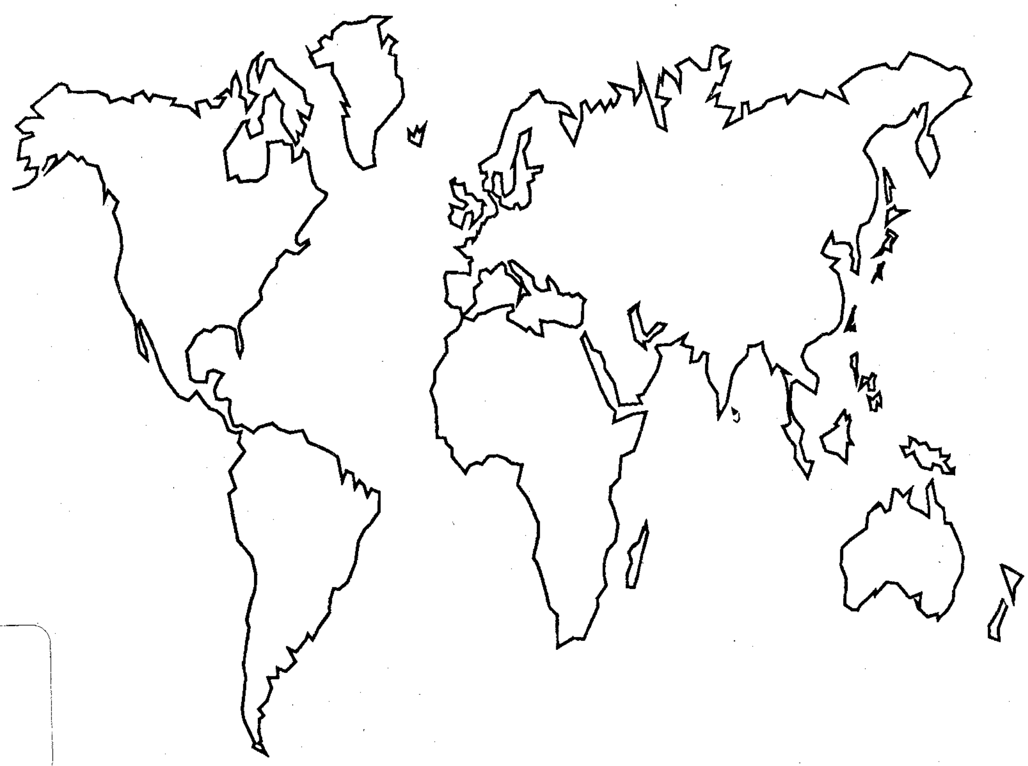
Agricultural Economics Report No. 239

September 1988

Effects of Resource Endowments on Agricultural Trade

Won W. Koo
Craig S. Anderson



Department of Agricultural Economics • North Dakota State University
Fargo, ND 58105

TABLE OF CONTENTS

List of Tables

List of Figures

Highlights

This study examines the impacts of resource endowments, technology, and transportation cost on agricultural trade of wheat, corn, and soybeans. The model used was specified on the basis of the theory of comparative advantage. Corn, soybean, and wheat models were estimated through pooling time series and cross section data.

This study reveals that resource endowments and farming technology play a very important role in determining market shares among exporting countries. This implies that the United States could expand its market share under free trade because resources such as land and farming technology are more abundant in the United States than other countries. The transportation system is found to be a very important factor in determining market shares of wheat and corn and a less important factor in determining market shares of soybeans. This is mainly because production locations are widely diversified for corn and wheat while they are concentrated for soybeans in North and South America. The models have R^2 that ranged between .20 and .40, indicating that the variables used in the models do not explain short-run fluctuations in agricultural trade volume. The endowment variables do not change dramatically over time, and therefore capture only long-term trends in export quantity and market share.

EFFECTS OF RESOURCE ENDOWMENTS ON AGRICULTURAL TRADE

Won W. Koo and Craig S. Anderson[*]

United States agricultural exports generally grew dramatically in the 1970s and have fallen in the 1980s. Total value of agricultural exports was $6,958 million in 1970, and grew to a peak of $43,780 million by 1981, and has since fallen to $31,187 million in 1985 (USDA). Wheat exports of the United States have followed a similar pattern. For instance, U.S. exports of wheat were 14.7 million metric tons in 1970, grew to 48 million metric tons in 1981/82, and since have fallen to 25 million metric tons in 1985/86. Market share of world trade in wheat for the United States has also experienced dramatic increases and decreases in the last two decades. U.S. market share of world wheat trade was 33 percent in 1970, increased to 51 percent in 1981, and has fallen to 29 percent in 1985/86. Similar patterns have occurred in the case of U.S. corn and soybean trade.

Agricultural production has been highly specialized based on weather conditions and soil types. As a result, distribution of agricultural products among countries is an important element in stabilizing the world food market. Production specialization for agricultural products could also be contributed by resource endowments and farming technology. Farming technology has especially played an important role in production specialization because it is a major factor influencing farming efficiency. Farming technology is expected to play an even more important role in the future. The role of resource endowments, however, is not conclusive in determining volume or direction of trade in agricultural products due mainly to trade restrictions imposed by importing and exporting countries. Exporting countries impose trade policies to maintain their market shares of agricultural trade. Importing countries impose trade restrictions to protect agricultural sectors which are less efficient than those in exporting countries. Although producing agricultural products is very costly in importing countries, they want to be self-sufficient for security purposes because food is a necessary good, and also alternative use of land and unskilled labor is limited. Studies by Leamer and Leontief suggest that factor endowments may play an important role in determining agricultural trade patterns. This may be true even though inefficient allocation of resources may occur in some countries based on the desire for self sufficiency in food and fiber, and also trade restrictions may further create inefficiencies in resource allocation. On the contrary, it was found that resource endowments play an important role in determining trading patterns in industries other than agriculture (Balassa and Bowen).

The overall objective of this study is to analyze the effects of resource endowments, farming technology, and transportation costs on trade patterns of wheat, corn, and soybeans. Specific objectives are as follows:

1. Investigate the impacts of resource endowments on U.S. export quantity and market share of wheat, corn, and soybeans in the world market.

---

[*]Koo is professor and Anderson was formerly research assistant, Department of Agricultural Economics, North Dakota State University, Fargo.

2. Examine the impact of transportation cost on U.S. export quantity and market share of wheat, corn, and soybeans in the world market.

Understanding trade patterns is a necessary means for the U.S. to regain its market share in world agricultural exports. This would help agricultural producers increase their net incomes and, therefore, revitalize the farm economy. Policy makers would be better able to make decisions involving trade policy with a good understanding of what determines trade patterns in the agriculture sector.

Development of Model

A review of the theory of comparative advantage was first proposed by Ricardo in 1817 with On the Principles of Political Economy and Taxation and this still remains the central feature of modern theory of international trade. Several refinements to the theory have taken place since; the most significant came in the 1933 publication of Ohlin's Interregional and International Trade.

More recently the theory of comparative advantage was explained with resource endowments by the Heckscher-Ohlin theorem. The Heckscher-Ohlin theorem attributes the existence of dissimilar production possibilities curves among countries to dissimilar factor endowments. The Heckscher-Ohlin theorem says: A country with balanced trade will export commodities that, in the production process, use intensively its relatively abundant factor and will import the commodity that uses intensively its relatively scarce factor (Leamer).

Application of the Heckscher-Ohlin theorem begins with independent measures of trade volume, factor intensity, and factor endowment. Studies by Hufbauer and more recently Balassa attempted to apply the theory by measuring all three concepts (trade volumes, factor intensity, and factor endowment). However, most studies have measured trade volume and factor intensity or factor endowment and inferred the other. Studies by Leontief and by Swerling measured trade volume and factor intensity and inferred factor abundance. Studies by Bowen and by Leamer measured trade and factor endowments and inferred the factor intensity matrix. This study used the latter method of estimating trade flows in that trade volume and factor endowments were used and factor intensity was inferred.

According to Leamer, the empirical model is specified on the basis of the Heckscher-Ohlin theorem as follows:

$$T_m = f(LD_m, LB_m, K_m, TN_m) \quad (1)$$

where

T_m is net exports or imports of wheat, corn, or soybeans in country m (+ for exports and - for imports)

LD_m is land endowment in country m

LB_m is labor endowment in country m

K_m is capital endowment in country m

TN_m is technology adopted in production in country m

Equation 1 shows each country's trade direction based on resource endowments. The equation can be modified to evaluate trade flows from exporting countries to importing countries. Under the assumption of a linear relationship between dependent and independent variables, equation 1 can be modified as:

$$T_{mnt} = B_0 + B_1(LB_{mt}/LB_{nt}) + B_2(LD_{mt}/LD_{nt}) + B_3(K_{mt}/K_{nt}) + B_4(TM_{mt}/TM_{nt}) + B_6(TR_{mnt}) + e_{it} \quad (2)$$

where:

T_{mnt} = Wheat, corn, or soybean flows from country m to country n in time t

LB_{mt}/LB_{nt} = Ratio of labor endowed in country m to that in country n in time t.

LD_{mt}/LD_{nt} = Ratio of land endowed in country m to that in country n in time t.

K_{mt}/K_{nt} = Ratio of capital endowed in country m to that in country n in time t.

TN_{mt}/TN_{nt} = Ratio of farming technology endowed in country m to that in country n in time t.

TR_{mnt} = Distance in nautical miles between exporting country m and importing country n.

e_{mt} = Random error term.

Equation 2 explains flows of commodities from producing countries (m) to importing countries (n) in time (t) based on resource endowments; however, two problems occur in pursuing this method. Since comparative advantage is primarily a supply phenomena and since both supply and demand conditions exist in equation 2, results are difficult to interpret. In addition, data are not available to empirically estimate equation 2.

To specify a supply side trade model, equation 2 is summed across all importing countries (n). For example, the capital variable for all sampled importing countries is added together in each year and used in a ratio. The ratio for the capital variable is then, in the case of the wheat model, each exporting country's capital endowment divided by the sum of the capital endowments of the sampled importing countries. This means that each endowment variable is a ratio of the exporting country to the sum of the importing countries endowments for each year. The model can be restated as follows:

$$T_{mt} = B_0 + B_1(LB_{mt}/\Sigma LB_{nt}) + B_2(LD_{mt}/\Sigma LD_{nt}) + B_3(K_{mt}/\Sigma K_{nt}) + B_4(TN_{mt}/\Sigma TN_{nt}) + B_5(\Sigma TR_{nmt}/n) + e_{it} \quad (3)$$

This model explains the long run trend of export quantity and market shares in terms of resource endowments, technology, and transportation costs. Thus, the model measures competitive advantage among exporting countries in exporting agricultural products.

The data used in equation 3 are pooled in a cross section and time series manner similar to that used by Maskus (16). This model can evaluate exporting countries' market share in the segment of the world market represented by the sampled importing countries (n).

The land variable has been left out of many studies because these studies have concentrated on manufacturing industries' exports where land is not an important element explaining these commodities' trade. Leamer has done work involving trade of agricultural products, and land in his study was divided into four subcategories, tropical, arid, humid mesothermal (California), and humid microthermal (Michigan), according to their various cultivation possibilities. Bowen disaggregated land in much the same way. This study aggregates land into one category by summing each country's land belonging to the latter three categories (arid, humid mesothermal, humid microthermal). This is done because wheat by its nature is a weed and can be grown in many diverse soil and climate conditions. The same is true for soybeans and corn only to a lesser extent; however, common practices of irrigation and chemical use enhance the diverse conditions of their cultivation.

Land was measured in thousands of hectares as published in a book by Leamer. The land endowed included all land except tropical and arctic land in the case of wheat, while tropical land was included in the case of corn.

Labor used in the production process varies greatly in quantity and its divisibility based on the product produced and the nature of labor's contribution. Typically labor is divided into at least two categories, skilled and unskilled, or three categories, skilled, semi-skilled, and unskilled, based upon the educational background of the labor force in a particular country. Leamer and Bowen each divided labor using the three-category system.

This study aggregates labor endowments of each country across all skill levels because all skill levels are present in agricultural production and disaggregation provided results not significantly different from labor on an aggregated level.

Labor was measured as the economically active population of each country in each year of the study period and was measured in thousands of persons as published in FAO Production Yearbook.

Capital endowment is an important resource in explaining trade patterns. Many studies of trade patterns involving capital intensive industries measured capital in two categories, physical capital and human capital (Maskus). Agriculture is more labor and land intensive than capital intensive, indicating that land and labor are more important in agricultural production than most other industries. This implies that a human capital element in the model would be inappropriate; therefore, physical capital stock was used for each country.

Capital was measured as an accumulated flow of gross capital formation over a 15-year period for each country as published by IMF Supplement on Output Statistics. Capital flows over the preceding 15-year period from a given year in the study period were depreciated on a straight-line method and a 6 percent discount rate was used to arrive at a present value of capital stock in each year for all countries, measured in billions of U.S. dollars. This method or one similar was used in almost all previous studies.

Technology, until recently, has been a resource that has been ignored in comparative advantage studies. Most previous studies employed a cross section regression approach to estimation of comparative advantage and the static nature of this technique allowed technology changes to become unimportant (Leontief, Swerling, Bowen). Researchers recently have recognized the importance of technological changes over time as a factor in explaining trade patterns. Maskus introduced technology in a recent study of manufacturing industry trade patterns. His measure of technology was the number of scientists and engineers employed in each sector of the manufacturing industry.

Technology in agriculture can best be measured in terms of changes in output over time. This change in output over time indicates the increased or decreased efficiency of inputs used in the production process relative to outputs. For purposes of this study, yield changes over time will be the basis for the measure of technology. Because factors other than technology affect yields, they must be isolated in order to measure the technology component of yield changes. Weather and the amount of additional land put into production have impacts on yields that may not be related to technology adoption in production. Weather is unpredictable, and over time its effects on crop yield are assumed to be normally distributed. The change in the amount of land devoted to production of any crop would have a negative impact on yields because the additional land put into production would be less productive than land already in production. Therefore, farming technology in wheat, corn, and soybean production is measured by the long-run trend on yield per acre.

Yield is expressed as a function of a linear trend and acres planted

$$Y_t = B_0 + B_1 \text{ TREND} + B_2 \text{ ACRE} + e_i \qquad (4)$$

where Y_t is wheat, corn, or soybean yield, TREND is a linear trend line, ACRE is acres planted of the particular crop, and e_i is the disturbance term. B_2 is expected to have a negative sign and the yield resulting from changes in technology can be estimated by eliminating the effects of changes in planted acres of each crop:

$$Y_t = (a_0 + a_2 \text{ ACRE}) + a_1 \text{ TREND} \qquad (5)$$

Yield was obtained from FAO Production Yearbook and IWC World Wheat Statistics and measured in quintals (100 kg.) per hectare.

Transportation distance variable is added because transportation cost for agricultural products is higher than that for most non-agricultural products and affect trade patterns of agricultural products. Transportation distance is used instead of transportation cost because of the unavailability of consistent transportation cost data between major exporting and importing countries included in the study.

Transportation distances between importing and exporting countries were obtained from Defense Mapping Agency Hydrographic/Topographic Center Distance Between Ports.

Export quantity of each commodity was measured in thousands of metric tons. This was obtained from IWC World Wheat Statistics for wheat and United Nations Yearbook of International Trade Statistics for corn and soybeans.

This model explains the long-run trend of export quantity and market shares. This model is applied to corn and soybean trade as well as wheat trade. Models are estimated analyzing export quantity and market share from major exporters to a sample of major importing countries for each crop. It is expected that the land and technology variables have a positive sign in the empirical models. Capital and labor may have a negative or positive sign depending on the contribution of the variables in the production process of each crop.

Data were collected for 10 years, 1975 to 1984. Exporting countries for wheat, soybeans, and corn were Argentina, Canada, United States, and Australia; United States, Brazil, and Argentina; and United States, Argentina, Thailand, and France, respectively. These were chosen because they represent consistent exporting behavior over the study period and compose about 70 to 90 percent of world exports in each commodity. Importing countries included for each commodity were selected based on their import volume and consistency of trade in the study period. Wheat importing countries included were Japan, South Korea, United Kingdom, West Germany, Italy, Peru, Morocco, Egypt, Algeria, The Netherlands, Pakistan, and Brazil. Soybean importing countries included were Canada, Mexico, Denmark, United Kingdom, The Netherlands, France, West Germany, Italy, Greece, Norway, Switzerland, Spain, Portugal, Japan, Israel, and South Korea. Corn importing countries included were Japan, Spain, The Netherlands, South Korea, United Kingdom, West Germany, Portugal, Egypt, Saudi Arabia, Italy, Venezuela, Malaysia, Greece, Canada, Singapore, Peru, Israel, and Mexico.

Empirical Results

Pooling technique of time series and cross section data is used to estimate equation 3. The model is based on 10 years' time series data from 1975 to 1984 and the cross section data for exporting countries of each crop.

From the preliminary estimates of the models, it was found that the models are cross sectionally heteroskedastic and timewise autoregressive. This implies that disturbance terms dealing with cross sectional units were independent but heteroskedastic and disturbance terms dealing with time series units were homoskedastic but autoregressive. Heteroskedasticity exists because of the relative size differences of the variables in the exporting countries. Serial correlation exits because of the time series component of the data. These problems were corrected by using the Park's procedure.

Estimated models are presented for wheat, corn, and soybeans. Two equations are estimated for each crop; export quantity and market share models with a sample of major importing countries.

ESTIMATED MODELS

Wheat Models

The estimated models for wheat are presented in Table 1. The t-values for the estimated parameters indicate that most variables introduced in this study are significant at the 5 percent level. R^2s are low for all models, indicating that the variables used in these models do not explain the short-run fluctuations in the quantities of grain exported by exporting countries. The models explain long-run trend in export volume by exporting countries.

The capital variable has a negative sign in both wheat models. The t-values for the capital variable indicate that the variable is statistically significant in both estimated wheat models. The negative sign on the capital variable indicates that capital is negatively related to wheat exports and market share of the major wheat exporting countries in this study. The negative sign also indicates that wheat production in the wheat exporting countries is not capital intensive. This is mainly because capital, in relation to other industries such as computers and automobiles, does not play an important role in the production of wheat.

TABLE 1. WHEAT EXPORT MODELS

Independent Variable	Export Quantity	Market Share
Intercept	-6,089	-.300
	(-5.13)*	(6.28)*
Land	7,136	.296
	(12.42)*	(13.17)*
Capital	-27,149	-1.09
	(-5.23)*	(-5.69)*
Labor	67,305	2.72
	(7.37)*	(8.12)*
Technology	9,820	.440
	(7.32)*	(9.45)*
Distance	-.458	-.000012
	(-4.37)*	(-2.95)*
R^2	.241	.334

t-values in parentheses
* significant at the 5 percent level.

The land variable displays a positive sign for both wheat models as expected. T-values in all models indicate that the land variable is significant at the 1 percent level. This means land is an important component of a country's resource endowments in determining wheat exports and market share. A country that has a large land area with the proper climatic conditions and soil type is able to become highly specialized in the production of certain crops as the United States is in wheat production. Therefore, land is a major source of comparative advantage in wheat production. If a country has a small land base in wheat production, that country may import wheat, as in the case of Japan.

The labor variable displays a positive sign and its t-values indicate the variable is significant at the 1 percent level in both wheat models. This implies that wheat production compared to other industries is relatively labor intensive. A country's endowment of labor is important in its ability to produce and export wheat.

Yield trend is used as an indicator of farming technology in both models. Farming technology variables display a high degree of statistical significance to the models as evidenced by their t-values which are significant at the 1 percent level. A positive sign and high significance level of the farming technology variable indicates a country's wheat exports are positively related to its changes in farming technology. This means farming technology is a source of comparative advantage in wheat production.

The distance variable is used as a proxy for transportation cost and exhibits a negative sign in the estimated wheat models. The t-values indicate that the variable is significant at the 1 percent level in both models. A negative sign is consistent with the theory of spatial equilibrium, which describes interregional price relationships and trading patterns between producing and consuming regions (Figure 1). Excess supply schedule in the producing region and excess demand schedule in the consuming region intersect at a price of P_1 per unit. If no transportation costs exist, q_1 units would be shipped from the producing to the consuming region. Transportation costs are derived from the vertical difference between the excess demand and excess supply schedule and

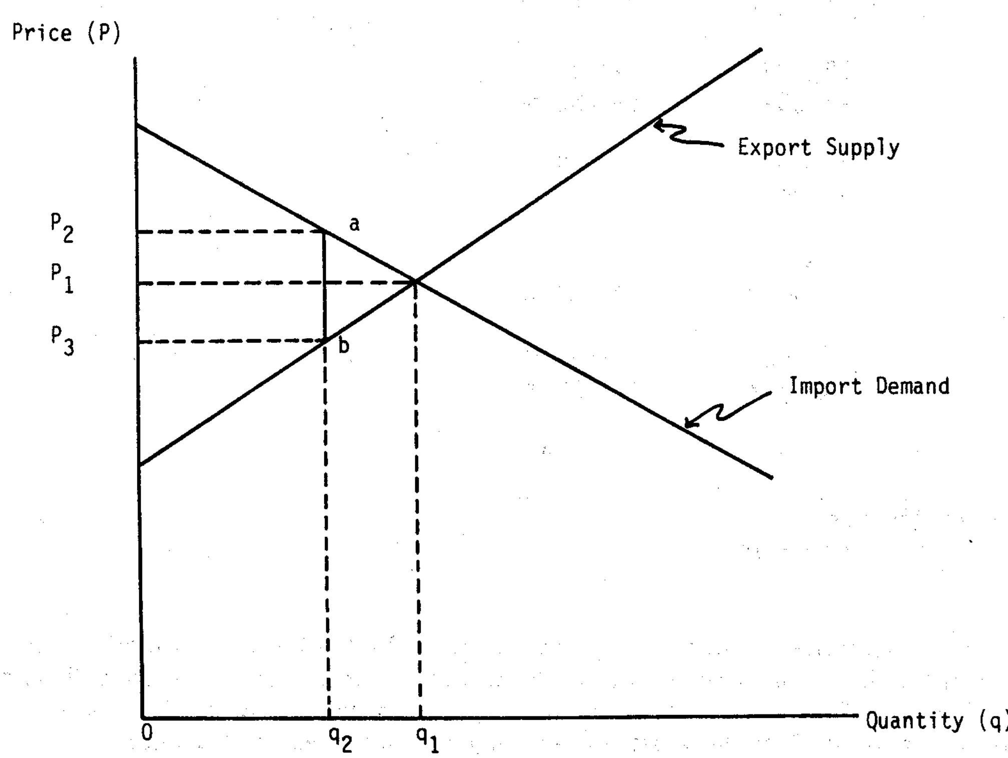


Figure 1. Two Region Spatial Equilibrium Model

SOURCE: Tomek, W.G. and Robinson, K.L., Agricultural Product Prices second edition, pg. 159.

depicted by line ab. The volume of goods traded would decline as transportation costs increase. No goods would be traded if the transfer costs exceed price differences between producing and consuming regions. If transportation costs are the vertical distance ab per unit, q_2 units would be traded between the producing and the consuming regions. This information allows the determination of prices that could be expected to prevail in each region (P_2 in importing region and P_3 in exporting region). Transportation costs are important in determining wheat exports and market share because wheat is widely accepted as a food grain in the world and wheat exporting countries are dispersed in all corners of the globe.

Predicted and actual values for market share and export quantity of wheat for models can be seen in figures 2 and 3. The predicted values are much smoother than the actual values because the model contains resource endowment variables which do not frequently change over time. As shown in the figures, the predicted values represent the long-run trend very well.

Elasticities are calculated for the variables included in the export quantity and market share models and presented in Table 2. Elasticities are near unity for all variables except the distance variable which, is -.34 for the export quantity model and -.22 for the market share model. For example, the elasticity for the labor variable in the export quantity is 1.27, meaning a 1 percent increase in the labor force in a particular country leads to an increase in wheat exports by 1.27 percent.

TABLE 2. ELASTICITIES FOR WHEAT MODELS

Model	Variable	Wheat
Export Quantity	Land	1.13
	Labor	1.27
	Capital	-.92
	Technology	.83
	Distance	-.34
Market Share	Land	1.15
	Labor	1.26
	Capital	-.92
	Technology	.92
	Distance	-.22

Corn Models

Estimated corn models are similar to estimated wheat models (Table 3). The land variable in both corn models is positive in sign, and its t-value indicates that the land variable is significant at the 1 percent level. This means

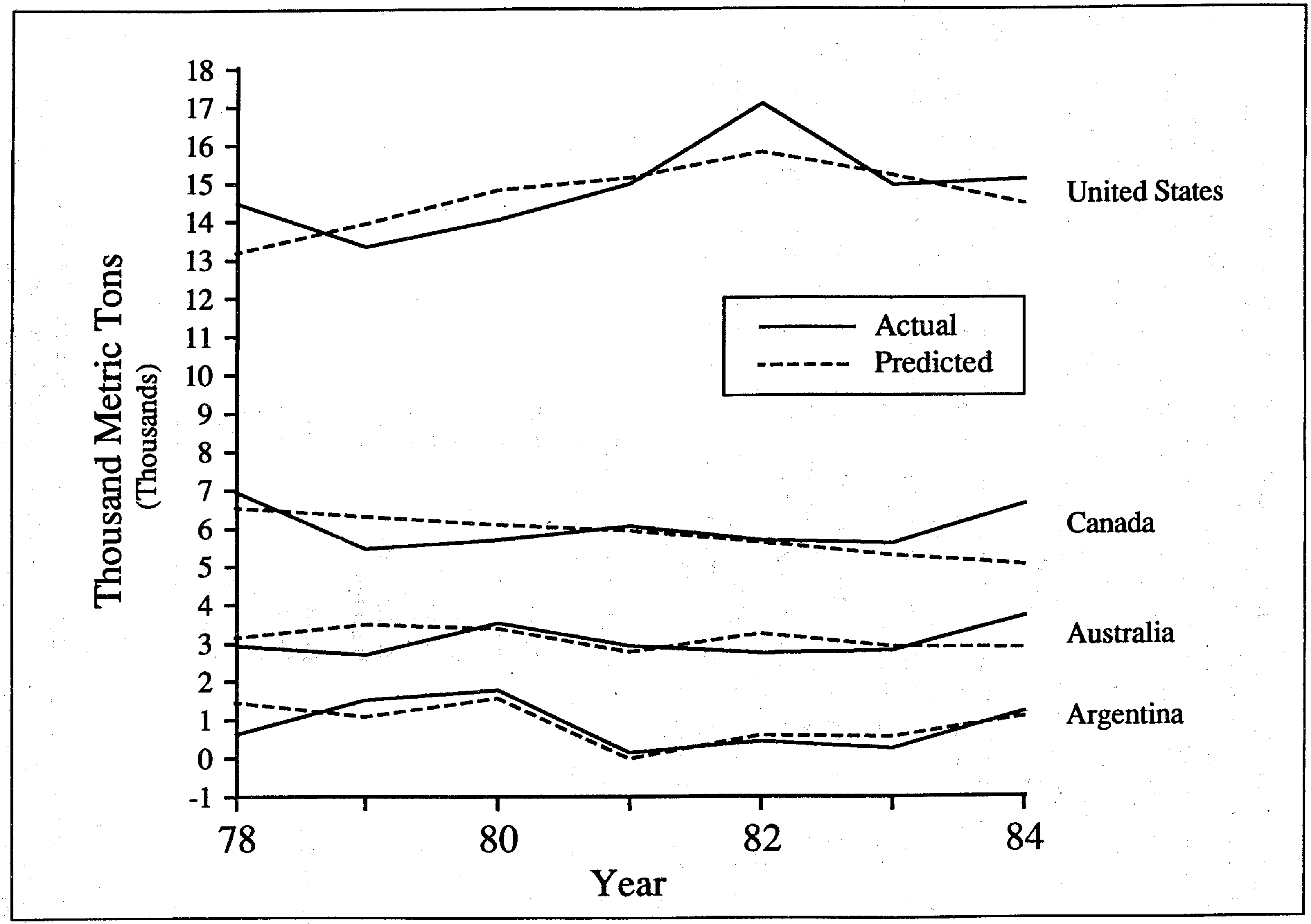


Figure 2. Wheat export quantity model.

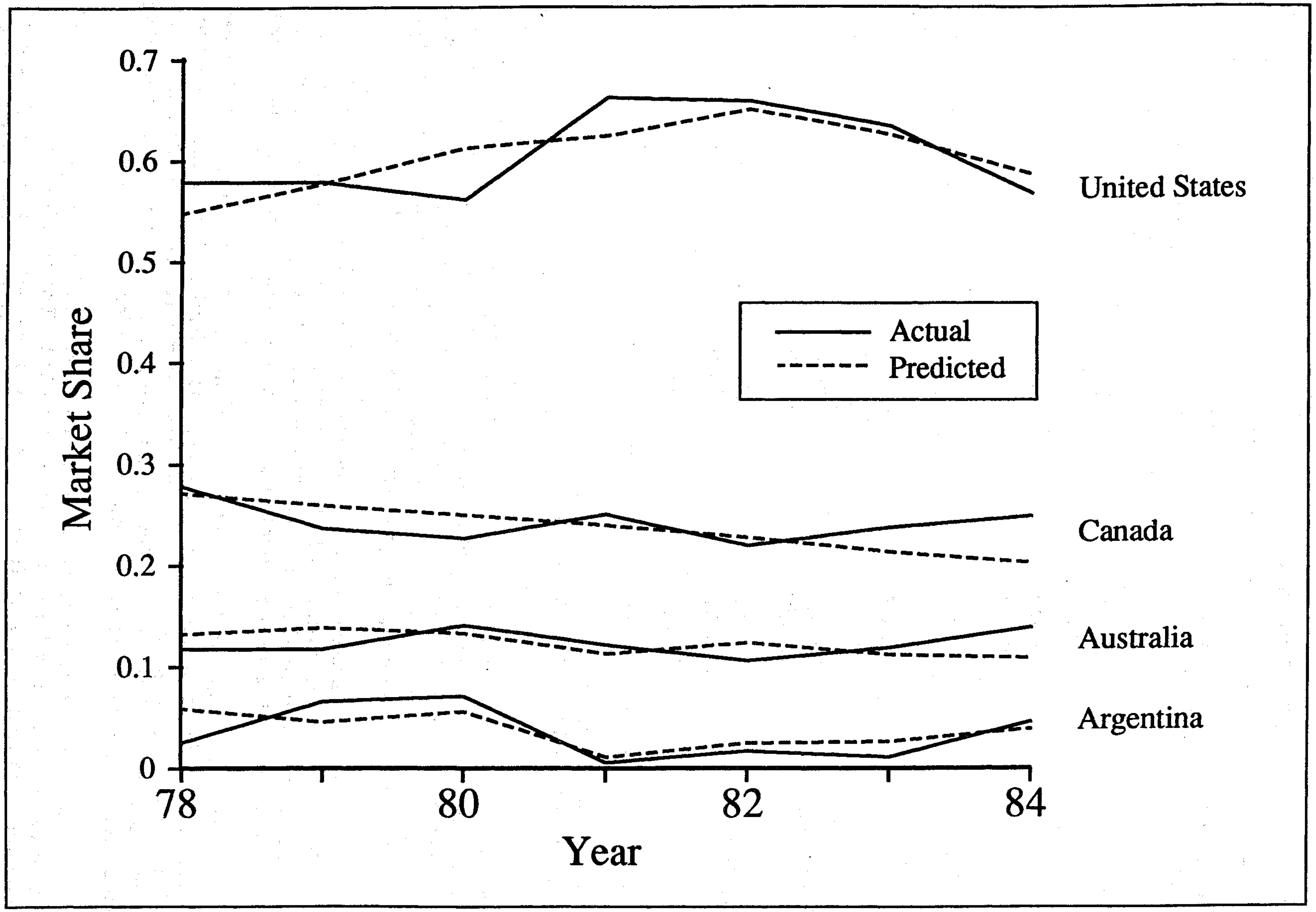


Figure 3. Wheat market share model

TABLE 3. CORN EXPORT MODELS

Independent Variable	Export Quantity	Market Share
Intercept	-12,706 (-3.56)*	-.210 (-3.72)*
Land	35,240 (4.94)*	.688 (4.77)*
Capital	-63,304 (-2.92)*	-.518 (-1.72)
Labor	99,976 (5.15)*	1.74 (5.70)*
Technology	13,917 (2.86)*	.160 (2.13)*
Distance	-.297 (-2.45)*	-.86E-06 (-.220)*
R2	.310	.255

t-values in parentheses
* significant at the 5 percent level.

land is an important resource in determining an exporting country's corn exports and market share and is a major source of comparative advantage in corn exports. A country with a large land endowment with proper soil types and weather conditions may choose to specialize in corn production to maximize this comparative advantage in producing and exporting corn.

The capital variable does not display as high a degree of statistical significance as other variables in the estimated corn models, indicating that corn production is not capital intensive. The variable is significant at the 1 percent level in the export quantity model but not in the market share model.

Labor variables in both models are positive. The t-values indicate that labor is significant at the 1 percent level. This implies that a country endowed with a relatively large amount of labor has a comparative advantage in exporting corn. Exports will be greater for an exporting country with a relatively large labor force than an exporting country with a smaller labor force.

The distance variable representing transportation costs in both models has a negative sign in both models as expected. The t-values indicate distance variable is statistically significant at the 5 percent level for the export quantity model, but it is statistically insignificant for the market share model. This is due mainly to the nature of the transportation variable used in the model, which is almost constant over time.

Estimated and actual values for export quantity and market share of corn based on the estimated models can be seen in figures 4 and 5. The predicted values generally represent the long-run trend of the actual values of corn very well except for quantity exported and market share of corn in Argentina. The differences between the predicted and actual values in Argentina are much larger than those in other exporting countries, mainly because Argentina's corn production has been unstable in the time period.

The R^2 for corn models is similar in value to those calculated for wheat. R^2 is .310 for the export quantity model and .255 for the market share model.

Elasticities are calculated for the variables included in both corn models and are presented in Table 4. Elasticities range from 2.03 for the labor variable in the export quantity model to .02 for the distance variable in the market share model. This indicates a wider variety of response of the dependent variable to changes in the independent variables.

TABLE 4. ELASTICITIES FOR CORN MODELS

Model	Variable	Corn
Export Quantity	Land	.85
	Labor	2.03
	Capital	-1.48
	Technology	1.29
	Distance	-.15
Market Share	Land	.57
	Labor	1.22
	Capital	-.42
	Technology	.51
	Distance	-.02

Soybean Models

Soybean models are the same as those for corn and wheat. The only difference is exclusion of the distance variable in the soybean model.

The distance variable is eliminated in the soybean model because soybean production is concentrated in North and South America, suggesting that transportation costs do not play an important role in determining trade patterns of soybeans. Most variables are statistically significant at the 5 percent level as indicated by their t-values. The estimated models are presented in Table 5.

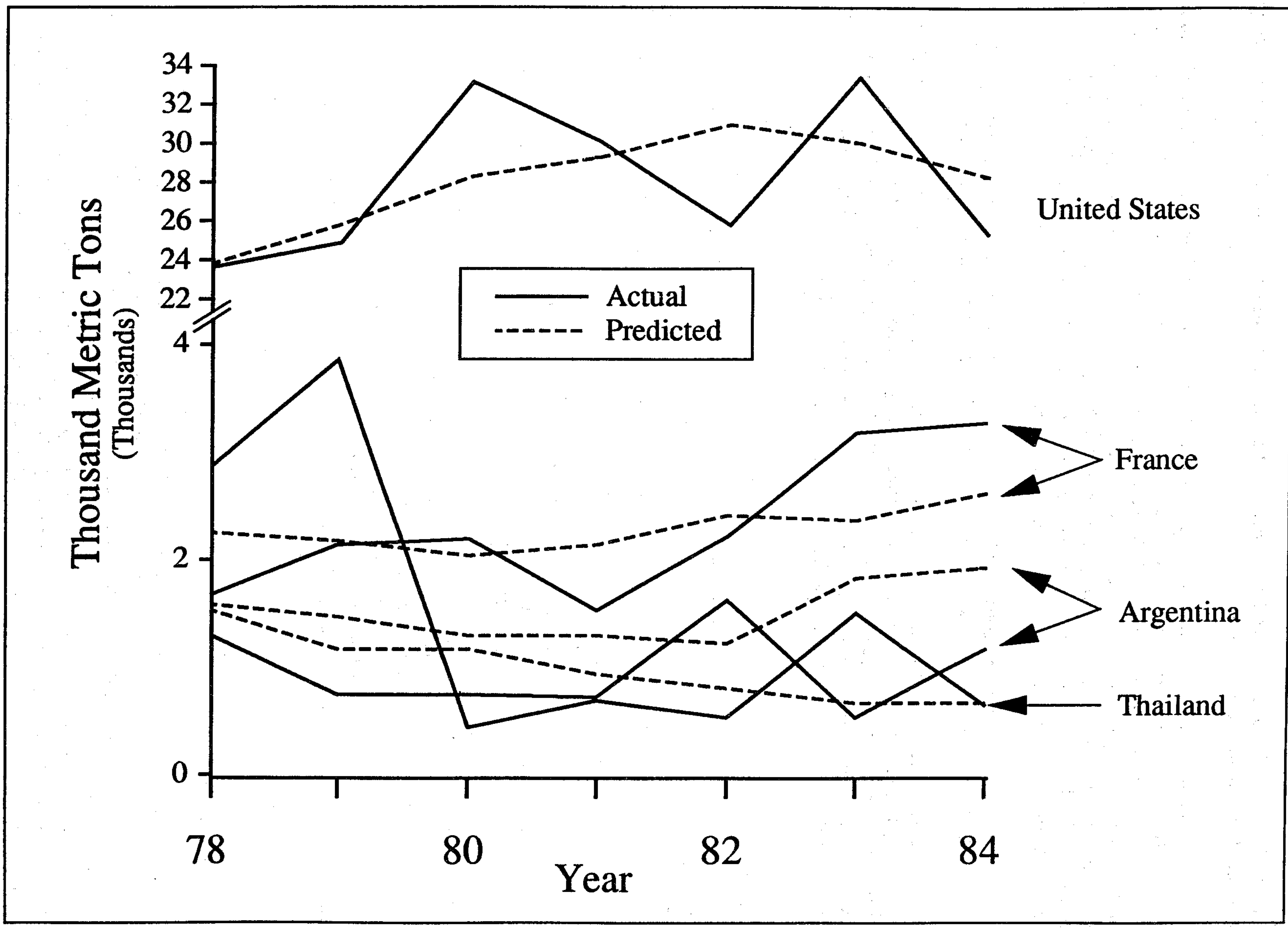


Figure 4. Corn export quantity model

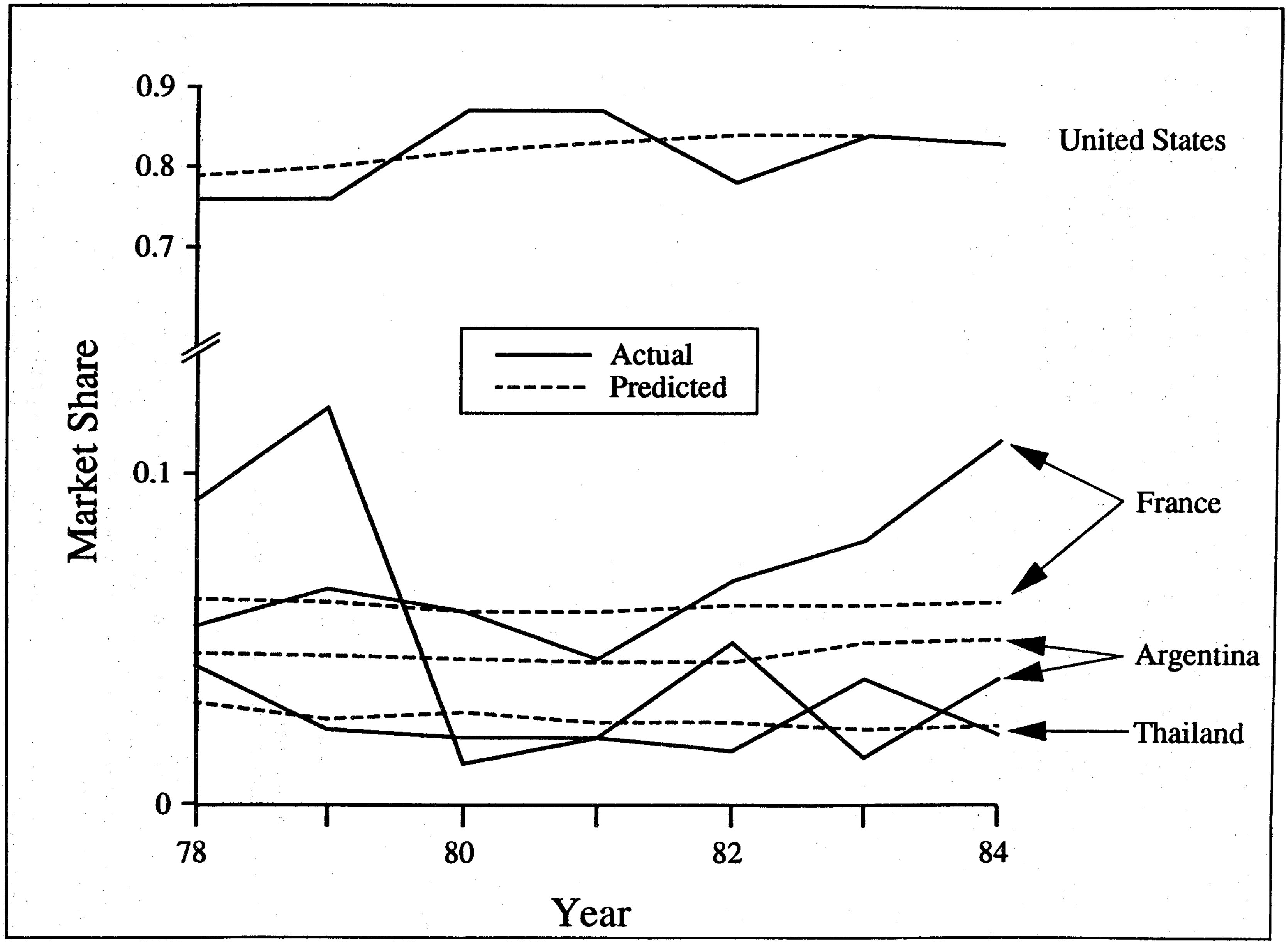


Figure 5. Corn market share model

The land variable is positive in sign for both models. The t-values indicate that land is important in the production and export of soybeans in both quantity and market share values. Generally, the more land an exporting country has the more it is capable of exporting soybeans assuming it chooses to specialize in soybean production and has the proper producing conditions with respect to weather and soil type.

The capital variable is negative in sign, and the t-values for capital variables indicate that capital is significant above the 5 percent level for both models. The negative sign on the estimated parameters indicates that capital probably does not play as significant a role as other factors of production such as land and labor in the explanation of soybean trade because soybean production is more labor and land intensive than capital intensive.

TABLE 5. SOYBEAN EXPORT MODELS

Independent Variable	Export Quantity	Market Share
Intercept	442 (.060)	.227 (.605)
Land	44,110 (3.75)*	1.78 (5.07)*
Capital	-63,199 (-2.44)*	-1.92 (-3.67)*
Labor	56,357 (3.31)*	1.76 (4.41)*
Technology	-8,328 (-1.10)	-.497 (-1.33)
R^2	.352	.451

t-values in parenthesis
* indicates significant at the 5 percent level.

The labor variable is positive in sign in both estimated soybean models and the t-values indicate that labor is significant at the 1 percent level in all models. This means that soybean production is labor intensive relative to other nonagricultural industries and it may play a significant part in determining soybean trade.

The farming technology variable is negative in both soybean models and is statistically insignificant. This is mainly because farming technology in soybean production has not changed in the given time period.

Estimated and actual values for export quantity and market share of soybean models can be seen in figures 6 and 7. The predicted values (dotted line) represent the long-run trend of export volume and market shares of soybean in exporting countries. The predicted line is much smoother than the actual one, mainly because the model contains only resource endowment variables which do not frequently change over time.

Elasticities are calculated for the variables included in the soybean models and are presented in Table 6. Elasticities for all variables in both models are greater than unity indicating response of the dependent variables to changes in the independent variables can be termed elastic in nature.

TABLE 6. ELASTICITIES FOR SOYBEAN MODELS

Model	Variable	Soybean
Export Quantity	Land	2.16
	Labor	1.79
	Capital	-1.76
	Technology	-1.25
Market Share	Land	1.83
	Labor	1.16
	Capital	-1.18
	Technology	-1.55

Summary and Conclusions

This study evaluates competitive advantage in exporting wheat, corn, and soybeans among exporting countries. The exporting countries included are the United States, Argentina, Canada, and Australia for wheat; the United States, France, Thailand, and Argentina for corn; and the United States, Brazil, and Argentina for soybeans.

The specific objectives are to investigate the impacts of resource endowments on agricultural exports in exporting countries and these countries' market shares of wheat, corn, and soybeans in the world market.

The theoretical model was based on the theory of comparative advantage as explained by the Heckscher-Ohlin theorem, which says that a country's net exports are a linear function of its resource endowments. The model based on sample countries analyzes export quantity and market share for each crop on the basis of resource endowments in these countries.

The wheat and corn models include resource endowment variables (land, labor, and capital technology) as well as transportation distance. The soybean model differed from the wheat and corn models in that transportation distance was excluded.

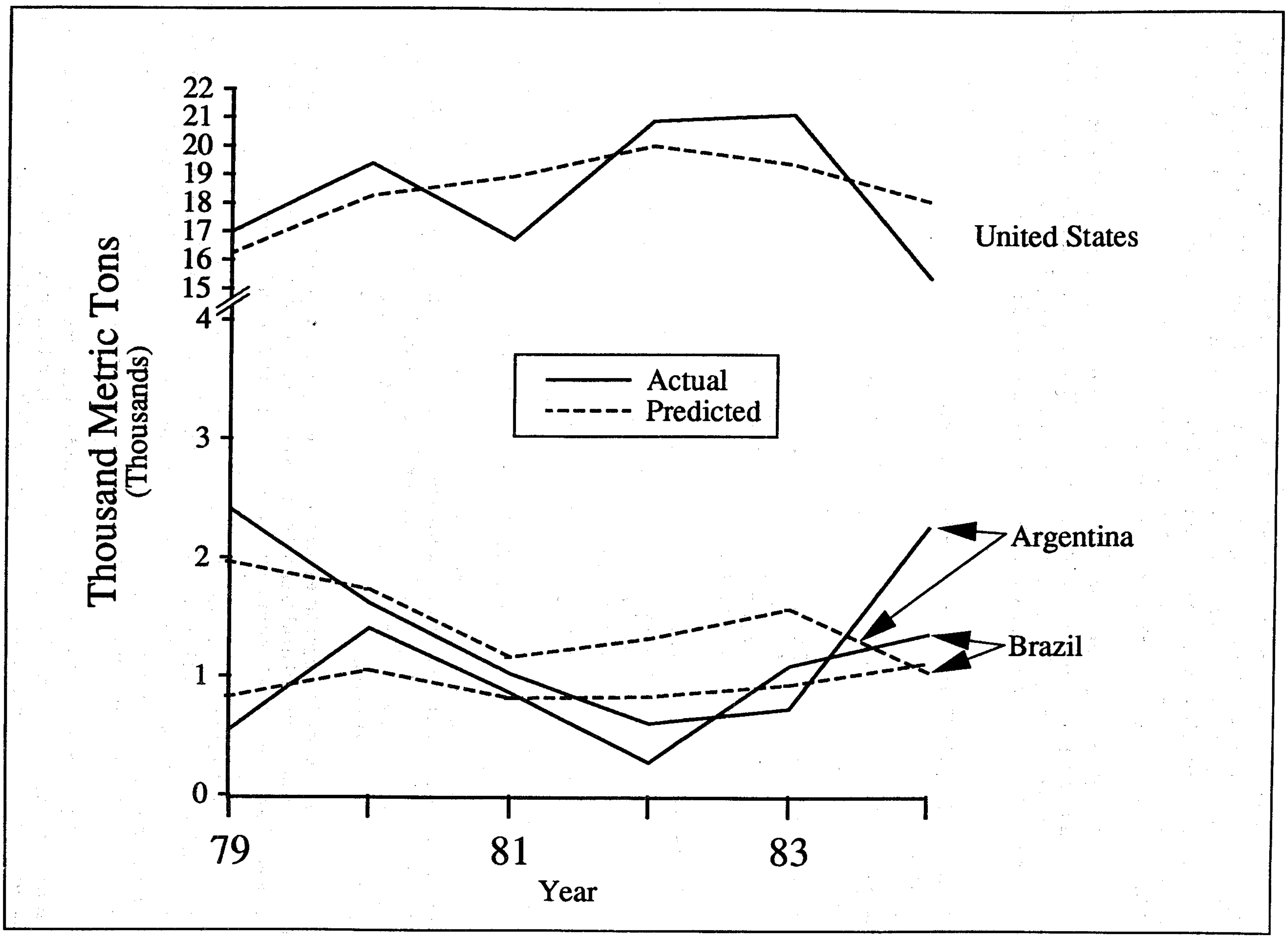


Figure 6. Soybean export quantity model

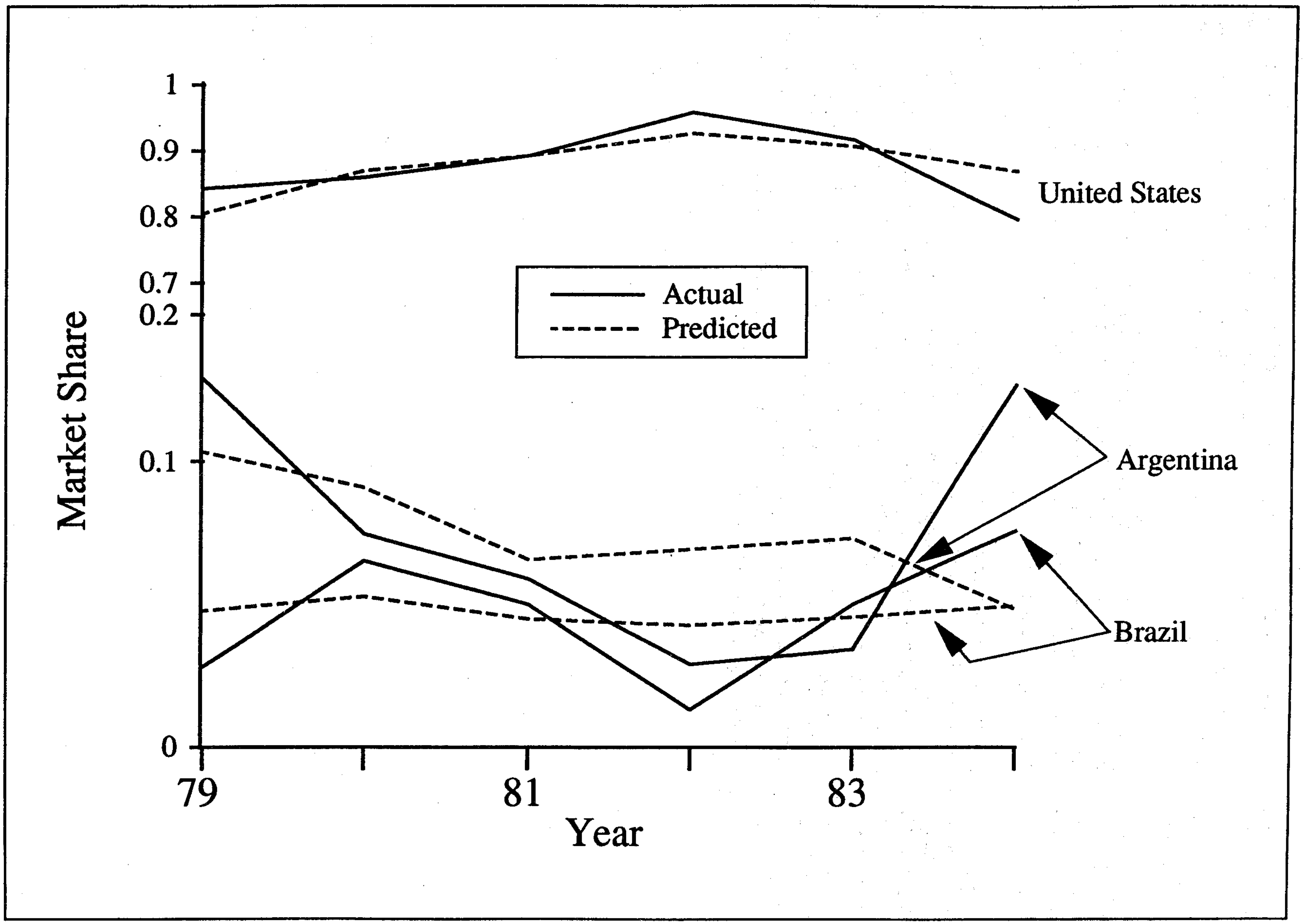


Figure 7. Soybean market share model

The models are estimated by using a pooling technique of cross section and time series data. Heteroskedasticity associated with cross section data and serial correlation associated with time series data are corrected in all models by using Park's estimation procedure, which is equivalent to maximum likelihood estimation.

The estimated models have low R^2s ranging between .24 and .45. The t-values, however, indicate that most variables are significant at the 5 percent level. This implies that due to the nature of the endowment variables which do not change dramatically over time, the model explain only long-run trends of exports for exporting countries.

Long-run trade patterns and exporting countries' market share are determined somewhat by resource endowments and technology. Land, labor, capital, and technology play an important role in agricultural trade, which implies that the Heckscher-Ohlin theorem is working to some extent for agricultural products in the presence of heavy trade restrictions. This implies that the United States could expand its market shares of wheat, corn, and soybeans under free trade because resources such as land and farming technology are more abundant in the United States than in other countries. The transportation system is found to be a very important factor in determining market shares of wheat and corn. This is another factor benefiting the United States in exporting agricultural products under free trade.

References

Balassa, Bela, "Comparative Advantage in Manufactured Goods: A Reappraisal," Review of Economics and Statistics, May 1986, pp. 315-319.

Bowen, H. P., "Changes in the International Distribution of Resources and Their Impacts on U.S. Comparative Advantage," Review of Economics and Statistics, Vol. 65, 1983, pp. 402-414.

Food and Agriculture Organization of the United Nations, Production Yearbook, Rome, Various Issues.

Hufbauer, G.C., "The Impact of National Characteristics and Technology on the Commodity Composition of Trade in Manufactured Goods," Technology Factor in Intermediate Trade, ed. R. Vernon, New York: Columbia University Press, 1970, pp. 145-231.

International Monetary Fund, International Financial Statistics Supplement on Exchange Rates, 1985.

International Monetary Fund, International Financial Statistics Supplement on Output Statistics, 1984.

International Wheat Council, World Wheat Statistics, London, Various Issues.

Kreinen, M. E., International Economics: A Policy Approach, Harcourt Brace Jovanovich Inc., New York, 1983.

Leamer, E. E., Sources of International Comparative Advantage: Theory and Evidence, MIT Press, Cambridge, Massachusetts, 1984.

Leontief, Wassily, "Domestic Production and Foreign Trade: Capital Position Re-Examined," American Philosophical Society Proceedings, Vol. 97, 1953, pp. 332-349.

Maskus, K. E., "Evidence on Shifts in the Determinants of the Structure of U.S. Manufacturing Foreign Trade," Review of Economics and Statistics, Vol. 65(2), 1983, pp. 415-422.

Ohlin, Bertil, Interregional and International Trade, Harvard University Press, Cambridge, Massachusetts, 1952.

Pindyck, R. S. and D. L. Rubinfeld, Econometric Models & Economic Forecasts, McGraw-Hill Book Company, New York, 1981.

Ricardo, David, On the Principles of Political Economy and Taxation, E. P. Dutton & Co., New York, 1948.

Swerling, B. C., "Capital Shortage and Labor Surplus in the United States?" Review of Economics and Statistics, 1954, pp. 286-289.

Tomek, T. G. and K. L. Robinson, Agricultural Product Prices, Cornell University Press Ltd., Ithaca, New York, 1980.

United Nations, Yearbook of International Trade Statistics, Vol. 2, New York, Various issues.

United States Defense Mapping Agency, Distance Between Ports, Defense Mapping Agency: Hydrographic/topographic Center, Publication No. 151, 1985.

United States Statistical Reporting Service, "Agricultural Statistics," Various Issues. USDA, Foreign Agriculture Service, Foreign Agriculture Circular, Grains, Various Issues.

United States Foreign Agriculture Service, Foreign Agriculture Circular, Oilseeds and Products, Various Issues.

sds/Koo/Report1
6/20/88