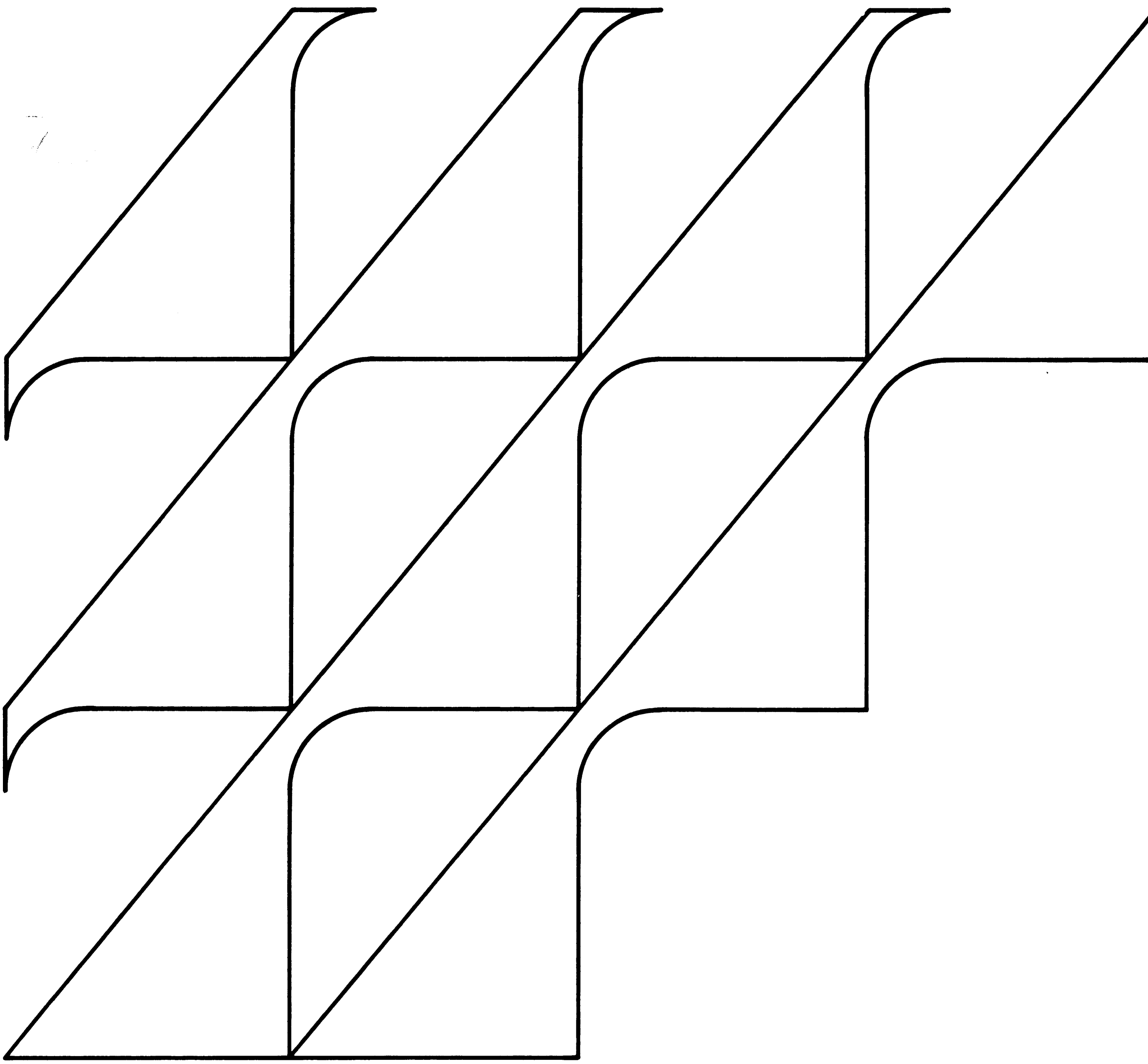
United States
Department of
Agriculture

Economic
Research
Service

Technical
Bulletin
Number 1748

U.S. Soybean Trade and Exchange Rate Volatility

Margot Anderson



SALES INFORMATION

Additional copies of this report can be purchased from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161. Order by title and series number and indicate whether you want paper copies ($12.95 each) or microfiche copies ($6.95 each). Enclose a check or money order payable to NTIS; add $3 handling charge for each order. Call NTIS at (703) 487-4650 and charge your purchase to your VISA, MasterCard, American Express, or NTIS Deposit Account. NTIS will RUSH your order within 24 hours for an extra $10; call (800) 336-4700.

The Economic Research Service has no copies for free distribution.

U.S. SOYBEAN TRADE AND EXCHANGE RATE VOLATILITY. By Margot Anderson, Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1748.

ABSTRACT

Unanticipated changes in exchange rates can affect the foreign demand for U.S. soybeans. Short-term variations in exchange rates change the actual price importers pay for goods. These changes may cause adjustments in quantities traded, domestic prices, or in the timing of sales to avoid the effects on profits. Effects may vary among countries, depending on their access to forward (futures) markets, the degree of market concentration in the domestic soybean processing industry, and the degree of risk importers are willing to assume. This report develops a theoretical model that incorporates soybean trade under exchange rate uncertainty to determine the extent to which soybean trade is vulnerable to variations in exchange rates. The model is estimated for bilateral soybean trade flows between the United States and Japan, France, and Spain.

Keywords: Trade, exchange rate risk, variability, uncertainty, soybeans, export demand.

ACKNOWLEDGMENTS

I would like to thank Nicole Ballenger, Barry Krissoff, and Noel Uri for their helpful suggestions and comments. Thanks also to Mary Maher for providing editorial guidance.

1301 New York Ave., NW.
Washington, DC 20005-4788

October 1988

CONTENTS

SUMMARY

Unanticipated changes in exchange rates can affect the foreign demand for U.S. soybeans. Short-term variations in exchange rates change the actual price importers pay for goods. These changes may cause adjustments in quantities traded, domestic prices, or in the timing of sales to avoid the effects on profits. Effects may vary among countries, depending on their access to forward (futures) markets, the degree of market concentration in the domestic soybean processing industry, and the degree of risk traders are willing to assume.

Previous research examined the effects of exchange rate uncertainty on manufactured goods trade. But those results focused only on aggregate trade, which may obscure effects on specific sectors of the economy. The effects of exchange rate uncertainty need to be examined using less aggregated data. Previous studies were limited by the level of aggregation and by a small sample period (the floating exchange rate system began in 1974).

This report develops a model that incorporates trade under exchange rate uncertainty to determine the extent to which soybean trade is vulnerable to variations in bilateral exchange rates. The model is empirically tested using quarterly bilateral soybean trade flows between the United States and Japan, France, and Spain during 1974 to 1985. Results indicate that exchange rate variability has a small, but significantly negative, effect on the foreign demand for U.S. soybeans.

U.S. Soybean Trade and Exchange Rate Volatility

Margot Anderson

INTRODUCTION

The flexible exchange rate has generated controversy since its inception in the early 1970's because of concerns over the variability in exchange rates and its potentially destabilizing effect on world trade. Trade disruptions may occur since exchange rate variations change the actual price paid or received for traded goods, causing adjustments in quantities traded, prices, or the timing of sales to avoid the effects of variability on profits. Exchange rate variability, by itself, may not harm trade, but the uncertainty associated with variations may cause traders to adjust behavior. Exchange rates that exhibit frequent variations may not be a concern if traders can forecast future exchange rates. On the other hand, more stable exchange rates may be associated with a great deal of uncertainty if changes are unanticipated. The literature on exchange rate determination is divided on how closely next period's exchange rate can be predicted [see (21) for a recent review of this literature].1/ In empirical studies, exchange rate uncertainty is approximated as exchange rate variability even though common measures of volatility, such as the variance or absolute percentage changes, may overstate or understate uncertainty.

This report determines the extent to which exchange rate uncertainty affects the short-term demand for U.S. soybeans. Using quarterly data from 1974 to 1985, the import behavior of three major soybean importers (Japan, Spain, and France) is examined to find how exchange rate variability affects soybean trade. Exchange rate variability has been shown, in some cases, to reduce trade in manufactured goods and in aggregate trade. This report determines the extent to which agricultural markets are also vulnerable to variations in the exchange rate. This report develops a theoretical model that incorporates trade under exchange rate uncertainty. Empirical estimates of the model's parameters are compared across countries.

The degree to which exchange rate uncertainty affects trade depends, in part, on how traded goods are invoiced. When an importer is required to settle accounts payable in the exporter's currency, an appreciation of the exporter's currency increases the importer's cost of traded goods.2/ This increase may provoke importers to reduce the quantity ordered or to increase domestic prices. Longer term effects may occur if exchange rate uncertainty persists over time. If goods are substitutable, importers may seek alternative sources of

---

1/ Underscored numbers in parentheses cite sources listed in the References section.

2/ Shortrun prices do not fully adjust to offset currency appreciations or depreciations. Models focusing on a longer time period need to account for exchange rate pass-through.

foreign supply or exhibit a sustained preference for domestic suppliers over foreign suppliers. The magnitude of the effect of exchange rate uncertainty on the quantity imported depends on, among other things, the respective exchange rate elasticities and the importer's response to variability.

It is important to determine factors contributing to the decline in the demand for U.S. agricultural goods, aside from stagnant world income, increased competition, extensive use of trade barriers, and the level of the exchange rate. The effects of exchange rate uncertainty on agricultural trade have not been adequately examined. Most research in this area has concentrated primarily on trade in manufactured goods.

PREVIOUS RESEARCH

Empirical testing of the hypothesis that exchange rate variability harms short-term trade flows has produced mixed results. Using a quarterly sample period extending from 1965 to 1975, Hooper and Kohlhagen estimated the effect of nominal exchange rate uncertainty on both volume traded and equilibrium price (17). They obtained estimates for trade in manufactured goods for the major trading partners of the United States and West Germany. In some cases, nominal exchange rate uncertainty had statistically significant effects on price but not on volume traded.

Cushman extended the Hooper-Kohlhagen analysis by estimating the effect of real exchange rate uncertainty on trade volume and price, and by focusing on a slightly longer sample period (1965-77) (9). He found real exchange rate uncertainty significantly affects volume traded, particularly for U.S. trade with Canada, Japan, and France.

Akhtar and Hilton estimated volume and price equations for West German and U.S. multilateral manufactured goods trade (1). Unlike previous studies, their sample period, 1974-81, excluded observations from the fixed exchange rate period. Their results showed that effective (trade-weighted) nominal exchange rate uncertainty significantly affects aggregate trade volume for the United States and West Germany.

The International Monetary Fund (IMF) estimated bilateral trade volume equations using a measure of real exchange rate uncertainty for seven industrial countries (18). Using observations from both the fixed and flexible exchange rate periods, the IMF found that real, bilateral, exchange rate uncertainty was not a statistically significant variable in explaining volume traded.

Gotur questioned previous methods and re-estimated the Akhtar-Hilton model for manufactured goods trade for four industrialized countries (14). Gotur argued that the Akhtar-Hilton results are misleading because of incorrect econometric procedures. Gotur's estimates indicated that exchange rate uncertainty has little effect on trade volumes for the major industrialized trading partners of the United States and West Germany.

Maskus hypothesized that exchange rate uncertainty yields differential effects across sectors of the economy depending on, among other things, a sector's openness to trade and the degree of market concentration within the sector (31). Market concentration and sensitivity to exchange rate uncertainty are connected through the firm's ability to absorb risk. Highly profitable firms may be able to absorb risk, at least in the short run. These firms are often associated with a high degree of market concentration, so the level of concentration may indicate a sector's sensitivity to variations in the exchange rate (31). Maskus found that agricultural trade is more sensitive to exchange rate uncertainty than are other sectors in the economy, such as machinery and chemicals trade. Maskus argues that this sensitivity stems from the amount of trade relative to domestic output in agricultural products and the sector's low level of industry concentration.

Kenen and Rodrik estimated the exchange rate uncertainty effects on quarterly manufactured goods trade using an effective exchange rate measure (27). Their results indicate that exchange rate volatility has statistically significant negative effects on aggregate trade volume for the United States, Canada, West Germany, and the United Kingdom.

The inconclusive results obtained to date may be partially attributed to: focusing on aggregate trade, which can obscure important exchange rate effects for specific commodities; using a sample period encompassing too few observations from the floating rate period; choosing an inappropriate exchange rate uncertainty measure; and not adequately accounting for lagged responses to prices and/or quantities traded. While this report addresses all four of these issues, the concern centers on disaggregating trade to isolate effects that may be concealed in an aggregated approach. Maskus provides a link between this report and previous studies by comparing the exchange rate risk effects across major sectors of economy, such as manufactured goods, agriculture, and chemicals.

This report focuses on the effects of exchange rate uncertainty on bilateral soybean trade flows. Soybeans are chosen because, unlike other internationally traded agricultural commodities, they are relatively freely traded. While the European Community (EC) and Japan direct policies at substitutable commodities (which can discourage soybean imports), soybeans enter most countries duty-free and without quotas (22). According to Maskus, this relatively open environment should make soybean trade more susceptible to exchange rate changes. On the other hand, the level of concentration in domestic importing and processing sectors, particularly in Japan, may decrease the degree of sensitivity to exchange rate variability. Soybeans are known to be invoiced in U.S. dollars, implying that any exchange rate risk falls on the importer. Studies focusing on aggregated trade are unable to state explicitly, *a priori*, which trading partner bears the exchange rate risk. Therefore, results showing that exchange rate uncertainty is not a significant factor may reflect only the fact that the trader is not bearing the risk.

CONCEPTUAL MODEL

Theoretical models focusing on the trade effects of exchange rate uncertainty rely on the theory of the competitive firm under uncertainty and risk aversion (6, 13, 25). It is assumed that firms maximize the expected utility of profit. A von Neumann-Morgenstern utility function summarizes the firm's attitude toward risk. For an importing firm facing uncertain future import costs (due to a change in the exchange rate), the optimal level of imports will deviate from the well-known competitive solution. At the optimum, the firm operates at the point where marginal revenue exceeds expected marginal cost. The firm imports less (relative to the amount imported under certainty) and charges a higher domestic price. The degree to which exchange rate variability affects optimal trade volume depends on the currency used to invoice traded goods, the domestic demand and supply elasticities, the openness of the industry or country to trade, and the degree to which traders use forward markets for hedging foreign currency.

The model below is a variant of the model developed by Hooper and Kohlhagen (17). The model in this report considers an importing firm producing two joint outputs, soybean meal and soybean oil, from a single imported input, raw soybeans. Both outputs are consumed only in the domestic market, and domestically produced imperfect substitutes are available.

The input is purchased from a single source, the United States.[3/] The importing firm is assumed to be a price-taker in the world market (the small country assumption; appendix table 1 shows annual share of U.S. exports shipped to Japan, Spain, and France for 1975-84). Each country faces a downward-sloping domestic demand curve for its outputs. A two-period order/payment process is depicted for illustrative purposes. The firm orders unprocessed soybeans at a known price in the initial period.[4/] Payment is rendered in the exporter's currency (U.S. dollars) in the subsequent period. Uncertainty affects the firm's importing behavior through the exchange rate, which may change between the time the order is placed and the time payment is due. This uncertainty results in an unknown domestic import cost of soybeans. Notice that the focus is on nominal exchange rates, which are the relevant rates in the short run, when the decision is to import goods under known prices and costs (18).

The importing firm's demand schedules for its two outputs, soybean meal and soybean oil, are,

$$Q_{sm} = \beta_0 + \beta_1 \cdot P_{sm} + \beta_2 \cdot P_{rm} + \beta_3 \cdot Y \qquad \beta_1 < 0, \ \beta_2, \beta_3 > 0 \tag{1}$$

$$Q_{so} = \gamma_0 + \gamma_1 \cdot P_{so} + \gamma_2 \cdot P_{sfo} \qquad \gamma_1 < 0, \gamma_2 > 0 \tag{2}$$

where: Q_{sm} and Q_{so} indicate the quantity demanded of soybean meal and soybean oil in the domestic market; P_{sm} and P_{so} are the respective domestic prices; P_{rm} and P_{sfo} are the prices of rapeseed meal and sunflowerseed oil, respectively; and γ_0 and β_0 are constants. Rapeseed meal and sunflowerseed oil represent domestic substitutes for soybean meal and soybean oil (while these commodities are not necessarily produced in each country, the collinearity among oilseed meal prices and edible oilseed oil prices allows this specification). Domestic income, Y, is included in the soybean meal equation as a proxy for a variable reflecting the domestic demand for livestock products (an adequate quarterly livestock production variable is not available for the countries examined).

3/ For the sample period of this study, the United States has been the major soybean supplier for the three countries examined. While Argentina and Brazil have increased domestic production of soybeans, their share of the Japanese market is negligible. Brazil has always been an important supplier to Spain, while Argentina's share of the Spanish market has declined since 1978 (the first year for which detailed data were available). Brazil, once an important supplier to France, has lost market share in recent years. Argentina's share market in France has been erratic.

4/ This study ignores the additional complications of export price uncertainty by assuming that the price of soybeans is known to both trading partners at the time orders are made. Internationally traded commodities are generally flat-priced or basis-priced (7). Flat-priced trade agreements stipulate future delivery at a specified price. Basis-priced contracts establish a payment date and set the price by adjusting the current futures price by an agreed basis. Including price uncertainty would yield demand equations that depend on the covariance between the export price and the exchange rate (25, 26). This covariance is often very small in the short run. For example, computing the cross-correlation coefficient for quarterly soybean prices and bilateral exchange rates (by regressing soybean price on past prices, and cross-correlating the residuals with the residuals from a similar regression for the bilateral exchange rate) yields correlation coefficients of -0.27 for Japan, -0.09 for France, and -0.05 for Spain. None of these coefficients statistically differ from zero at α = 0.05.

The production technology is assumed fixed in the short run. The explicit relationships between soybean meal, soybean oil, and soybeans are,

$$Q_{sm} = k_1 \cdot q_s, \quad Q_{so} = k_2 \cdot q_s$$

where: k_1 and k_2 are fixed production coefficients relating yield of soybean meal and soybean oil for each unit of soybeans ($k_1 = 0.788$, $k_2 = 0.179$) (38). It is assumed that the firm does not use forward markets for hedging foreign currency.[5/] While participation in the forward market can reduce exchange rate uncertainty, the associated costs and limited availability of currency may restrict participation. Three costs are important: the premium (discount), which is the actual cost of obtaining cover; the opportunity cost associated with profits foregone (realized) through the forward market; and the transactions cost. Opportunity costs arise if actual exchange rate changes are not accurately reflected in the premium (discount). The transactions cost has been shown to increase with increases in exchange rate volatility [see (3) for a discussion of these and other costs associated with the use of forward markets]. The availability of forward currency may be a constraining factor for some traders because only a few currencies have active forward (futures) markets. Countries faced with financial constraints may have laws prohibiting the obtaining of cover. Based on the above assumptions, the firm's profit, π, in domestic currency is,

$$\tilde{\pi} = P_{sm} \cdot Q_{sm} + P_{so} \cdot Q_{so} - PC \cdot q_s - \tilde{R}_{t+1} \cdot P_s \cdot q_s \tag{3}$$

where: PC is the per unit cost of processing soybeans, P_s is the dollar price of raw soybeans, and $\tilde{R}_{t+1}$ is the exchange rate (units of domestic currency per U.S. dollar) prevailing when payment is due. This variable is stochastic and assumed i.i.d. normal with $E[\tilde{R}_{t+1}] = R$ and variance, σ^2.

The firm maximizes the expected utility of profit.[6/] A von Neumann-Morgenstern expected utility framework is used to account for this uncertainty. The objective function for an individual firm is,

$$\underset{q_s}{\text{MAX}}\ E[U(\tilde{\pi})] = E[U(P_{sm} \cdot Q_{sm} + P_{so} \cdot Q_{so} - PC \cdot q_s - \tilde{R}_{t+1} \cdot P_s \cdot q_s)] \tag{4}$$

5/ The effects of forward contracting have been examined in a theoretical framework (26). When a forward market is included, the firm optimizes over two decision variables: quantity demanded and the optimal portion of imports hedged. Inclusion of a financial market yields a classic separation theorem result; the quantity demanded is not a function of the firm's attitude toward risk. The risk coefficient is important in determining only the optimal proportion of the import bill hedged. With hedging, the importer acts as an optimal hedger choosing the amount hedged based on the difference between the forward rate and the spot rate and on the firm's risk attitude. Hooper and Kohlhagen include forward contracting by specifying, *a priori*, that a fixed proportion of the trade bill is hedged (17). The firm faces exchange rate risk on only the unhedged portion.

6/ Uncertainty for publicly owned companies can be incorporated into the firm's objective function if it is assumed that individual shareholders exhibit uniform preferences about risk, are unable to manage risk, and rely instead on the firm to do so (16, 25). A corporation can also be thought of as a market-value maximizer and, under this decision rule, exposure to foreign exchange risk may be desirable. For example, a Japanese firm reporting earnings in yen can exhibit higher accounting earnings if dollar-invoiced accounts payable are computed when the dollar is weak. On the other hand, corporations may limit exposure if reporting procedures, such as those in the United States, require full disclosure of losses and gains attributed to foreign exchange fluctuations (4).

The utility function is a negative exponential, $U(\tilde{\pi}) = \alpha-\beta\cdot e^{-\gamma\cdot\pi}$, with constants α, β, and γ. Under the assumption of normally distributed profit, the maximization of the negative exponential utility function yields a decision rule that depends only on the first two moments of profit (11). This decision rule is equivalent to a mean-standard deviation decision rule, since both yield an identical efficient set (15). The mean-standard deviation rule is widely used when analyzing the exchange rate variability effects on trade (13, 17). The decision rule for the soybean importing firm is,

$$\underset{q_s}{\text{MAX}}\ E[U(\tilde{\pi})] = \text{MAX}\ E(\tilde{\pi}) - \phi\cdot[Var(\tilde{\pi})]^{1/2} \tag{5}$$

where: ϕ is a measure of the firm's degree of absolute risk aversion. Because output is joint, maximizing equation (5) with respect to Q_{so} is equivalent to maximizing with respect to Q_{sm}. Given the fixed relationship between input and output, maximizing with respect to either output is equivalent to maximizing with respect to the raw input, soybeans. Using the inverse of equations (1) and (2), the first and second moments of profit are,

$$E(\tilde{\pi}) = [(Q_{sm} - \beta_0 - \beta_2\cdot P_{rm} - \beta_3\cdot Y)/\beta_1]\cdot Q_{sm} + [(Q_{so} - \gamma_0 - \gamma_2\cdot P_{sfo})/\gamma_1]\cdot Q_{so} - PC\cdot q_s - R\cdot P_s\cdot q_s \tag{6}$$

$$[Var(\tilde{\pi})]^{1/2} = P_s\cdot q_s\cdot\sigma \tag{7}$$

where: σ is the standard deviation of the exchange rate. Substituting for q_s in equations (6) and (7) and using the fixed production relationships equations, equation (5) is maximized with respect to q_s. This yields a domestic demand equation for imported soybeans,

$$q_s^* = A + [k_1\cdot\gamma_1\cdot\beta_2\cdot P_{rm} + k_1\cdot\gamma_1\cdot\beta_3\cdot Y + k_2\cdot\beta_1\cdot\gamma_2\cdot P_{sfo} + \beta_1\cdot\gamma_1(PC+R\cdot P_s) + \beta_1\cdot\gamma_1\cdot\phi\cdot P_s\cdot\sigma]/[2\cdot k_1^2\cdot\gamma_1+2\cdot k_2^2\cdot\beta_1] \tag{8}$$

where: $A = [k_1\cdot\gamma_1\cdot\beta_0 + k_2\cdot\gamma_0\cdot\beta_1]/[2\cdot k_1^2\cdot\gamma_1 + 2\cdot k_2^2\cdot\beta_1] > 0$

and $B = [2\cdot k_1^2\cdot\gamma_1 + 2\cdot k_2^2\cdot\beta_1] < 0$

All other things being equal, an increase in the standard deviation of the spot rate decreases the demand for imported soybeans for a risk-averse importer ($\phi > 0$) as does an increase in the domestic currency price of soybeans. Equations (9) and (10) show how a change in the import price and exchange rate uncertainty affect the quantity imported:

$$\partial(q_s^*)/\partial(P_s\cdot\sigma) = (\beta_1\cdot\gamma_1\cdot\phi)/B < 0 \tag{9}$$

$$\partial(q_s^*)/\partial(R\cdot P_s) = (\beta_1\cdot\gamma_1)/B < 0 \tag{10}$$

Equations (11) and (12) show that with soybean price constant, the elasticity associated with an increase in σ is less (in absolute value) than the elasticity associated with an increase in the exchange rate, as long as $\phi\cdot\sigma < R$:

$$\eta_{q_s,P_s\cdot\sigma} = [\beta_1\cdot\gamma_1\cdot\phi\cdot P_s\cdot\sigma]/[q_s\cdot B] < 0 \tag{11}$$

$$\eta_{q_s,R\cdot P_s} = [\beta_1\cdot\gamma_1\cdot R\cdot P_s]/[q_s\cdot B] < 0 \tag{12}$$

The coefficient on risk times the standard deviation of the spot rate, $\phi\cdot\sigma$, will generally be relatively small compared with R, the expected value of next period's spot rate. This result shows that an appreciation of the dollar, which raises the domestic currency cost of importing soybeans, has a stronger effect on quantity imported than does an increase in the variation of the import price caused by an increase in exchange rate uncertainty. The intrinsically nonlinear model in equation (8) can be transformed into a linear model with nonlinear parameter restrictions (29).[7/] The unrestricted parameters (δ_i) are related to the restricted parameters (β_i, γ_i) as follows:

$$\delta_0 = [k_1 \cdot \gamma_1 \cdot \beta_0 + k_2 \cdot \gamma_0 \cdot \beta_1]/B, \qquad \delta_1 = [k_1 \cdot \gamma_1 \cdot \beta_2]/B, \qquad \delta_2 = [k_1 \cdot \gamma_1 \cdot \beta_3 /B,$$

$$\delta_3 = [k_2 \cdot \beta_1 \cdot \gamma_2]/B, \qquad \delta_4 = [\beta_1 \cdot \gamma_1]/B, \qquad \delta_5 = [\beta_1 \cdot \gamma_1]/B, \qquad \delta_6 = [\beta_1 \cdot \gamma_1 \cdot \phi]/B$$

The resulting linear estimatable equation with seasonal dummy variables and i.i.d errors is,

$$q_s^* = \delta_0 + \delta_1 \cdot P_{rm} + \delta_2 \cdot Y + \delta_3 \cdot P_{sfo} + \delta_4 \cdot PC + \delta_5 (P_s \cdot R) + \delta_6 \cdot (P_s \cdot \sigma) + \mu_1 \cdot D1 + \mu_2 \cdot D2 + \mu_3 \cdot D3 + e \tag{13}$$

Equation (13) is interpreted as a market demand curve, derived by aggregating over n, the number of identical importing firms. The coefficients δ_1, δ_2, and δ_3 are expected to be positive; δ_4, δ_5, and δ_6 are expected to be negative. The risk aversion coefficient, $\phi = \delta_6/\delta_5$, is the only structural parameter that is uniquely determined. Unique solutions for the remaining structural parameters cannot be obtained due to overidentifying parameter restrictions. This study is not concerned with recovering the parameters of the domestic soybean meal and soybean oil demand equations, so not finding unique solutions for the remaining parameters is not a serious drawback. This study focuses on the coefficients affecting the demand for imported soybeans: the unrestricted parameters. These coefficients are estimated to determine the sensitivity of imported soybeans to exchange rate changes, prices, and income (the OLS estimates of the restricted coefficients have only large sample properties).

ESTIMATION AND RESULTS

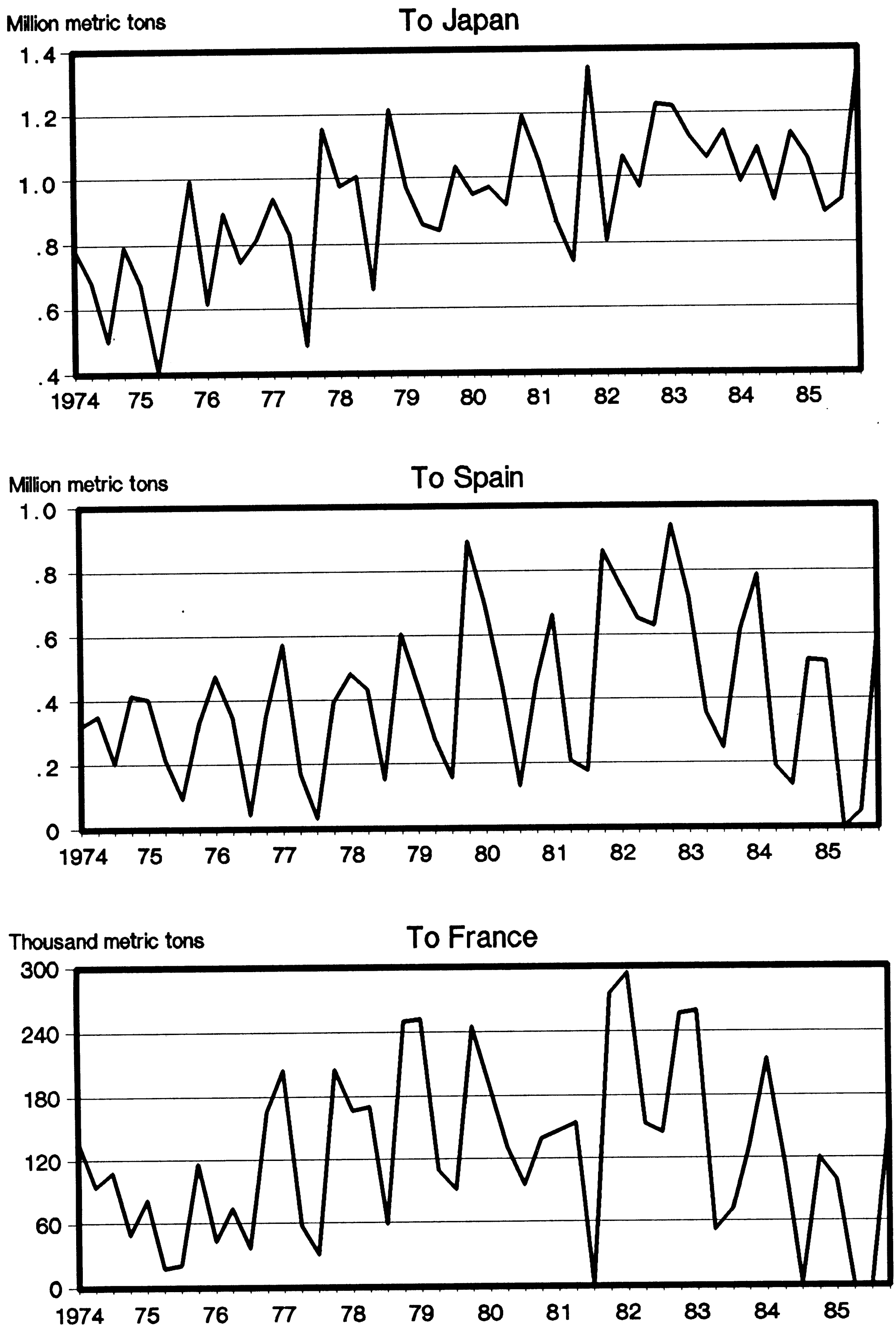
Equation (13) is estimated for quarterly bilateral soybean trade flows between the United States and Japan, Spain, and France from the first quarter of 1974 to the last quarter of 1985. Figure 1 shows quarterly soybean imports for these three countries. The intrayear patterns indicate that the quantity imported by all importers is highest in the first or fourth quarter of the calendar year (more is imported soon after the U.S. harvest). Price movements are not the sole cause of this seasonal pattern because neither the dollar price nor the import price is lowest during these quarters. Quarterly dummy variables are used in the estimable equations to account for these seasonal patterns.

Preliminary analysis of the data indicates collinearity among the exogenous variables. Condition numbers and condition indices are computed for X, the T x K data matrices (for the country examined) to systematically determine the degree of collinearity among the explanatory variables [see (2) for a complete discussion of condition numbers and indices]. A small value of X'X indicates a high degree of collinearity, which implies that at least one of the eigenvalues of X'X is also small. There are moderate to strong

---

7/ Estimating equation (8) using nonlinear regression techniques did not produce reliable results. While some of the parameters had reliable coefficient estimates, the coefficient on risk, $\hat{\phi}$, the most difficult to estimate, is very sensitive to starting values, indicating a flatness in the nonlinear demand function in ϕ-space. Hooper and Kohlhagen experienced similar difficulties when estimating nonlinear demand functions (17).

Figure 1. Quarterly U.S. soybean exports



Source: (33).

linear dependencies among the columns of X if the condition number, the ratio of the largest to the smallest eigenvalue (the relative smallness of the smallest eigenvalue), exceeds 30. The condition index (ratios of the largest eigenvalue to the remaining eigenvalues) indicates which near dependencies exist among the columns; there are as many near dependencies as there are high condition indices. Based on the condition numbers, indices, and partial correlation analysis, the likely collinear variables are income and the proxy variable representing unit-processing cost. The harmful effects of collinear variates on ordinary least squares (OLS) estimates can be mitigated by including more data or by using *a priori* information to impose linear constraints on the parameters of the data (23). Other solutions to collinearity include using estimators that reduce the effect of linear dependency (such as principal components and ridge regression), but these methods often produce estimators that are inferior to OLS (23).

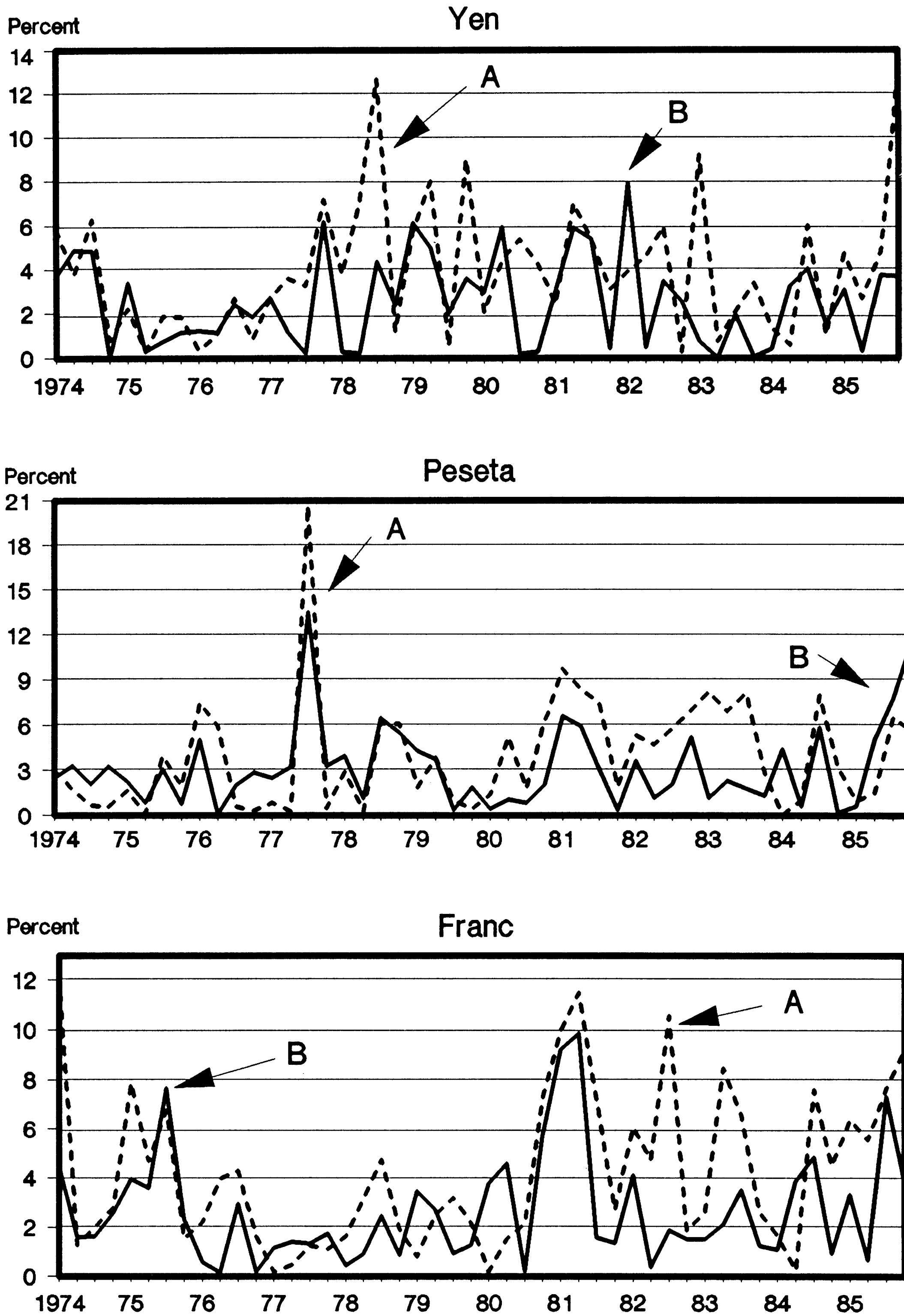
Imposing linear restrictions is a possible remedy in this case because the theoretical model specifies the constraint that the coefficient on processing cost is identical to the coefficient on import price ($\delta_4 = \delta_5$). This restriction is not imposed for two reasons. First, quarterly unit-processing costs for soybeans are not available for the countries examined. Second, the proxy variable available, unit wage rate, reflects only part of the total cost of processing soybeans. The hourly wage indices increase over time and cannot capture unit cost decreases associated with using more efficient processing plants or cost changes associated with idle capacity. Because of the lack of an adequate processing cost variable, this variable is dropped from the equation.

All models are estimated under two different measures of import price ($P_S \cdot R$, where R is the expected value of next quarter's exchange rate) and two different measures of exchange rate risk ($P_S \cdot \sigma$). The import price variables tested are the current U.S. export price of soybeans times the current spot exchange rate and the U.S. export price of soybeans times the prevailing forward rate. These measures assume that the best predictors of next period's exchange rate are the current spot rate and the current forward rate, respectively. A forecast based on a time series or on an econometric model also measures next period's spot rate. The forward rate is selected as an optimal predictor of next period's exchange rate, based on research indicating that the current forward rate, on average, yields unbiased and efficient estimates of next period's spot rate (30). The spot rate is chosen based on results obtained by Meese and Rogoff, who compared the out-of-sample predictive ability of econometric models of foreign exchange with time-series models (32). Meese and Rogoff concluded that a random walk model generates the best available forecast of next period's spot rate; that is, the current spot rate is the best predictor of the future spot rate.

The standard deviation of daily or weekly rates within the quarter can be used as a measure of exchange rate variability for a quarterly model. But the standard deviation is appropriate only when the underlying population is normally distributed. The mean and the variance from non-normally distributed random variables are not appropriate measures of central tendency and scale (5). Evidence suggests that many exchange rates (nominal, real, bilateral, and effective) have non-normal distributions. Non-normality is particularly evident in short-term rates (daily, weekly, and monthly), making the standard deviation over daily or weekly rates an inappropriate measure of variation.[8/] Other measures of variability are used because short-term rates are not normally distributed. Figure 2 shows the two measures of exchange rate variability used in this study: the absolute percentage change in quarter-to-quarter spot rates, and the absolute

8/ Tests for normality are based on either percentage changes in period-to-period spot rates or on the log ratios of adjacent spot rates. Using changes or approximations of changes removes the effect of any steady movements along an upward or downward trend.

Figure 2. Exchange rate variability measures



$$A = \left| \frac{R(t) - R(t-1)}{R(t-1)} \right| \qquad B = \left| \frac{R(t) - F(t-1)}{F(t-1)} \right|$$

Sources: (19, 20) .

percentage change between the current spot rate and last period's forward rate. These two measures, used in previous research, adjust for trend and reflect period-to-period change (13, 18).

Estimation Techniques

Equations that include lagged exogenous variables to reflect order/delivery lags and price expectations best describe trade flows. Incorporating lags on prices (and/or on exchange rates) is a common procedure in empirical international trade models; all of the exchange rate variability studies discussed in the Introduction allow lagged independent variables. Previous researchers generally did not systematically test for the appropriate lag structure. Equation (13), without the processing cost variable, is specified to include lags on all the exogenous variables. Single lags are specified on income and on rapemeal and sunflower seed price. Lags up to eight quarters are allowed for the import price ($P_s \cdot R$) and exchange rate risk variables ($P_s \cdot \sigma$). Multicollinearity may result when long lag lengths are considered, so a variety of polynomial distributed lag structures are specified and compared using model selection criteria. The distributed lag model can be written as,

$$q_s = \beta_0 + \beta_1 \cdot P_{rm} + \beta_2 \cdot Y + \beta_3 \cdot P_{sfo} + \sum_{i=0}^{n^*} \alpha_i \cdot (P_s \cdot R)_{t-i} + \sum_{i=0}^{m^*} \gamma_i \cdot (P_s \cdot \sigma)_{t-i} + u \qquad (14)$$

where: $\alpha_i = \lambda_0 + \lambda_1 \cdot i + \ldots\ldots\ldots, + \lambda_q \cdot i_q$

and $\gamma_i = \delta_0 + \delta_1 \cdot i + \ldots\ldots\ldots, + \delta_q \cdot i_q$

The unknown lag lengths are n* and m*. The lag weights, α_i and γ_i, can be expressed as polynomials of degree q. Using a model selection criteria, one can search over all possible lag lengths and polynomial degrees since the polynomial degree and the lag lengths are not known prior to estimation. Two selection criteria, the Schwarz information criterion (SIC) and Sawa's information criterion (BIC) are used to select the optimal lag length and the optimal polynomial degree,

$$SIC(n+m) = \ln(\hat{\sigma}^2_{n+m}) + n \cdot \ln(T)/T$$

$$BIC(n+m) = \hat{\sigma}^2_{n+m} + (n \cdot \hat{\sigma}^2_{N_T} \cdot \ln(T))/(T-N_T-1)$$

For both measures, m and n are the lag lengths on import price and the exchange rate uncertainty variable, $\hat{\sigma}^2_{n+m}$ is the maximum likelihood estimate of the variance when n+m regressors are included, N_T is the maximum number of regressors considered, and T is the sample size available.

The search procedure begins by estimating equation (13) specified with a third-order polynomial degree (q=3) and eight lags both on $P_s \cdot R$ and $P_s \cdot \sigma$ (n and m set equal to 8). Subsequent regression reduces the lag on $P_s \cdot \sigma$ by one until the lag length on $P_s \cdot \sigma$, m, equals q+1. Two additional regression equations are also estimated for n=8: allowing one lag on $P_s \cdot \sigma$ and no lag specified on $P_s \cdot \sigma$. No constraints are placed on the lagged variables in the latter two regressions because the lag length is less than the polynomial degree. The procedure is repeated with n=7, and so on, until all lag length combinations are examined. The search procedure continues with a lower order polynomial, q=2. The selection criteria are examined at each stage to determine which model specification yields the minimum selection criteria values. Both criteria consist of a measure of the precision of the estimate, $\hat{\sigma}$, and the number of regressors in the model. As the lag length increases, the number of regressors increases and $\hat{\sigma}$ declines. The selection criteria are based on the tradeoff between the precision of the estimate and parsimony associated with the number of regressors. The models selected are then tested for first-order and fourth-order correlation

(12, 28, 39). The residuals are examined to determine if there are other, more complicated error structures. When necessary, models are re-estimated using an iterative Cochrane-Orcutt procedure.

Estimation Results

Based on the selection criteria, the models show that the polynomial distributed lag models with long lags are inferior to models with one-period (unrestricted) lags on the exogenous variables. Longer lag lengths (up to eight quarters) on the exchange rate uncertainty variable have been reported in the bilateral manufactured trade studies (1). But, this finding may be a function of the contract period, which is generally longer for manufactured goods than for most agricultural products. Agricultural markets are considered more price-flexible than manufactured goods markets. Long price series may have little informational content if prices for agricultural goods adjust more rapidly to economic shocks. Lack of a systematic testing procedure that determines the optimal lag length may also cause the estimates of long lag lengths found in other studies.

Table 1 presents the estimation results (see the box for a description of the variables and their sources). France's and Japan's results correspond to the models with one lag on all the exogenous variables except for the exchange rate uncertainty variable (the model specification chosen according to the selection criteria). The results for Spain include one lag on all exogenous variables. Only the first import price variable is reported (current spot rate times the dollar price of soybeans) because the results are invariant across the two measures of import price variables tested. Also, results are only marginally sensitive to the exchange rate variability measure tested, so only the first measure tested (the variation in the spot rate) is reported. Table 1 also reports elasticities, η_i, and the risk coefficient, ϕ (computed using the estimated coefficients). The exact distributions of these elasticities and the risk coefficient are difficult to compute because they are nonlinear functions of normally distributed random variables and classical hypothesis tests are inappropriate (33). In order to construct 95-percent confidence intervals, the asymptotic variances of $\hat{\phi}$ and $\hat{\eta}_1$ are approximated using a second-order Taylor's series (see app. table 2) (33).

The quarterly dummy variables confirm the seasonal variation encountered in the preliminary analyses of the data. Imports are generally higher in either the first or fourth quarter of the calendar year. The coefficient on income (quarterly time trend variable for Spain) is positive and significant for all three countries. The coefficient on rapemeal price is significant and positive for Japanese, French, and Spanish imports, indicating that oilseed meal is a substitute for unprocessed soybean imports. The statistical model may not be able to differentiate between the prices of the two oilseed meals because the price of rapemeal is collinear with the price of soybean meal. These estimates, therefore, may reflect substitution between rapemeal and raw soybeans and between soybean meal and soybeans. Importers substitute between oilseed meals and unprocessed soybeans: France and Spain have increased total soybean meal imports in recent years and have decreased total soybean imports (34). Japan continues to rely on imports of raw oilseeds to meet meal and oil demand (34). The lower cross-price elasticity obtained for rapemeal also indicates this behavior.

The coefficient on sunflowerseed oil, the substitute edible oil, is positive but not significant for Spain and France but is negative and significant for Japan. The unanticipated negative sign may be explained by the existence of many available substitutes for soybean oil and by the collinearity among prices of edible oils. An increase in the price of sunflowerseed oil may not increase the demand for imported soybeans if there are a variety of other substitute oils available to meet local demand. Since edible oil prices move together, the empirical model may be capturing the increase in the price of soybean oil, which would tend to lower the demand for unprocessed soybeans (see app. table 3).

Table 1--Regression results for quarterly soybean demand (1974-85)[1/]

Variable	France (A)	France (B)	Japan (A)	Japan (B)	Spain (A)	Spain (B)
Y_t	38.05*	0.810	1.83*	0.439	10209.00*	0.624
	(12.95)	(.528)	(.145)	(.100)	(5042.30)	(.444)
$P_{rm_{t-1}}$	1047.90*	1.375	901.30*	.158	1443.70*	.577
	(208.68)	(.936)	(265.30)	(.059)	(803.77)	(.472)
$P_{sfo_{t-1}}$	14.97	.081	-213.64*	-.155	78.04	.129
	(67.03)	(.365)	(87.06)	(.075)	(247.80)	(.415)
$R \bullet P_{s_{t-1}}$	-79.26*	-.970	-4.56*	-.310	-9.57**	-.587
	(11.26)	(.392)	(1.14)	(.103)	(5.95)	(.386)
$P_s \bullet RSK1_{t-1}$	-28.56*	-.165	-40.10**	-.028	-46.10**	-.089
	(11.26)	(.072)	(26.10)	(.019)	(34.07)	(.068)
DV1	134393.00*		-12800.00		160590.00*	
	(12417.00)		(27713.00)		(32430.00)	
DV2	-38944.00*		-45004.00		-119210.00*	
	(11858.00)		(27548.00)		(31951.00)	
DV3	-65417.00*		-131980.00**		-243590.00*	
	(11648.00)		(27633.00)		(30857.00)	
Constant	-15554.00		833090.00*		147250.00	
	(64798.00)		(95402.00)		(229320.00)	
ϕ	.362**		8.79		4.82	
	(.177)		(5.24)		(4.42)	
R^2	.676		.823		.689	
DW	1.85		1.87		1.95	
ρ_1	--		-.580*		.342*	
			(.135)		(.019)	
ρ_2	--		-.384*		--	
			(.134)			

Note: Column (A) refers to parameter estimates, where standard errors are in parentheses; *, ** denote significance at α=0.05, α=0.10, respectively. Two-tailed tests are performed for the coefficients on the dummy variables; one-tailed tests are performed for the remaining coefficients. Column (B) refers to the point elasticity. Asymptotic standard errors are in parentheses (app. table 2 shows exact 95-percent confidence intervals). Dashes indicate that these coefficients are not estimated.

1/ See box for a list of variables and their sources.

Variables and Data	
q_s	= Quarterly quantity of soybeans imported from the United States, metric tons (34, 35, 36).
P_{rm}	= Price of rapemeal, Rotterdam, 34-percent protein, f.o.b ex-mill, Hamburg, dollars per metric ton (34, 37).
P_{sfo}	= Price of sunflowerseed oil, any origin, ex-tank, Rotterdam, dollars per metric ton (34, 37).
Y	= Japan: quarterly nominal gross national expenditure. France: quarterly nominal gross domestic product (19). Spain: quarterly time trend variable.
P_s	= Price of soybeans, dollars per metric ton. Spain and France: Rotterdam, c.i.f, dollars per metric ton (34). Japan: Export price, based on the selling price, including inland freight and other charges to U.S. ports (37).
R	= Expected value of next period's spot rate; two measures are used: the current forward rate and next period's actual spot rate. Both rates are bilateral, nominal rates expressed in units of foreign currency per $U.S. The spot rate is a quarterly average rate. The forward rate is computed from published premiums and the end-of-period spot rate (19, 20).
RSK1	= Exchange rate variability measure, absolute percentage change between nominal, bilateral spot rates from t-1 to t (19, 20).
DV_i	= Quarterly dummy variables: $DV_i = \begin{cases} 1 \text{ if observation is from quarter i} \\ 0 \text{ if otherwise} \end{cases}$

The coefficient on import price is negative and significant for all three countries. The coefficient estimate reflects both the effects of price and the exchange rate because the import price is, by definition, the exchange rate times the price of soybeans. The elasticity of demand measures sensitivity to changes in the dollar price of soybeans or to the bilateral exchange rate.[9/] Greater own-price elasticities are expected for French and Spanish imports. These countries use domestic products and soy products from South America, relying less on the United States to satisfy domestic soybean demand (34). Unlike the two European countries, Japan imports mostly U.S. soybeans (despite the soybean embargo of the early 1970's) and does not substitute meal imports for raw soybeans. The lower price elasticity of demand obtained for Japanese imports reflects this continued reliance on U.S. soybeans.

9/ Recall that the model is not designed to answer questions pertaining to exchange rate effects versus price effects. However, a Davidson and MacKinnon J-test is conducted because previous empirical trade research suggests separating the effective price into its two components (10). This procedure tests one econometric model (with effective price) against an alternative non-nested model (with price and the exchange rate). The test is unable to categorically reject the effective price model in favor of the alternative.

France, Japan, and Spain show negative and significant responses to exchange rate variability. These results are invariant over the exchange rate or measure of exchange rate uncertainty used. As expected, the coefficient on exchange rate uncertainty yields an elasticity measure that is less than the elasticity associated with import price. Japan is the least sensitive to exchange rate risk, followed by Spain and then France. Although there are forward markets for the French franc and the Spanish peseta, importers hesitate in using them due to lack of availability, experience, or to financial constraints (8). French soybean imports may be sensitive to exchange rate changes because the French Government periodically limits the availability of foreign exchange (35). The exchange rate uncertainty elasticity for Spain was expected to be the greatest among the three countries examined because the Spanish peseta is not actively traded in the forward or the futures markets.

Finding that Japanese imports are less sensitive to exchange rate variability can be explained by a number of factors. First, the yen is actively traded in the forward and futures markets for foreign exchange, and Japanese traders may be relatively more adept at using these markets to protect themselves from exchange rate uncertainty. Second, a few firms control the soybean importing and processing sectors in Japan (24). This structure, combined with the government's price-stabilization fund, allows importers and processors to pass on price changes and expectations about price changes to domestic customers.

France yields a realistic estimate of $\hat{\phi}$. The precision of the estimate of the risk coefficient cannot be gauged by comparing $\hat{\phi}$ to its asymptotic standard error. The confidence interval for $\hat{\phi}$ is relatively narrow but skewed for France, while the interval is both extremely wide and skewed for Japan. The exact 95-percent confidence interval for Spain is not closed (this is caused by the low significance level of both $\hat{\delta}_4$ and $\hat{\delta}_5$). It is difficult to compare these elasticities with previous research because other studies focused on different countries, other traded products, or did not report elasticities. Cushman reports elasticities of exchange rate uncertainty for U.S.-French total trade, but his are larger (in absolute value) than those in this study. This difference may further demonstrate Maskus' hypothesis that some sectors of the economy are more sensitive to exchange rate uncertainty than others.

CONCLUSION

Exchange rate variability can have a slightly negative effect on U.S. soybean trade. The effects vary across the three countries examined, Japan, France and Spain. The effects depend on a country's access to forward markets and the degree of market concentration in the domestic industry. Although policies may alleviate exchange rate uncertainty or reduce its effects, it is difficult to prescribe macroeconomic policies to reduce variation in exchange rates. Reducing the variation is particularly difficult, given the uncertainty surrounding the causes of exchange rate movements. Managing the exchange rate to ensure exchange rate stability can be costly because the effects of variation may vary across sectors of the economy. Also, stabilizing exchange rates to maintain or increase exports can counteract the macroeconomic benefits of a floating exchange rate system.

Reducing the effects of exchange rate variability for the countries and sectors that are most affected may be a more appropriate response. For example, foreign customers could be encouraged to use foreign exchange forward or futures markets. Exports could be priced in third currencies that are readily available to both parties if their nation's currencies are not actively traded in established markets. U.S. exporters may increase exports by invoicing goods in foreign currencies to assume some of the foreign currency risk borne by importers. Exporters could also guarantee an exchange rate for the day payment is due.

However, more research on the effects of exchange rate variability is needed before one advocates corrective policy. It is crucial to determine these effects for developing countries because they are becoming increasingly more reliant on U.S. exports. The model needs to be tested on other U.S. commodity exports, such as corn and wheat. It may be useful to compare these results with results for inter-EEC trade, which occurs under a more stable exchange rate system.

REFERENCES

(1) Akhtar, M.A., R.S. Hilton. "Effects of Exchange Rate Uncertainty on German and U.S. Trade," *Federal Reserve Bank of New York Quarterly Review*, Vol. 9, No.1 (1984):7-16.

(2) Belsley, D., E. Kuh, and R.E. Welsch. *Regression Diagnostics*. New York, NY: John Wiley and Sons, Inc., 1980.

(3) Bergstrand, J.H. "Is Exchange Rate Volatility Excessive?" *New England Economic Review*, Sept./Oct. 1983:5-14.

(4) Bilson, J.F. "The Choice of an Invoice Currency in International Transactions," *Economic Interdependence and Flexible Rates*. J.S. Bhandari and B.H. Putman, eds. Cambridge, MA: MIT Press, 1984.

(5) Boothe, P., D. Glassman. "The Statistical Distribution of Exchange Rates: Empirical Evidence and Economic Implications," *Journal of International Economics*, 22(1987):297-319.

(6) Clark, P.B. "Uncertainty, Exchange Risk and the Level of International Trade," *Western Economic Journal*, 11(1973):302-13.

(7) Conklin, N. "Market Structure and Pricing Efficiency of the U.S. Export System," GAO No. 82-61. Commod. Econ. Div., General Accounting Office, 1982.

(8) Cordier, J.E. "An Analysis of Efficient Purchasing Strategies for a Soybean Meal User in France," Ph.D. thesis. University of Illinois at Champaign-Urbana, 1981.

(9) Cushman, D.O. "The Effects of Real Exchange Rate Risk on International Trade," *Journal of International Economics*, 13(1983):45-63.

(10) Davidson, R., J.G. MacKinnon. "Several Tests for Model Specification in the Presence of Alternative Hypothesis," *Econometrica*, 49(1981):781-93.

(11) Deaton, A., J. Muellbauer. *Economics and Consumer Behavior*. Cambridge, UK: Cambridge University Press, 1980.

(12) Durbin, J., G. Watson. "Testing for Serial Correlation in Least Squares Regression I," *Biometrika*, 37(1950):409-28.

(13) Ethier, E. "International Trade and the Forward Exchange Market," *American Economic Review*, 65(1974):494-503.

(14) Gotur, P. "Effects of Exchange Rate Volatility on Trade: Some Further Evidence," *International Monetary Fund Staff Papers*, 32(1987):475-512.

(15) Hazell, P.B.R., R.D. Norton. *Mathematical Programming for Economic Analysis in Agriculture*. New York, NY: Macmillan Publishing Co., Inc., 1986.

(16) Helpman, E., A. Razin. *A Theory of International Trade Under Uncertainty.* New York, NY: Academic Press, Inc., 1978.

(17) Hooper, P., S. Kohlhagen. "The Effect of Exchange Rate Uncertainty on the Prices and Volume of International Trade," *Journal of International Economics,* 8(1978):483-511.

(18) International Monetary Fund. "Exchange Rate Volatility and World Trade," Occasional Paper No. 28. Washington, DC, 1984.

(19) ____________. *International Financial Statistics.* Washington, DC, various issues.

(20) ____________. *International Financial Statistics: Supplement on Exchange Rates.* Washington, DC, 1984.

(21) Isard, P. "Lessons for Empirical Models of Exchange Rates," *International Monetary Fund Staff Papers,* 34(1987):1-28.

(22) Jabara, C.L. *Trade Restrictions in International Grain and Oilseed Markets: A Comparative Country Analysis,* FAS-162. U.S. Dept. Agr., For. Agr. Serv., 1981.

(23) Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T.C. Lee. *The Theory and Practice of Econometrics.* New York, NY: John Wiley and Sons, Inc., 1985.

(24) Kalmbach, P.M., J.W. Sharp, and F.E. Walker. "The Japanese Food and Feed Grain Economy," Research Bulletin 1126. Ohio Agricultural and Development Center, 1981.

(25) Kawai, M. "The Behavior of An Open-Economy Firm Under Flexible Exchange Rates," *Economica,* 48(1984):45-60.

(26) Kawai, M., I. Zilcha. "International Trade with Forward-Futures Markets Under Exchange Rate and Price Uncertainty," *Journal of International Economics,* 20(1986):83-98.

(27) Kenen, P., D. Rodrik. "Measuring and Analyzing the Effects of Short-Term Volatility in Real Exchange Rates," *Review of Economics and Statistics,* 68(1986):311-15.

(28) King, M.L. "The Durbin-Watson Test for Serial Correlation: Bounds for Regressions with Trend and/or Seasonal Dummy Variables," *Econometrica,* 49(1981):1571-81.

(29) Kmenta, J. *Elements of Econometrics.* New York, NY: Macmillan Publishing Co., Inc., 1971.

(30) Levich, R.M. "The Efficiency of Forward Markets in Foreign Exchange," *International Financial Management,* D. Lessard, ed. Boston, MA: Waren, Gorham, and Lamont, Inc., 1978.

(31) Maskus, K.E. "Exchange Rate Risk and U.S. Trade: A Sectoral Analysis," *Economic Review of the Federal Reserve Bank of Kansas City,* Vol. 71, No.3 (1986):16-28.

(32) Meese, R.A., K. Rogoff. "Empirical Exchange Rate Models of the Seventies," *Journal of International Economics,* 14(1983):3-24.

(33) Miller, S.E., O. Capps., and G.J. Wells. "Confidence Intervals for Elasticities and Flexibilities from Linear Equations," *American Journal of Agricultural Economics,* 66(1984):392-95.

(34) *Oilworld*, Hamburg, FRG: Oilworld Publications, various issues.

(35) *Picks Currency Yearbook*, Franz Pick, ed. New York, NY: Pick Publishing Corp., various issues.

(36) U.S. Bureau of Census, *U.S. Exports: Schedule E, Commodity by Country*, Washington, DC, various issues.

(37) U.S. Department of Agriculture, Foreign Agricultural Service. *Oilseeds and Products: World Oilseed Situation and Market Highlights*, FAS Circulars, various issues.

(38) U.S. Department of Agriculture, Economics, Statistics, and Cooperatives Service. *Conversion Factors and Weights and Measures for Agricultural Commodities and Their Products*, SB-616. 1979.

(39) Wallis, K.F. "Testing for 4^{th} Order Autocorrelation in Quarterly Regression Equations," *Econometrica*, 40(1971):617-36.

Appendix table 1--Share of total U.S. exports to Japan, Spain, and France

Year	Japan	Spain	France
		Percent	
1975	0.22	0	0.22
1976	.20	.08	.02
1977	.21	.07	.03
1978	.19	.08	.03
1979	.19	.08	.03
1980	.19	.08	.03
1981	.19	.09	.03
1982	.16	.12	.03
1983	.16	.07	.02
1984	.21	.08	.02

Source: (34).

Appendix table 2--Exact 95-percent confidence intervals for price and income elasticities and risk coefficient

Elasticity	----France----		----Japan----		----Spain----	
			Intervals			
Y	0.259	1.380	0.368	0.510	0.007	1.240
P_{rm}	.820	1.960	.040	.277	-.065	1.220
P_{sfo}	-.650	.814	-.282	-.028	-.691	.948
$R \cdot P_s$	-1.650	-.312	-.465	-.155	-1.319	.143
R•RSK1	-.296	-.034	-.064	.008	-.222	.042
Risk coefficient, $\hat{\phi}$	.071	1.27	-2.78	26.18	(interval not closed)	

Computational notes:

The elasticities and $\hat{\phi}$ are combinations of normally distributed random variables,

$$\hat{\eta}_k = (x_k/y) \cdot \hat{\delta}_k$$

$$\hat{\phi} = \hat{\delta}_5/\hat{\delta}_4$$

where: x_k is the mean value of the ith independent variable, y is the mean value of the dependent variable, and $\hat{\delta}_k$ is the k^{th} coefficient estimate ($\hat{\delta}_4$ is the estimated coefficent on price and $\hat{\delta}_5$ is the estimated coefficient on exchange rate uncertainty). Confidence intervals for the $\hat{\eta}_k$ and $\hat{\phi}$ are constructed from the parameter estimates and their asymptotic variances. As shown in Kmenta (29), the formula for the asymptotic variance in the general case where an estimator is a function of other estimators, that is, $\hat{\beta} = f(\hat{\delta}_1, \hat{\delta}_2, .., \hat{\delta}_k)$, is,

$$\mathrm{Var}(\hat{\beta}) \simeq \sum_k (\partial f/\hat{\delta}_k)^2 \cdot \mathrm{Var}(\hat{\delta}_k) + 2 \sum_{j<k} (\partial f/\hat{\delta}_j)(\partial f/\hat{\delta}_k)^{\cdot} \mathrm{Cov}(\hat{\delta}_j)(\hat{\delta}_k) \quad (j,k = 1,2,..,K;\ j<k).$$

Let $R = r_1/r_2$, that in the case of the point elasticities, $r_1 = \hat{\delta}_{2k} \cdot x_k$, $r_2 = y$; for ϕ, $r_1 = \hat{\delta}_5$, $r_2 = \hat{\delta}_4$. Following Miller, Capps, and Wells (33), the end points of a 95-percent confidence interval are the values of R that solve the quadratic equation,

$$R^2 \cdot (r_2{}^2 - t^2 \cdot s_2{}^2) - 2 \cdot R \cdot (r_1 \cdot r_2 - t^2 \cdot c_{12}) + r_1{}^2 - t^2 \cdot s_1{}^2 \qquad = 0$$

where: t^2 is the squared value of the upper $\alpha/2$ percentage point of the tabular *t*-distribution with T-K-1 degrees of freedom, and c_{12} is the estimated covariance between r_1 and r_2.

Appendix table 3--Correlation coefficients for prices of soybean products and substitutes

Price	P_s	P_m	P_{so}	P_{po}	P_{sfo}	P_{rm}
P_s	1.00					
P_m	.749	1.00				
P_{so}	.512	.039	1.00			
P_{po}	.633	.484	.585	1.00		
P_{sfo}	.422	-.083	.893	.537	1.00	
P_{rm}	.503	.713	-.110	.451	-.098	1.00

Note:
P_s = Export price of soybeans,
P_m = Export price of soybean meal,
P_{so} = Price of soybean oil (Rotterdam),
P_{po} = Price of palm oil (Rotterdam),
P_{sfo} = Price of sunflowerseed oil (Rotterdam), and
P_{rm} = Price of rapeseed meal (Rotterdam).

Source: (34).

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
1301 NEW YORK AVENUE, NW.
WASHINGTON, D. C. 20005-4788

☆U.S.GOVERNMENT PRINTING OFFICE:1988-241-852:80294/ERS