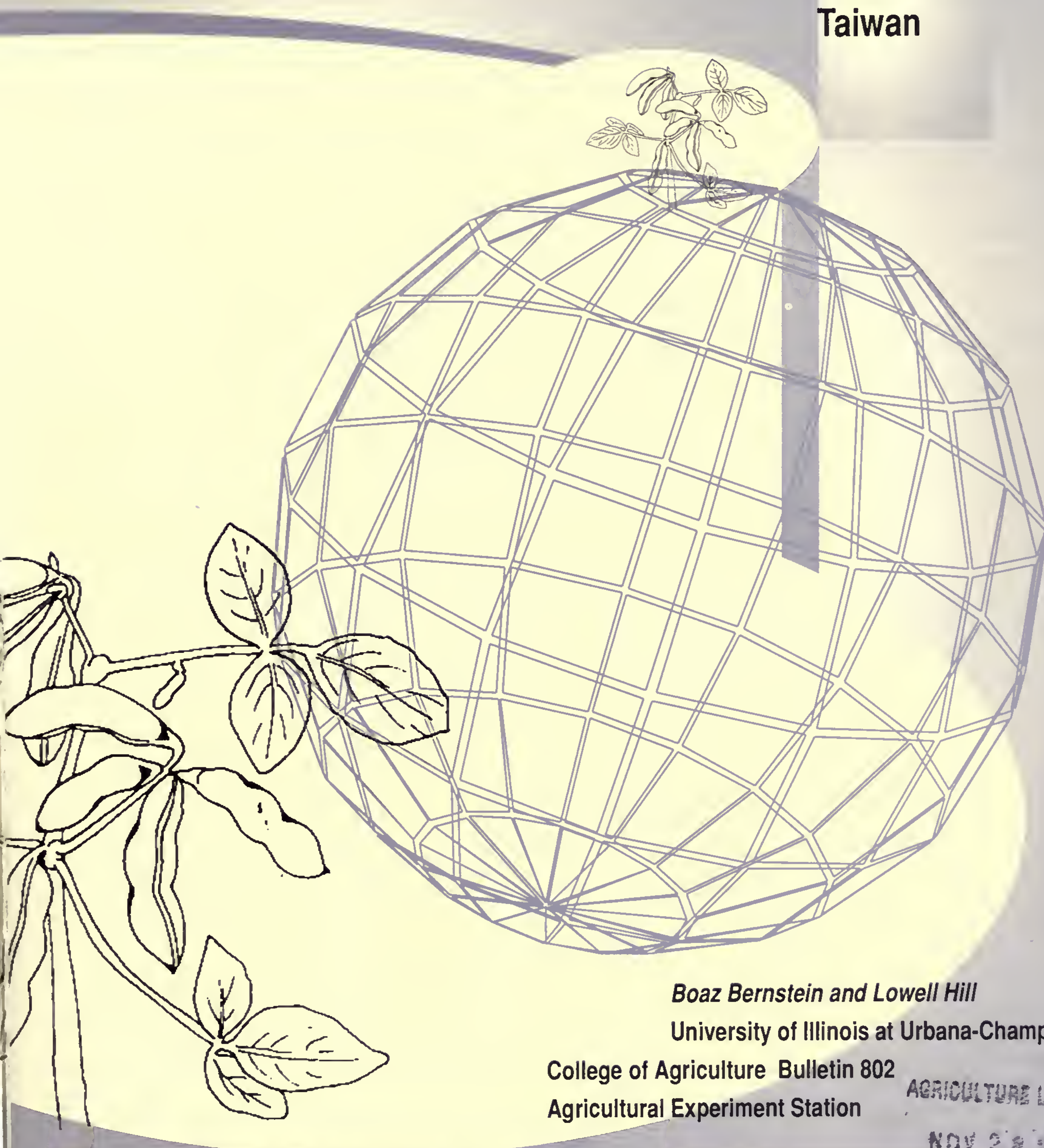
The Impact of Economic Growth and Policy Intervention Upon Import Demand for Soybeans in Taiwan



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Introduction

The extensive literature on soybean and soybean products testifies to the importance of this crop for meeting the world's protein requirements. Many researchers familiar with this literature refer to the soybean as the "golden" or "miracle" bean. Soybeans have also become increasingly important to U.S. agriculture, accounting for 10.5 percent of U.S. agricultural exports in 1965 and for about 15.1 percent of these exports in the 1980s (Table 1).

Exports of soybeans grew faster than exports of any other U.S farm products until the early 1980s. This growth reflected the fact that between 1965 and 1969, U.S. soybean exports accounted for over 85 percent of world soybean exports in dollar value. In the 1970s, soybean exports held a record 17.4 percent share of the total value of U.S agricultural exports. The United States had its largest share — 93.4 percent — of world soybean exports in 1970. The early 1980s, however, brought a reversal in their growth trend: U.S. soybean exports fell from $5.9 billion in 1980, to about $3.64 billion in 1988. Since the early 1970s, therefore, the United States has lost ground in the world soybean market. Although its share dropped to 67.4 percent in 1988, the United States is still the world's largest producer and exporter of the miracle bean (4).

The slow growth of farm exports since the early 1980s adversely affected U.S. farm income; therefore, policymakers who wanted to expand exports and regain past export market shares were forced to reconsider the direction of their international agricultural policies. U.S. efforts to increase exports of feedgrains and soybean products will be aided by the rapid growth in foreign demand for meat and livestock products, especially in Asian countries.

Despite growing awareness of the many uses of the remarkably versatile soybean, production is not keeping pace with the growth in demand for soybeans in most countries in the tropical zone. The rapid increase in the domestic livestock industry and the growth in poultry and egg production in these countries, moreover, will further enhance the average level of soybeans used as feed. Because soybeans have considerable potential as a low-cost source of

Table 1. Value of U.S Soybean Exports, 1965 to 1988

Year	U.S. agricultural exports	U.S. soybean exports	Soybean's share of U.S. exports	World soybean exports	U.S. share of world soybean export value
	million dollars		*percent*	*million dollars*	*percent*
1965	6,201	650	10.5	749	86.8
1965 to 1969[a]	6,223	762	12.2	862	88.4
1970	6,958	1,216	17.4	1,300	93.5
1970 to 1974	11,940	2,069	17.3	2,413	85.7
1975	21,817	2,865	13.1	3,688	77.7
1975 to 1979	25,560	4,299	16.8	5,254	81.8
1980	40,481	5,883	14.5	7,103	82.8
1980 to 1984	39,230	5,937	15.1	7,106	83.5
1985	31,187	3,749	12.0	7,105	52.8
1986	28,148	4,334	15.4	5,593	77.5
1987	27,726	3,898	14.1	5,005	77.9
1988	26,640	3,640	13.7	5,400	67.4

Source: *USDA, ERS, Foreign Agricultural Trade of the United States by Commodities,* Various Issues. FAO, *Trade Year Book,* Various issues.
[a] Average values have been calculated for 1965 to 1969 and the other five-year periods in this table.

protein in this zone, both for human consumption and animal feed, more efforts must be made to examine the main factors and trading rules that will facilitate future growth of soybean import demand in the economies of tropical countries.

This study will focus on Taiwan, one of the fastest-growing countries in Asia, and its potential as a soybean market. It will evaluate the main causes for the rapid growth in import demand for soybeans as well as their impact on the soybean sector and on soybean import demand. It will also explore the role of government intervention and trade policies in the development of the soybean market.

Over the past thirty years, Taiwan has achieved an impressive record of economic development and has been moving gradually toward more open trade. The movement of Taiwan's economy toward open trade and investment policies promotes exports — the lifeblood of Taiwan's industrialization. As a result, living standards in Taiwan have greatly improved, and the Taiwanese have been shifting their diets from starch and fiber-based food to protein. For example, per capita daily consumption of nutrients increased from 2,078 to 2,969 calories, and protein intake jumped from 49.04 to 85.4 grams between 1955 and 1986 (2).

The ability to enhance the supply and consumption of soybeans in this fast-growing market is extremely important both for the future welfare of the Taiwanese society as well as for increasing international trade in agricultural products.

During its present phase of economic development, Taiwan has become one of the most important and dynamic growth markets for U.S. soybeans in East Asia. Increasing soybean exports to Taiwan is part of ongoing U.S. efforts to be more competitive in agricultural exports. Soybean imports into Taiwan increased from less than 0.1 million metric tons (mmt) in 1962, to 1.4 mmt in 1984. In 1988, Taiwan imported 2.02 mmt, and imports for 1990 are forecasted at 2.67 mmt (18). Taiwan's market accounts for almost 30 percent of the total Asian market and for about 10 percent of total U.S exports.

Will import demand for soybeans from the United States keep increasing with Taiwan's future economic growth? What will be the role of the livestock sector and increasing pork exports to Japan? Have growth factors in Taiwan's economy had a greater impact on its soybean imports than policy factors? To answer these questions, this study briefly describes Taiwan's agricultural economy and uses econometric models to estimate the importance of various economic and policy factors perceived to influence soybean import demand in Taiwan.

General Economic Indicators

National Income Trends. Asian countries bordering on the Pacific basin have recently made headlines in the world of finance. The economic growth achieved by Taiwan during the past 30 years is a remarkable example of an outstanding performance among the developing countries. It achieved an incredible increase in real income per capita from $NT 33,680 (new Taiwanese dollars) in 1966 to $NT 151,373 in 1988 in spite of the fact that it almost doubled its population during the same period (Table 2). The average annual growth rate of the Gross National Product (GNP) between 1966 and 1988 was 9.24 percent (11). This record is all the more remarkable in view of the fact that the 13,900 square miles of this small island are very densely populated and poorly endowed with natural resources. Between 1966 and 1986, the economy was transformed from a predominantly agricultural to a manufacturing and services-based one, while keeping its foreign debt very low and improving its distribution of income (1,12).

Although agriculture was the main support of the economy, manufacturing and exports have become the primary engines of economic growth in recent years. In this context, Taiwan provides a good example of an economy following its comparative advantage and acquiring the gains from trade as noted by the traditional theory of international trade. Houck (6) defines the principle of comparative advantage as the differing ability of nations to alter and specialize their mix of outputs by shifting resources internally. Relying upon its abundant labor resources, Taiwan sends exports to less developed countries requiring low intensity with respect to capital and skill; to developed countries, it exports relatively labor-intensive light manufacturing goods.

Bilateral Trade Between Taiwan and the United States. Taiwan's economy is currently fueled by foreign trade on the demand side and manufacturing on the supply side. In 1987, exports accounted for 60 percent of its GNP; imports accounted for 40 percent. Almost all exports are manufactured goods, and the manufacturing sector accounted for 42 percent of the GNP (3). Between 1965 and 1988, exports of goods and services rose at an average annual rate of 24.3 percent; imports, 22.8 percent (Table 3).

Taiwan maintained a sizable surplus in its trade balance during most of the 1970s, except for the year 1974-1975, when the economy slid into a depression following the two oil shocks and the associated boom in commodity prices.

Table 2. Country GNP, Population, and Growth Rate, 1966 to 1988

Year	GNP[a]	Growth rate	Population	Growth rate	GNP per capita[a]	Growth rate
	NT$	*percent*	*thousands*	*percent*	*$NT*	*percent*
1966	474.4	9.0	12,993	2.9	33,680	6.1
1967	494.6	10.6	13,297	2.3	36,325	7.9
1968	539.5	9.1	13,650	2.6	38,689	6.5
1969	588.1	9.0	14,335	5.0	41,226	6.6
1970	654.3	11.3	14,676	2.4	44,926	9.0
1971	738.7	12.9	14,995	2.2	49,695	10.6
1972	837.0	13.3	15,289	2.0	55,278	11.2
1973	944.3	12.8	15,665	1.8	61,212	10.7
1974	954.9	1.1	15,852	1.8	60,788	−0.7
1975	995.7	4.3	16,150	1.9	62,228	2.4
1976	1130.0	13.5	16,508	2.2	69,204	11.2
1977	1243.6	10.1	16,813	1.8	74,642	7.9
1978	1416.5	13.9	17,136	1.9	83,452	11.8
1979	1536.4	8.5	17,479	2.0	88,768	6.4
1980	1645.9	7.1	17,805	1.9	93,293	5.1
1981	1739.8	5.7	18,136	1.9	96,817	3.8
1982	1797.2	3.3	18,458	1.8	98,223	1.5
1983	1938.9	7.9	18,733	1.5	104,263	6.1
1984	2142.9	10.5	19,106	2.0	113,544	8.9
1985	2251.9	5.1	19,440	1.7	117,677	3.6
1986	2494.4	10.8	19,765	1.7	128,895	9.5
1987	2692.5	10.7	19,982	1.1	145,392	12.7
1988	3264.0	12.1	20,220	1.2	151,373	4.1

Source: *National Income in Taiwan Area, ROC.* Directorate-General of Budget, 1951 to 1987. Bank of Taiwan, ROC. Annual Report, Various Issues.

[a] GNP figures are in real terms (at 1981 constant prices).

Since 1967, Taiwan has had a trade surplus with the United States. This surplus grew rapidly from $80 million in 1967 to $16 billion in 1987 (Table 4), when it peaked by rising 18 percent. In 1988, it declined to $10.42 billion (13). Continuous pressure from U.S policymakers to eliminate the trade surplus through lowering of tariffs and other trade barriers has encouraged Taiwan to lower trade restrictions on imports of U.S-produced agricultural products (16). In its last concession, the Board Of Foreign Trade (BOFT) announced a program to narrow the trade surplus with the United States to less than $3 billion by 1992 (17). This program includes further reduction of tariffs on agricultural products and liberalization of its purchasing system for bulk grain commodities. The special levy of NT$ 280 per mmt will be abolished, and purchases of soybean and coarse grains from the United States will receive licenses automatically. Purchases from all other sources will require special permits. The average tariff rate in 1985 was 23 percent and is estimated to be reduced to 18 percent by 1990 (18).

Since 1986, the United States has overtaken Japan as the most important market for Taiwan's exports. The United States is also now the major source of Taiwan's agricultural imports, supplying over 60 percent by value. In view of these developments, the trade patterns

Table 3. Taiwan's Total Trade, 1965 to 1988

Year	Exports	Growth rate	Imports	Growth rate	Trade balance
	US$billion	*percent*	*US$billion*	*percent*	*US$billion*
1965	0.45	3.9	0.55	29.9	−0.1
1966	0.54	19.1	0.62	11.9	−0.08
1967	0.64	19.6	0.8	29.6	−0.16
1968	0.79	23.1	0.9	12.0	−0.11
1969	1.05	33.0	1.21	34.3	−0.16
1970	1.48	41.2	1.52	25.6	−0.04
1971	2.06	39.1	1.84	21.0	0.22
1972	2.99	45.0	2.51	36.3	0.48
1973	4.49	50.0	3.80	50.8	0.69
1974	5.64	25.8	6.97	83.7	−1.33
1975	5.31	−5.8	5.95	−14.6	−0.64
1976	8.17	53.8	7.60	27.7	0.57
1997	9.36	14.6	8.51	12.0	0.85
1978	12.69	35.5	11.03	29.6	1.66
1979	16.1	26.9	14.77	34.0	1.4
1980	19.81	23.0	19.73	33.6	0.08
1981	22.61	14.1	21.2	7.4	1.41
1982	22.2	−1.8	18.89	−10.9	3.31
1983	25.12	13.1	20.29	7.4	4.83
1984	30.46	21.2	21.96	8.3	8.5
1985	30.77	1.0	20.10	−8.5	10.67
1986	39.65	28.9	24.17	20.2	15.48
1987	53.53	35.0	34.56	43.0	18.97
1988	60.58	13.2	49.65	43.7	10.92

Source: ROC, *Monthly Bulletin of Import and Export Statistics*, Department of Statistics, Ministry of Finance, Various issues, 1965 to 1988.

and the competitive position of U.S. exports in Taiwan should be analyzed, and the growth of the livestock sector should be evaluated. This sector consumes much of the bulk commodities, primarily soybeans, which are mainly from the United States.

Taiwan's Soybean Industry. Soybean production in Taiwan has declined substantially in the past two decades from a peak of 75,000 tons in 1967 to only 18,000 tons in 1987, providing only one percent of domestic requirements. The area planted to soybeans has also decreased from 52,300 hectares to 11,000 hectares in the same period (14). The decline can be attributed to the rising cost of labor and price competition from imported soybeans, all contributing to unattractive prices for producers. Domestic competition from other planted crops, mainly corn and peanuts, has also contributed to the decline in soybean production.

The demand for soybeans is principally a derived demand for its products, oil and meal, because only small amounts of whole beans are consumed directly. Soybeans have become

Table 4. Bilateral Trade Between Taiwan and the United States, 1965 to 1988

Year	ROC's exports to the United States	Growth rate	ROC's imports of U.S goods	Growth rate	Trade balance
	US$billion	*percent*	*US$billion*	*percent*	*US$billion*
1965	0.096	18.5	0.18	26.6	−0.084
1966	0.12	20.8	0.17	−5.7	−0.05
1967	0.17	44.8	0.25	48.8	0.08
1968	0.28	65.5	0.24	−3.2	0.04
1969	0.4	43.2	0.29	22.2	0.11
1970	0.56	41.3	0.36	24.7	0.2
1971	0.86	52.3	0.41	12.0	0.45
1972	1.25	45.6	0.54	33.0	0.71
1973	1.67	33.6	0.95	75.5	0.72
1974	2.04	21.9	1.68	76.3	0.36
1975	1.28	−10.5	1.65	−1.7	−0.37
1976	3.04	66.7	1.8	8.8	1.24
1977	3.64	19.6	1.96	9.2	1.68
1978	5.01	37.8	2.38	21.0	2.63
1979	5.65	12.8	3.38	42.3	2.27
1980	6.76	19.6	4.67	38.3	2.09
1981	8.16	20.7	4.77	2.0	3.39
1982	8.76	7.3	4.56	−4.3	4.2
1983	11.33	29.4	4.65	1.8	6.68
1984	14.87	31.2	5.04	8.5	9.83
1985	14.77	−1	4.75	−5.9	10.02
1986	18.99	28.6	5.42	14.1	13.57
1987	23.62	24.4	7.62	40.6	16
1988	23.43	−1	13.0	70.6	10.43

Source: *ROC, Monthly Bulletin of Import and Export Statistics,* Department of Statistics, Ministry of Finance, 1965 to 1988. *Two-Way Trade Statistics Between the United States and the ROC, 1987,* Board of Foreign Trade, Ministry of Economic Affairs.

the most important source of fats and oils in Taiwan, whereas marine, animal, and palm products have decreased in relative importance mainly because of the growing demand for protein meal, which is a joint product with soyoil from the crushing of soybeans.

The need for soyoil accounted for most of the demand for soybeans before the rapid development of the livestock industry. Soyoil consumption increased from 0.026 mmt in 1965 to 0.31 mmt in 1988. Total oil demand will keep increasing because soyoil has become the favorite cooking oil of the rapidly growing fast-food industry (5). Soybean production costs per unit of fat or oil are also lower than the production cost of animal products. Moreover, Taiwanese are rapidly becoming more westernized. Like their western counterparts, they are purchasing more vegetable oils because of health concerns. Total production of soyoil has increased from 0.086 mmt in 1970 to 0.33 mmt in 1988 (18). Soybeans are consumed in a variety of forms that have very few substitutes as foods: soymilk, soy sauce, bean pastes, and soy sprouts. Although the Taiwanese are well acquainted with these products, it is not likely that consumption will increase significantly to affect their overall demand for soybeans.

Soymeal is the main protein source used in animal feed. It provides most of their essential amino acid requirements and is highly nutritious. It is also of better quality and more efficient in digestion than other competing meals, such as fishmeal, meat meal, and peanut meal.

Soymeal is extracted in the crushing process through a petroleum-based solvent. This process yields about 80 percent soymeal, which contains an average of 44 percent protein (7).

Taiwan does not import soymeal: most of the domestic demand is met by its crushing industry. The demand for meal has increased rapidly in the last decade; consumption rose steadily from 0.14 mmt in 1965 to 1.29 mmt in 1987. As of December 1988, soymeal use increased to 1.35 mmt (15,18). The expanding hog and poultry industries are the main reason for the rapid development of the feed industry, growing on the average of 8.5 percent annually between 1975 and 1985. Of total feed output, hog feed constitutes about 50 percent; chicken feed, 45 percent; and cattle feed, the remaining 5 percent.

Conceptual Model of Taiwan's Soybean Sector

Mathematical Presentation of the Soybean Sector. Econometric model building has developed throughout this century into a sophisticated science. It provides crucial economic tools for estimating the values of parameters appearing in structural equations and for studying the implications of these parameters.

This study concentrates on estimating the demand for soybeans in Taiwan. Soymeal, a major product from soybeans, is crucial in the growth of Taiwan's livestock sector and further economic development. The three kinds of demand important in the soybean market are consumer demand for food uses, derived demand for feed to livestock, and demand for soyoil. The domestic changes in demand for livestock are also taken into account as the major force behind the growth in the soybean sector. The aspects of demand theory that can be used to explain the demand for soybeans in Taiwan are analyzed empirically below.

This economic model of Taiwan's soybean sector, therefore, is composed of demand equations for soybeans, soymeal, and soyoil and of world price linkages. For purposes of estimating this model, the following assumptions have been made:

- Taiwan and its three soybean economies are price takers according to the "small country" theory;
- No tariff or trade restrictions are applied;
- Imported and domestic soybeans and their products are perfect substitutes.

The mathematical presentation of the model is a 13-equation system consisting of domestic soybean production, soybean food demand, soyoil demand, soymeal demand, soybean crush demand, livestock demand presented as high protein animal unit (HPAU), four market-clearing equations, and three price linkages (Figure 1).

Equation 1.1 in Figure 1 represents the soybean acreage (BA) planted in Taiwan, which is a function of lagged acreage planted, the government's declared real soybean support prices, and other exogenous variables, such as technology, weather, and government policies. The planted acreage for the current crop year is determined by information on acreage that was planted last year and soybean support prices declared by the government before the crop year. Because the acreage planted does not change quickly in response to changes in production incentives, soybean producers in Taiwan will make their production decisions according to the acreage planted in the previous year and the government's real support prices for the current year. Lagged soybean acreage, therefore, is expected to have a positive relationship with acreage planted in the previous year. Soybean support prices are also expected to have a positive effect upon current soybean production. Because support prices are announced by the government before soybeans are planted, an increase in the support price of soybeans will increase soybean production.

Equation 1.2 in this figure illustrates per capita demand for soybean food (PFD). The relationships used to explain food demand for soybean products originate from consumer demand theory and are based on the maximization of consumer utility, subject to an appropriate budget constraint. The solution relates the consumption of the commodity to its own price, income, and other variables that influence consumer taste and preference. Under the assumption of identical consumer preferences, total market demand can be written in per capita terms. The demand for food is expected to be negatively related to the soybean import price and positively related to per capita income. The dummy variable DV67 is expected to explain the variability in consumption caused by the removal of soybean import barriers in 1967. Long ago, Taiwan adopted tariffs and quantity controls as its main trade barriers on most imports. Since the mid-1960s, Taiwan has reduced tariffs on many agricultural imports, including the removal of quantity controls on soybeans in 1967. The dummy variable DV67 is expected to have a positive relationship with food demand.

Equation 1.3 represents per capita oil demand (POD). The demand for oil is derived from the demand for soybeans crushed and used for cooking or salad oil. It is a function of per capita real income, its own price, and the dummy variable DV67. Per capita income is anticipated to have a positive sign, whereas the soyoil retail price is expected to be negatively correlated to soyoil consumption. The dummy variable DV67 is expected to have a positive correlation, reflecting the elimination of the soybean import embargo.

Domestic crush demand (SCM) in equation 1.4 is explained by the crush value and HPAU. The crushing value is measured by the value of soymeal and soyoil produced from one unit of crushed soybeans divided by the input cost. The crushing value indicates the profitability of the crushing industry and is expected to be positively related to the domestic crush demand.

Domestic soymeal demand (MDM) is presented in equation 1.5. Soymeal demand is determined by the soymeal retail price, HPAU, and the dummy variable DV67. Soymeal price is expected to have a negative effect on soymeal demand. HPAU is anticipated to be positively related to the demand for meal. HPAU is introduced in the model to link the growth of the soybean sector with changes in the domestic production of livestock in Taiwan as well as livestock exports overseas. Soymeal is mostly used in the swine and poultry sectors and is

Figure 1. Mathematical Presentation of the Model.

1.1. BA = f(SP, LSA, T)

1.2. PFD = f(BIP, Y/POP, DV67)

1.3. POD = f(OP, Y/POP, DV67)

1.4. SCM = f(CRV, HPAU)

1.5. MDM = f(MP, HPAU, DV67)

1.6. HPAU = f(LSPI, Y x POP, HPAUX)

1.7. CRV = (MXR × MP + OXR × OP) / BIP

1.8. BED = PFD + SCM − BPR

1.9. MED = MDM − SCM × MXR

1.10. OED = POD − SCM × OXR

1.11. BIP = UXPB × EXR

1.12. MP = UXPM × EXR

1.13. OP = UXPO × EXR

ENDOGENOUS VARIABLES

BA = soybean acreage
HPAU = high protein animal unit
PFD = per capita food demand
POD = per capita oil demand
MDM = soybean meal demand
SCM = soybean crush demand
BED = soybean excess demand
OED = soybean oil excess demand
MED = soybean meal excess demand

PREDETERMINED VARIABLES

SP = soybean support price
LSA = lagged soybean acreage
LSPI = livestock price index
HPAUX = high protein animal units exported
T = time trend
Y = per capita income
DV67 = dummy variable
POP = population
MXR = meal extraction rate
OXR = oil extraction rate
EXR = exchange rate

UXPB = United States soybean export price
UXPM = United States soybean meal export price
UXPO = United States soybean oil export price
BPR = soybean domestic production
CRV = soybean crush value
BIP = soybean import price
MP = soybean meal retail price
OP = soybean oil retail price

the main protein source for animal feed. The dummy variable is expected to be positively related to soymeal demand.

Equation 1.6 represents the demand for livestock presented as the number of HPAU produced. HPAU is a weighted average of animal units incorporating the amount of soybeans required for producing hogs, poultry, and eggs. It is calculated using the equation:

HPAU = pork production + (2.5 chicken production + 2.4 egg production)/3.

HPAU demand is expected to be negatively related to the livestock price index, but positively related to the growth in livestock exports and total income. The data supporting the mathematical model appear in the Appendix.

Estimation Methodology and Econometric Techniques. Several econometric theories and techniques are relevant to this regression model. The basic requirement that an economic model must satisfy is that the number of endogenous variables must be equal to the number of independent relationships in the model. In order to identify the proper techniques to be used in estimating the parameters of the model, the appropriate relationships among the equations should be specified. If we assume the general simultaneous econometric equation system, presented in matrix form:

$$YB + X\Gamma = U$$

where:

Y = matrix of endogenous variables.

B = matrix of coefficients of endogenous variables.

X = matrix of exogenous variables.

Γ = matrix of coefficients on exogenous variables.

U = matrix of disturbances.

The model is a system of simultaneous equations, where a typical equation is part of a set of simultaneous equations and has at least one endogenous variable as an independent variable (9).

Simultaneous equation models are commonly estimated using estimation techniques, such as the Two- and Three-Stage Least Squares — 2SLS and 3SLS. These techniques solve the problem of correlation of the disturbance term in an equation with the endogenous variables as regressors. If a correlation exists among disturbances across equations, the 3SLS estimator is more asymptotically efficient than the 2SLS estimation (8).

There are two steps in the 2SLS procedure. First, the endogenous variables, which appear on the right-hand side of one or more equations, are regressed on all exogenous variables in the system. Second, predicted values are used as instruments for those endogenous variables, and an instrumental variable estimator is applied. The final estimates are unbiased and consistent but not asymptotically efficient if correlation is present across equations (8,19).

The 3SLS estimation method takes into account the correlation of the disturbances across equations. The 3SLS procedure is similar to 2SLS in the first two steps. Once the 2SLS parameters have been calculated, the residuals of each equation are used to estimate the cross-equation variances and covariances. As stated before, the 3SLS estimation method provides more efficient estimators than the 2SLS.

The simultaneous equation-estimating technique used in this model has been designed to estimate structural parameters in the overidentified case, where the number of unrestricted coefficients exceeds the number of the restricted parameters.

For the equations that consist of only independent variables in the right-hand side, Ordinary Least Squares (OLS) estimation is applied. Because the independent variables are not likely to be correlated with the disturbance term in these equations, OLS estimates will generally be consistent. For those equations where dependent variables appear as regressors, however, OLS estimation will yield biased and inconsistent parameter estimates. In those cases, therefore, the 2SLS estimation method is applied. These results are then compared with the 3SLS system estimation method, which yields more efficient estimators than the 2SLS when right-hand side endogenous variables are correlated with the disturbance term (19).

The presence of autocorrelation was adjusted using the OLS transformation procedure obtained by the default option on Shazam's AUTO command. The option will estimate the first-order autocorrelation parameter, RHO, and will proceed in a modified Cochrane-Orcutt correction.

The model specified in this study is a system of simultaneous equations that will be estimated both by single-equation and system-equation methods. The system method takes into account the possible correlation among the error terms across equations and is more efficient than OLS estimation. But in the case of a small sample size, an error in specification may bias estimates.

Results. The summary of results presented in Figures 2 and 3 contains the coefficient estimates of both techniques as well as their corresponding signs. R square, the Durbin Watson statistic (Durbin-W), the elasticity at means, and t-ratios are also shown. In general, the estimation results were satisfactory, and the relationships among all variables agreed with the economic expectations. When assessing the estimator's properties, however, the 3SLS system method appears to have smaller standard errors than does the single estimation method.

Soybean acreage (BA) in Taiwan was significantly influenced by the lagged soybean acreage (LSA) and the time trend variable (T). The soybean price, however, was not significant, possibly because of the shortcomings in acquiring data on competitive crops. The negative influence of T indicates that soybean acreage has been decreasing gradually with time. Most of the planting area is along the coastline, where land has greater economic returns when utilized for the industrial sector. Other possible factors that may have contributed to a decrease in acreage are increasing labor costs and the shifts from full-time farming to part-time farming. The scope for expanding planted area is quite limited, and Taiwan, it appears, will continue to rely on grain imports in the future. The real soybean support price (SP) does not appear to be a significant factor in determining soybean acreage. This fact may reflect the shift of the Taiwanese farmer from soybeans to alternative crops, especially fruits and winter-season vegetables. It would have been useful to add a price variable for those alternative crops. Because of the difficulty in acquiring data on market prices for fruits and vegetables, however, the movement in these prices is not taken into account, a fact that might explain the lack of insignificance of the variable for the real soybean support price.

Per capita soybean food demand (PFD) was positively influenced by per capita income (Y), as was expected, and by the dummy variable (DV67), which captured the removal of the

Figure 2. Estimation Results of Taiwan's Soybean Sector Using OLS or 2SLS as Appropriate.[a]

2.1. BA[b] = 43.341 − 2.129T + .173LSA + .094SP
(7.812) (−4.011) (1.964) (.175)
⟨1.672⟩ ⟨−.890⟩ ⟨.163⟩ ⟨.086⟩
R square = 0.939 D-M = 2.96 df = 18

2.2. PFD[c] = 6.433 − .053BIP + .006Y + 3.152DV67
(5.047) (−1.205) (3.358) (4.20)
⟨.564⟩ ⟨−.038⟩ ⟨.227⟩
R square = 0.811 D−W = 1.458 RHO = .332

2.3. POD[c] = −0.463 − .073P + .018Y + .805DV67
(−2.818) (−2.264) (5.795) (2.217)
⟨−.072⟩ ⟨−.032⟩ ⟨1.244⟩
R square = 0.961 D-W = 1.516 RHO = .394

2.4. SCM[d] = −178 + 89.1CRV + 1.052HPAU
(−1.65) (1.875) (12.978)
⟨−.261⟩ ⟨.131⟩ ⟨1.082⟩
R square = 0.944 D−W = 1.614 df = 19

2.5. MDM[d] = −17.24 − 8.381MP + .825HPAU + 31.26DV67
(−2.3) (−1.872) (16.636) (4.215)
⟨−.032⟩ ⟨−.0016⟩ ⟨1.069⟩
R square = 0.907 D−W = 1.548 df = 18

2.6. HPAU = 53.15 − .448LSPI + .013Y*POP + .924HPAUX
(2.162) (−2.183) (1.754) (74.4)
⟨.072⟩ ⟨−.061⟩ ⟨.036⟩ ⟨.949⟩
R square = 0.995 D−W = 1.775 df = 18

ENDOGENOUS VARIABLES

BA = soybean acreage
HPAU = high protein animal unit
PFD = per capita food demand
POD = per capita oil demand
MDM = soybean meal demand
SCM = soybean crush demand
BED = soybean excess demand
OED = soybean oil excess demand
MED = soybean meal excess demand

PREDETERMINED VARIABLES

SP = soybean support price
LSA = lagged soybean acreage
LSPI = livestock price index

HPAUX = high protein animal units exported
T = time trend
Y = per capita income
DV67 = dummy variable
POP = population
MXR = meal extraction rate
OXR = oil extraction rate
EXR = exchange rate
UXPB = United States soybean export price
UXPM = United States soybean meal export price
UXPO = United States soybean oil export price
BPR = soybean domestic production
CRV = soybean crush value
BIP = soybean import price
MP = soybean meal retail price
OP = soybean oil retail price

[a] ( ) is t ratio; ⟨ ⟩ is elasticity at mean values.
[b] Corrected for autocorrelation with lagged dependent variable.
[c] Corrected for autocorrelation.
[d] Estimated using 2SLS.

soybean import embargo in 1967. The soybean import price (BIP) was not significant and had a low elasticity. The low elasticity, -.002, can be explained by the dominance of soybean food in the Taiwanese diet with few existing substitutes for soyfood. As expected, the relaxation of the import barriers in 1967 had a positive effect on PFD.

All the coefficients for the per capita oil demand equation (POD) were significant, with the expected signs. Y and DV67 were both positive, whereas the soyoil price (OP) had a negative influence on the growth of soyoil demand. Per capita income elasticity indicated a strong relationship with the demand for oil in Taiwan. This relationship is explained by the domestic food industry's growing demand for cooking oil.

Soybean crushing demand (SCM) was positively influenced by both the domestic livestock demand (HPAU) and the crushing value (CRV). Domestic livestock demand had the most influence on the growth in soybean crush demand.

In equation 3.5, for soymeal demand (MDM) in Figure 3, the number of high animal protein units was found to be the most important explanatory variable. It linked the livestock sector with the soybean sector and was the major force driving the soymeal demand. The soymeal demand elasticity with respect to HPAU was 1.085, a figure that reflects the strong relationship between the explanatory variable and soybean meal demand. The deflated soymeal price had a negative impact upon soymeal demand, but it was not significant in the 3SLS estimation. Furthermore, soymeal demand, −.002, was found to be price inelastic. The coefficient of DV67 had the expected positive sign and was similar to the two other cases: per capita food demand (PFD) and per capita oil demand (POD). In all three cases, the coefficients had significant values.

Livestock demand as measured by HPAU was a function of the livestock price index (LSPI),

Figure 3. Estimation Results Using 3SLS Method.[a]

3.1. BA = 52.22 − 2.523T + .129LSA + .194SP

(10.88)	(−5.801)	(2.055)	(.424)
⟨1.73⟩	⟨−.961⟩	⟨.127⟩	⟨.105⟩

R square = 0.938 D−h = −2.31 df = 19

3.2. PFD = 4.482 − .065BIP + .007Y + 3.079DV67

(2.89)	(−0.962)	(5.549)	(5.216)
⟨.391⟩	⟨−.002⟩	⟨.272⟩	

R square = 0.813 D−W = 1.472 df = 19

3.3. POD = −.514 − .076OP + .016Y + .554DV67

(−2.418)	(−2.243)	(11.05)	(2.831)
⟨−.09⟩	⟨−.010⟩	⟨1.124⟩	

R square = 0.907 D−W = 1.302 df = 19

3.4. SCM = −131 + 51.212CRV + 1.064HPAU

(−2.291)	(1.637)	(17.712)
⟨−.196⟩	⟨.102⟩	⟨1.096⟩

R square = 0.943 D−W = 1.509 df = 19

3.5. MDM = −26.2 − 4.01MP + .829HPAU + 27.695DV67

(−1.782)	(−1.473)	(19.97)	(3.032)
⟨−.485⟩	⟨−.002⟩	⟨1.085⟩	

R square = 0.948 D−W = 1.562 df = 18

3.6. HPAU = 44.82 − .261LSPI + .011Y*POP + .907HPAUX

(2.65)	(−1.781)	(2.322)	(55.647)
⟨.064⟩	⟨−.035⟩	⟨.036⟩	⟨.932⟩

R square = 0.99 D−W = 1.801 df = 18

[a] ( ) is t ratio; ⟨ ⟩ is elasticity at mean values.

livestock exports (HPAUX), and total income (Y x POP). Total income had an anticipated positive influence on the demand for livestock, which was also found to be an important explanatory variable. The coefficient for the livestock price index (LSPI) had an expected negative sign, whereas, HPAUX had a positive influence on livestock demand. The number of exported animal units had a high elasticity at the mean, .932. This high elasticity indicated the growing demand for livestock products abroad.

Both estimation methods yielded similar results with satisfactory and acceptable statistical tests. The estimated behavioral equations fit the data fairly well; and in some cases, the modified Cochrane-Orcutt method was used to correct for first-order autocorrelation. All the explanatory variables had the expected signs and similar magnitudes for both estimation methods; and in most cases, the *t* statistics were significant.

Implications. The numerical results in Figures 2 and 3 represent the main economic forces in

Taiwan's soybean sector and their impact on the endogenous variables. Soybean acreage planted in Taiwan is positively influenced by the lagged planting of soybeans. Soybean producers determine the acreage planted in the current year according to the amount planted in the previous year and the government's real support price. Therefore, an increase in acreage planted last year will increase acreage planted in the current year.

Although the government's real support prices were not found to be significant, their full effect on soybean acreage could not be analyzed; but previous studies have shown a positive influence on soybean acreage, and consequently, on domestic soybean production (1,10,13).

Two main objectives account for the increase in soybean price: the government's desire to decrease rice production and increase domestic production of soybeans. Price incentives for replacement crops should help achieve the first of these objectives. Heavily dependent on U.S. imports of soybeans, Taiwan is trying to achieve the second with price incentives for growing soybeans. Higher profits for domestic soybean growers would decrease the volume of imports. This price scheme is financed through a per-ton surcharge on soybean imports and the imposition of a 7 percent tariff. This money goes into a fund that is used to support soybean prices and thus soybean production, potentially decreasing — on the one hand — the demand for U.S. and other soybeans.

On the other hand, the growth of real per capita income has increased demand for imported soybeans. It has had a positive impact on the demand for livestock, oil, and food. For example, per capita consumption of pork — by far the dominant meat in the typical diet — increased rapidly in the last decade although poultry and beef consumption grew to a lesser extent. The high demand for pork and other meat products has strengthened the demand for crushed soybeans and soymeal for use in livestock production. Once the soybean crushing demand is determined, fixed proportions of soymeal and soyoil are produced.

The positive income elasticity for PFD, .272, indicates that future income growth is likely to produce further significant shifts in the composition of the Taiwanese diet. These shifts will probably continue the trend away from rice, sweet potatoes, and other starchy foods and toward the consumption of livestock products.

Soymeal prices, however, had a negative influence on meal demand. Higher soymeal prices increased the cost of livestock production; therefore, less soymeal was demanded. The livestock price index also had a negative influence on livestock demand, −.448.

In the last few years, policymakers in Taiwan have placed considerable emphasis on expanding export markets, especially the export markets for livestock products. In 1986, Taiwan became Japan's major pork supplier and will probably remain so as a result of transportation advantages and lower production costs. An increase in Taiwan's livestock exports will increase domestic livestock production and therefore will have a strong impact on soymeal demand and the demand for crushing soybeans. The elasticity of livestock exports was .949.

We can conclude from the preceding analysis that the soybean support price had no effect on the total demand for soybeans. The effect of the soybean price on acreage was positive but insignificant. The lack of significance was probably due to the lack of data on competing crops.

The study also demonstrated that livestock exports affected the domestic demand for livestock the most; they have had progressively less of an effect on the livestock price index and per capita income. The elasticity at mean values of livestock exports was also higher than that for the other two variables. The increase in domestic livestock production enhanced the demand for soybeans imported for animal feed. Livestock exports also had a high elasticity,

.949, with regard to the demand for crushing soybean and the demand for soybean meal.

The coefficients in the models showed that per capita income had a slight effect on oil and food demand, but a larger impact on livestock demand. Although soyoil is widely used in the fast-food industry, restaurants, and other commercial facilities, other oil sources, such as corn and vegetable oil, can be easily substituted. As indicated by the inelastic price demand, the markets for soyoil and soyfood are insensitive to the growing per capita income, which has little effect on the consumption of soybeans.

According to these results, growth factors in Taiwan's economy have had a greater impact than policy factors. For example, the increase in per capita income had a larger impact on the soybean economy than the domestic production policy of increasing the "guaranteed price." An increase in per capita income increased the demand for livestock. The increased demand for livestock in turn increased the demand for crushing soybeans. Declining quantities of soybean production, as indicated by the downward trend, however, suggest that domestic policy is not likely to encourage the production of a sufficient amount of beans by Taiwanese farmers. Soybean import demand, therefore, is likely to increase.

Economic factors similar to those observed in Taiwan are also present in other Asian economies, such as South Korea and Japan. The growing demand for livestock products in these economies opens new opportunities to increase livestock exports, opportunities that have a strong impact on the production of domestic livestock.

Conclusions

In this study, we developed an econometric model to evaluate key economic factors operating in the Taiwanese soybean sector in order to determine the effect of economic growth factors and policy intervention on Taiwan's soybean import demand. In the first section, we discussed some general economic indicators, trade patterns, and foreign trade policies; and we described Taiwan's agricultural sector, particularly its soybean industry. These sections provided the theoretical background for the subsequent conceptual framework.

The estimation of the model coefficients in the second section were based upon data from 1965 to 1986. The results were satisfactory, and the estimated directional relationships among variables were consistent with economic expectations. Some important characteristics of Taiwan's soybean and soymeal markets were obtained from the estimation and are summarized below.

The soybean support price has a positive but insignificant effect on soybean acreage; however, acreage levels are inelastic with respect to price. Lagged soybean acreage was also found to have a positive influence on acreage in the current year, reflecting slow production adjustments to changes in technology and economic incentives. The negative trend variable was also significant, indicating a general decrease in soybean acreage despite governmental efforts to increase domestic soybean production through price support policies. This decrease suggests that domestic soybean production is unlikely to expand and will eventually exert very little influence on soybean import demand.

We also found that per capita income had a significant influence on soyfood demand and soyoil demand and that total income had a significant influence on domestic livestock demand. The results also indicate that livestock demand is the most important factor influencing the demand for crushing soybeans. Income growth, therefore, is one of the major forces behind the increase in the soybean and soymeal sectors, facilitating the growing demand for soybean imports.

Soymeal demand, we discovered, is very inelastic with respect to its own price. Its price elasticity was −.002. This demand is primarily influenced by the livestock demand and is very sensitive to the changes in this sector.

The elimination of soybean import barriers since 1967 had a significant influence on all three markets: soyfood, soyoil, and soymeal. This influence may indicate the effects of the trade barrier on Taiwan's current trade policy — retaining high tariffs for agricultural commodities. Efforts to liberalize its domestic trade policies and expand markets for livestock abroad would most likely force higher quantities of imported soybeans into the country to meet the demand for high protein feed.

Livestock demand measured by high protein animal units was a major factor in the demand for soymeal and soybean crush. The crushing industry, therefore, closely follows the growth of the domestic livestock sector in Taiwan. Consequently, government policies to encourage domestic production, like the integrated swine production project in 1962 and the artificial insemination and feed inspection programs, would have a significant impact on the demand for soybean crush and soybean imports.

Taiwan's continued economic growth and efforts to liberalize its trade policies and expand markets for pork will increase the quantity of soybeans imported to meet the demand for high protein meal for feed. The recent decline in U.S. agricultural exports and corresponding decline in cash receipts from agricultural marketing are encouraging U.S. policymakers to increase exports through market development programs and lower export prices in the importing country. Taiwan's growing demand for agricultural products, primarily soybeans, has made it the tenth largest importer of U.S. agricultural products. The primary beneficiary of Taiwan's recent trade liberalization programs is the United States, and it will probably continue to enjoy Taiwan's growing demand for soybeans through the early 1990s.

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Appendix

Annual Data for Variables Used in the Model, 1965 to 1986

	Soybean meal extraction rate (MXR)	Soybean oil extraction rate (OXR)	Soybean support price (SP)	Livestock price index (LSPI)	Exchange rate (EXR)	U.S. soybean export price (UXPB)	U.S. soymeal export price (UXPM)	U.S. soyoil export price (UXPO)	Dummy variable (DV)
	Percent	*Percent*	*$NT/kg*	*1976=100*	*$NT/U.S.$*	*U.S.$/kg*	*U.S.$/kg*	*U.S.$/kg*	
1965	0.779	0.14	8	46.1	40.1	0.107	0.118	0.262	0
1966	0.779	0.14	8	48.7	40.1	0.118	0.130	0.273	0
1967	0.779	0.14	9	48.0	40.1	0.106	0.133	0.225	0
1968	0.779	0.14	9	50.3	40.1	0.101	0.134	0.192	1
1969	0.779	0.132	9	47.9	40.1	0.098	0.132	0.212	1
1970	0.779	0.132	10	50.7	40.1	0.107	0.128	0.262	1
1971	0.799	0.132	10	56.8	40.1	0.119	0.129	0.315	1
1972	0.779	0.132	10	59.6	40.1	0.134	0.145	0.297	1
1973	0.779	0.132	10	65.5	38.1	0.273	0.265	0.345	1
1974	0.779	0.132	15	94.8	38.05	0.256	0.285	0.754	1
1975	0.779	0.132	15	110.9	38.05	0.210	0.260	0.471	1
1976	0.779	0.132	17	100.0	38.05	0.223	0.285	0.573	1
1977	0.779	0.155	17	107.9	38.05	0.271	0.377	0.612	1
1978	0.779	0.155	17	14.1	36.05	0.259	0.382	0.681	1
1979	0.779	0.155	17	106.5	36.08	0.278	0.323	0.623	1
1980	0.779	0.155	17	124.3	36.06	0.272	0.379	0.522	1
1981	0.779	0.155	22	145.3	37.79	0.272	0.422	0.464	1
1982	0.779	0.167	25	151.9	39.8	0.233	0.380	0.404	1
1983	0.779	0.167	25	155.6	40.22	0.269	0.410	0.518	1
1984	0.779	0.167	25	163.8	39.42	0.271	0.425	0.678	1
1985	0.779	0.167	25	167.4	39.80	0.214	0.445	0.596	1
1986	0.779	0.167	25	161.7	37.70	0.200	0.430	0.361	1

[a] $NT = new Taiwanese dollars.
[b] 000 mt = thousand metric tons.

Annual Data for Variables Used in the Model, 1965 to 1986

	Per capita income (Y)	Soybean excess demand (BED)	Soybean domestic production (BPR)	Soybean food demand (PFD)	Per capita oil demand (POD)	Soybean oil excess demand (OED)	Soybean meal excess demand (MED)	Soybean crush demand (SCM)	Soybean acreage (BA)
	$NT[a]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*hectares*
1965	20,026	161.4	65.7	89.3	24.1	1.4	0	144.0	53.2
1966	21,219	164.5	63.3	89.6	24.9	1.5	0	152.7	51.3
1967	22,922	342.0	75.2	130.7	46.3	1.2	0	218.0	52.3
1968	24,425	384.9	73.0	111.9	47.5	1.7	0	312.6	49.5
1969	25,280	472.2	67.1	144.7	51	0.9	0	364.8	45.3
1970	27,473	617.5	65.2	173.0	66.7	1.0	0	483.6	42.7
1971	30,363	524.9	61.0	172.8	66.7	6.9	0	428.8	40.2
1972	33,736	711.6	60.2	185.9	80.2	6.4	0	543.2	36.1
1973	37,337	599.7	60.6	174.5	72.3	4.7	0	496.8	36.5
1974	37,047	609.3	66.9	174.9	67.3	1.0	0	487.6	44.5
1975	37,981	860.8	61.9	209.7	90.8	10.1	0	645.4	41.5
1976	42,167	831.5	53.0	219.1	100.3	1.0	0	713.1	35.5
1977	45,483	717.6	51.7	194.6	105.6	0	0	616.8	30.1
1978	50,805	959.4	40.8	219.4	120.4	0	15	754.7	24.5
1979	53,813	1110.6	31.8	216.9	126.4	0	0	774.3	19.3
1980	56,366	939.0	25.9	244.3	140.4	−4.0	10	821.5	15.3
1981	58,094	1042.4	15.9	217.6	136.8	0	0	830.5	10.3
1982	59,551	1150.4	12.1	235.2	164.0	3.1	0	959.1	7.8
1983	61,538	1320.0	8.6	237.7	182.5	0	0	1080.8	5.6
1984	63,362	1470.0	9.5	248.1	202.4	−20	−5	1200	5.5
1985	67,104	1590.0	12.2	258.7	232.5	6	−30	1261.1	7.1
1986	69,354	2001.0	14.9	262.3	282.2	−7	−52	1677.8	9.3

[a] $NT = new Taiwanese dollars.
[b] 000 mt = thousand metric tons.

Annual Data for Variables Used in the Model, 1965 to 1986

	Livestock demand (HPAU)	Livestock exports (HPAUX)	Pork production	Chicken production	Egg production	Pork exports	Chicken exports	Egg exports
	000 mt[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]	*000 mt*[b]
1965	261.39	262.13	196.75	48	30.8	0.6	0	0.3
1966	295.92	296.58	221.77	55	35.4	0.5	0	0.3
1967	343.07	344.39	256.42	70	35.4	1.3	0	0.3
1968	367.79	367.79	262.92	79	48.8	1.0	0	0.4
1969	394.43	396.07	283.88	79	55.9	1.3	0	0.7
1970	437.14	439.95	320.09	82	60.9	2.6	0	0.8
1971	458.82	462.64	326.05	100	61.8	4.1	0	0.5
1972	496.26	509.23	348.87	109	70.7	14.6	0	1.0
1973	596.82	575.44	425.97	101	74.6	5.3	0.2	1.5
1974	526.37	529.33	376.92	107	71.6	2.4	−0.4	1.2
1975	500.53	511.33	322.18	133	84.4	12.1	−0.4	0.9
1976	653.42	683.37	425.40	148	97.1	34.8	1.9	1.6
1977	698.07	721.52	468.35	174	105.9	26.7	1.9	1.5
1978	739.68	765.16	472.15	197	129.2	29.1	1.4	1.3
1979	844.97	867.25	566.28	203	136.9	25.2	1.4	1.6
1980	891.47	917.36	597.87	216	142.1	30.3	0.1	0.8
1981	917.30	941.93	595.37	238	154.5	28.4	0.3	1.2
1982	977.13	1002.16	614.45	294	147.1	28.5	0.3	1.6
1983	1119.20	1147.51	655.59	353	211.8	33.3	0.2	0.7
1984	1210.94	1254.40	762.72	321	225.9	51.2	0	1.2
1985	1326.18	1383.8	831.54	372	230.8	67.8	0	1.4
1986	1373.66	1445.8	868.86	384	231.6	85.8	0	0.8

[a] $NT = new Taiwanese dollars.
[b] 000 mt = thousand metric tons.

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