The Impact of Multiple Volatilities on Import Demand for U.S. Grain: The Case of Soybeans

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Introduction

Foreign exchange rates have been highly volatile since the ending of the Bretton Wood system. The unpredicted volatility of exchange rate movements has led researchers to investigate the impact of such uncertainty on international trade. Second, commodity markets are also unstable, and the volatility in commodity markets fluctuates over time. Grain prices respond rapidly to changes in actual and expected supply and demand conditions in world markets. Price volatility in cash markets increases cash flow variability and affects the profits for exporters and importers. Third, the traders have to face a major risk from the volatility of spot charter rates when they ship bulk commodities via ocean carriage because prices of basic energy, which is the main cost of freight, are generally more volatile than prices of other commodities.

The general objective of this study is to investigate the impacts of multiple risks that importing firms encounter on their import demand for U.S. grain. These multiple risks are exchange rate, commodity price, and ocean freight costs. In this paper, the focus is on U.S. soybeans. This paper will take into account regional differences as the main U.S. soybean export markets are included in this study: the European Union, China, Mexico, Japan, Taiwan, South Korea, Indonesia, and Thailand. Brazil is the most important competitor for U.S. in the world soybean market, and the effects of these risks on import demand for Brazil soybeans also will be considered in this study. The specific objectives of the study are: 1) to obtain import demand equations for soybeans by certain soybean importing countries of the world; 2) to investigate the effects of multiple volatilities that influence the import demand for U.S. soybeans; 3) to extend the analysis to the import demand for Brazil soybeans and to compare these effects with the findings for U.S. soybeans. The model will include other variables for importing countries (e.g., tariffs) and they are considered to make the demand equations for soybeans more accurate for achieving the main objectives.

Based on bilateral data between the U.S. and its trade partners, a panel data analysis can be applied to investigate the effects of exchange rate, soybean price, and ocean freight costs on import demand with forward-futures markets. Two-way fixed effects and random effects models will be estimated with both short-term and long-term measures of multiple volatilities. Due to its pegged currency system, China can be considered as a specific case without exchange rate risk. Also, because of physical distance, the volatility of ocean freight costs can be omitted for Mexican importing companies. These two countries are excluded from the panel data analysis and investigated as two specific case analyses. Furthermore, the bilateral data of Brazilian exported soybeans to the above importing countries with the same procedures are employed as comparisons with U.S.

Literature Review

1. Study in General Economics

Much of the empirical work in international trade has focused on the impact of exchange rate risk on total imports or total exports of a country. In modeling the impact of either nominal or real exchange rate volatility on trade, different methods have been employed since the 1970s (Ethier, 1973; Clark, 1973). The traditional hypothesis is that unexpected exchange rate volatility reduces the incentives to trade for risk-averse traders. In an early study, Hooper and Kohlhagen (1978) examine the effects of exchange rate volatility using the nominal exchange rate based on a bilateral framework. They first derive the import demand and the export supply model for individual firms and then aggregate them to get a market-based nonlinear reduced form equation for market equilibrium price and quantity. Through analyzing German and U.S. trade with major industrial countries, they conclude the negative effect of exchange rate volatility on the risk-averse traders. However, they think the currency denomination of the contracts, the risk preference of traders, and the proportion of financial hedging are three important factors impacting the outputs of their models. These exogenous factors determine the degree of currency risk on trade. Cushman (1983) extends Hooper and Kohlhagen's model and uses real terms to identify the effect of exchange rates on trade, and this method is further developed by Cushman (1988), who finds a significant adverse effect of currency risk on U.S. based trade flow. However, the empirical findings about the effects of exchange rate risk on trade in general economics are ambiguous. Other studies, for example, De Grauwe (1988), Franke (1991), and Viaene et al. (1992), demonstrate that increased currency risk has a positive or ambiguous effect on trade flow depending on circumstances. The overall evidence is sensitive to the choices of the sample period, model specification, kinds of sectors and commodities, and considered countries.

2. Study in Agricultural Economics

Many previous studies in agricultural economics investigate the influence of exchange rate risk on aggregate or individual commodity trade. Schuh (1974) first employed the impact of exchange rates on agricultural trade. His basic model has the exchange rate as a major factor in his economic analysis of the U.S. agricultural sector. Batten and Begonia (1986) involve real exchange rate and monetary factors into their U.S. agricultural export determination model by using a single real trade weighted exchange rate, and they find the increased real value of the dollar decreases export volumes. Pick (1990) follows Cushman's model by using bilateral real exchange rates and he finds that the exchange rate risk has an effect on U.S. agricultural trade to developed countries and has a significantly negative effect to developing countries.

Anderson and Garcia (1989) research the impact of exchange rate uncertainty on U.S. soybeans exporting to Japan, France, and Spain by using a demand function which is derived from a risk-averse firm's searching for maximizing profits. They find all three of these countries have significantly negative responses to exchange rate variability, and Japan is the least sensitive to currency uncertainty. Sun and Zhang (2003) analyze the impact of exchange rate uncertainty on U.S. forest commodity exports by using an error-correction model for time series data. They find the impact of currency risk on U.S. forest exports is negative in the long-run, but in the short-run the impact depends on the individual commodity. Cho, Sheldon, and McCorriston (2002) develop a gravity model which includes real exchange rate uncertainty for either total trade or sectoral trade in four main areas. They conclude that exchange rate uncertainty has a more adverse effect on the agricultural sector compared with total trade and other trade sectors. Due to price volatility and the shipping characteristics of agricultural commodities, some researchers focus on how to hedge the exchange rate, commodity price, and freight rate uncertainty in financial markets (Thuong and Visscher 1990, Haigh and Holt 2000). Theoretically, Kawai and Zicha (1986) analyze international trade with forward-futures markets under exchange rate and price uncertainty from either the importers' or the exporters' perspective. However, the empirical impacts of exchange rate and price uncertainty on trade are not analyzed based on a theoretical model.

For the model specification, there is no unique way either of measuring exchange risk or of estimating the impact of this risk on trade flow. For measuring the exchange risk, there are two traditional ways in empirical studies; one is based on the standard deviation of the level or percentage of the actual exchange rate, the other is based on the difference between the actual and forward exchange rate. Measures based on the ARCH or GARCH model have been used since Bollerslev (1986) developed the GARCH model in studying financial risk premium. Many researchers have employed several regression models. Traditionally, a reduced form demand function or other demand function derived from microeconomics theory is an important method to measure the impact of exchange rate volatility on trade (Hooper and Kohlhagen, 1978; Cushman, 1983; Pick, 1990; Anderson and Garcia, 1989). Some time series techniques, such as VAR, GARCH in mean, and Error-Correction, are used in analyses (Koray and Lastrapes, 1989; Kroner and Lastrapes, 1993; Sun and Zhang, 2003). In addition, Frankel (1993), Cho, Sheldon, and McCorriston (2002) used a gravity model of bilateral trade flows to test the effect of currency volatility.

3. Needed Extensions on Previous Work

Many studies focus on the effect of exchange rate on either aggregate trade or individual commodity. However, compared with the studies about the impact of currency volatility on trade, little research focuses on the impact of commodity price uncertainty on trade. With forward-futures markets, the effects of commodity price and exchange rate uncertainty are joined together to impact import demand. But this joint effect is not measured in any empirical model.

In the case of international grain trade, ocean freight rates definitely have an effect on the costs of grains for the importing countries. Historically, ocean freight rates have high volatility. For example, the average freight rate from a U.S. gulf port to Japan was $60.83 per metric ton in the fourth quarter of 2004 and was $46.75 in the fourth quarter of 2005, a percentage change of -23%. For the fourth quarter, the ocean freight rates have varied widely during the 1996-2005 periods with a high of $60.83 in 2004 and a low of $13.33 in 1998. Furthermore, crude oil prices are more volatile and the changes in crude oil prices are reflected directly in the ocean freight rates. In the empirical model, the ocean freight costs should be taken into consideration in the demand for importing countries. On the other hand, despite being important U.S. grain export partners, the importers in Asian countries are not involved in previous studies for hedging main market risks. Hedging strategies are important for some Asian importers who face a floating foreign exchange rate and higher ocean shipping costs due to long physical distance. A Japanese soybean importer is representative for such study.

Model Description

This study employs a modified version of Hooper and Kohlhagan's trade model, which assumes the demand for grain imports are a derived demand. From an importing country perspective, this paper develops a model of a competitive firm engaged in international trade of grains under exchange rate, price, and ocean freight cost uncertainty.

1. Import Demand

Suppose the importing firm produces final goods using an imported commodity as an input. The exchange rate, foreign currency price of the imported commodity, and the ocean freight rate are random, whereas the domestic currency price of final goods is assumed to be known with certainty. Also, the importer can hedge foreign exchange risk by purchasing foreign exchange forward and hedge commodity price and freight rate price by going long in futures markets.

An import firm faces a domestic demand for its output (Q^o), which is a function of its own price (P), prices of substitutes and complements (PD), and domestic income (Y). This function is written in linear form:

(1) $Q^o = aP + bPD + cY$

A risk-averse importing firm's optimization problem may be formulated as:

(2) $\max_{Q} EU(\pi) = E(\pi) - \gamma (V(\pi))^{1/2}$

Where E is the expected value operator, U is total utility. V is the variance of profit operator, and γ is the relative measure of risk preference (γ >0 is risk aversion, γ <0 is risk taker, and γ =0 is risk neutral). Utility can be considered as an increasing and differentiable function of profits and a decreasing and differential function of standard deviation of profits. It is assumed that the firm receives orders for its output and places the orders for its imported inputs in the first period, and it pays for and ships imports and receives payments for its output in the second period. This firm's profits in domestic currency units can be expressed as

(3) $\pi = Q^o * P(Q^o) - UC * Q^o - HMq - HNq$

Where UC is the unit cost of production, H is the foreign exchange variable, M is the price of the imported input, N is the freight cost, and q is the imported quantity. A constant input-output ratio i can be assumed as

(4) $q = iQ^o$, where i is the fixed ratio of imports needed to produce output.

It is assumed that the imported commodity is invoiced in foreign currency (i.e., U.S. dollars) and the firm has access to both foreign exchange and commodity futures contracts. The firm is assumed to hedge some constant proportion (α) in the futures market at the futures exchange rate F. The firm can hedge some constant proportion (β) in the commodity futures market at the price $F^{'}$. It can also hedge some constant proportion (δ) in the freight rate futures market at the price $f^{'}$.

(5) $H = (1-\alpha)R + \alpha F$

(6) $M = p^d(1-\beta) + (F^{'} - \tilde{F} + p^d)\beta$

(7) $N = p^0(1-\delta) + (f' - \tilde{f} + p^o)\delta$

R is the spot exchange rate on the date of payment

p^d is the foreign currency price of imports

$F^{'}$ is the commodity futures market price at the first period.

$\tilde{F}$ is the commodity futures market price at the second period.

p^o is the foreign currency price of freight rate.

f' is the commodity futures market price at the first period.

$\tilde{f}$ is the freight rate futures market price at the second period.

Substitute equation (4), (5), (6), and (7) into equation (3), the importer’s profits are
(8)

$$\pi = Q*P(Q^o) - UC*Q^o - [(1-\alpha)R + \alpha F]\{[p^d(1-\beta) + (F' - \tilde{F} + p^d)\beta] + [p^o(1-\delta) + (f' - \tilde{f} + p^o)\delta]\}*iQ^o$$

All the variables in above equation, except $R, \tilde{F}, \tilde{f}$, are assumed known with certainty on the contract date. For simplification, covariances between the variables are assumed to zero. Therefore, the variance in the importing firm profits can be described as

(9)
$$V(\pi) = [(1-\alpha)^2(p^d + p^o - F'\beta - f'\delta)^2\sigma_R^2 + (\alpha F\beta)^2\sigma_{\tilde{F}}^2 + (\alpha F\delta)^2\sigma_{\tilde{f}}^2 + - (1-\alpha)^2\beta^2\sigma_{R\tilde{F}}^2 - (1-\alpha)^2\delta^2\sigma_{R\tilde{f}}^2]*(iQ^o)^2$$

Where $\sigma_R^2, \sigma_{\tilde{F}}^2, \sigma_{\tilde{f}}^2, \sigma_{R\tilde{F}}^2, \sigma_{R\tilde{f}}^2$ are the variances of $R, \tilde{F}, \tilde{f}, R\tilde{F}, R\tilde{f}$

Hooper and Kohlhagen derive reduced-form import demands by substituting equations (8) and (9) into (2) and differentiating with respect to Q to obtain first-order conditions. Then, they substitute $\partial P/\partial Q$ from (1) and assume the importing firm is a price taker in the import market.

The F.O.C. is

$$(10)\ \frac{Q^o}{a} + P - UC - (E(HM)i + E(HN)i + \gamma\frac{\partial V(\pi)}{\partial Q^o}) = 0$$

Furthermore, they substitute $P = (Q^o - bPD - cY)/a$ from (1) and q/i for Q^o into (10),

$$(11)\ q = \frac{i}{2}[aUC + bPD + cY + \frac{\partial E(HM + HN)}{\partial Q^o}i + \gamma\frac{\partial V(\pi)}{\partial Q^o}] = 0$$

Combining equation (11), (5), (6), (7), and (8), obviously, the imported quantity is the function of UC, PD, Y, $E(\tilde{F})$, $E(\tilde{f})$, $E(R)$, $E(R\tilde{F})$, $E(R\tilde{f})$, $\sigma_R, \sigma_{\tilde{F}}, \sigma_{\tilde{f}}, \sigma_{R\tilde{F}}, \sigma_{R\tilde{f}}$, where $\sigma_R, \sigma_{\tilde{F}}, \sigma_{\tilde{f}}, \sigma_{R\tilde{F}}, \sigma_{R\tilde{f}}$ is the standard deviation for each random variable.

This equation can be extended to obtain the importing market level:

(12) Import demand

$$Q^d = f(UC, PD, Y, E(R), E(\tilde{F}), E(\tilde{f}), E(R\tilde{F}), E(R\tilde{f}), \sigma_R, \sigma_{\tilde{F}}, \sigma_{\tilde{f}}, \sigma_{R\tilde{F}}, \sigma_{R\tilde{f}}, T, D)$$

Equation (12) also involves T, which represents the protection measure (e.g., tariffs), PD, which is the importing country's price of a competitive grain product (the price of soybeans of U.S. competitors may be considered as a proxy because the grain is typically invoiced in U.S. dollars in the world market), and D, which represents seasonality.

2. Export Supply

Assuming that the exporter maximizes his utility, which is an increasing function of expected profits (π^e) and a decreasing function of the standard deviation of profits:

(13) $$\max_Q EU(\pi^e) = E(\pi^e) - \gamma^e (V(\pi^e))^{1/2}$$

Where γ^e is the measure of the exporter's relative aversion to risk. Compared to the importer's profit function, the exporter does not use the imported goods as inputs in production. More importantly, the exporter only faces one market risk, that is, commodity price risk. Furthermore, the exporter can use commodity futures to hedge commodity price risk. This firm's profits in U.S. dollars units can be expressed as

(14) $$\pi^e = Q^s * M^e - UC^e * Q^s$$

Where UC^e is the exporter's unit cost of production, M^e is the price variable of the exported grain, and Q^s is the total export supply.

The firm can hedge some constant proportion (ρ) in the commodity futures market at the price $F^{'}$.

(15) $M^e = p^d(1-\rho) + (F^{'} - \tilde{F} + p^d)\rho$

Substitute equation (15) into equation (14), the exporter's profit is

(16) $\pi = Q^s * [p^d(1-\rho) + (F^{'} - \tilde{F} + p^d)\rho] - UC^e * Q^s$

All the variables in the above equation, except $\tilde{F}$, are assumed known with certainty on the contract date. Therefore, the variance in the importing firm profits can be described as

(17) $V(\pi^e) = (Q^s\rho)^2\sigma^2_{\tilde{F}}$

Where $\sigma^2_{\tilde{F}}$ is the variance of $\tilde{F}$.

It is reasonable to assume no relationship between futures market price and every individual country's import demand in the short run. Substituting equation (16) and (17) into equation (13), and differentiating it with respect to the quantity to obtain the first-order condition:

(18) $E(M^e - UC^e) - \gamma^e\rho\sigma^2_{\tilde{F}} = 0$

The exporter can maximize his profits by satisfying equation (18). The quantity is not impacted by the random variables, so it is reasonable to assume that Q^s is infinitely elastic. In the short-run, it is reasonable to assume the U.S. supplies importing demands for grain in quantity competition with other major exporting countries.

(19) Import market clearing condition

$Q^d = Q^s$

Empirical Model and Data

In this study, since soybeans are selected for analysis, the U.S.'s competitors are Argentina and Brazil. The data for Argentina are not available, and it is reasonable that only Brazil is involved in this study because Brazil is the most important competitor for the U.S. and the U.S. and Brazil take more than 70% of the world export market.

1. Explanatory Variables Measures

The empirical model includes expected values standard deviations for the three random variables, and competitors' price index. Consistent with Hooper and Kohlhagen, the expected values of $\tilde{F}, \tilde{f}$ are considered as the next period futures market price for simplicity. For the variable R, it is reasonable to think that importers consider the futures market price as their expected value. Also, the futures market price for the exchange rate is used to measure exchange rate volatility. Furthermore, the expected value of $R\tilde{F}, R\tilde{f}$ can be calculated based on corresponding values of $R, \tilde{F}, \tilde{f}$. The standard deviation (risk) measure of these variables can be obtained in two ways. One is by a moving sample standard deviation of percentage exchange rate (Koray and Lanstapes, 1989; Baba et al., 1992; Chowdhury ,1993; Arize et al. 2000; Sun et al., 2002). Mathematically, it can be described as:

(20) $$V_t = [\frac{1}{m}\sum_{i=1}^{m}(\ln X_{j,t+i-1} - \ln X_{j,t+i-2})^2]^{1/2}$$

Where m is the order of moving average, specified as four for this study and X_j represents $R, \tilde{F}, \tilde{f}, R\tilde{F}, R\tilde{f}$, respectively. Empirically, m is specified as 4 in this study for measuring short (medium) term risk.

Another way is based on Peree and Steinherr's method (1989) for measuring exchange rate uncertainty. They postulate that traders can remember the changes of highs and lows of random variables during a previous period and adjust such changes through the idea of the "equilibrium" exchange rate. Such method is called long-run exchange rate volatility (Cho et al., 2002). Mathematically, it is

$$(21)\ V_t = \frac{\max X_{j,t-k}^{t} - \min X_{j,t-k}^{t}}{\min X_{j,t-k}^{t}} + [1 + \frac{\left| X_{j,t} - X_{j,t}^{p} \right|}{X_{j,t}^{p}}]^2 \ ,$$

Where X_j represents $R, \tilde{F}, \tilde{f}, R\tilde{F}, R\tilde{f}$, respectively; Max (min) $X_{j,t-k}^{t}$ refers to maximum (minimum) value of the absolute value of j^{th} variable over a given time interval size k (specified as five in this study) up to time t; $X_{j,t}^{p}$ is the "equilibrium" value of j^{th} variable, but no obvious measure for this equilibrium value is available from previous studies so the mean of a given time interval is used as a proxy in much of the literature (Sun et al., 2002; Cho et al., 2002).

For a competitor's price, PD is the trade weighted index of the average export prices of U.S. competitors which is measured using Houthakker and Magee (1969). Thus,

(22) $PD = \sum_k \sigma_k P^d{}_k$, where K represents the U.S.'s competitor and σ_k is the k^{th} share of total exports of the k^{th} competitor in world market, $p^d{}_k$ is the export price of k^{th} competitor.

2. Two Specific Cases for China and Mexico

Soybeans are selected in this analysis. The main U.S. soybeans export markets are the European Union, China, Mexico, Japan, Taiwan, South Korea, Indonesia, and Thailand. These countries should be included in this study. However, China and Mexico are excluded from the panel data analysis. The exchange rate uncertainty can be omitted for China because of its pegged currency system. Due to the physical distance, the ocean freight rate volatility has no significant effect on Mexico's import from U.S. For these two countries, the model is adjusted to

(23) $Q^d = f(UC, PD, Y, E(\tilde{F}), E(\tilde{f}), \sigma^2_{\tilde{F}}, \sigma^2_{\tilde{f}}, T, D)$ for China

(24) $Q^d = f(UC, PD, Y, E(\tilde{F}), E(R), E(R\tilde{F}),, \sigma^2_R, \sigma^2_{\tilde{F}}, \sigma^2_{R\tilde{F}}, T, D)$ for Mexico

The results from these two specific cases can be used as the comparisons for the panel data analysis.

Based on previous studies (Hooper and Kohlhagen, Cushman), the empirical models are linearized and the explanatory variables are adjusted based on the soybeans trade characteristics and data availability. Compared with trade in other agricultural commodities, trade in soybeans is relatively unrestricted by tariffs and other border measures (ERS, USDA). Also, there were no big tariff changes in the sample period. Unit costs of production are not available in every importing country, so this variable is excluded. Even though some previous studies have used the hourly wage rate index as a proxy, this proxy cost variable is not an inadequate measure because it can not reflect the exact total processing cost for soybeans. More importantly, it should be highly collinear with income. According to partial correlation analysis, variables of $E(R\tilde{F}), E(R\tilde{f})$ have high collinearity with expected exchange rate and futures price, so these two variables are dropped from the empirical model. Correspondingly, their standard deviations are dropped from the empirical model.

The freight futures market – The Baltic International Freight Futures Exchange, which was based on Baltic Freight Index -- was established in 1986. Since then, it had been modestly successful in some years, but it was ceased in 2001 due to lack of liquidity. However, as the largest component of variable shipping cost, the price of fuel oil is volatile and it impacts the ocean ship cost changes significantly. The fuel oil futures can be considered as a substitute for hedging ocean freight risk in practice. In this study, heating oil futures are used to hedge diesel fuel.

Because the theoretical model is based on a two-period framework, all empirical equations are estimated with one period lag on all of the explanatory variables. All the variables which are used in this study are nominal values. The linear models for empirical study are:

For panel data

(25) $Q = b_0 + b_1 PD + b_2 Y + b_3 E(R) + b_4 E(\tilde{F}) + b_5 E(\tilde{f}) + b_6 \sigma_R + b_7 \sigma_{\tilde{F}} + b_8 \sigma_{\tilde{f}} + b_{di} D_i$

For China

(26) $Q = c_0 + c_1 PD + c_2 Y + c_3 E(\tilde{F}) + c_4 E(\tilde{f}) + c_5 \sigma_{\tilde{F}} + c_6 \sigma_{\tilde{f}} + c_{di} D_i$

For Mexico

(27) $Q = m_0 + m_1 PD + m_2 Y + m_3 E(R) + b_4 E(\tilde{F}) + m_5 \sigma_R + m_6 \sigma_{\tilde{F}} + m_{di} D_i$

Where D_i is the dummy variable, for monthly data, $i = 1,...,11$; for quarterly data, $i = 1,2,3$.

3. U.S. Soybeans Exports

The data used are based on the U.S monthly value (1000 U.S. dollar) and quantity (1000 MT) of soybeans exports to selected destination markets from February 1996 to March 2005, and export prices of soybeans are obtained by dividing the export value by quantity exported. As the main U.S. soybean export markets, the European Union, Japan, Taiwan, South Korea, Indonesia, and Thailand are selected for panel data analysis. China and Mexico are selected for specific case analysis. Monthly data allow for higher frequency and more observations to investigate the relationships among the variables in the model. The data source is the Foreign Agricultural Service (FAS) of the U.S. Department of Agriculture (USDA). The monthly futures market prices for soybeans, heating oil, and exchange rate of every destination (importing country's currency per U.S. dollar) market are obtained from the published CD-ROM of Commodity Research Bureau (CRB). Yearly nominal per capital GDP for every destination market is used as the measure of income, which is available from USDA, Economic Research Service (ERS). The monthly data for per capital GDP are derived from yearly data based on the growth rate and trial-and-adjust method.

4. Brazil Soybeans Exports

The major soybeans markets for Brazil include the EU, China, Japan, Taiwan, South Korea, and Thailand. Except for China, other five countries and regions are included into panel data model. China is a specific case for Brazil as well. Because many zero observations exist for Brazilian monthly data, the empirical analyses for Brazil are based on a quarterly basis from the second quarter in 1996 to the first quarter in 2005. The quarterly quantity (1000 MT) and unit price of Brazilian soybeans exports are obtained from the Brazilian Department of Agriculture (accessed from http://www.aliceweb.desenvolvimento.gov.br). The quarterly futures market prices for soybeans, heating oil, and exchange rate of every destination market (importing country's currency per U.S. dollar) are obtained from the published CD-ROM of Commodity Research Bureau (CRB). In order to compare with the findings from Brazil, a U.S. model based on a quarterly basis is run as well.

Estimation and Empirical Results

1. Panel Data Analysis

In practice, panel data analyses include several methods from the simple OLS method to a fixed or random effects panel model, to a more generalized seemingly unrelated regression model (SUR). Even though it is difficult to choose a best model for panel data analysis among various panel data models, this study will employ the fixed effects or random effects model to consider the heterogeneity of the data. The fixed effects and random effects models are estimated with both short (medium)- term measures and long-term measures of random variables volatilities.

In the fixed effect model, it is assumed that the panel data has constant slopes, but the intercepts differ according to the cross-sectional unit. In the random effects model intercepts become a random variable. Slopes are assumed to be the same for all countries and regions. Since the destination markets and soybeans trading volumes in the sample are part of the world soybean trade, the random effects model which considers individual specific constant terms as randomly distributed among destination markets maybe is more appropriate in this study (e.g., Greene, 2003; and Sun et al., 2002). When comparing the results from the fixed and the random effects models, some differences were noted. In order to find which model is more appropriate in this study, it is necessary to run a Hausman test comparing fixed with random effects. For both the U.S. and Brazilian models, the Hausman statistics for testing the random against fixed effects model are insignificant at the 5% level, which suggests that it is safe to use the random effects model. Large Breusch and Pagan's Lagrange multiplier test suggest that intercepts vary across individuals.

In order to measure the possibility of endogeneity between competitor's price (soybean export price of Brazil) and the U.S. export quantity, as well as the soybean futures market price and the U.S. soybean export quantity, a Durbin–Wu–Hausman test is performed for both of variables. For the competitor's price, the Hausman statistic is marginally significant at the 5% level, which suggests that it can run an instrumental variable for panel data; however, the results are not changed much. For the endogeneity test of soybean futures price, the Hausman statistic is insignificant at the 5% level.

The results from the random effects models are presented in table 1. The results are consistent for both volatility measures. As the measure of income, per capita GDP has a positive effect on soybeans trade though it is statistically insignificant. The income effect is small for soybeans which is in accordance with expectations because soybeans belong to bulk commodities. As the substitute of the U.S. soybeans, the export price of Brazil has a significantly positive effect on the U.S. soybeans exports. It indicates price competition is an important factor for the U.S. soybeans exports.

The expected exchange rate has a positive effect on U.S. soybean exports though it is insignificant. Theoretically, when an importing country's currency depreciates or the U.S. dollar appreciates the demand for importing goods should decrease. However, one should remember that the U.S. dollar is the common currency in the international soybeans market. It is reasonable to assume that the domestic supply can not change dramatically when exchange rates change between the importing country's currency and the U.S. dollar. Under this assumption, exchange rate changes induce import demand changes between exporting countries. On the other hand, the soybean market is an imperfect competitive market and the U.S. may price discriminate based on the pricing-to-market approach of Krugman (1987). The corresponding effect of exchange rate changes on Brazilian soybean exports will be checked later. Both expected soybeans price and ocean shipping cost have negative effects on U.S. soybeans exports as expected. Furthermore, the expected shipping cost is statistically significant in explaining the U.S. soybeans exports.

The market uncertainty variables are the focus to this study. All of these three volatilities have negative effects on the U.S. soybeans exports. The exchange rate volatility has a statistically significant effect on soybean exports.

Soybean trade has a high seasonal characteristic for exporting countries due to the differences in harvesting dates in the U.S. and the South America. Generally speaking, import demand for U.S. soybeans is higher in either the first or fourth quarter of the calendar year. The monthly dummy variables confirm the seasonal changes of import demand for U.S. soybeans. The largest monthly import demand for U.S. soybeans is in January.

Table 2 presents the results for the U.S. soybeans export based on quarterly data. All but one of the signs of estimated coefficients are consistent with the monthly data, with the differences in the coefficients' magnitude. The only difference is the expected soybeans price, which has an insignificant positive effect on import demand. These results can be compared with the findings for the Brazilian export model.

Table 3 describes the results for Brazilian soybean exports. Some important variables have the opposite effects on Brazilian soybean exports as compared to the findings from the U.S. model. Income has an insignificant positive effect, while the U.S. export price has significant positive effects on export demand for Brazil. Compared with the results from the U.S. model, the expected exchange rate and soybeans price impact Brazilian soybeans exports negatively and the impacts are statistically significant. This implies when the U.S. dollar appreciates the import demand for Brazilian soybeans falls significantly. Brazilian exports are much more sensitive to changes in world price (as reflected in the futures price) than for the US. As world price increases, Brazilian exports fall. Results show that when ocean shipping costs increase, importing countries are inclined to purchase more soybeans from Brazil. However, for these three market risks, the impacts on Brazilian soybeans exports are insignificantly positive for short (medium)-term measures. However, volatility in soybean and oil prices have a negative effect on demand for long-term measures. The different effects of these market volatilities on exports are difficult to explain.

2. Two Specific Cases

China has become the number one soybean importer in the world and it is an important market where the U.S. and Brazil compete. During the selected data period, China chose a pegged exchange rate system, so exchange rate volatility is dropped from this study. In this study, a simple OLS method is used to analyze the impact of the explanatory variables on import demands for both the U.S. and Brazil soybeans exports. The endogeneity test shows that no endogenous variables exist on the right side of the model.

Table 4 presents the results for U.S. soybean exports to China. For both measures of volatility, the analysis consistently shows that the Brazilian price has a significantly positive impact on the demand. Also, the expected soybean price has a negative effect though it is insignificant. Because China is also a large soybean producer, it will adjust its domestic supply of soybeans or the supply of soybeans substitutes and reduce the importing volumes when the soybean price increases in the world market. However, exchange volatility has a different effect on import demand between the short (medium)-term volatility measure and the long-term volatility measure. The impacts of the expected shipping cost and its volatility are insignificantly positive for demand. China might prefer volatility in the long run because they can adjust their import quantities as prices change.

Comparing the findings from the U.S. model, the results from the Brazilian model are consistent for both volatilities measures. As table 5 shows, the impact of competitor's price is negative on the import demand, but that result is difficult to explain. These unexpected results may be because of omitted variable bias, e.g., the supply from Argentina. On the contrary, when the expected shipping cost increases, the import demand for Brazil reduces. The impact of soybean price volatility is negative. For shipping cost volatility, the results from the two volatility measures are different, but both of them are statistically insignificant.

Finally, the models for U.S. soybean exports to Mexico are estimated and the results are presented in table 6. Because Mexico is not a major exporting market for Brazil, the Brazilian price is dropped from the model. The simple OLS model shows that both the expected soybean price and shipping cost have negative effects on the import demand. The volatility of the expected exchange rate has a positive effect while the volatility of the expected soybean price has a negative effect on demand for both volatility measures.

Summary and Conclusion

The world is in an era where commodity prices, exchange rates, and other variables are more volatile. It is reasonable to analyze import demand with forward-futures markets under exchange rate, price, and ocean freight uncertainty. A short-term (moving sample standard deviation of the percentage random variable) and a long-run method (based on Peree and Steinherr’s formula) for measuring volatility are constructed and compared empirically. After the statistical comparison, the random effects model for panel data analysis is selected. The panel data cover the major exporting markets for U.S. soybeans over the last decade.

Comparing the results of import demand for U.S. and Brazil, the major findings include: if the U.S. dollar appreciates or the importing country’s currency depreciates, it induces an increase of the U.S. soybean exports while reducing the demand for Brazilian soybeans significantly in the major exporting markets. When the expected soybeans price increases, the demand for Brazilian soybeans decreases significantly while the demand for the U.S. soybeans increases. The impact of the expected shipping cost on demand of the U.S. soybeans is negative but it is positive for demand of Brazilian soybeans.

The volatility of exchange rate, soybean price, and ocean shipping cost has negative impacts on the U.S. model. For the Brazilian model, the impacts of these volatilities are positive for the short (medium)-term measures while negative for the long- term measures; but the effects are statistically insignificant.

For China, the effects of explanatory variables for the U.S. and Brazilian model have differences comparing with panel data analysis involving many countries. Without the exchange rate impacts, when the Brazilian price increases in the US model, China's demand for U.S. soybeans increases significantly. The increase in soybean futures price induces a decrease in import demand for U.S. soybeans, while its volatility has a negative effect for a short (medium)-term measure and a positive effect for a long-term measure. The shipping cost and its volatilities also have positive effects on import demand. For the Brazilian model, the U.S. export price has a negative effect, which is difficult to explain. It could be when world prices are high, soybean stocks are low and Brazil tends to have its stocks already exhausted. The impact of the expected soybean price, though, is insignificant positive while the impact of the expected ocean shipping cost is negative, and the effects of both market volatilities are negative for the short (medium)-term measure.

The U.S. dominates the soybean import market for Mexico. This study also measures the effects of the expected soybeans price and exchange rate as well as their volatility on import demand for U.S. soybeans. Negative effects are found for the expected soybean price and exchange rate. The volatility of the exchange rate impacts import demand positively, and volatility of soybean price has a negative effect.

Overall, the results presented make a contribution to understanding the implications of some important factors in soybean export competition. Similar methods can be used to analyze other individual agricultural commodities based on data availability. The impacts of the exchange rate, commodity price, ocean shipping cost, and their corresponding volatility on specific commodities can be much different from aggregate level results. Furthermore, some specific factors that are related to individual commodities and countries, for example invoicing patterns in world markets, commodity market structures, and forward-futures market access for traders, can impact the above effects significantly. More detailed research about these factors and their effects on export patterns can provide better support for U.S. exporters to remain competitive in world market.

Further research consideration is necessary based on the problems in the present empirical study and others like it. These include: (1) model and explanatory variables selection; (2) the potential impact of the exchange rate between the U.S. dollar and Brazilian real; (3) the potential impact of EU countries; (4) special concerns about the Chinese import market; and (5) the incorporation of genetically modified soybeans as differentiated goods

As has been mentioned above, there are no unique rules in selecting the appropriate model for panel data analysis. Other models, such as the classical regression model with cross-sectional heteroscedasticity and autocorrelation, the random coefficients model, and seemingly unrelated regressions can be employed in this study or other commodity research. On the other hand, some time series techniques, such as the ARCH model and GARCH model, have been used in empirical studies. These models can also serve as useful substitutes for this study.

The empirical results differ in some cases from the theoretical concepts. The probable cause of these unexpected results is an absence of important factors influencing demand and other econometric problems. A problem for econometric analysis is endogeneity. In the U.S. model, the competitor's price has an endogeneity problem, but the instrumental variable method did not improve the results. So a concern is how to select the appropriate variables for instruments.

Even though the U.S. dollar is the common currency in world soybeans markets, it is necessary to consider the effects of exchange rate changes between the U.S. dollar and Brazilian real on export price and supply. Furthermore, the import market clearing condition must be modified if the real is incorporated into the analysis..

In this study, the EU is considered as a single market. The EU and other European countries are the most important export markets for Brazil. Analyzing the effects of explanatory variables on individual countries of the EU is necessary for the U.S. traders to improve their competitiveness in the European countries. Integrating the effects of EU agricultural policies into the model might improve the results concerning U.S. and Brazilian exports.

Currently, China is the most important individual country for the competitiveness of soybeans exports for the U.S. and Brazil. In this study, the econometric specification for China may be not appropriate. There may be more appropriate explanatory variables and models (e.g., time series models) that can be employed in the future studies. Recently, researchers have paid more attention to genetically modified (GM) food production and trade. It would be interesting to integrate GM soybeans into the model as a differentiated product.

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Table 1. Empirical Results for the U.S. Monthly Model

	Short-term Volatility	long-term Volatility
Constant	388.555***	456.648***
	(5.54)	(5.09)
Per capita GDP (U.S. dollar)	0.032	0.048*
	(1.11)	(1.91)
Competitor's price (U.S. dollar)	0.167**	0.181**
	(2.05)	(2.22)
Expected exchange rate (importing country's currency/U.S. dollar)	0.004	0.005
	(0.7)	(0.94)
Expected soybeans price (U.S. dollar/kg)	-0.025	-0.045
	(-0.16)	(-0.27)
Expected ocean shipping cost (U.S. dollar/gallon)	-97.512***	-100.299***
	(-4.39)	(-4.43)
Exchange rate volatility	-323.121**	-61.972**
	(-2.33)	(-2.9)
Soybeans price volatility	-348.333	-29.108
	(-1.61)	(-0.89)
Ocean shipping cost volatility	-174.968	-15.09
	(-0.81)	(-0.46)
Jan	21.145	14.177
	(0.59)	(0.4)
Feb	-19	-20.366
	(-0.55)	(-0.59)
Mar	-96.4***	-98.316***
	(-2.77)	(-2.82)
Apr	-193.115***	-198.278***
	(-5.5)	(-5.71)
May	-226.207***	-231.001***
	(-6.29)	(-6.61)
Jun	-233.482***	-247.426***
	(-6.35)	(-7.05)
Jul	-231.798***	-250.544***
	(-6.32)	(-7.1)
Aug	-218.466***	-237.774***
	(-5.9)	(-6.79)
Sep	-211.28***	-224.762***
	(-5.9)	(-6.46)
Oct	-9.046	-15.121
	(-0.26)	(-0.44)
Nov	25.753	21.194
	(0.75)	(0.61)
Breusch and Pagan LM statistic	1652.33	1646.96
Hausman test	26.26	29.18

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding
coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics

Table 2. Empirical Results for the U.S. Quarterly Model

	Short-term Volatility	long-term Volatility
Constant	677.632**	880.321***
	(1.96)	(2.6)
Per capita GDP (U.S. dollar)	0.074**	0.069*
	(2.55)	(1.93)
Competitor's price (U.S. dollar)	0.871**	0.696*
	(2.1)	(1.68)
Expected exchange rate (importing country's currency/U.S. dollar)	0.008	0.011
	(0.33)	(0.41)
Expected soybeans price (U.S. dollar/kg)	0.774	0.285
	(0.79)	(0.32)
Expected ocean shipping cost (U.S. dollar/gallon)	-123.97	-263.124
	(-0.62)	(-1.4)
Exchange rate volatility	-524.614	-37.924
	(-1.27)	(-0.77)
Soybeans price volatility	-1314.215*	-143.2
	(-1.68)	(-1.17)
Ocean shipping cost volatility	-217.064	14.241
	(-0.3)	(0.2)
Quarter 2	-513.999***	-516.608***
	(-5.06)	(-5.09)
Quarter 3	-652.11***	-622.642***
	(-5.75)	(-5.54)
Quarter 4	73.921	86.924
	(0.69)	(0.82)
Breusch and Pagan LM statistic	183.84	184.72
Hausman test	1.3	7.3

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics

Table 3. Empirical Results for the Brazilian Quarterly Model

	Short-term Volatility	long-term Volatility
Constant	80.494	72.564
	(0.14)	(0.11)
Per capita GDP (U.S. dollar)	0.004	0.004
	(0.14)	(0.16)
Competitor's price (U.S. dollar)	2.393**	2.34**
	(2.05)	(2.00)
Expected exchange rate (importing country's currency/U.S. dollar)	-0.588***	-0.587***
	(-3.87)	(-3.82)
Expected soybeans price (U.S. dollar/kg)	-4.314**	-3.527*
	(-2.13)	(-1.88)
Expected ocean shipping cost (U.S. dollar/gallon)	214.576	575.597*
	(0.58)	(1.66)
Exchange rate volatility	1564.417	232.47
	(1.12)	(0.95)
Soybeans price volatility	1612.434	-36.759
	(1.11)	(-0.16)
Ocean shipping cost volatility	447.547	-110.406
	(0.33)	(-0.81)
Quarter 2	628.073***	638.168***
	(3.3)	(3.31)
Quarter 3	539.557***	523.705***
	(2.77)	(2.68)
Quarter 4	58.528	51.168
	(0.31)	(0.27)
Breusch and Pagan LM statistic	1194.67	1201.66
Hausman test	13.38	16.4

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding
coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics

Table 4. Empirical Results for the U.S. Monthly Exports to China

	Short-term Volatility	long-term Volatility
Constant	31.377 (0.1)	-385.385 (-0.87)
Per capita GDP (U.S. dollar)	5.921 (1.23)	2.885 (0.63)
Competitor's price (U.S. dollar)	1.166*** (2.51)	0.785 (1.66)
Expected soybeans price (U.S. dollar/kg)	-1.105 (-1.33)	-1.759** (-2.1)
Expected ocean shipping cost (U.S. dollar/gallon)	295.384 (1.21)	392.324* (1.68)
Soybeans price volatility	-1965.81* (-1.65)	448.498** (2.49)
Ocean shipping cost volatility	142.274 (0.13)	50.225 (0.3)
Jan	246.16 (1.31)	214.671 (1.18)
Feb	238.088 (1.3)	216.796 (1.22)
Mar	90.009 (0.5)	87.39 (0.49)
Apr	-295.47 (-1.62)	-333.234* (-1.88)
May	-506.303*** (-2.67)	-541.235*** (-2.98)
Jun	-435.743** (-2.28)	-468.235** (-2.6)
Jul	-448.232** (-2.35)	-459.574** (-2.53)
Aug	-466.413** (-2.38)	-536.184*** (-2.94)
Sep	-417.645** (-2.2)	-515.161*** (-2.87)
Oct	460.317** (2.5)	397.813** (2.23)
Nov	457.695** (2.53)	375.811** (2.13)
R-sq	0.630	0.630

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics

Table 5. Empirical Results for the Brazilian Monthly Exports to China

	Short-term Volatility	long-term Volatility
Constant	-792.816***	-791.148**
	(-3.56)	(-2.66)
Per capita GDP (U.S. dollar)	12.461***	13.74***
	(4.19)	(4.83)
Competitor's price (U.S. dollar)	-0.425	-0.335
	(-1.51)	(-1.19)
Expected soybeans price (U.S. dollar/kg)	0.458	0.786
	(0.77)	(1.31)
Expected ocean shipping cost (U.S. dollar/gallon)	-208.476	-239.522
	(-1.25)	(-1.51)
Soybeans price volatility	-558.513	-260.499**
	(-0.65)	(-2.07)
Ocean shipping cost volatility	-60.686	102.944
	(-0.07)	(0.85)
Jan	39.528	13.042
	(0.3)	(0.1)
Feb	53.665	5.766
	(0.41)	(0.05)
Mar	31.158	-20.191
	(0.24)	(-0.16)
Apr	138.543	108.445
	(1.06)	(0.86)
May	191.953	180.338
	(1.42)	(1.4)
Jun	323.186**	295.811**
	(2.34)	(2.29)
Jul	550.411***	497.536***
	(4.08)	(3.92)
Aug	382.607**	354.861***
	(2.8)	(2.83)
Sep	406.561**	412.616***
	(3.05)	(3.28)
Oct	525.245***	527.538***
	(4.05)	(4.2)
Nov	125.921	134.747
	(0.98)	(1.07)
R-sq	0.51	0.53

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding
coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics

Table 6. Empirical Results for the U.S. Monthly Exports to Mexico

	Short-term Volatility	long-term Volatility
Constant	356.997***	273.06**
	(3.54)	(2.09)
Per capita GDP (U.S. dollar)	0.264**	0.396***
	(2.24)	(3.25)
Expected soybeans price (U.S. dollar/kg)	-0.226	-0.25*
	(-1.54)	(-1.65)
Expected exchange rate (Mexican Peso/U.S. dollar)	-13.682	-35.322**
	(-0.93)	(-2.31)
Exchange rate volatility	1047.469*	229.462*
	(1.87)	(1.93)
Soybeans price volatility	-369.442	-2.836
	(-1.57)	(-0.09)
Jan	0.996	-1.737
	(0.03)	(-0.05)
Feb	-19.378	-28.106
	(-0.59)	(-0.87)
Mar	30.842	26.925
	(0.94)	(0.83)
Apr	-2.532	-8.253
	(-0.08)	(-0.26)
May	-21.593	-28.716
	(-0.64)	(-0.89)
Jun	-30.911	-48.291
	(-0.88)	(-1.48)
Jul	-32.153	-53.634*
	(-0.92)	(-1.65)
Aug	-32.949	-53.274*
	(-0.91)	(-1.65)
Sep	-107.348***	-124.188***
	(-3.13)	(-3.82)
Oct	152.511***	140.001***
	(4.74)	(4.33)
Nov	24.205	17.59
	(0.76)	(0.55)
R-sq	0.53	0.52

Note: dependent variable: import quantity (1000 MT)
single, double, and triple asterisks (*) denote that corresponding coefficient estimates are significant at the 10%, 5%, and 1% levels, respectively.
values in parentheses are t-statistics