value measures. The partial correlation coefficient between the two variables is 0.94. Because the destabilizing effect this had on the coefficient estimates for both the meal value variable

TABLE 4
COEFFICIENT ESTIMATES OF THE U.S. EXPORT PRICE OF SOYBEANS RELATIONSHIPS

	All Observations Major Importers		Rest of the World		Japan	
	Estimate	*t*-stat*	Estimate	*t*-stat	Estimate	*t*-stat
Intercept	7.052	7.346	8.156	16.71	4.132	16.267
Oil Value	0.266	9.852	0.248	7.084	0.309	10.655
Meal Value	0.597	6.219	0.470	4.278	0.442	3.911
Margin	-0.152	-8.000	-0.139	-6.197	-0.108	-5.889
Protein low obs			-0.455	-3.095		
Splits Beans			0.030	1.824	-0.060	-3.528
Damaged Kernels	-0.023	-1.769	-0.042	-3.114		
Foreign Material	-0.027	-1.928	-0.015	-4.977		
Quantity Sum			-0.797	-3.08		
Japan	0.017	3.400				
Korea	0.028	4.167	0.019	3.276		
Dutch	0.009	1.800				
Jan 90			0.020	1.813		
May 90					0.079	4.937
Aug 90					-0.035	-3.182
Sep 90					0.048	4.264
Feb 91					-0.031	-2.818
Oct 91	0.039	4.875	0.034	3.190	0.046	5.750
Number of Observations	213		154		59	
Adjusted R^2	0.65		0.82		0.47	

Note: * : The *t*-statistic.

and the test weight variable for each of the models in preliminary analysis, the decision was made to drop the test weight variable from the specification. (To maintain the integrity of the specification, it is necessary to have a variable reflecting the oil value of a shipment as well as the meal value.)

A) The Full Model

A full model, containing observations from major importers of U.S. soybeans (Japan, the Republic of Korea, The Netherlands, and the Rest of Europe) was estimated (Table 4). While alternative specifications were examined, the best specification in the sense indicated previously proved to be a linear-in-logarithms specification. The explanatory power of this multinational model was not exceptional in an absolute sense (the adjusted coefficient of determination (R^2) was 0.65) although the estimated coefficients generally had the expected signs. In a relative sense, however, this order of magnitude for the coefficient of determination is what one anticipates from cross sectional data (Intriligator 1983). Thus, the explanatory power of the estimated relationship is acceptable and is not indicative of any inherent misspecification.

The estimated coefficients for the meal value and oil value of the soybeans variables were positive and statistically significant at the one percent level. The estimated coefficients for the foreign material and damaged kernels variables were negative and statistically significant at the 5 and 10 percent levels, respectively. The statistically significant coefficient estimates were typically robust, with little change in either sign or magnitude as other variables entered or left the specification in preliminary analysis.

The coefficient on the processing margin variable was highly statistically significant (at the one percent level) and negative. Moreover, the coefficient estimate for the margin variable was robust. Because this result is contrary to *a priori* expectations and inconsistent with any theoretical explanation, a further examination of these data seemed warranted.

Monthly U.S. soybean processing margins were regressed against a constant term, the current and lagged soybean prices and 11 dummy variables representing the months February through December. (January 1990 was eliminated to avoid the singularity problem because of the inclusion of a constant term.) First order serial correlation was detected and corrected for using the iterative Cochrane-Orcutt procedure. The analysis found that a linear model containing monthly adjustments for February, March, April, and May, and a constant explained 84 percent of the variation in the processing margin. That is, over the period of study there was a relatively strong monthly effect on soybean processing margins.

This result suggests a reason for the negative coefficient on the soybean processing margin variable. The coefficient on each of the monthly dummy variables for February through May was statistically significant at the one percent level and negative, reflecting a seasonal decline for the first five months for both years in the sample in the processing margins suggesting that the decline in the processing margin was not necessarily related to any change in the export price of soybeans.

Although this monthly relationship for the processing margin variable is probably a statistical aberration (this obviously is a topic for future research) and is serving as a proxy for changes in absolute market conditions in the sense previously discussed, the decision was made to retain the soybean processing margin variable in order to maintain the integrity of the soybean export price specification. The variable was retained because there is a strong theoretical reason to expect the processing margin variable to influence export prices (Uri, Chomo, Hoskin, and Hyberg 1993). The coefficients obtained were significant and robust and the relationship with price over the period examined is implicitly understood.

SUM, the variable measuring the percentage oil and protein in the shipment, also entered the full model in a somewhat anomalous manner. The coefficient estimated for *SUM* tended to be unstable. This instability was not surprising because *SUM* is related to value of oil and meal in a shipment. Collinearity diagnostics strongly support this conclusion, indicating that the *SUM* variable was poorly conditioned and highly related to the intercept, meal value, oil value, and processing margin variables. However, including the *SUM* variable did not change, in a significant manner, the coefficients on these variables based on a preliminary analysis of alternative specifications. Consequently, the variable was retained in the final model specification. *SUM* did not enter in any of the other models.

B) The Country/Region Specific Disaggregated Models

In the full model, coefficient estimates on the country specific variables for Japan and other countries/regions were positive and statistically significant suggesting that policies and cultural preferences in the individual countries might lead to differences in the market valuation of soybean characteristics between countries. Separate models for Japan and the Rest of the World were estimated and compared to the full model to test this hypothesis.

The adjusted coefficient of determination was 0.47 for the Japanese model and 0.82 for the model of the ROW. A Chow (1960) test was used to examine whether the estimated coefficients on the explanatory variables for Japan and the other major soybean importing countries were the same. The test results indicated that Japan had different implicit prices for the various soybean characteristics. The computed *F*-statistic for a null hypothesis of coefficient homogeneity was 5.28.[9] Country specific results are highlighted below.

(i) The Rest of the World Model—The estimation results for the ROW model was similar to the results for the full model in most respects. The coefficients on the oil value and meal value of the soybeans were positive and highly statistically significant (at the one percent level). The estimated coefficients for the foreign material and damaged kernels variables were negative and statistically significant at the 5 percent level. Also, the coefficient on the processing margin variable was negative and significant at the one percent level. The statistically significant coefficient estimates were typically robust, with little change in either sign or magnitude as other variables entered or left the specification in preliminary analyses.

There were several differences between the ROW and the full model. A variable that entered the ROW model but not the full model in a statistically significant fashion was the quantity (in metric tons) of soybeans in a shipment. The coefficient was negative suggesting quantity discounts were a factor in shipments to countries other than Japan. The percentage of split variable also entered the ROW model but not the full model. The coefficient for the percentage of split soybeans had a positive sign and was significant at the 10 percent level. The unexpected sign and lower level of significance may indicate incidental significance. It is difficult to explain a positive association between split soybeans and soybean prices.

(ii) Japan Model—The estimated model for the valuation of the physical and intrinsic characteristics of soybeans imported by Japan was robust with an adjusted coefficient of determination of 0.47 The signs of the estimated coefficients conform well with theoretical expectations (Table 4). The coefficients for the value of meal and oil were both positive and statistically significant at the one percent level. The coefficient on the crushing margin variable was statistically significant at the one percent level and negative. The price Japanese purchasers paid for soybeans declined as the percentage of split soybeans in the shipload increased. Coefficient estimates on variables measuring the percentage of damaged kernels, moisture and foreign material were not significant and these variables were deleted from the final specification of the model. Thus, only one of the U.S. standards affecting soybeans (i.e., the percentage of splits) is statistically significant in explaining the

[9]The critical $F_{0.01}$ (9, 120) = 2.56.

price paid by Japanese purchasers.

A comparison of the coefficients for the oil and meal value, split soybeans, and margin variables in the Japan and ROW models reveals a number of interesting differences. There are statistically significant differences between the coefficients for oil value, splits, and margins for the two models. The coefficient on oil value is significantly larger for Japan suggesting the Japanese crushing industry places a greater value on the oil content than the crushers in other markets. The coefficient on the percentage of split soybeans in the Japan model had an opposite sign and was significantly different from the same variable in the ROW model. This also reflects back on the soybean oil market and suggests that the FFA content of soybean oil is a greater concern in the Japanese market. Finally, the coefficient on the margin variable was also significantly different in the Japanese model, but due to the ambiguity discussed earlier, this is difficult to interpret.

Monthly dummy variables used to capture exogenous fluctuations in the world soybean market were significant in May, August, and September of 1990 and February and October of 1991.

VI. Conclusions

The foregoing analysis of the implicit prices of the physical and intrinsic characteristics of soybeans exported by the United States provides three basic pieces of information. First, the U.S. grades and standards assigned to a shipment do enter in a statistically significant way in the empirical relationships considered. Thus, information on the percent of split beans is valued by Japan while the percent of damaged kernels and the percent of foreign material are valued by the rest of the world (importing countries other than Japan). This suggests that the U.S. grades and standards do provide information used by the market.

Second, in Japan there are two identifiable soybean markets—a premium food bean market and a crushing market. The soybeans going into the food market for processing can be identified by their lower oil content, lower percentage of split and damaged beans, and a lower amount of foreign material, as well as smaller shipment sizes. The soybeans which have characteristics which satisfy those demanded in the food bean market are bid (or more accurately contracted) into that market.

Finally, soybean buyers are shown to be able to satisfy the demands for their individual markets by selecting soybeans with specific characteristics. Japanese purchases of U.S. soybeans reflect this ability. Soybean prices for shipments to Japan reflect a higher contribution of the value of the soybean oil and a stronger discount on split soybeans which can raise the FFA content and thereby degrade the value of soybean oil in a shipment. The empirical results suggest that Japanese processors are able to identify and acquire soybeans which permit them to satisfy a quality conscious domestic market.

Previous studies found that the soybeans, soybean meal, and soybean oil markets are all linked and efficient (e.g., Uri, Chomo, Hoskin and Hyberg 1993). Price movements in these markets parallel one another and price shocks to the market are quickly dissipated. These relationships place restrictions on the price differentials that can exist for a soybean shipment thereby insuring that the difference between the prices paid for soybeans after adjustment for quality differentials by various importing countries is not significant. This is precisely what was found in this study.

(Received August, 1994; Revised December, 1995)

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