# Soybean Import Demand in Taiwan: Economic Growth and Policy Impacts

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***Working Paper 86-WP 8***
July 1986

## Abstract

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A simultaneous equation model of the soybean sector in Taiwan is developed and estimated. The model integrates domestic supply and demand for soybeans, soymeal, and soyoil, in addition to the livestock market. The impacts of economic growth and policy changes upon the soybean market are evaluated through dynamic simulation analyses.


## Introduction

Taiwan is one of the most important and dynamic growth markets for U.S. soybeans in East Asia. U.S. soybean exports to this area increased from less than 0.1 million metric tons in 1962 to 1.3 million metric tons (6.7 percent of the total U.S. soybean exports) in 1984.

Many intriguing questions surround the past and future growth of soybean import demand in Taiwan. For example, what are the main factors that influence the import demand for soybeans in the natural-resource-poor East Asian economy? To what extent do these factors exert their influence? Will the soybean market continue to expand in the near future as the economy continues to grow? How would policy intervention, such as a domestic soybean support price, affect the soybean market?

The general objective of this study was to develop a quantitative description of the soybean market in Taiwan, and to evaluate the impacts of economic growth and policy intervention upon the import demand for soybeans.

## The Conceptual Model

The conceptual model of the soybean sector for this soybean importing economy is presented in Table 1. Partly for simplicity, and partly because almost all of the soybeans imported to Taiwan are from the United States, a "small country" assumption was adopted in building the model. The regional model specified is a recursive equation system comprised of equations for domestic soybean supply, soybean crushing demand, soybean food demand, soymeal demand, livestock demand, soyoil demand, price linkages, and trade clearance identities. The salient characteristic of this model is that it integrates domestic supply and demand for soybeans, soymeal, and soyoil, in addition to the livestock sector, for the important U.S. soybean market that other studies have often neglected.

## Model Estimation and Validation

Seemingly unrelated regression, or joint generalized least squares, was adopted to estimate the empirical model. The estimation was based upon

Table 1. Conceptual model of the soybean markets in Taiwan

(1) Soybean Acreage = f(deflated soybean support price$^{+}$, lagged soybean acreage$^{+}$, others)

(2) Soybean Crushing Demand = f(deflated soybean crushing ratio$^{+}$, livestock production$^{+}$, others)

(3) Soymeal Demand = f(deflated soymeal retail price$^{-}$, livestock production$^{+}$, others)

(4) Livestock Consumption, per capita = f(real income per capita$^{+}$, weighted livestock real price index$^{-}$, others)

(5) Soybean Food Demand, per capita = f(real income per capita$^{+}$, deflated soybean price$^{-}$, others)

(6) Soyoil Demand, per capita = f(real income per capita$^{+}$, deflated soyoil retail price$^{-}$, others)

**Price Linkages**

(7) Soybean Import Price = f(U.S. soybean export price * exchange rate$^{+}$, others)

(8) Soymeal Retail Price = f(U.S. soymeal export price * exchange rate$^{+}$, others)

(9) Soyoil Retail Price = f(U.S. soyoil export price * exchange rate$^{+}$, others)

**Identities**

(10) Soybean Excess Demand = Soybean Crushing Demand + Soybean Food Demand + Soybean Seeds Demand and Waste + Soybean Net Stock Change - Soybean Acreage * Soybean Yield

(11) Soymeal Excess Demand = Soymeal Demand + Soymeal Net Stock Change - Soybean Crushing Demand * Soymeal Yield

(12) Soyoil Excess Demand = Soyoil Demand + Soyoil Net Stock Change - Soybean Crushing Demand * Soyoil Yield

(13) Livestock Production = Livestock Consumption + Livestock Net Stock Change + Livestock Net Exports

(14) Soybean Crushing Ratio = (Soymeal Retail Price * Soymeal Yield + Soyoil Retail Price * Soyoil Yield)/Soybean Import Price

annual data from 1960 through 1983. The SAS/ETS program was used to perform the calculations. The results of the estimation for the regional model including $R^2$, Durbin Watson statistics (DW), t-ratio, and elasticity values, are presented in Table 2.

The first-order serial correlation coefficient ($\rho$) is also reported in some of the behavioral equations that showed a problem of serial correlation. For those equations, the Cochrane-Orcutt procedure was adopted to correct the first-order serial correlation and to increase their efficiency of estimation. Furthermore, for the equations containing lagged dependent variables, Durbin's h statistics [DW(h)] are reported.

The estimates were quite satisfactory. Behavioral equations generally had high predictability. The estimated directional relationships among variables were consistent with economic expectations. The historical simulation results tracked the endogenous variables' actual data well with reasonably low root-mean-square (rms) percent errors (see Table 3). The Theil statistics also indicated that errors in the simulation were mainly due to disturbances, and that the empirical model contained relevant explanatory variables. In addition, the model was able to duplicate most of the turning points or rapid changes in the actual data. Moreover, the model proved to be stable.

## Conclusions from the Model Estimation

Four major conclusions can be drawn from the estimated results. First, the soybean support price has a positive influence upon domestic soybean acreage in the economy (see Equation 1 in Table 2). The acreage level is, however, inelastic relative to the support price. The soybean acreage of an ensuing crop year is significantly influenced by the acreage planted in a current year. These results indicate a slow soybean production adjustment to changing economic incentives in Taiwan. Therefore, although policymakers in Taiwan have been encouraging domestic soybean production through price supporting policies, it is unlikely that these policies will substantially expand domestic soybean production and influence soybean import demand in the near future.

The multiple-cropping index (MCI), defined as the ratio of total crop area divided by the area of cultivated land, is an indicator of the intensity at which farmland is utilized. The estimated results indicated that the less intensively the farmland was utilized in Taiwan, the fewer the acres of soybeans that were planted. This result can be explained, following Sillers (1983), by noting that soybeans are relatively labor-intensive winter crops planted between the monsoon and the spring rice crop in Taiwan. With relatively low prices for soybeans, an increasing shortage of hired agricultural labor, rising production costs, and good off-farm employment opportunities, cropland is no longer used as intensively as it was before. This has resulted in reduced production of winter crops such as soybeans.

The second major conclusion to be drawn from the estimated results is that domestic livestock production is the most decisive determinant of soybean crushing demand (see Equation 2 in Table 2). The result suggests that growth in the soybean crushing demand keeps pace with the growth of the livestock

Table 2. Structural estimates of the soybean model in Taiwan[a]

Soybean Acreage Equation

(1) BA = -66.752 + 0.756 BAL + 0.5536 BSP + 0.38 MCI + 10.56 DV74
(-4.39) (8.47) (3.03) (3.59) (6.58)
[0.979] [0.101] [1.067]

$R^2$ = 0.992 DW(h) = -2.31

Soybean Crushing Demand Equation

(2) BCD = -113.57 + 0.696 LPR + 58.46 CR + 153.73 DV2
(-2.96)(19.26) (1.93) (6.40)
[0.897] [0.084]

$R^2$ = 0.993 DW = 1.93

Soymeal Demand Equation

(3) MD = 28.76 + 0.558 LPR - 0.601 (MRP/CPI) + 119.43 DV2
(1.05)(23.36) (-2.84) (7.35)
[0.904] [-0.064]

$R^2$ = 0.998 DW = 2.65

Livestock Demand Equation

(4) LDPC = 31.9 - 0.13 LFPI + 0.211 Y
(4.32)(-3.26) (6.30)
[-0.0114] [0.782]

$R^2$ = 0.973 DW = 2.07

Soybean Food Demand Equation

(5) BFDPC = 9.29 - 0.0125 (BIP*EXR/WPI) + 0.061 Y - 1.154 DV74 + 1.74 DV2
(16.98)(-3.15) (1.38) (-4.89) (6.87)
[-0.122] [0.053]

$R^2$ = 0.931 DW = 1.48 $\rho$ = .54

Soyoil Demand Equation

(6) ODPC = -7.05 + 3.74 log(Y) - 0.81 log(ORP/CPI) + 2.08 DV2 - 1.37 DV74
(-1.55) (9.72) (-1.26) (6.21) (-3.34)
[0.673] [-0.165]

$R^2$ = 0.965 DW = 1.59

Price Linkage Equations

(7) BIP = 8.66 + 1.032 USBP - 32.88 DV73 + 41.52 DV3
(1.06)(23.32) (-2.33) (-4.81)
[0.944]

$R^2$ = 0.976 DW = 2.01

(8) MRP = 22.36 + 1.24 (USMP*EXR) + 2589.04 DV1 + 0.194 Lag(BIP*EXR)
(0.12)(22.92) (14.01) (5.41)
[0.800] [0.198]

$R^2$ = 0.996 DW = 2.41

(9) ORP = 1968.14 + 0.793 (USOP*EXR) + 3859.41 DV1 + 1.95 Lag (BIP*EXR)
(0.96) (7.92) (2.87) (8.28)
[0.378] [0.523]

$R^2$ = 0.986 DW = 1.54 $\rho$ = 0.67

Table 2. Structural estimates of the soybean model in Taiwan (continued)

Identities

(10) BIM = BFDPC * POP + BCD - BA * BY + BBL + BSC

(11) MIM = MD - BCD * MY + MBL + MSC

(12) OIM = ODPC * POP - BCD * OY + OBL + OSC

(13) LPR = LDPC * POP + LSC + LEX + ERP

(14) CR = (MRP * MY + ORP * OY)/(BIP * EXR)

[a]Numbers in parentheses ( ) are t-values; numbers in brackets [ ] are elasticities.

Endogenous variables:

BA = Soybean acreage planted, 000 ha
BCD = Soybean crushing demand, 000 MT
BFDPC = Per capita soybean food demand, kg
BIM = Soybean imports, 000 MT
BIP = Soybean import price, $/MT
CR = Soybean crushing ratio
LDPC = Per capita meat demand, kg
LPR = Livestock production, 000 MT
MD = Soymeal demand, 000 MT
MIM = Soymeal imports, 000 MT
MRP = Soymeal retail price, NT$/MT
ODPC = Per capita soyoil demand, kg
OIM = Soyoil imports, 000 MT
ORP = Soyoil retail price, NT$/MT

Exogenous variables:

BAL = Soybean acreage planted in the previous year, 000 ha
BBL = Soybean other uses and waste, 000 MT
BSC = Soybean stock change, 000 MT
BSP = Deflated soybean support price, at constant price of 1976, NT$/kg
BY = Soybean yield, MT/ha
CPI = Consumer price index, 1976 = 100
DV1 = Dummy variable indicating implement of the "uniform import price plan", years since 1977 = 1, other year = 0
DV2 = Dummy variable indicating the removal of soybeans from the import control list, years since 1967 = 1, other years = 0
DV3 = Dummy variable indicating the raise in the base price of the "uniform import price plan", years 1980-1982 = 1, other years = 0
DV73 = Dummy variable for the year 1973 = 1, other years = 0
DV74 = Dummy variable for the year 1974 = 1, other years = 0
EPR = Egg production, 000 MT
EXR = Exchange rate, NT$/US$
LEX = HPAU net exports, 000 MT
LFPI = Ratio of meat price to fish price, 1976 = 100
LSC = Livestock ending-stock changes, 000 MT
MBL = Soymeal other uses and waste, 000 MT
MCI = Multiple-cropping index (total crop area/total cultivated land), %
MSC = Soymeal stock change, 000 MT
MY = Soymeal extraction rate
OBL = Soyoil other uses and waste, 000 MT
OSC = Soyoil stock changes, 000 MT
OY = Soyoil extraccion rate
POP = Population, million
USBP = U.S. soybean export price, $/MT
USOP = U.S. Soyoil export price, $/MT
WPI = Wholesale price index, 1976 = 100
Y = Per capital real income index, 1976 =100

Table 3. Validation statistics for simulation performance

| Variable | Statistics of Fit | | Theil's Forecast Error Measures | | | |
|---|---|---|---|---|---|---|
| | RMS Error | RMS % Error | UM | UR | UD | Accuracy |
| Soyoil Retail Price | 2029.37 | 0.0790 | 0.03 | 0.17 | 0.80 | 0.0000 |
| Soymeal Retail Price | 279.57 | 0.0283 | 0.00 | 0.11 | 0.89 | 0.0000 |
| Soybean Import Price | 13.16 | 0.0556 | 0.00 | 0.00 | 1.00 | 0.0003 |
| Livestock Demand (per capita) | 1.89 | 0.0838 | 0.01 | 0.37 | 0.63 | 2.4049 |
| Soybean Acreage | 1.25 | 0.0547 | 0.00 | 0.07 | 0.93 | 0.0011 |
| Soyoil Demand (per capita) | 0.48 | 0.0811 | 0.02 | 0.12 | 0.86 | 13.8345 |
| Livestock Production | 26.50 | 0.0773 | 0.01 | 0.23 | 0.76 | 0.0001 |
| Soybean Food Demand (per capita) | 0.31 | 0.0318 | 0.01 | 0.00 | 0.99 | 3.2257 |
| Soybean Crushing Ratio | 0.10 | 0.0656 | 0.00 | 0.18 | 0.82 | 0.0430 |
| Soymeal Demand | 24.64 | 0.1513 | 0.01 | 0.00 | 0.99 | 0.0002 |
| Soybean Crushing Demand | 38.79 | 0.1695 | 0.01 | 0.00 | 0.99 | 0.0002 |
| Soyoil Import Demand | 6.55 | 373,824[a] | 0.00 | 0.47 | 0.53 | 0.6541 |
| Soymeal Import Demand | 11.03 | 948,995[a] | 0.62 | 0.38 | 0.00 | 0.0664 |
| Soybean Import Demand | 40.70 | 0.2317 | 0.01 | 0.00 | 0.98 | 0.0002 |

[a]Due to relatively big fluctuations and small quantities

sector. Consequently, policies encouraging domestic livestock production, such as import controls on livestock products, will increase domestic soybean crushing demand and import demand in Taiwan.

Third, although soymeal demand is very inelastic relative to its own price, it is influenced primarily by domestic livestock production (see Equation 3 in Table 2). These findings imply both that soymeal is an essential ingredient of formula feed for livestock, and that changes in soymeal price will not influence the demand greatly. This can be explained, following Coyle (1983), by noting that corn, sorghum, barley, and brans have been the principal price-dependent elements in formula feed production. Soymeal is treated as an ingredient that supplies the balance of protein and total digestible nutrients (TDN) not provided by the price-dependent ingredients and, therefore, it is less price dependent.

Fourth, per capita real income and the relative price of meat to fish are the major factors influencing per capita meat demand (see Equation 4 in Table 2). If domestic livestock production is defined as the sum of total domestic meat consumption, changes in livestock ending stocks, net meat exports, and egg production, then it is the most important factor influencing soybean crushing demand and soymeal demand. Therefore, income and population growth have important influences upon demand for soybeans and soymeal. These results indicate that per capita real income and population growth have been the major factors facilitating the rapid growth of the soybean import market. As the economy continues to grow in the near future, the soybean import market is likely to continue to expand because of the demand potential of a large affluent population for meat and the limited potential for soybean production in Taiwan.

## The Impacts of Economic Growth and Policy Intervention

To evaluate the impacts of economic growth and policy changes upon this soybean market, exogenous changes were hypothesized, individually, to perform dynamic simulation analyses using the established model. The hypothetical changes, which were assumed to have been introduced since 1975, included devaluation of domestic currency, increase in soybean support price, technolgical improvements in the domestic soybean crushing process, and increases in net livestock exports.

After adjustment for each policy change, the dynamic simulation was repeated for the period 1975 to 1983 was repeated. The differences between the new simulation results and the base simulation results represented the impacts of each policy change upon the endogenous variables. The average percentage impacts of different policies upon several endogenous variables are summarized in Table 4. In addition, population and per capita real income in the economy were, individually, assumed to be fixed as of 1970 in order to measure the impacts of economic growth on the soybean market. The differences between the new simulation results and the base simulation results of the last period (1983) indicated the impacts of population growth and per capita real income growth since 1970. These results are also reported in Table 4.

Table 4. Relative impacts of economic growth and of different policies on several variables

| Variable | Simulation Base: Averaged Value Since 1975 | Simulation Base: Last Period 1983 | 10 Percent Devaluation | 10 Percent Increase In Soybean Support Price | 10 Percent Increase In Soybean Crushing Ratio | 10 percent Increase In Livestock Net Exports | Population Growth Effect Since 1970 | Per Capita Real Income Growth Effect Since 1970 |
|---|---|---|---|---|---|---|---|---|
| Soybean Acreage | 21,680 ha | 4,780 ha | -- | 16.54 | -- | -- | -- | -- |
| Soybean Crushing Demand | 809,340 MT | 1,016,510 MT | -0.19 | -- | 1.25 | 0.14 | 14.92 | 22.45 |
| Soybean Food Demand (per capita) | 10,706 kg | 11.01 kg | -0.98 | -- | -- | -- | -- | 4.58 |
| Soybean Import Demand | 992,770 MT | 1,349,040 MT | -0.35 | -0.28 | 1.03 | 0.12 | 14.55 | 17.62 |
| Soymeal Demand | 641,440 MT | 809,917 MT | -0.79 | -- | -- | 0.14 | 14.99 | 22.57 |
| Soymeal Import Demand[a] | 6,720 MT | 16,868 MT | -3,753 MT | -- | -72,005 MT | 17 MT | 3,153 MT | 4,746 MT |
| Soyoil Demand (per capita) | 8.27 kg | 9.25 kg | -0.78 | -- | -- | -- | -- | 33.27 |
| Soyoil Import Demand[a] | -901 MT | -9,371 MT | -867 MT | -- | -16,447 MT | -191 MT | 10,280 MT | 16,637 MT |
| Meat Demand (per capita) | 46.51 kg | 53.67 kg | -- | -- | -- | -- | -- | 32.60 |
| Livestock Production | 991,810 MT | 1,281,190 MT | -- | -- | -- | 0.16 | 16.99 | 25.58 |

[a] Impacts upon soymeal imports and soyoil imports are reported in quantity changed; the other impacts are in percentage changed.

## Conclusions from the Impact Analysis

These simulations of growth and policy impacts, lead to three interesting conclusions. First, growth factors had greater impacts than policy factors had upon soybean import demand. This can be explained by the fact that population and income growth stimulate growth in the livestock sector, which in turn is the major factor causing growth in soymeal demand and soybean crushing demand. As a result, growth factors have an important influence upon soybean import demand in Taiwan. On the other hand, because domestic soybean production is relatively small compared with the total soybean demand, and because the supply elasticity is low with respect to the support price, agricultural production policies usually have only limited effects on domestic soybean production and soybean import demand. Moreover, the elasticities of the demand for soybeans and their products with respect to their own prices are generally low. Therefore, policies such as devaluation in domestic currency that influence domestic prices of soybeans and their products cannot have much influence upon soybean import demand.

Second, technological improvement in the soybean crushing process would increase soybean import demand but decrease soymeal and soyoil import demand. This result suggests that policies augmenting the profitability of the soybean crushing industry will raise soybean crushing demand and import demand and make formula feed producers less dependent upon soymeal imports.

Third, an increase in net livestock exports would increase soybean import demand. Therefore, policies stimulating livestock exports or restricting livestock imports, given fixed domestic demand, will increase domestic livestock production and cause soybean demand to rise.

## Summary and Conclusions

This study has provided important information about the soybean market in Taiwan. The regional model integrating domestic supply and demand for soybeans, soymeal, soyoil, and the livestock sector was developed and estimated to give a quantitative description of the soybean market. The impacts of economic growth and policy changes upon the soybean market were evaluated through dynamic simulations to illustrate the effectiveness of economic growth and different exogenous interventions.

Policymakers, producers, consumers, traders, and researchers in Taiwan, the United States, and other countries can utilize the results of this study for the following purposes: (1) to enrich their understanding of the soybean market in Taiwan and to extend this understanding to other potential Asian markets; (2) to project and plan future supply and demand for soybeans, soybean products, and livestock products, and (3) to help decide upon proper policies in production, consumption, and trade.

One should, however, be aware of the limitations of this study while applying its results. Although the study has quantified the relative impacts of the final results of policy interventions upon soybean markets, the feasibilities and the costs of implementing those policies have not been discussed. Moreover, the relative effectiveness of various policy interventions does not represent the relative "importance" of these policies

to decision makers. For example, even though a 10 percent change in domestic soybean support price may not influence the soybean market substantially, the price policy may still be an important policy for achieving other objectives, such as increasing the farm income.

Therefore, the results of the current research cannot be applied directly without taking into account the goals and objectives of particular policies, as well as the costs and the feasibility of implementing such policies.

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