

## **An Analysis of International Price and Exchange Rate Elasticity for US Soybeans: The Case of Japan**

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## **An Analysis of International Price and Exchange Rate Elasticity for US Soybeans: The Case of Japan**

### Abstract

Stepwise model selection criteria were tested against the restrictive forms to determine the appropriate model and to confirm the law of one price for the US soybeans. Analysis shows less than one international price transmission and exchange rate elasticities in the long run indicate an incomplete exchange rate pass through.

*Key words: Exchange rate, Law of one price, model selection, and Price transmission*

With the export of more than half of the world's soybeans and soybean products, the United States is one of the leading soybean exporters of the world (American Soybean Association). Before 1974, the United States (US) had dominant position in the international soybeans market. However, the emergence of other competitor countries mainly due to the growing strength of the US dollars threatened the market position of US soybeans in recent years. Price transmission elasticity and exchange rate elasticity define the mechanism of international export market and changing market positions of exporting countries. The relationship between international prices and the domestic prices, which brings internal adjustment in supply and demand, is crucial to define the responses of importers and exporters to international price changes.

In spite of the significant role of price transmission and exchange rate elasticity in international export markets, There exist conflicting views among the marketing researchers about the magnitude of price transmission and exchange rate elasticities. The study results of Bredahl,

Myers, and Collins (1979) suggest zero and one values for the price transmission elasticity.

Johnson (1977) assumes perfect price transmission, and Pick and Carter (1994) indicate less than one exchange rate pass through.

The law of one price maintains that the foreign and domestic prices of a commodity will be equal when both are expressed in the same currency unit net of transportation costs (Goodwin, Grennes, and Wohlgenant, 1990). The purpose of this research is to confirm whether international price transmission elasticities for US soybeans confirm the law of one price (LOP). The freight rates and their volatility impact international soybeans price and omission of transportation costs while examining the price linkage could lead to a specification error. Therefore, we include transportation cost in our analysis.

### **Model Specification**

For the estimation of exchange rate and price transmission elasticities, a simple mark up model was developed:

$$P_i = (p_d + t_i) Z_i \quad \text{-----(1)}$$

where  $i$  indexes the export market,  $P_i$  is the foreign market price of soybeans expressed in the foreign currency (FCU),  $p_d$  is the domestic farm price of soybeans expressed in domestic currency (US dollar),  $t_i$  is the transportation cost expressed in domestic currency (US dollar), and  $Z_i$  is the bilateral exchange rate (FCU/ US dollar). Taking the total differential of (1):

$$\Delta P_i = Z_i \Delta p_d + p_d \Delta Z_i + \Delta T_i \quad \text{.....(2)}$$

Where  $T_i = t_i Z_i$  is the transportation cost expressed in foreign currency units (FCU). Dividing the above equation by  $P_i$ , and noting that  $P_i = p_i Z_i$  where  $p_i$  is the export price expressed in

domestic currency (US dollars), yields:

$$\Delta P_i / P_i = (\rho_d / p_i) \Delta p_d / p_d + (\rho_d / p_i) \Delta Z_i / Z_i + (t_i / p_i) \Delta T_i / T_i \dots\dots\dots (3)$$

which can be written in a simpler notation as

$$P_i^* = \psi_i p_d^* + \zeta_i Z_i^* + \delta_i T_i^* \dots\dots\dots(4)$$

Where asterisked variables indicated relative changes (e.g.,  $P_i^* = \Delta P_i / P_i$ ) and  $\psi_i = \zeta_i < 1$ ) that is, equation (1) implies that the price transmission and exchange rate elasticities are equal and less than one. Similarly, (1) introduces a restriction on the transportation cost,  $\psi_i = (1 - \delta_i)$ . Namely, the transportation cost elasticity equals one minus the price transmission elasticity, which implies  $\psi_i + \delta_i = 1$ .

In order to analyze the issue, we adopted a modeling philosophy suggested by Hendry (1995). A general to specific modeling methodology was adopted to select the consistent model (Tomek and Kaiser, 1999). Specifically, seasonality, trend, and inflation are included along with transportation cost in the price transmission model, since these variables have been found in the literature to be potentially important. Based on the outcome of seasonality, trend, and inflation tests, increasingly restricted models were tested to determine the lag structure. A double log model and 2SLS procedure taking the US price as endogenous variable were used to estimate the price transmission elasticity, transportation cost elasticity, and exchange rate elasticity. The stepwise model selection criteria were to follow the modeling philosophy of Hendry. The general price linkage equation was specified as follows.

**Model 1**

$$\ln P_t = \beta_0 + \sum_{i=1}^{11} \beta_i D_i + \beta_{12} \ln P_{t-1} + \beta_{13} \ln P_{t-2} + \beta_{14} \ln P_{us} + \beta_{15} \ln P_{us\ t-1} + \beta_{16} \ln P_{us\ t-2} + \beta_{17} \ln Ex +$$

$$\beta_{18} \ln Ex_{t-1} + \beta_{19} \ln Ex_{t-2} + \beta_{20} \ln Tn + \beta_{21} \ln inf + \beta_{22} \text{Time} + \varepsilon_t$$

Where

$\beta_0$  = intercept

$D_i$  = Seasonality variables where  $i = 1, \dots, 11$ ;

$P_t$  = Export price of soybeans;

$P_{t-1}$  = Export price of soybeans expressed in FCU in one period lag;

$P_{t-2}$  = Export price of soybeans expressed in FCU in two period lag;

$P_{us}$  = US farm price of soybeans expressed in dollar per ton;

$P_{us\ t-1}$  = US farm price of soybeans expressed in dollar per ton in one period lag;

$P_{us\ t-2}$  = US price of soybeans expressed in dollar per ton in two period lag;

$Ex$  = Exchange rate expressed in unit of domestic currency;

$Ex_{t-1}$  = Exchange rate expressed in FCU in one period lag;

$Ex_{t-2}$  = Exchange rate expressed in FCU in two period lag;

$Tn$  = Transportation cost of soybeans expressed in FCU per ton;

$Inf$  = Inflation rate of the different export countries;

$Time$  = Trend variable;

$\varepsilon_t$  = a white noise error term in the model;

The sign of price, transportation cost, and exchange rate are expected to be positive. The foreign price, domestic price, and exchange rate were specified with two lags (Ravalion, 1986). Given the monthly data, two lag models were considered sufficient to reflect a plausible lag structure. In order to minimize multicollinearity problem, lags of inflation and transportation cost were ignored. Initially, eleven dummy variables were included in the model to capture the seasonal variations in export markets. The exchange rate and export prices were included in the model to account for the inflation rate.

### **Model 2**

$$\ln P_t = \beta_0 + \beta_1 D_t + \beta_{12} \ln P_{t-1} + \beta_{15} \ln P_{us\ t-1} + \beta_{16} \ln P_{us\ t-2} + \beta_{17} \ln EX + \beta_{18} \ln EX_{t-1} + \beta_{19} \ln EX_{t-2} + \varepsilon_t$$

After selecting the most appropriate model for Japanese export market, hypothesis testing for exchange rate elasticity and price transmission elasticity were carried out as:

$$H_0: \beta_{16} = \beta_{18}$$

$H_1: H_0$  not true.

### **Data**

In order to find out the price transmission elasticity and exchange rate elasticity, the monthly time series data from January 1995 to December 2002 were collected from different sources.

The soybean transportation rate data is obtained from Heigh and Hazzle of Texas A& M University and USDA. The monthly exchange rate was gathered from Pacific Commerce.

The US farm price was collected from the National Agricultural Statistics Service (NASS). The soybean export price of Japan was gathered from the Foreign Agricultural Service (FAS). Except exchange rates, remaining data were in the nominal terms. The export price, exchange rate, and transportation cost data were expressed in Japanese yen while the US farm price was expressed in US dollars. The Japan CPI information was gathered from the official web pages of central bank of Japan. The inflation rate was calculated by dividing the Japan's CPI by the US CPI.

### **Results and Discussions**

The step wise analysis using SAS statistical package shows the significant effect of exchange rate (first and second lag), US price (first and second lag), and seasonal effects of January, February, May, and August. Analysis reveals no significant effects of transportation cost, inflation, US price, and time. As the impacts of transportation cost was statistically insignificant, we select the model 2 as the best model.

Due to the use of double log functional form, the estimated coefficients represent the estimated elasticities of corresponding variables. The estimated coefficient of the lagged dependent variable was significant and between zero and one as required to satisfy a stable condition. The model has high  $R^2$  and adjusted  $R^2$  values showing the validity of the model. Plotting of residual versus predicted value to test the heteroscedasticity shows no such a pattern (figure 1). The DW test indicates no autocorrelation problem (Figure 2).

The estimated coefficients of the model (Table 1) are short run elasticities. The estimated international price transmission elasticities (first lag and second lag) and the exchange rate

elasticities (base, first, and second lag) of Japan were (0.18, 0.33) and (0.46, 0.61, and -0.46) respectively and were statistically significant.

**Table 1. Estimate of Parameter in Japan Export Market Using Model Selection Criteria**

Variables	Estimate	Error	T-value	P-value
Intercept	1.32	0.206	6.43	0.0001
PJ <sub>t-1</sub>	0.33	0.085	3.87	0.0003
PUS <sub>t-1</sub>	0.18	0.086	2.10	0.0402
PUS <sub>t-2</sub>	0.33	0.118	2.99	0.0041
EX	0.46	0.114	4.02	0.0002
EX <sub>t-1</sub>	0.61	0.190	3.21	0.0022
EX <sub>t-2</sub>	-0.46	0.118	-3.86	0.0003
D1	0.039	0.013	3.07	0.0032
D2	0.035	0.013	2.62	0.0112
D5	0.025	0.011	2.12	0.0386
D8	-0.023	0.012	-1.93	0.0587
F- Value	407.72 (<0.0001)			
RMSE	0.02			
R <sup>2</sup>	0.98			
ADJ R <sup>2</sup>	0.98			

*Note: (t-1) and (t-2) indicates the lag structure of that variable in the model*

The long run elasticities were calculated by dividing the short run elasticities by one minus the estimated coefficients of the lagged dependent variables. Long run and short run elasticities



are presented in Table 2. The estimated long run elasticities of US farm price and exchange rates were (0.27, 0.49) and (0.69, 0.91, and  $-0.69$ ) respectively. It reflects an unequal effect of farm price and exchange rate changes in the Japanese market. Study results reveal that the law of one price does not exist in Japanese market.

**Table 2. Estimates of Long Run and Short Run Elasticities in the Japanese Export Market:**

Variables	SR Elasticity	LR Elasticity
$PUS_{t-1}$	0.18	0.27
$PUS_{t-2}$	0.33	0.49
$LEX$	0.46	0.69
$LEX_{t-1}$	0.61	0.91
$LEX_{t-2}$	-0.46	-0.69

*Note: (t-1) and (t-2) indicates the lag structure of that variable in the model*

The significant lagged dependent variables suggest a time lag to adjust the changes in exchange rate and the US price. By using the adjustment formula,  $\{(coefficient\ of\ lagged\ dependent\ variable)^N = 0.01\}$ , it takes about 4.15 months to respond fully to a permanent change in the US farm price and bilateral exchange rate. If the estimated coefficient of the lagged dependent variable was not significant, soybean price in Japan would respond instantaneously to changes in the US soybean farm price, and exchange rates resulting in to a well integrated and efficient market mechanism.

In the long run, the exchange rate change had stronger effects on soybean export price than change in US farm prices. The estimated coefficient of exchange rate was closure to unity in the first lag suggesting an almost complete exchange rate pass through in the Japanese market. It means an 1% change in the US-foreign currency rate results in a less than 1% change in the foreign price given the sufficient time for markets to adjust.

In order to test the law of one price, we tested a hypothesis, which suggests an equal price transmission elasticity and exchange rate elasticity in the long run. The test results of the above hypothesis tests are presented in Table 3. The elasticity of the transportation cost was not significant in Japan rejecting the law of one price. Rejection of LOP might have resulted from the market interventions which are not explicitly modeled in our study, an issue worthy of further study.

**Table 3. Hypothesis Test**

Countries	Calculated F test <sup>a</sup>	Calculated F test <sup>b</sup>	Critical F test <sup>c</sup>	Probability level	
				a	b
Japan	16.90	7.22	3.96	0.0001	0.0091

<sup>a</sup> the hypothesis of exchange rate elasticity is equal to the transmission price elasticity.

<sup>c</sup> Critical values are expressed in 0.05% level

Based on the number of significant variables, the model has performed well in defining the price transmission and exchange rate elasticities. The estimated coefficients of the US farm price had the correct signs and were significant at the 1% probability level. The study results suggest significant impacts of changes in the US farm prices and bilateral exchange rates on Soybeans export price. In the long run, the exchange rate had stronger effect on export price than change in US farm prices.

**Figure1. Test of Homoscedasticity in the US Soybean export market: Japan**

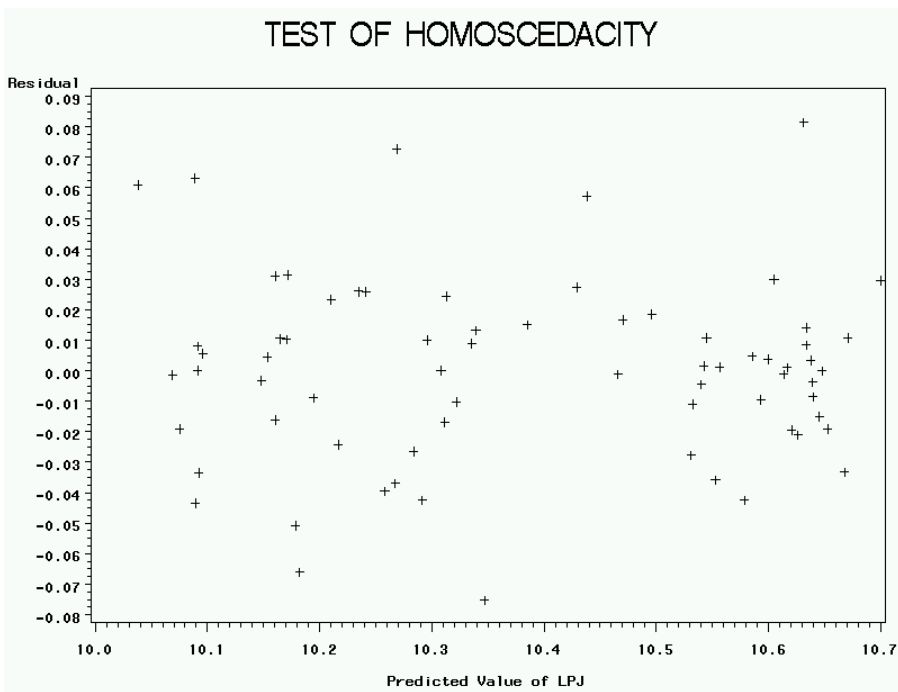
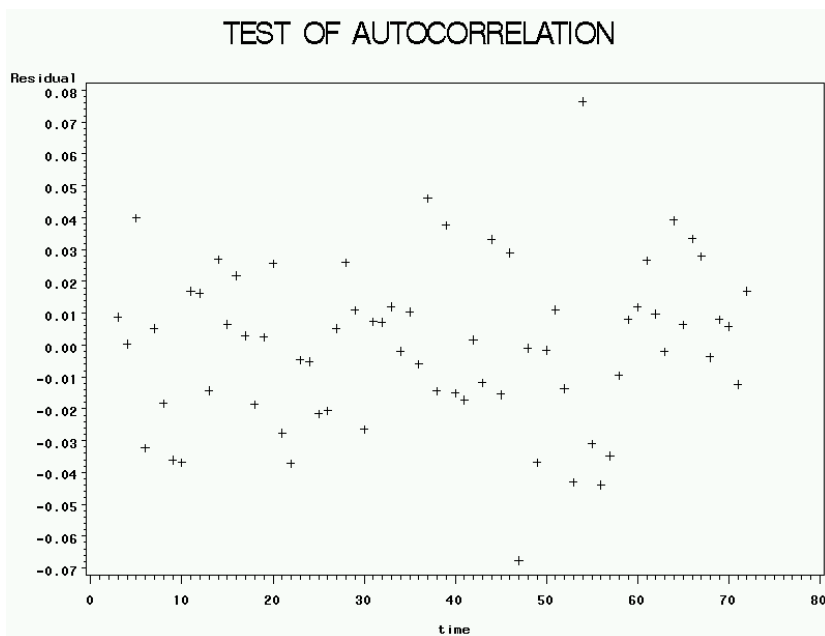


Figure 2: Test of

Autocorrelation in the US Soybean export market: Japan



## Conclusions

Information regarding exchange rate and transmission price elasticities is crucial for policy purposes. In this analysis, the stepwise model selection criteria were used to choose the consistent model. The elasticities were estimated by using 2SLS procedures. Out of other major US trading partners, Japan was selected for the study purpose as Japan represents the major US soybeans exporting country. The econometric analysis suggests that international price transmission elasticities and exchange rate elasticities for soybeans are less than one in both the short and the long runs.

Exchange rate elasticity tends toward unity but not to exact unity in the long run, which suggests an incomplete exchange rate pass through, i.e., a 1% change in the US foreign currency results in a less than 1% change in the foreign price. In our analysis, the transportation cost was not significant which suggests that omission of transportation cost does not significantly affect the results. Study results also show that the law of one-price does not hold in the Japanese market. Rejection of LOP in Japanese market might be due to market interventions which is not explicitly modeled in our study.

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