**Who Dominates the U.S. Soybean Industry:
Producers, Consumers, or Agribusinesses?**

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Abstract

Globally the U.S. is the number one producer, consumer and exporter of soybeans. Nationally, U.S. soybean production value ranks second among all agricultural bulk commodities, having a significant impact on U.S. farm incomes. U.S. soybean has been a subsidized commodity since 1941 and the 2002 Farm Bill provides soybeans for the first time direct government payment and counter-cyclical payments. Using welfare economics, this research explores the political economy of U.S. soybean subsidy policies. Results for the U.S. soybean industry indicate that in aggregate terms, consumer interests dominate and in per capita terms, producer interests dominate.

Introduction

An Overview of U.S. Soybeans

The soybean industry in the U.S. plays an important role in the world. Globally, the U.S. is the leading country in soybean production, consumption and exports as shown in figure 1-a, figure 1-b, and figure 1-c. These three figures also show that in the last decade, Brazil and Argentina have become major competitors for the U.S. in the world soybean market (Schnefp, Dohlman, and Bolling, 2001). In 2003, U.S. soybean production was 65.80 million metric tons, accounting for 35% of world production; U.S. soybean consumption was 43.25 million metric tons, 21.68% of world consumption; and U.S. soybean exports were 24.49 million metric tons, 39.07% of world exports (FAO, 2004). However, U.S. soybean imports were very low, only 0.22 million metric tons in 2003 (USDA-FAS, 2004).

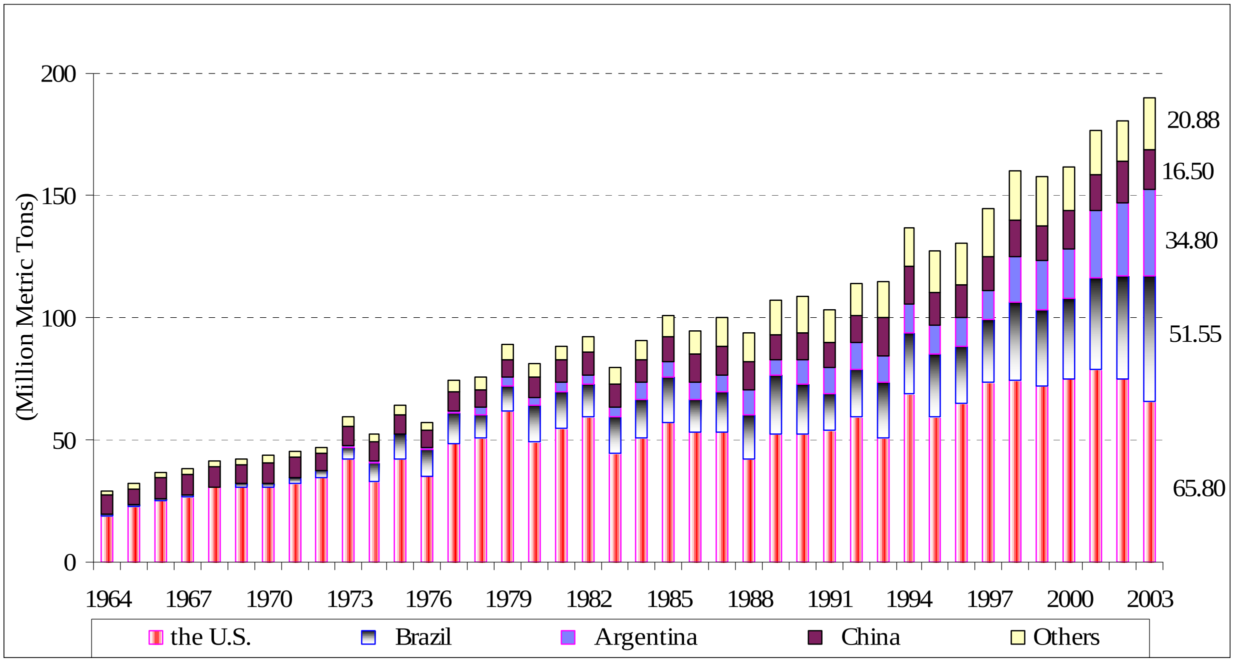

Figure 1-a. Soybean Production Comparison between the U.S. and other Countries.
Source: FAO, online statistical databases, 2004.

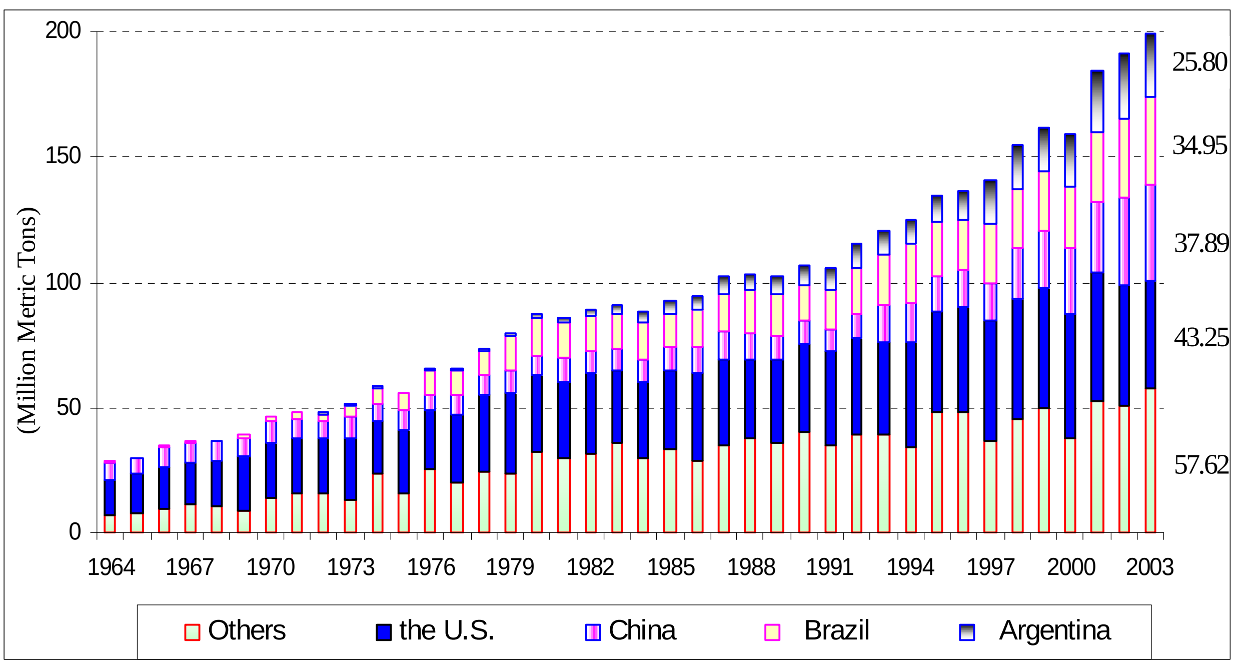

Figure 1-b. Soybean Consumption Comparison between the U.S. and Other Countries.
Source: USDA-FAS, PS&D online dataset, 2004.

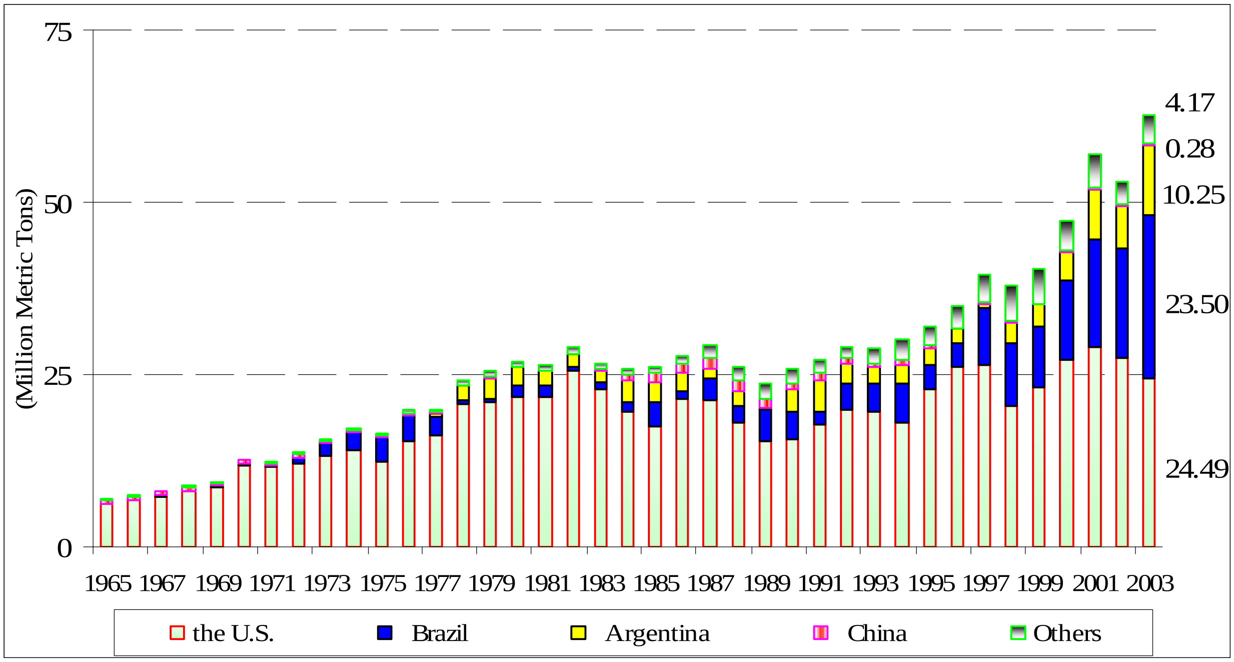

Figure 1-c. Soybean Export Comparison between U.S. and Other Countries.
Source: USDA-FAS, PS&D online dataset, 2004.

Nationally, the soybean industry is a crucial sector in U.S. agriculture. U.S. soybean production value was $16.18 billion in 2002/2003, ranking second among all agricultural bulk commodities. Since 2000, soybeans have been U.S.'s leading agricultural export for agricultural bulk commodities, exceeding corn and wheat. Soybeans have been one of the U.S. government-supported commodities since 1941. Before the 2002 Farm Bill, the primary government support programs for soybeans included commodity loan and marketing loan programs. Under these programs, government payments for the soybean industry increased quickly, especially in the last decade. The net government expenditures on the soybean subsidy program were - $86 million in 1990 and increased to $3,281 million in 2001 (USDA-FSA, 2004). Even with the increasing subsidy burden, the 2002 Farm Bill further placed soybeans under the direct payment and the counter-cyclical payment programs, and set $5.80/bushel as the target price through 2007 (American Soybean Association, 2002).

Objectives

In this research, our objectives include 1) developing a soybean model at the industry level, which incorporates endogenous supply, demand and prices and other related exogenous variables; 2) estimating the model as a simultaneous equation system; 3) conducting economics welfare analyses for the U.S. soybean industry; 4) identifying which interest group dominates the U.S. soybean industry.

U.S. Government Soybean Subsidy Programs

The main U.S. soybean subsidy programs include soybean loan program and government payments. The soybean loan program was first introduced in 1941 and has been in place since then, except in 1975 (Westcott and Price, 2001). The original form of the soybean loan program was the *commodity loan program*, which supported the market price. The *marketing loan program* started in the mid-1980s, which mainly supported producers' income instead of the market prices.

Under the *commodity loan program*, producers must keep the crop designated as loan collateral in approved storage to preserve the crop's quality. Producers may choose to either default on the loan at the end of the loan period, keeping the loan money and forfeiting ownership of collateral to the government or sell the commodity and repay the loan plus interest, depending on the market price level (Westcott and Price, 1999). While under the *marketing loan program* producers may operate as described above. Alternatively, the marketing loan provisions also allow repayment of commodity loans at less than the original loan rate when market prices are lower (USDA-ERS, 2004). This feature decreases the loan program's potential effect on supporting prices because stock accumulation by the government, through loan defaults, is reduced. Instead, farmers are provided economic incentives to retain ownership of the crops and sell them rather than default on loans and forfeit ownership of the crops to the government (Westcott and Price, 1999).

Another subsidy form for soybeans is government payments, including direct payments and counter-cyclical payments within the 2002 Farm Bill. The formula for direct payments is:

Direct Payment = Base Acres x Program Yield x 85% x Direct Payment Rate

Base acres and program yields are calculated on the average level of the recent history of planted acres and yields, while the direct payment rate (DPR) is decided by the USDA. The 2002 Farm Bill set the DPR for soybeans at $0.44/bushel. Direct payments only relate to the planted area, so farmers and eligible landowners will receive annual direct payments.

The Counter-Cyclical Payments formula is:

Counter-Cyclical Payment=Base Acres × Program Yield × 85% × CCP Rate
CCP Rate = Max (0, Target Price – Effective Price)
Effective Price = Max (MYA Price, Loan Rate) + Direct Payment Rate

The MYA price is the marketing year average price, and the 2002 Farm Bill set the target price for soybeans at $5.80/bushel. The counter-cyclical payment is closely related to the market price. If the market price is high enough, the counter-cyclical payment will not occur.

Literature Review

In modeling the soybean industry, different methods have been employed. Piggott et al. (2000), estimated soybeans, soybean meal and soybean oil demand and supply elasticities using 1974 to 1998 annual data. The cross effect between supply and demand could not be examined because they estimated the demand and supply independently. Since they used the domestic disappearance as the total demand, the effects of some exogenous factors on soybean supply and demand cannot be examined. The USDA also has its own estimation model to predict the supply and demand (Reed, et al., 2002). Given the estimated elasticities and baseline demand and prices, they estimate the demand using a system of equations, including export demand, feed demand, crushing demand, industrial demand, domestic demand, food demand, etc. Similar methods were used for the supply side. Gardner (1990) used cross elasticities (among wheat, corn and soybeans), estimated by Tyers and Anderson and Johnson et al., to determine producers' gains and losses. However, many previous works did not incorporate exports as an endogenous variable in the model. The U.S. is the biggest soybean exporter in the world, and in 2003 U.S. soybean exports comprised 37% of U.S. soybean output (USDA-FAS, 2004). The empirical estimation results might not be reliable when the export effect on the U.S. soybean industry was ignored.

Modeling the Soybeans Industry

The Structure of the U.S. Soybean Industry

To accurately describe the U.S. soybean industry, the structure of the demand and supply system and the factors that will affect the system were introduced first. As shown in Figure 3, the entire soybean industry can be viewed as interaction of four components: supply, demand, prices and exogenous factors.

Supply comes from three sources: production, beginning stocks and imports. Demand includes four parts: crush demand, export demand, stocks, and others, among them the crushed soybeans can be further divided into the sub-categories of soybean oil and soybean meal. Soybean oil and soybean meal can be allocated based on usage into domestic consumption, exports, and stocks. Three levels of soybean price---farm-level prices, retail-level prices and world prices are taken into consideration as price variables. Seven defined exogenous variables are included in this system. Technology, production cost, government subsidy and yield affect the producer's decision on outputs. Corn price (hypothesizing that corn is a substitute product for soybeans), disposable personal income and population affect the total demand.

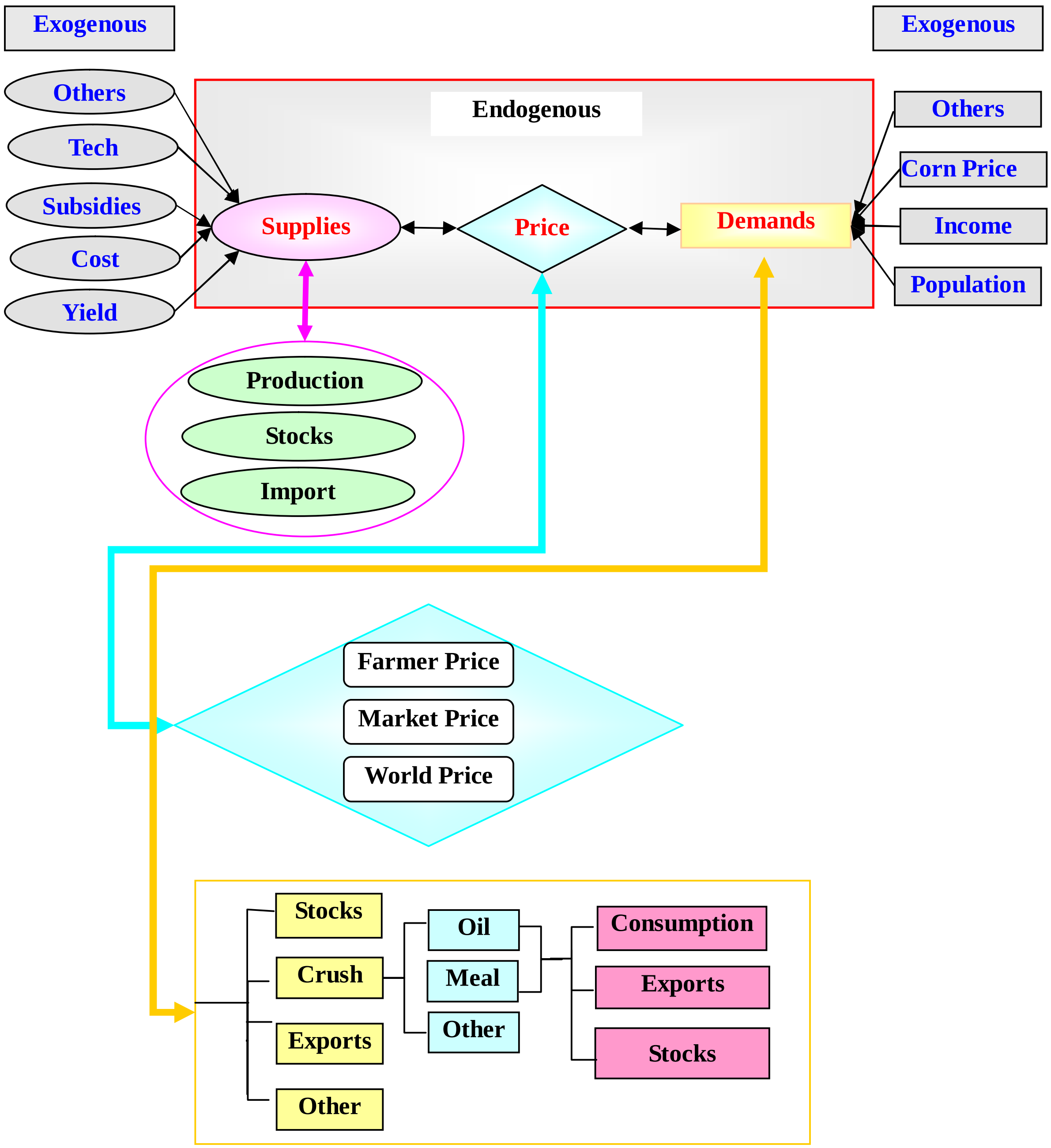

Figure 2. Structural Diagram of the U.S. Soybean Industry.

Theoretical Model

From the above structure, the model of U.S. soybean industry can be expressed as below:

$$
\begin{cases}
(1)\ S=f(EP^{Farm}, Stk, LR, EYD, Tech, Cost, Others) \\
(2)\ D=g(P^{Rtl}, P^{Corn}, INC, POP, Others) \\
(3)\ E=h(STK, S, D, Others) \\
(4)\ P^{Farm}=\varphi(P_{t-1}^{Farm}, GS, S, Others) \\
(5)\ P^{Rtl}=\psi(P^{Farm}, Others) \\
(6)\ P^{Wld}=\pi(P_{t-1}^{Wld}, E, Others) \\
(7)\ Stk=(Stk_{t-1}, M^{*}, E, D)
\end{cases}
$$

* Since U.S. soybean imports were quite small, we do not include import equation in the model.

Where

S: Supply of soybeans;

EP^{Farm}: Expected farm-level prices;

LR: Loan rates of soybeans;

EYD: Expected yields;

Stk: Domestic stocks of soybeans;

Tech: Technology;

Cost: Production costs for soybeans;

M: Import;

P^{Rtl}: Retail prices for soybeans;

P^{Corn}: Retail prices for corn;

E: Exports of soybeans;

M: U.S. soybean Imports;

P^{Wld}: World prices for soybeans;

INC: Personal disposable income;

POP: Population;

GS: Government subsidy.

Based on the above analysis, empirical equations are expressed as follows. The expected signs for the coefficients are shown below the coefficients.

$$
\begin{cases}
(1)\ \hat{S}=\hat{a}_0+\underset{(+)}{\hat{a}_1}EP^{Farm}+\underset{(+)}{\hat{a}_2}LR+\underset{(+)}{\hat{\alpha}_3}EYD+\underset{(+)}{\hat{\alpha}_4}T \\
(2)\ \hat{D}=\hat{b}_0+\underset{(-)}{\hat{b}_1}P^{Rtl}+\underset{(+)}{\hat{b}_2}P^{corn}+\underset{(+)}{\hat{b}_3}PINC \\
(3)\ \hat{E}=\hat{g}_0+\underset{(+)}{\hat{g}_1}P^{Wld}+\underset{(+)}{\hat{g}_2}STK_{t-1}+\underset{(+)}{\hat{g}_3}S \\
(4\ \hat{P}_t^{Farm}=\hat{q}_0+\underset{(+)}{\hat{q}_1}P_{t-1}^{Farm}+\underset{(-)}{\hat{q}_2}S \\
(5)\ \hat{P}_t^{Rtl}=\hat{l}_0+\underset{(+)}{\hat{l}_1}P_{t-1}^{Rtl}+\underset{(+)}{\hat{l}_2}P^{Farm} \\
(6)\ \hat{P}_t^{Wld}=\hat{w}_0+\underset{(+)}{\hat{w}_1}P_{t-1}^{Wld}+\underset{(+)}{\hat{w}_2}P^{Farm}+\underset{(-)}{\hat{\omega}_3}P^{Rtl} \\
(7)\ STK_t=STK_{t-1}+S+M-D-E
\end{cases}
$$

where S: Supply of soybeans, equaling the domestic production (million bushels);
EP^{Farm}: Expected prices received by farmers (dollars/bushel);
LR: Loan rates of soybeans (dollars/bushel);
EYD: Expected soybean yields (bushels/acre);
STK: Domestic stocks of soybeans (million bushels);
D: Domestic crush demand (million bushels);
P^{Farm}: The prices received by farmers (dollars/bushel);
P^{Rtl}: Retail prices for soybeans (dollars/bushel);
P^{Corn}: Retail prices for corn (dollars/bushel);
$PINC$: Per capita personal disposable income (dollars);
E: Exports of soybeans (million bushels);
M: U.S. soybean imports (million bushels);
P^{Wld}: World prices for soybeans (dollars/bushel).
T: Time trend variable.

Equation (1) assumes that the soybean supply (S) is influenced by the following factors: a) the expected farm level price (EP^{Farm}), based on the assumption that the farmers can easily get the forecast price information; b) the loan rate (LR), which is normally announced before the farmers make their decisions; c) expected yield (EYD); and d) a time trend variable (T), which captures the technology progress. In this equation, costs are not included because correlation between cost and the time trend variable (0.98) causes a severe multicollinearity problem.

Equation (2) shows that the domestic consumption (D) of soybeans (including waste and seed) is influenced by: a) the retail price for soybeans (P^{Rtl}); b) the price of corn (P^{Corn}), based on the assumption that corn can be a substitute for soybeans, either in terms of feed usage, oil usage or in terms of the planting area; and c) U.S. per capita personal disposable income ($PINC$).

Equation (3) says that exports (E) of soybeans is a function of a) world price (P^{Wld}); b) previous stocks of soybeans (STK_{t-1}); and c) production (S).

Equation (4) expresses that the farm level price (P^{Farm}) is affected by the lagged price level (P^{Farm}_{t-1}), based on the assumption that the lagged price contains information that determines current prices; and b) the domestic supply level (*S*), based on the assumption that, once the farmers decide their production level, price will clear the markets. Equation (5) tries to capture the relationship between the two prices --- retail price (P^{Rtl}) and farm level price (P^{Farm}), and we also assume that the lagged retail price (P_{t-1}^{Rtl}) has some impact on the current retail price. Equation (6) tries to show how the world price (P^{Wld}) relates to the U.S. soybean retail price and the U.S. soybean farm level price. We also assume the lagged world price (P_{t-1}^{Wld}) will affect the current world price.

Equation (7) is an identity. It shows that the ending stock level (STK_t) equals the beginning stock level (STK_{t-1}) plus domestic production (*S*) and import (*M*) minus domestic crushing demand (*D*) and export (*E*).

Empirical Estimation

Data Description

All data used in this research are annual data from 1965 to 2002. The data of demand, supply, stock, export and import comes from the USDA-FAS PS&D online databases. The data of soybean prices is from the USDA-ERS *Oil Crops Yearbook.* We used the wholesale price of No. 1 yellow soybean prices in the Chicago Market for the retail price, assuming a constant margin between wholesale prices and retail prices. The world prices for soybeans are derived prices---the export value divided by export quantity---from the FAO statistical databases. Corn prices are the Chicago Market prices for No. 2 yellow corn from the USDA-ERS *Feed Yearbook.* The income, population and price indexes data is from the *Economic Report of the President (2003).* In addition, all data related to price and incomes are transformed into real terms. Income has been deflated by the GDP deflator (1982=100). Prices are deflated by the consumer price index (1982~1984=100).

Estimation Results

Equations (1) – (7) were estimated simultaneously using three stage least square (3SLS) method by SAS. For variables as expected yield (*EYD*) and expected price (EP^{Farm}), the actual yields and actual prices were used in the estimation. Estimation results are reported in table 1.

Table 1. Estimation Results of the U.S. Soybean Model

Equation	Variable	Estimate	S.E.
(1) Supply	Intercept	-2199.28***	394.36
	EP^{Farm}	97.79***	16.28
	LR	140.93***	32.80
	EYD	52.24***	8.53
	T	58.66***	6.13
(2) Demand	Intercept	-569.48*	286.10
	P^{Rtl}	-38.70**	18.80
	P^{Corn}	75.49*	39.94
	INC	0.16***	0.02
(3) Export	Intercept	-318.93***	76.94
	P^{Wld}	21.68***	5.62
	Stk_{t-1}	0.53***	0.08
	S	0.39***	0.02
(4) Farm Level Price	Intercept	4.47***	1.32
	P^{Farm}_{t-1}	0.67***	0.10
	Prd	0.0004***	0.00
(5) Retail Price	Intercept	-0.38	0.60
	P^{Rtl}_{t-1}	-0.94**	0.43
	P^{Farm}	2.11***	0.47
(6) Export Price	Intercept	0.02	0.12
	P^{Wld}_{t-1}	0.27***	0.03
	P^{Farm}	0.95***	0.05
	P^{Rtl}	-0.17***	0.04

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

For the supply function, all the coefficients have correct signs as we expected and are statistically significant (5% significance level). In the demand function, all variables have correct signs and are statistically significant (5% significance level). The sign of the corn price supports the hypothesis that corn can be considered as a substitute product for soybeans. The slopes of the prices in the supply and demand functions tell us that the supply of soybeans is more elastic than the demand for soybeans with respect to price changes. Equation (4) shows that the U.S. farm level price is negatively related to soybean output. This means that overproduction leads to a fall in the farm level price. Equation (6) tells us that the U.S. export price is positively related to the U.S. farm level price and negatively related to the retail price.

Economic Welfare Analyses for the U.S. Soybean Industry

Given the above estimation results, economic welfare analyses of the U.S. soybean industry can be conducted.

As shown in figure 4, in ***period t***, the demand curve is D_t and the supply curve is S_t. At the farm level price P_t^{Farm}, the output level is Q_t^S. At the retail price P_t^{Rtl}, the consumption quantity is Q_t^D. Assuming that the U.S. soybean stock level is constant over time,

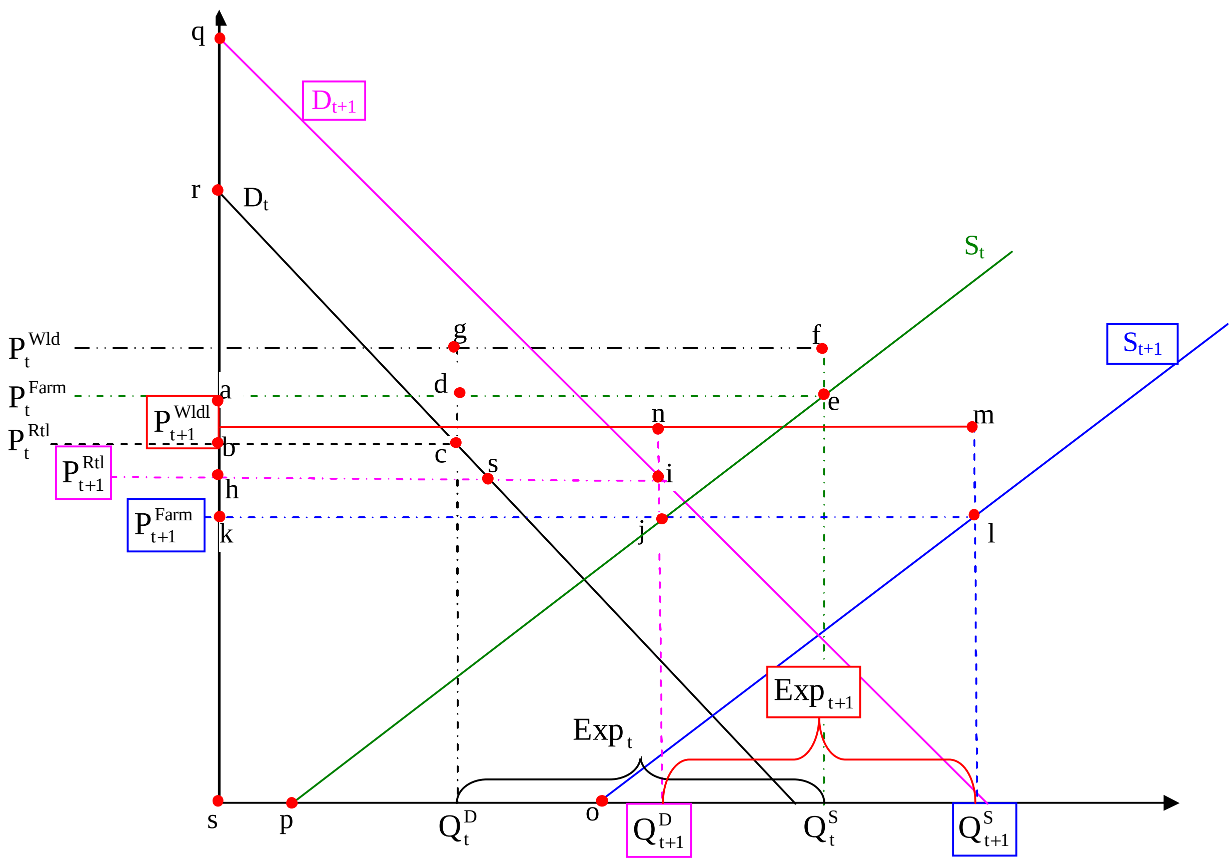

Figure 4. Economic Welfare Analysis of the U.S. Soybean Industry.

the difference between Q_t^S and Q_t^D is the volume of U.S. soybean exports at ***period t*** and the export price is P_t^{Wld}. In ***period t+1***, at the farm level price P_{t+1}^{Farm}, the output level is Q_{t+1}^S. At the retail price P_{t+1}^{Rtl}, the U.S. domestic demand is Q_{t+1}^D. The difference between Q_{t+1}^S and Q_{t+1}^D is the volume of U.S. soybean exports in ***period t+1***, and the export price is P_{t+1}^{Wld}. Given the above information, producer surplus (PS) and consumer surplus (CS) as well as the changes of PS and CS can be found by the following formulas:

(8) PS_t=aeps
(9) CS_t=rcb
(10) $\Delta PS_{t+1,\,t}$=jlop-aejk
(11) $\Delta CS_{t+1,\,t}$=qrsi+bcsh

Government costs (GC) include two parts. The first part is the government costs for consumption (GCC), which equals the difference between the farm level price and the retail level price times the U.S. domestic demand quantity. If the retail price is higher than the farm level price, then we consider this price difference between the retail price and the farm level price times the U.S. domestic demand quantity as profits obtained by agribusiness firms (PAF).

The second part of government costs is government costs for exports (GCE), which equals the difference between the farm level price and the export price times the export quantity. If the export price is higher than the farm level price, then we consider this price difference between the export price and the farm level price times the export quantity as profits obtained by U.S. soybean exporters (PE). Government costs for consumption and exports as well as the changes of GCC and GEC can be found by the following formulas:

(12) GCC_t=abcd
(13) GCE_t= gfed
(14) $\Delta GCC_{t+1,\,t}$= hijk - abcd
(15) $\Delta GCE_{t+1,\,t}$= nmlj - gfed

Assuming 1990 as the base year, the results of (8)-(15) are reported in table 2.

Table 2. Economics Welfare Analyses for the U.S. Soybean Industry ($million, 1982-1984=100)

Year	PS	ΔPS	CS	ΔCS	GCC*	ΔGCC	GCE	ΔGCE	PAF	ΔPAF	PE	ΔPE
1990	7,921	--	26,075	--	99	--	0	--	0	--	226	--
1991	7,726	-195	26,410	335	0	-99	0	0	95	95	275	49
1992	8,494	768	29,141	2,732	0	0	0	0	360	265	286	11
1993	8,179	-315	28,162	-979	0	0	0	0	496	136	191	-95
1994	10,198	2,020	30,347	2,185	485	485	0	0	0	-496	324	133
1995	8,370	-1,829	30,002	-346	0	-485	0	0	1250	1,250	336	12
1996	11,060	2,691	32,625	2,623	347	347	0	0	0	-1250	344	8
1997	11,623	563	31,536	-1,089	762	415	0	0	0	0	245	-99
1998	9,102	-2,521	35,309	3,773	958	196	0	0	0	0	364	119
1999	6,551	-2,552	35,977	668	0	-958	0	0	337	337	397	33
2000	7,001	450	39,735	3,758	0	0	0	0	39	-298	302	-95
2001	6,636	-365	39,690	-46	0	0	0	0	243	203	390	88
2002	7,115	479	42,079	2,389	212	212	0	0	0	-243	319	-71
Average	**$8,460**	**$-67**	**$32,853**	**$1,334**	**$220**	**$9**	**$0**	**$0**	**$217**	**$0**	**$308**	**$8**

* Government costs do not include the costs associated with soybean stocks, loan interests, and other costs occurred in export support programs.

Table 2 shows that in 1990s, consumer surplus (CS) and producer surplus (PS) were $32,853 million and $8,460 million on average respectively (all results are reported in real terms, 1982~1984=100). In aggregate terms, consumer surplus is much higher than producer surplus. However, taking the number of individuals in each group into consideration, the results are quite different. In per capita terms, producer surplus was about $11,900[1] and consumer surplus was only $104. From 1990 to 2002, on average, U.S. soybean producers lost $67.18 million each year and, in per capita terms, they lost $100 annually. Because of the low prices of soybeans the U.S. soybean consumers gained $1,333.69 million each year in aggregate terms and $5 in per capita terms.

In 1990, government costs for consumption (GCC) was $99 million. From 1990 to 2002, the average of government costs for consumption was $220 million with an annual increase of $9

[1] The number of soybean producers was 663,880 in 2003 (USDA-FSA). We assume that the number of soybean producers did not change from 1990 to 2003.

million in the past twelve years. These government costs were paid by taxpayers. On the other hand, from 1990 to 2002, on average, U.S. soybean agribusiness firms made a profit (PAF) of $217 million each year.

Since 1990, U.S. soybean export prices were always higher than U.S. soybean farm level prices. Therefore government costs were realized. Due to high export prices, in 1990, U.S. soybean export firms made a profit (PE) of $226 million. From 1990 to 2002, on average, U.S. soybean export firms made a profit of $308 million each year with an annual increase of $8 million.

Due to the unavailability of the number of U.S. soybean business firms and U.S. soybean exporters, the per capita gain can not be calculated directly. Assuming the number of agribusiness firms and exporters is 10% of U.S. producers, in per capita terms, on average agribusiness firms made a profit of $3,268 each year and exporters made a profit of $4,635.

In summary, in aggregate terms the descending order of the benefits obtained by different interest groups in the U.S. soybean industry is: consumers, producers, exporters, agribusinesses, and taxpayers. In per capita terms, the descending order of the benefits obtained by different interest groups is: producers, exporters, agribusinesses, consumers, and taxpayers. These differences stem from the number of individuals in each group, i.e., there are a large number of taxpayers and consumers, and relatively small number of producers, agribusiness firms, and export firms. Comparing the changes of the benefits obtained by different interest groups over the past 12 years, producers and taxpayers were losing money, exporters were gaining more and more profits, the profits of agribusinesses were stable, and consumers were benefited because of the low price of soybeans.

Conclusions

The soybean industry is a crucial sector for U.S. agriculture. U.S. soybeans have been a subsidized commodity since 1941 and the 2002 Farm Bill provides direct government and counter-cyclical payments for the first time. The 2002 target price for soybeans was set at $5.80/bushel, which was expected to be effective through 2007. This research developed a soybean industry level model and conducted welfare economic analyses on the U.S. soybean industry. Results indicate that in the last 12 years, in aggregate terms U.S. consumers dominated other interest groups in the U.S. soybean industry. However, in per capita terms, U.S. soybean producers were the dominant interest group, although their benefits declined gradually. U.S. exporters and agribusiness firms also took profitable positions in the U.S. soybean industry while taxpayers paid for the government costs associated with U.S. soybean subsidy policies.

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Who Dominates the U.S. Soybean Industry:
Producers, Consumers, or Agribusinesses?

Abstract

Globally the U.S. is the number one producer, consumer and exporter of soybeans. Nationally, U.S. soybean production value ranks second among all agricultural bulk commodities, having a significant impact on U.S. farm incomes. U.S. soybean has been a subsidized commodity since 1941 and the 2002 Farm Bill provides soybeans for the first time direct government payment and counter-cyclical payments. Using welfare economics, this research explores the political economy of U.S. soybean subsidy policies. Results for the U.S. soybean industry indicate that in aggregate terms, consumer interests dominate and in per capita terms, producer interests dominate.

Introduction

An Overview of U.S. Soybeans

The soybean industry in the U.S. plays an important role in the world. Globally, the U.S. is the leading country in soybean production, consumption and exports as shown in figure 1-a, figure 1-b, and figure 1-c. These three figures also show that in the last decade, Brazil and Argentina have become major competitors for the U.S. in the world soybean market (Schnefp, Dohlman, and Bolling, 2001). In 2003, U.S. soybean production was 65.80 million metric tons, accounting for 35% of world production; U.S. soybean consumption was 43.25 million metric tons, 21.68% of world consumption; and U.S. soybean exports were 24.49 million metric tons, 39.07% of world exports (FAO, 2004). However, U.S. soybean imports were very low, only 0.22 million metric tons in 2003 (USDA-FAS, 2004).

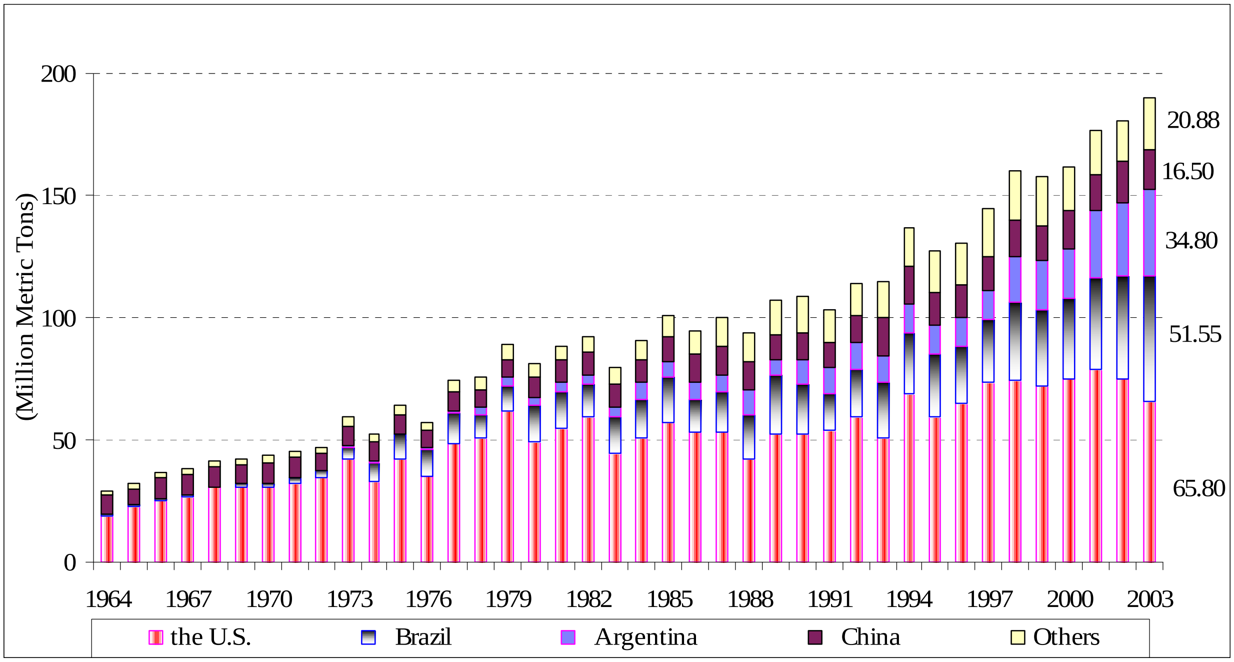

Figure 1-a. Soybean Production Comparison between the U.S. and other Countries.
Source: FAO, online statistical databases, 2004.

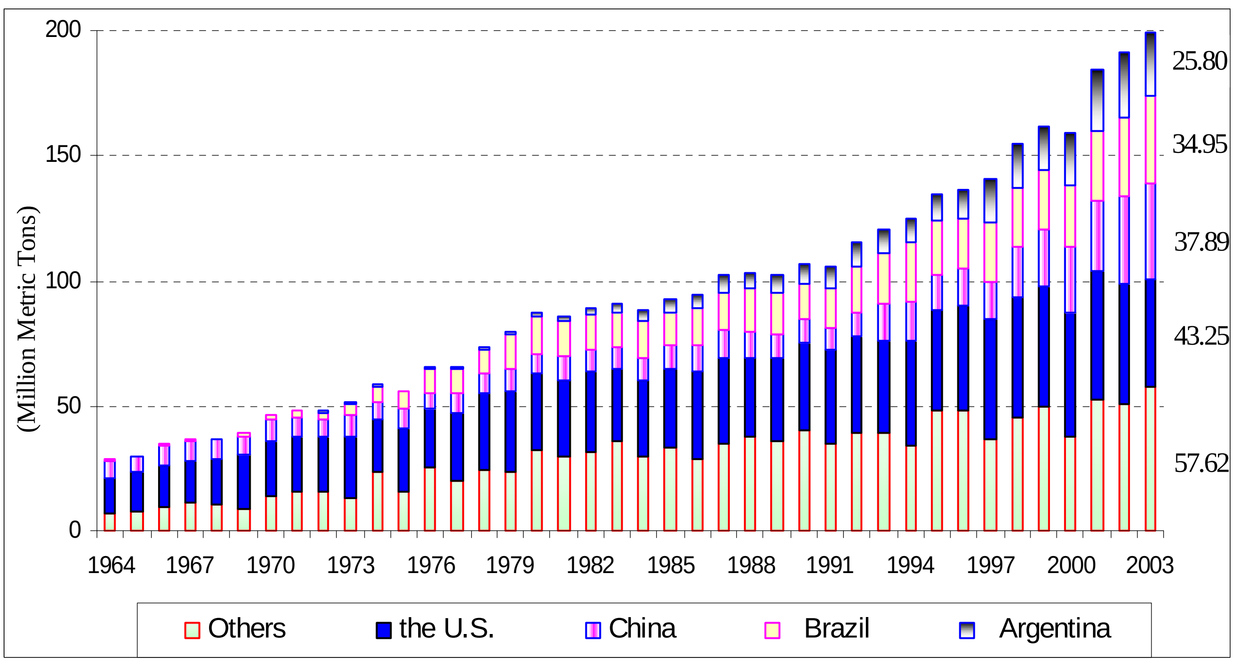

Figure 1-b. Soybean Consumption Comparison between the U.S. and Other Countries.
Source: USDA-FAS, PS&D online dataset, 2004.

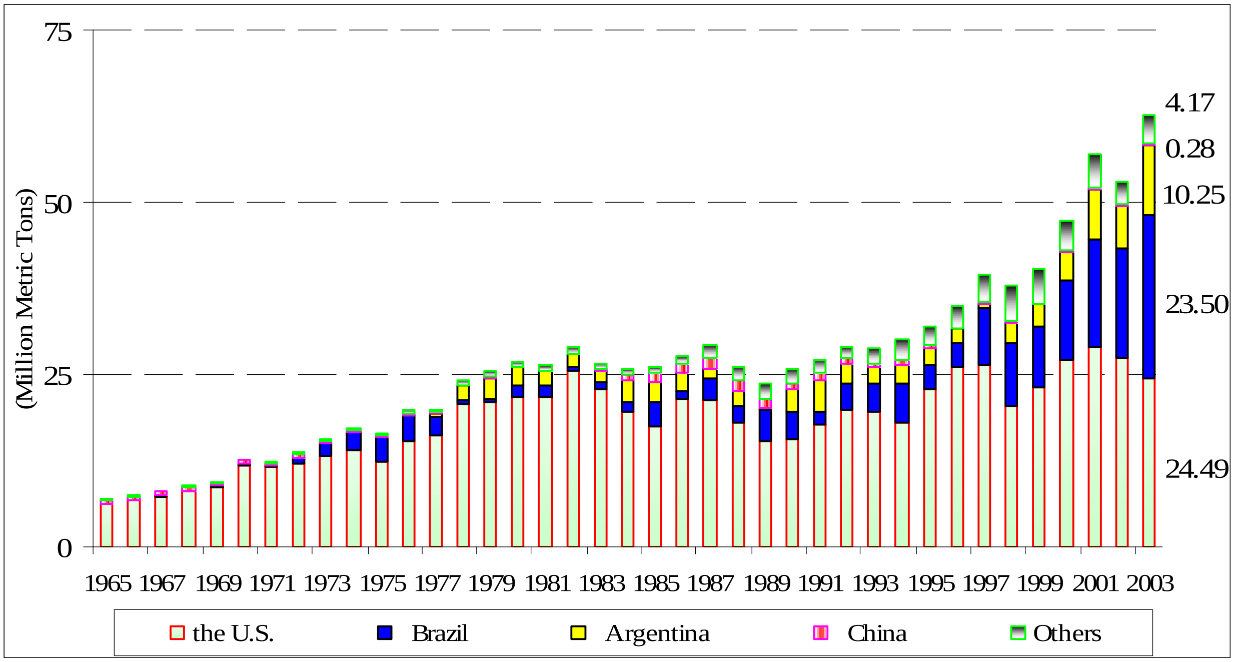

Figure 1-c. Soybean Export Comparison between U.S. and Other Countries.
Source: USDA-FAS, PS&D online dataset, 2004.

Nationally, the soybean industry is a crucial sector in U.S. agriculture. U.S. soybean production value was $16.18 billion in 2002/2003, ranking second among all agricultural bulk commodities. Since 2000, soybeans have been U.S.'s leading agricultural export for agricultural bulk commodities, exceeding corn and wheat. Soybeans have been one of the U.S. government-supported commodities since 1941. Before the 2002 Farm Bill, the primary government support programs for soybeans included commodity loan and marketing loan programs. Under these programs, government payments for the soybean industry increased quickly, especially in the last decade. The net government expenditures on the soybean subsidy program were - $86 million in 1990 and increased to $3,281 million in 2001 (USDA-FSA, 2004). Even with the increasing subsidy burden, the 2002 Farm Bill further placed soybeans under the direct payment and the counter-cyclical payment programs, and set $5.80/bushel as the target price through 2007 (American Soybean Association, 2002).

Objectives

In this research, our objectives include 1) developing a soybean model at the industry level, which incorporates endogenous supply, demand and prices and other related exogenous variables; 2) estimating the model as a simultaneous equation system; 3) conducting economics welfare analyses for the U.S. soybean industry; 4) identifying which interest group dominates the U.S. soybean industry.

U.S. Government Soybean Subsidy Programs

The main U.S. soybean subsidy programs include soybean loan program and government payments. The soybean loan program was first introduced in 1941 and has been in place since then, except in 1975 (Westcott and Price, 2001). The original form of the soybean loan program was the *commodity loan program*, which supported the market price. The *marketing loan program* started in the mid-1980s, which mainly supported producers' income instead of the market prices.

Under the *commodity loan program*, producers must keep the crop designated as loan collateral in approved storage to preserve the crop's quality. Producers may choose to either default on the loan at the end of the loan period, keeping the loan money and forfeiting ownership of collateral to the government or sell the commodity and repay the loan plus interest, depending on the market price level (Westcott and Price, 1999). While under the *marketing loan program* producers may operate as described above. Alternatively, the marketing loan provisions also allow repayment of commodity loans at less than the original loan rate when market prices are lower (USDA-ERS, 2004). This feature decreases the loan program's potential effect on supporting prices because stock accumulation by the government, through loan defaults, is reduced. Instead, farmers are provided economic incentives to retain ownership of the crops and sell them rather than default on loans and forfeit ownership of the crops to the government (Westcott and Price, 1999).

Another subsidy form for soybeans is government payments, including direct payments and counter-cyclical payments within the 2002 Farm Bill. The formula for direct payments is:

Direct Payment = Base Acres x Program Yield x 85% x Direct Payment Rate

Base acres and program yields are calculated on the average level of the recent history of planted acres and yields, while the direct payment rate (DPR) is decided by the USDA. The 2002 Farm Bill set the DPR for soybeans at $0.44/bushel. Direct payments only relate to the planted area, so farmers and eligible landowners will receive annual direct payments.

The Counter-Cyclical Payments formula is:

Counter-Cyclical Payment=Base Acres × Program Yield × 85% × CCP Rate
CCP Rate = Max (0, Target Price – Effective Price)
Effective Price = Max (MYA Price, Loan Rate) + Direct Payment Rate

The MYA price is the marketing year average price, and the 2002 Farm Bill set the target price for soybeans at $5.80/bushel. The counter-cyclical payment is closely related to the market price. If the market price is high enough, the counter-cyclical payment will not occur.

Literature Review

In modeling the soybean industry, different methods have been employed. Piggott et al. (2000), estimated soybeans, soybean meal and soybean oil demand and supply elasticities using 1974 to 1998 annual data. The cross effect between supply and demand could not be examined because they estimated the demand and supply independently. Since they used the domestic disappearance as the total demand, the effects of some exogenous factors on soybean supply and demand cannot be examined. The USDA also has its own estimation model to predict the supply and demand (Reed, et al., 2002). Given the estimated elasticities and baseline demand and prices, they estimate the demand using a system of equations, including export demand, feed demand, crushing demand, industrial demand, domestic demand, food demand, etc. Similar methods were used for the supply side. Gardner (1990) used cross elasticities (among wheat, corn and soybeans), estimated by Tyers and Anderson and Johnson et al., to determine producers' gains and losses. However, many previous works did not incorporate exports as an endogenous variable in the model. The U.S. is the biggest soybean exporter in the world, and in 2003 U.S. soybean exports comprised 37% of U.S. soybean output (USDA-FAS, 2004). The empirical estimation results might not be reliable when the export effect on the U.S. soybean industry was ignored.

Modeling the Soybeans Industry

The Structure of the U.S. Soybean Industry

To accurately describe the U.S. soybean industry, the structure of the demand and supply system and the factors that will affect the system were introduced first. As shown in Figure 3, the entire soybean industry can be viewed as interaction of four components: supply, demand, prices and exogenous factors.

Supply comes from three sources: production, beginning stocks and imports. Demand includes four parts: crush demand, export demand, stocks, and others, among them the crushed soybeans can be further divided into the sub-categories of soybean oil and soybean meal. Soybean oil and soybean meal can be allocated based on usage into domestic consumption, exports, and stocks. Three levels of soybean price---farm-level prices, retail-level prices and world prices are taken into consideration as price variables. Seven defined exogenous variables are included in this system. Technology, production cost, government subsidy and yield affect the producer's decision on outputs. Corn price (hypothesizing that corn is a substitute product for soybeans), disposable personal income and population affect the total demand.

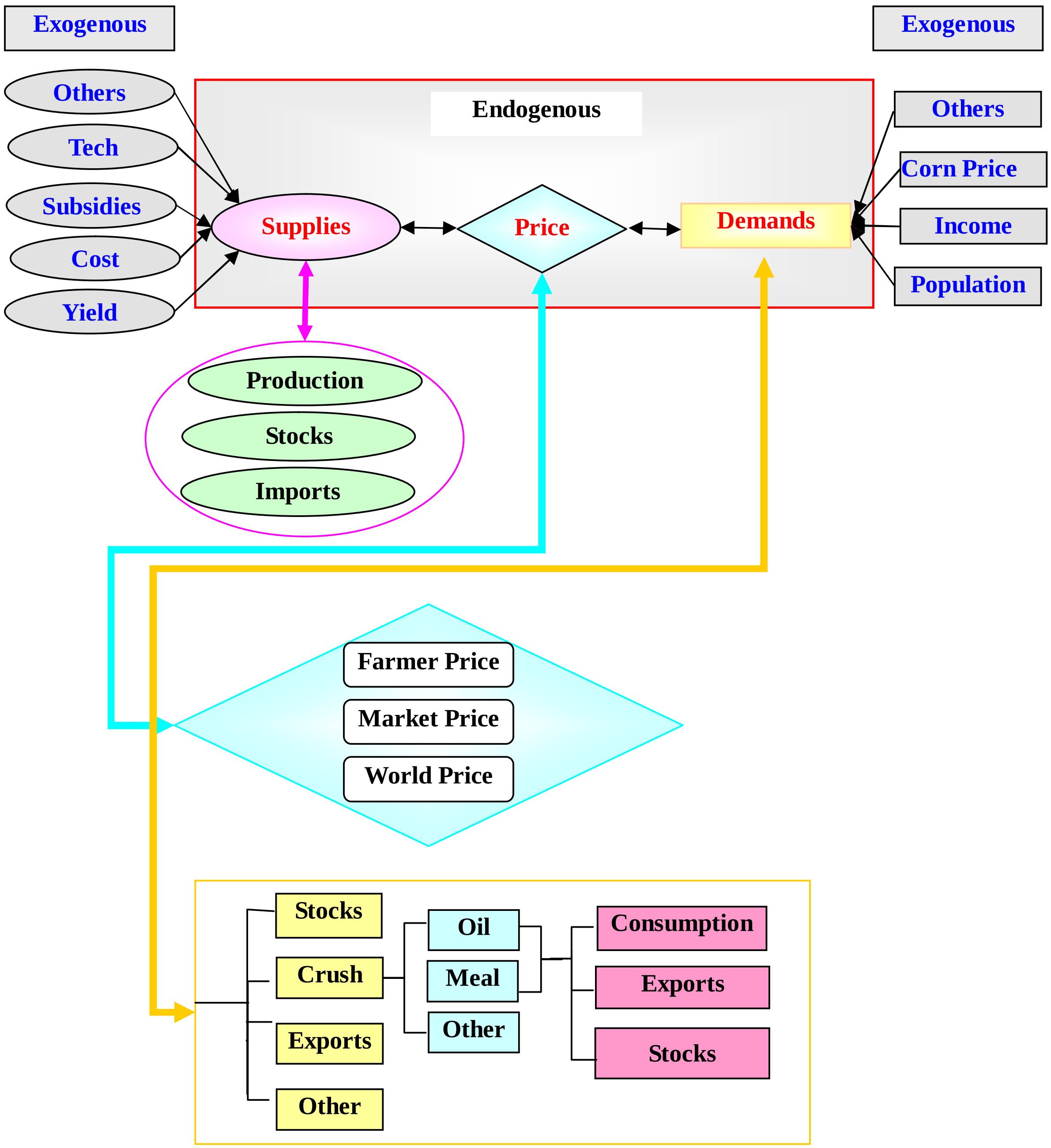

Figure 2. Structural Diagram of the U.S. Soybean Industry.

Theoretical Model

From the above structure, the model of U.S. soybean industry can be expressed as below:

$$\begin{cases} (1)\ S=f(EP^{Farm}, Stk, LR, EYD, Tech, Cost, Others) \\ (2)\ D=g(P^{Rtl}, P^{Corn}, INC, POP, Others) \\ (3)\ E=h(STK, S, D, Others) \\ (4)\ P^{Farm}=\varphi(P^{Farm}_{t-1}, GS, S, Others) \\ (5)\ P^{Rtl}=\psi(P^{Farm}, Others) \\ (6)\ P^{Wld}=\pi(P^{Wld}_{t-1}, E, Others) \\ (7)\ Stk=(Stk_{t-1}, M^*, E, D) \end{cases}$$

* Since U.S. soybean imports were quite small, we do not include import equation in the model.

Where

S: Supply of soybeans;
EP^{Farm}: Expected farm-level prices;
LR: Loan rates of soybeans;
EYD: Expected yields;
Stk: Domestic stocks of soybeans;
Tech: Technology;
Cost: Production costs for soybeans;
M: Import;
P^{Rtl}: Retail prices for soybeans;
P^{Corn}: Retail prices for corn;
E: Exports of soybeans;
M: U.S. soybean Imports;
P^{Wld}: World prices for soybeans;
INC: Personal disposable income;
POP: Population;
GS: Government subsidy.

Based on the above analysis, empirical equations are expressed as follows. The expected signs for the coefficients are shown below the coefficients.

$$\begin{cases} (1)\ \hat{S}=\hat{a}_0+\underset{(+)}{\hat{a}_1} EP^{Farm}+\underset{(+)}{\hat{a}_2}LR+\underset{(+)}{\hat{\alpha}_3}EYD+\underset{(+)}{\hat{\alpha}_4}T \\ (2)\ \hat{D}=\hat{b}_0+\underset{(-)}{\hat{b}_1} P^{Rtl}+\underset{(+)}{\hat{b}_2} P^{corn}+\underset{(+)}{\hat{b}_3}PINC \\ (3)\ \hat{E}=\hat{g}_0+\underset{(+)}{\hat{g}_1}P^{Wld}+\underset{(+)}{\hat{g}_2} STK_{t-1}+\underset{(+)}{\hat{g}_3}S \\ (4\ \hat{P}^{Farm}_t=\hat{q}_0+\underset{(+)}{\hat{q}_1} P^{Farm}_{t-1}+\underset{(-)}{\hat{q}_2} S \\ (5)\ \hat{P}^{Rtl}_t=\hat{l}_0+\underset{(+)}{\hat{l}_1}P^{Rtl}_{t-1}+\underset{(+)}{\hat{l}_2} P^{Farm} \\ (6)\ \hat{P}^{Wld}_t=\hat{w}_0+\underset{(+)}{\hat{w}_1} P^{Wld}_{t-1}+\underset{(+)}{\hat{w}_2} P^{Farm}+\underset{(-)}{\hat{\omega}_3} P^{Rtl} \\ (7)\ STK_t=STK_{t-1}+S+M-D-E \end{cases}$$

where S: Supply of soybeans, equaling the domestic production (million bushels);
EP^{Farm}: Expected prices received by farmers (dollars/bushel);
LR: Loan rates of soybeans (dollars/bushel);
EYD: Expected soybean yields (bushels/acre);
STK: Domestic stocks of soybeans (million bushels);
D: Domestic crush demand (million bushels);
P^{Farm}: The prices received by farmers (dollars/bushel);
P^{Rtl}: Retail prices for soybeans (dollars/bushel);
P^{Corn}: Retail prices for corn (dollars/bushel);
$PINC$: Per capita personal disposable income (dollars);
E: Exports of soybeans (million bushels);
M: U.S. soybean imports (million bushels);
P^{Wld}: World prices for soybeans (dollars/bushel).
T: Time trend variable.

Equation (1) assumes that the soybean supply (S) is influenced by the following factors: a) the expected farm level price (EP^{Farm}), based on the assumption that the farmers can easily get the forecast price information; b) the loan rate (LR), which is normally announced before the farmers make their decisions; c) expected yield (EYD); and d) a time trend variable (T), which captures the technology progress. In this equation, costs are not included because correlation between cost and the time trend variable (0.98) causes a severe multicollinearity problem.

Equation (2) shows that the domestic consumption (D) of soybeans (including waste and seed) is influenced by: a) the retail price for soybeans (P^{Rtl}); b) the price of corn (P^{Corn}), based on the assumption that corn can be a substitute for soybeans, either in terms of feed usage, oil usage or in terms of the planting area; and c) U.S. per capita personal disposable income ($PINC$).

Equation (3) says that exports (E) of soybeans is a function of a) world price (P^{Wld}); b) previous stocks of soybeans (STK_{t-1}); and c) production (S).

Equation (4) expresses that the farm level price (P^{Farm}) is affected by the lagged price level (P_{t-1}^{Farm}), based on the assumption that the lagged price contains information that determines current prices; and b) the domestic supply level (*S*), based on the assumption that, once the farmers decide their production level, price will clear the markets. Equation (5) tries to capture the relationship between the two prices --- retail price (P^{Rtl}) and farm level price (P^{Farm}), and we also assume that the lagged retail price (P_{t-1}^{Rtl}) has some impact on the current retail price. Equation (6) tries to show how the world price (P^{Wld}) relates to the U.S. soybean retail price and the U.S. soybean farm level price. We also assume the lagged world price (P_{t-1}^{Wld}) will affect the current world price.

Equation (7) is an identity. It shows that the ending stock level (STK_t) equals the beginning stock level (STK_{t-1}) plus domestic production (*S*) and import (*M*) minus domestic crushing demand (*D*) and export (*E*).

Empirical Estimation

Data Description

All data used in this research are annual data from 1965 to 2002. The data of demand, supply, stock, export and import comes from the USDA-FAS PS&D online databases. The data of soybean prices is from the USDA-ERS *Oil Crops Yearbook.* We used the wholesale price of No. 1 yellow soybean prices in the Chicago Market for the retail price, assuming a constant margin between wholesale prices and retail prices. The world prices for soybeans are derived prices---the export value divided by export quantity---from the FAO statistical databases. Corn prices are the Chicago Market prices for No. 2 yellow corn from the USDA-ERS *Feed Yearbook.* The income, population and price indexes data is from the *Economic Report of the President (2003).* In addition, all data related to price and incomes are transformed into real terms. Income has been deflated by the GDP deflator (1982=100). Prices are deflated by the consumer price index (1982~1984=100).

Estimation Results

Equations (1) – (7) were estimated simultaneously using three stage least square (3SLS) method by SAS. For variables as expected yield (*EYD*) and expected price (EP^{Farm}), the actual yields and actual prices were used in the estimation. Estimation results are reported in table 1.

Table 1. Estimation Results of the U.S. Soybean Model

Equation	Variable	Estimate	S.E.
(1) Supply	Intercept	-2199.28***	394.36
	EP^{Farm}	97.79***	16.28
	LR	140.93***	32.80
	EYD	52.24***	8.53
	T	58.66***	6.13
(2) Demand	Intercept	-569.48*	286.10
	P^{Rtl}	-38.70**	18.80
	P^{Corn}	75.49*	39.94
	INC	0.16***	0.02
(3) Export	Intercept	-318.93***	76.94
	P^{Wld}	21.68***	5.62
	Stk_{t-1}	0.53***	0.08
	S	0.39***	0.02
(4) Farm Level Price	Intercept	4.47***	1.32
	P^{Farm}_{t-1}	0.67***	0.10
	Prd	0.0004***	0.00
(5) Retail Price	Intercept	-0.38	0.60
	P^{Rtl}_{t-1}	-0.94**	0.43
	P^{Farm}	2.11***	0.47
(6) Export Price	Intercept	0.02	0.12
	P^{Wld}_{t-1}	0.27***	0.03
	P^{Farm}	0.95***	0.05
	P^{Rtl}	-0.17***	0.04

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

For the supply function, all the coefficients have correct signs as we expected and are statistically significant (5% significance level). In the demand function, all variables have correct signs and are statistically significant (5% significance level). The sign of the corn price supports the hypothesis that corn can be considered as a substitute product for soybeans. The slopes of the prices in the supply and demand functions tell us that the supply of soybeans is more elastic than the demand for soybeans with respect to price changes. Equation (4) shows that the U.S. farm level price is negatively related to soybean output. This means that overproduction leads to a fall in the farm level price. Equation (6) tells us that the U.S. export price is positively related to the U.S. farm level price and negatively related to the retail price.

Economic Welfare Analyses for the U.S. Soybean Industry

Given the above estimation results, economic welfare analyses of the U.S. soybean industry can be conducted.

As shown in figure 4, in ***period t***, the demand curve is D_t and the supply curve is S_t. At the farm level price P_t^{Farm}, the output level is Q_t^S. At the retail price P_t^{Rtl}, the consumption quantity is Q_t^D. Assuming that the U.S. soybean stock level is constant over time,

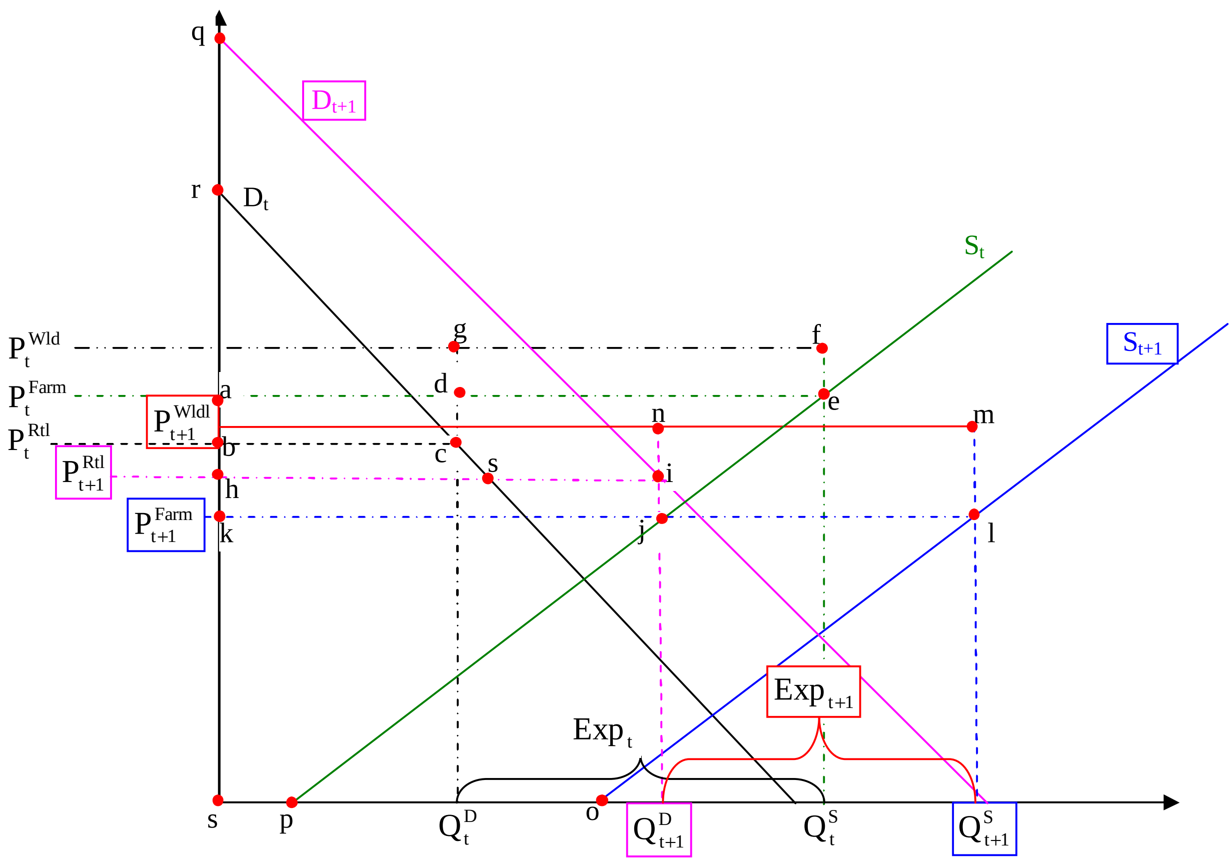

Figure 4. Economic Welfare Analysis of the U.S. Soybean Industry.

the difference between Q_t^S and Q_t^D is the volume of U.S. soybean exports at ***period t*** and the export price is P_t^{Wld}. In ***period t+1***, at the farm level price P_{t+1}^{Farm}, the output level is Q_{t+1}^S. At the retail price P_{t+1}^{Rtl}, the U.S. domestic demand is Q_{t+1}^D. The difference between Q_{t+1}^S and Q_{t+1}^D is the volume of U.S. soybean exports in ***period t+1***, and the export price is P_{t+1}^{Wld}. Given the above information, producer surplus (PS) and consumer surplus (CS) as well as the changes of PS and CS can be found by the following formulas:

(8) PS_t=aeps
(9) CS_t=rcb
(10) $\Delta PS_{t+1,\,t}$=jlop-aejk
(11) $\Delta CS_{t+1,\,t}$=qrsi+bcsh

Government costs (GC) include two parts. The first part is the government costs for consumption (GCC), which equals the difference between the farm level price and the retail level price times the U.S. domestic demand quantity. If the retail price is higher than the farm level price, then we consider this price difference between the retail price and the farm level price times the U.S. domestic demand quantity as profits obtained by agribusiness firms (PAF).

The second part of government costs is government costs for exports (GCE), which equals the difference between the farm level price and the export price times the export quantity. If the export price is higher than the farm level price, then we consider this price difference between the export price and the farm level price times the export quantity as profits obtained by U.S. soybean exporters (PE). Government costs for consumption and exports as well as the changes of GCC and GEC can be found by the following formulas:

(12) GCC_t=abcd
(13) GCE_t= gfed
(14) $\Delta GCC_{t+1,\,t}$= hijk - abcd
(15) $\Delta GCE_{t+1,\,t}$= nmlj - gfed

Assuming 1990 as the base year, the results of (8)-(15) are reported in table 2.

Table 2. Economics Welfare Analyses for the U.S. Soybean Industry ($million, 1982-1984=100)

Year	PS	ΔPS	CS	ΔCS	GCC*	ΔGCC	GCE	ΔGCE	PAF	ΔPAF	PE	ΔPE
1990	7,921	--	26,075	--	99	--	0	--	0	--	226	--
1991	7,726	-195	26,410	335	0	-99	0	0	95	95	275	49
1992	8,494	768	29,141	2,732	0	0	0	0	360	265	286	11
1993	8,179	-315	28,162	-979	0	0	0	0	496	136	191	-95
1994	10,198	2,020	30,347	2,185	485	485	0	0	0	-496	324	133
1995	8,370	-1,829	30,002	-346	0	-485	0	0	1250	1,250	336	12
1996	11,060	2,691	32,625	2,623	347	347	0	0	0	-1250	344	8
1997	11,623	563	31,536	-1,089	762	415	0	0	0	0	245	-99
1998	9,102	-2,521	35,309	3,773	958	196	0	0	0	0	364	119
1999	6,551	-2,552	35,977	668	0	-958	0	0	337	337	397	33
2000	7,001	450	39,735	3,758	0	0	0	0	39	-298	302	-95
2001	6,636	-365	39,690	-46	0	0	0	0	243	203	390	88
2002	7,115	479	42,079	2,389	212	212	0	0	0	-243	319	-71
Average	**$8,460**	**$-67**	**$32,853**	**$1,334**	**$220**	**$9**	**$0**	**$0**	**$217**	**$0**	**$308**	**$8**

* Government costs do not include the costs associated with soybean stocks, loan interests, and other costs occurred in export support programs.

Table 2 shows that in 1990s, consumer surplus (CS) and producer surplus (PS) were $32,853 million and $8,460 million on average respectively (all results are reported in real terms, 1982~1984=100). In aggregate terms, consumer surplus is much higher than producer surplus. However, taking the number of individuals in each group into consideration, the results are quite different. In per capita terms, producer surplus was about $11,900[1] and consumer surplus was only $104. From 1990 to 2002, on average, U.S. soybean producers lost $67.18 million each year and, in per capita terms, they lost $100 annually. Because of the low prices of soybeans the U.S. soybean consumers gained $1,333.69 million each year in aggregate terms and $5 in per capita terms.

In 1990, government costs for consumption (GCC) was $99 million. From 1990 to 2002, the average of government costs for consumption was $220 million with an annual increase of $9

[1] The number of soybean producers was 663,880 in 2003 (USDA-FSA). We assume that the number of soybean producers did not change from 1990 to 2003.

million in the past twelve years. These government costs were paid by taxpayers. On the other hand, from 1990 to 2002, on average, U.S. soybean agribusiness firms made a profit (PAF) of $217 million each year.

Since 1990, U.S. soybean export prices were always higher than U.S. soybean farm level prices. Therefore government costs were realized. Due to high export prices, in 1990, U.S. soybean export firms made a profit (PE) of $226 million. From 1990 to 2002, on average, U.S. soybean export firms made a profit of $308 million each year with an annual increase of $8 million.

Due to the unavailability of the number of U.S. soybean business firms and U.S. soybean exporters, the per capita gain can not be calculated directly. Assuming the number of agribusiness firms and exporters is 10% of U.S. producers, in per capita terms, on average agribusiness firms made a profit of $3,268 each year and exporters made a profit of $4,635.

In summary, in aggregate terms the descending order of the benefits obtained by different interest groups in the U.S. soybean industry is: consumers, producers, exporters, agribusinesses, and taxpayers. In per capita terms, the descending order of the benefits obtained by different interest groups is: producers, exporters, agribusinesses, consumers, and taxpayers. These differences stem from the number of individuals in each group, i.e., there are a large number of taxpayers and consumers, and relatively small number of producers, agribusiness firms, and export firms. Comparing the changes of the benefits obtained by different interest groups over the past 12 years, producers and taxpayers were losing money, exporters were gaining more and more profits, the profits of agribusinesses were stable, and consumers were benefited because of the low price of soybeans.

Conclusions

The soybean industry is a crucial sector for U.S. agriculture. U.S. soybeans have been a subsidized commodity since 1941 and the 2002 Farm Bill provides direct government and counter-cyclical payments for the first time. The 2002 target price for soybeans was set at $5.80/bushel, which was expected to be effective through 2007. This research developed a soybean industry level model and conducted welfare economic analyses on the U.S. soybean industry. Results indicate that in the last 12 years, in aggregate terms U.S. consumers dominated other interest groups in the U.S. soybean industry. However, in per capita terms, U.S. soybean producers were the dominant interest group, although their benefits declined gradually. U.S. exporters and agribusiness firms also took profitable positions in the U.S. soybean industry while taxpayers paid for the government costs associated with U.S. soybean subsidy policies.

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