The U.S. and Iowa Soybeans Market: Implications to Iowa Soybean Producers

by

Mark S. Ash and William H. Meyers

The U.S. and Iowa Soybeans Markets: Implications to Iowa Soybean Producers

Mark S. Ash and William H. Meyers*

The specific objectives of this research are (a) to develop a theoretical model of the soybean, meal, and oil markets for the U.S. and Iowa to investigate the supply, demand, and price behavioral relationships of these products, (b) to link the prices from the national model to the Iowa soybean market, (c) to estimate a cost function of Iowa soybean production and derive the net income from the soybean production in Iowa, and (d) to evaluate the impacts of changes in external market and government policy variables on supply, demand, and price of soybean products and on net income of Iowa soybean producers.

Although several studies have looked at regional soybean markets, none have attempted to recursively link a major soybean producing state, such as Iowa, to a simultaneous national model. The model used in this study is divided into two sections. The first part has a national focus and examines supply and disposition of soybeans, meal, and oil. The national part of the model contains 23 equations of behavioral relationships and identities. The second part concentrates on the Iowa market. By linking the Iowa market to the national model through price linkages and behavioral equations, we can generate Iowa acreage response, determine soybean disposition within Iowa, compute measures of net returns from soybean farming, and examine the effect of certain changes in important policy and macroeconomic variables.

The sample period used for the study is 1961-1983. The model is block recursive in structure, i.e., the equations for the national block for soybeans, meal, and oil are solved simultaneously, and then the solutions for the equations of the Iowa submodel are derived. Considering the nonlinearity and simultaneous nature of the model, nonlinear two-stage least squares was used to estimate the model. The principal component technique is applied in the first stage of price estimation, because the number of exogenous variables exceeds the number of observations. The estimated coefficients have good statistical properties. The dynamic historical simulation, used for the validation of the model, has satisfactory Theil statistics and tracked the turning points of the endogenous variables very well.

---

*The authors are Agricultural Economist, Crops Branch, NED/ERS and Professor of Economics, Iowa State University. Paper presented at the NC-134 Conference on Applied Price Analysis, Forecasting, and Market Risk Management, St. Louis, April 22, 1984.

This research was partially supported by funding from the Iowa Soybean Promotion Board.

Using dynamic simulation methods, impact analyses were carried out to evaluate corn market and policy effects on Iowa farmers. All impacts were traced over a four year period to determine the dynamic behavior of the endogenous variables.

Iowa Submodel Specification

The purpose of this study is to disaggregate to a state level and, hopefully, to get more reliable parameter estimates for the evaluation of the production, storage, and marketing decisions of Iowa farmers. It is far easier to maintain the assumption of homogeneity among Iowa farmers than it is for a much broader national average with respect to planting decisions because of their similar circumstances with regard to weather conditions, output prices, and input costs, which vary considerably with geography. It also may be of some interest to trace through the disposition of soybeans within Iowa. What conditions will bring about greater inventory holding, or intra-state processing, or net exports to other states and nations? This model also seeks to examine the issue of how Iowa aggregate net farm income derived from soybeans has changed in the past, how it compares with other crops, and how it may be expected to fluctuate given shifts in certain important macroeconomic or policy variables.

The Iowa submodel contains 13 equations--some estimate demand and supply functions, while others connect the Iowa block recursively to the national model. The following section presents a discussion of each function from Table 1. Figure 1 gives a schematic presentation of the relationships in the model.

Iowa Soybean Acreage

The first equation of the Iowa sector is shown by (1), in Table 1 which estimates the expected harvested soybean acreage in Iowa. It is similar in specification to the U.S. equation, but uses Iowa prices and expected yields instead of national levels. The independent variables in this equation are: the deflated net returns from both soybeans and corn, a ratio of corn to soybean support prices, a ratio of U.S. corn diversion payment to Iowa corn price, lagged acreage, and a dummy variable for 1972 to account a large unexplained upward shift in that year.

Iowa Soybean Stocks

Equation (2) presents the factors thought to determine the amount of total stocks (including government-owned stocks held in Iowa). Soybean price is expected to be inversely related to stocks, as farmers generally try to hold onto their supplies, when prices are low speculating that their future returns will improve. Positive influences include: the Iowa corn price, since inventory holders will sell corn given a high price and free up limited storage space; current soybean production in the state, representing

Table 1. Structure of the Iowa submodel

$IASOYSAE = f(IASNR, IACNR, CORPD1/IACORPF, CORPE1/IASOYPL1, IASOYSAE_{-1})$	(1)
$IASOYHT = f(IASOYPF, IACORPF, IASOYSP, SOYHG, IASOYHT_{-1})$	(2)
$IASOYSC = f(IASOYPF, VALOM, IASOYSC_{-1})$	(3)
$IASOYPF = 0.99 * SOYPF$	(4)
$IACORPF = 1.004 * CORPF$	(5)
$IASOYPL1 = 0.995 * SOYPE1$	(6)
$IASOYSD = IASOYSP - IASOYUF - (IASOYHT - IASOYHT_{-1})$	(7)
$IASOYNX = IASOYSD - IASOYSC$	(8)
$IASOYVS = IASOYSD * IASOYPF$	(9)
$IASOYEXP = SYVC * IASOYSAE_{-1}$	(10)
$IASOYNFI = IASOYVS - IASOYEXP$	(11)
$IASOMSP = IASOMSC * IASOYSC * 50$	(12)
$IASOOSP = IASOOSC * IASOYSC * 100$	(13)

where

IASOYSAE = Iowa soybean acreage harvested for the next crop, 1000 acres
IASNR = Net returns from soybeans, Iowa, $/bu
IACNR = Net returns from corn, Iowa, $/bu
CORPD1 = Diversion payment for corn, Iowa, $/bu
IACORPF = Farm price for corn paid to Iowa farmers, $/bu
CORPE1 = U.S. corn effective support price, $/bu
IASOYPE1 = Soybean support price paid to Iowa farmers, $/bu
IASOYHT = Total stocks of soybeans held in Iowa, mil bu
IASOYPF = Soybean price received by Iowa farmers, $/bu
SOYHG = U.S. CCC owned soybean stocks, mil bu
IASOYSC = Soybean crush in Iowa, mil bu
SOYPF = U.S. average annual soybean price received by farmers, $/bu
IASOYSP = Iowa soybean production, mil bu
VALOM = Value of oil and meal = (oil price * oil yield) + (meal price * meal Yield)
SOYPE = U.S. soybean effective support price, $/bu
IASOYSD = Iowa soybeans sold during marketing year, mil bu
IASOYUF = Iowa soybeans used on farms where produced, mil bu
IASOYNX = Iowa soybean net exports to other states and nations
IASOYVS = Value of sales, Iowa soybeans, mil $
IASOYEXP = Total expenses for Iowa soybean production, mil $
SYVC = Variable cost of soybean production $/bu
IASOYNF1 = Net farm income to Iowa soybean producers

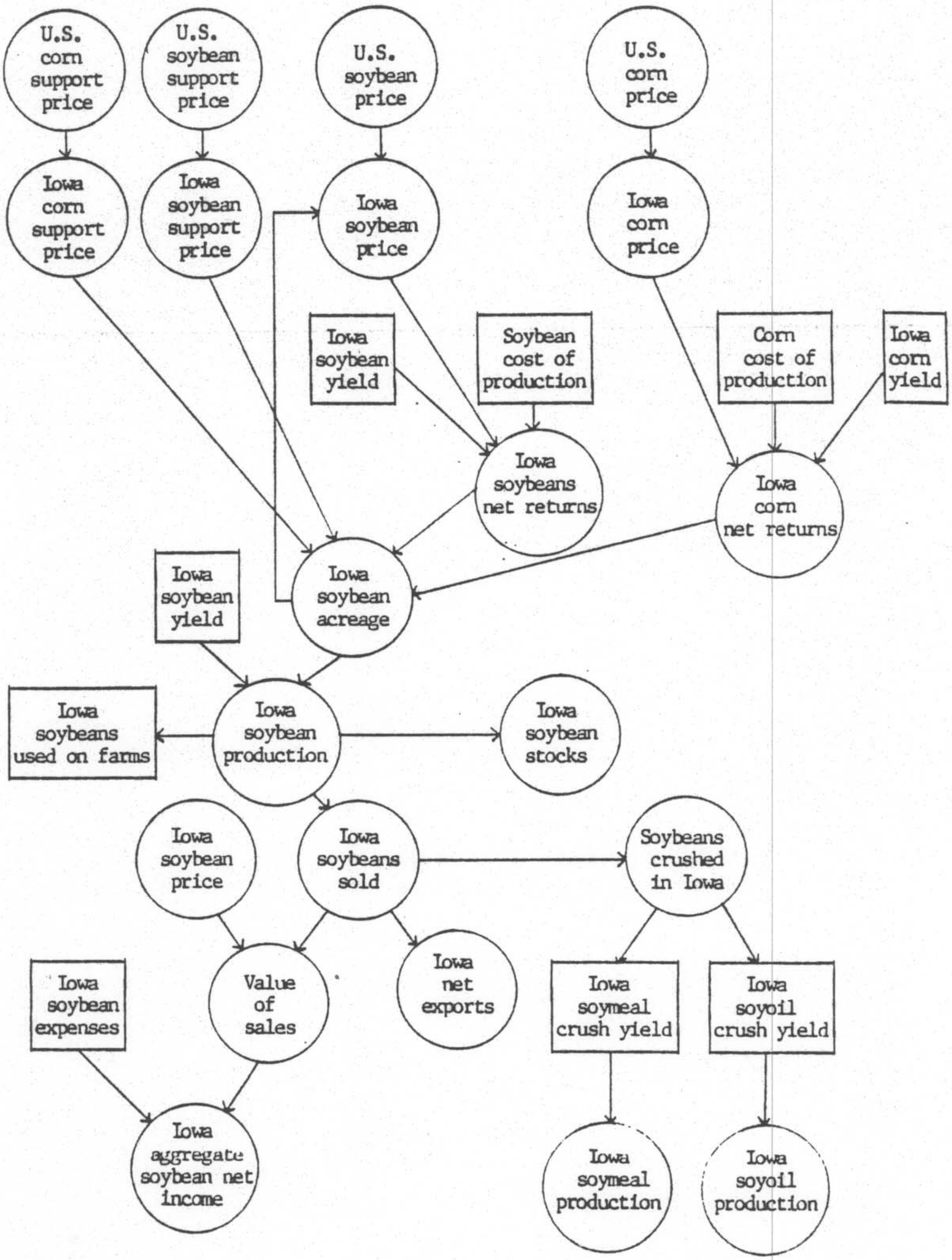

Figure 1. Flow chart of the Iowa submodel

transactions demand; total U.S. government stocks, the coefficient on which will be less than the proportion of government stock held in Iowa if there is a displacement effect in private storage; and the previous period's carryover. It would have been preferable to separate stocks held in Iowa into privately held and government owned, but the data were not available.

Iowa Crushing Demand

The crushing industry within Iowa is examined in equation (3). An increase in soybean price received by farmers is expected to reduce crush since it is a cost to the processing firm. But the value of the oil and meal component represents the revenue received by the crusher and is expected to have a positive sign. As a proxy for capital (or crushing capacity), crush in the previous year is included as an explanatory variable. Measures of the production of soybean meal and oil within Iowa are generated by equations (12) and (13), respectively.

Price Linkages

The bridge between the Iowa sector and the national sector comes through the price linkages in equations (4)-(6). The Iowa market prices for soybeans and corn are expressed as a proportion of the U.S. season average price which has been endogenously determined from the national model. Likewise, the Iowa support price for soybeans has been defined as a fixed percentage of the national effective support price. This rather simple approach assumes that prices are formed outside the state, i.e., Iowa is a price taker. This is not an unreasonable premise, considering the size of Iowa relative to the international scope of the soybean trade.

Iowa Net Farm Income

The contribution from sales of soybeans to Iowa net farm income is estimated by equations (7)-(11). From the total production, we subtract the amount added to stocks and used on Iowa farms for purposes of seed, feed, and livestock to get the quantity marketed. These sales can be broken down further into the portion crushed within the state, and that part that is exported to other states and countries for utilization. The model uses value of sales, i.e., quantity sold times season average price, as its estimate of gross cash receipts. The correlation between the two is quite close, and we lose little predictive ability by using value of sales. On the cost of production side, total expenses from soybean production are approximated by multiplying the national average variable cost of soybeans per acre times the Iowa planted acreage. The data on actual expenses do not exist, but the variable cost appears to be highly correlated with changes in more broadly based price indices, such as the producer price index. Finally, the proxy for net income from soybeans is merely the difference between value of sales and total expenses.

Evaluation of the Estimated Equations

The results of the OLS regressions for the Iowa sector are listed in Table 2. The variable definitions are footnoted in Table 1. In this section, the estimated coefficients from the system are presented in Table 2, as well as measures of their statistical significance. The equations for the national soybean sector model have been estimated by nonlinear two-stage least squares. The parameters derived from this procedure are then used to make a base simulation.

Overall, the model produces statistically significant relationships and reasonable signs and sizes of the coefficients. The price elasticities are generally close to values found by previous studies (Meyers and Hacklander), and support some conclusions made with regard to the relative sizes of elasticities of domestic, export, and inventory demands for soybeans, meal, and oil. Tests of the null hypothesis of no autocorrelation were either inconclusive or a failure to reject, except in the case of the Iowa soybean crushing equation. Since this equation is not a central issue of this study, the problem will be ignored here.

The acreage equations for the U.S. and Iowa suggest that Iowa farmers are less price responsive than all farmers on average. An increase in soybean net returns of ten percent will induce a positive 1.7 percent change in acreage planted in Iowa, whereas nationally a 3.5 percent acreage increase would occur, assuming all other effects are held constant. Unlike in the U.S. area equation, the corn diversion variable was omitted, since a negative coefficient could not be obtained.

The effect of soybean prices on Iowa and national inventory holdings seems to be roughly comparable. However, the price elasticities are considerably less elastic than estimates obtained in other studies, such as the elasticity of -2.29 found by Meyers and Hacklander (1979). The discrepancy may be due to the different periods covered by the studies and the addition of a corn price effect in the equation.

The price linkages between U.S. farm and wholesale levels and Iowa farm and U.S. farm prices have strong statistical relationships between them, evidenced by the very high correlation coefficients and parameter values of near unity.

Impact Analysis

Using the results of the system's parameters from the preceding section and the U.S. model reported by Ash (1984), we can now shock the model and determine the consequences of shifts in major exogenous variables. The shocks will be considered to be a constant yearly absolute or percentage increase, beginning in 1976 and until 1980. This time period should be able to tell us the year by year impact on prices, acreage, and production for the three commodities for both the U.S. as a whole and Iowa by itself. Comparative statics is used to analyze the impact of these shifts in relation to the base, or equilibrium, solution. Since the model is nonlinear, linear combinations

Table 2. Estimated equations for Iowa[a]

Iowa soybean acreage

$$(1)\ \text{IASOYSAE} = 0.24 + 0.013\ \text{IASNR} - 0.010\ \text{IACNR} - 1.07\ \frac{\text{CORPE1}}{\text{IASOYPL1}} + 1.0\ \text{IASOYSAE}_{-1} + 1.16\ \text{DUM72}$$

	Constant	IASNR	IACNR	CORPE1/IASOYPL1	$IASOYSAE_{-1}$	DUM72
(t)	(1.11)	(4.44)**	(-5.77)**	(-1.62)	(27.66)**	(4.65)**
[e]		[0.17]	[-0.11]	[-0.08]	[0.97]	

$R^2 = 0.988$, D.W. = 1.99, h = 0.053

Iowa soybean stocks[b]

$$(2)\ \text{IASOYHT} = -30.6 - 7.94\ \text{IASOYPF} + 30.83\ \text{IACORPF} + 0.205\ \text{IASOYSPE}_{-1} + 0.323\ \text{SOYHG} + 0.105\ \text{IASOYHT}_{-1}$$

	Constant	IASOYPF	IACORPF	$IASOYSPE_{-1}$	SOYHG	$IASOYHT_{-1}$
(t)	(-3.63)	(-1.99)	(3.23)**	(2.71)*	(6.40)**	(0.94)
[e]		[-0.76]	[1.20]	[0.92]	[0.21]	[0.09]

$R^2 = 0.894$, D.W. = 1.15

Iowa soybean crush[c]

$$(3)\ \text{IASOYSC} = 5.12 - 10.19\text{IA SOYPF} + 10.99\ \text{VALOM} + 0.917\ \text{IASOYSC}_{-1}$$

	Constant	IA SOYPF	VALOM	$IASOYSC_{-1}$
(t)	(0.53)	(-1.53)	(2.04)*	(6.18)**
[e]		[-0.37]	[0.45]	[0.88]

$R^2 = 0.905$, D.W. = 2.32

Iowa price linkages

$$(4)\ \text{IASOYPF} = 0.05 + 0.987\ \text{SOYPF}$$

(t) (0.69) (61.7)**

$R^2 = 0.995$, D.W. = 1.64

$$(5)\ \text{IACORPF} = -0.04 + 1.002\ \text{CORPF}$$

(t) (-1.45) (70.9)**

$R^2 = 0.996$, D.W. = 2.08

$$(6)\ \text{IASOYPL} = -0.01 + 0.994\ \text{SOYPE}$$

(t) (-0.16) (88.7)**

$R^2 = 0.998$, D.W. = 2.10

*Significant at a five percent level.
**Significant at a one percent level.
[a]Variable definitions on page 4.
[b]t-value of ρ^* is -0.78, hence we conclude no autocorrelation is present.
[c]t-value of ρ^* is 2.29, hence we can conclude autocorrelation is a problem.

of the impacts will not necessarily give comparable results. The impact may also depend on the time frame of the results and on the time frame of the base simulation. Examples of impact multipliers for 2 cases are presented in the tables of this section, with a brief discussion of each below.

Case 1: Corn Price

The chain of events for a ten cent rise in the corn price is illustrated in Figure 2 and the impacts are reported in Table 3. First, domestic demand for meal increases. However, this increase is more than offset by the rise in meal price except the second year. Furthermore, although the higher value of meal and oil increases crush demand, the expansion of foreign exports and inventories increases soybean prices as well and a lesser quantity of soybeans is processed. The cutback in meal and oil production reduces exports, stocks, and consumption of both meal and oil. In Iowa, we find a reduction in bean acreage and production in spite of a rise in soybean price. The corn price increase more than offsets higher soybean returns, and the net effect is a substitution towards corn production in Iowa. The value of the soybean crop increases and net income from soybeans rises by $26-37 million. The effect on income from corn is not included in this model.

Case 2: Corn Diversion Payments

Government policy can exert substantial change on farmers' production decisions. A paid diversion program awards cash payments of so many cents per bushel on a normal yield of planted acres to those farmers who voluntarily withdraw land from production of a commodity. We analyze here the effect of a ten cent per bushel increase in a corn diversion payment. The consequent reduction in corn acreage cuts corn production and pushes the price up. Previous work by Baumes and Meyers (1980) using a cross commodity crops model, calculated an increase of 47 cents in the corn price resulting from a ten cent rise in diversion payments. This estimate is added to the direct impact of the diversion payment on soybean acreage in the present model. The results are presented in Table 4.

Since the rise in corn price does not take effect until the anticipated rise in corn production is realized, the first year impact is due solely to the influence of the diversion payment on soybean acreage planted. The expected decline in soybean production increases the amount held in soybean and oil inventories. There is a tradeoff at the expense of soybean exports and crush, which lowers meal and oil production and increases their respective prices. Net income in Iowa rises by $3 million in the first year.

The subsequent years include the 47 cent rise in corn prices. This is by far the more dominant force in the market, and intensifies the magnitude of the multipliers. Iowa net farm income now jumps by $163-219 million. The effect of the diversion payment by itself (ignoring the impact of an inevitably higher corn price) would elevate net income by only $30-50 million in the subsequent years.

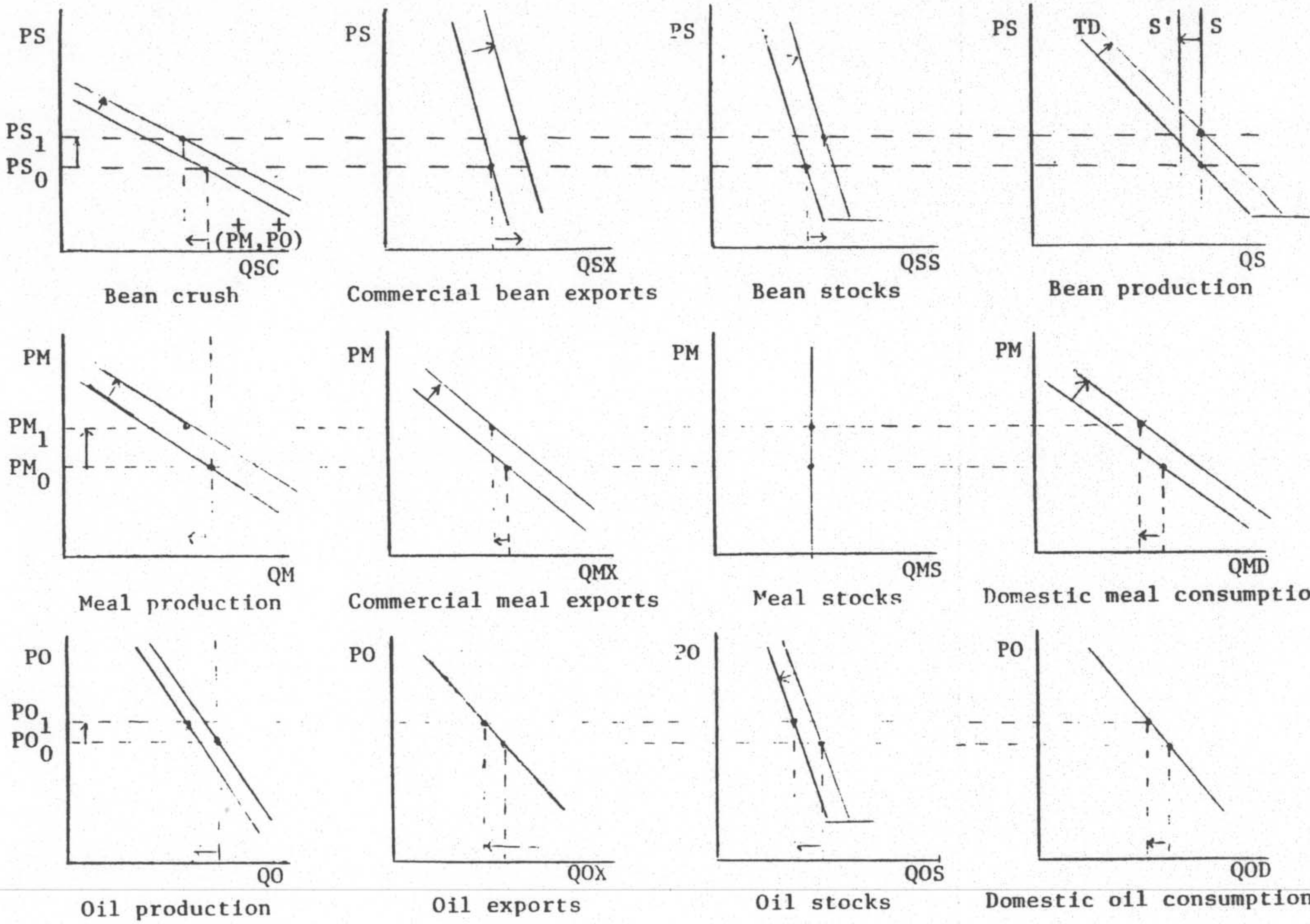

Figure 2. Graphical representation of the model's response to higher corn price

Table 3. Reduced form impact multipliers of the model (sector: component: unit: +10¢/bu. corn price)

	Year 1	Year 2	Year 3	Year 4	Year 5
U.S. Soybeans:					
Supply (mil. bu.)	0	7.2	5.1	3.8	3.4
Domestic crush (mil. bu.)	-4.4	-1.5	-2.6	-3.0	-2.9
Comm. exports (mil. bu.)	1.6	2.8	2.0	1.8	1.9
Comm. stocks (mil. bu.)	2.8	5.9	5.7	5.1	4.4
$Acreage_{t+1}$ (1000 acres)	144.5	-27.1	-60.8	-65.3	-38.2
Margin (¢/bu.)	0.8	1.0	1.0	1.0	1.2
Price (¢/bu.)	18.5	12.1	15.2	16.1	17.5
U.S. Meal:					
Supply (1000 tons)	-103.0	-37.4	-62.9	-72.9	-68.9
U.S. consumption (1000 tons)	-27.9	11.3	-9.8	-8.8	-24.7
Comm. exports (1000 tons)	-75.2	-48.7	-53.1	-64.1	-44.2
Price ($/ton)	5.93	4.25	5.16	5.11	5.8
U.S. Oil:					
Supply (mil. lbs.)	-48.0	-25.5	-32.6	-35.2	-34.1
U.S. consumption (mil. lbs.)	-26.1	-12.6	-15.8	-18.2	-17.1
Comm. exports (mil. lbs.)	2.2	-1.9	-3.3	-1.3	-1.3
P.L. 480 exports (mil. lbs.)	-15.7	-7.7	-10.9	-13.4	-13.7
Stocks (mil. lbs.)	-8.3	-3.4	-2.6	-2.3	-2.0
Price (¢/lb.)	0.50	0.25	0.35	0.43	0.45
Iowa beans:					
Iowa production (mil. bu.)	0	-0.4	-1.4	-2.2	-3.0
Iowa crush (mil. bu.)	0.3	0.5	0.8	1.0	1.2
Iowa stocks (mil. bu.)	1.7	2.3	1.9	1.6	1.3
Iowa net exports (mil. bu.)	-0.3	-0.9	-2.2	-3.2	-4.3
Iowa acreage (1000 acres)	-11.7	-38.3	-58.8	-80.3	-99.6
Iowa net income (mil. $)	34.9	26.6	29.8	37.0	26.4
Iowa meal production (1000 tons)	7.7	11.2	18.3	23.9	30.0
Iowa oil production (mil. lbs.)	3.7	5.3	7.8	9.8	14.7

Table 4. Reduced form impact multipliers of the model (sector: component: unit: +10¢/bu. corn diversion payment, +47¢)

	Year 1	Year 2	Year 3	Year 4	Year 5
U.S. Soybeans:					
Supply (mil. bu.)	0	-12.7	23.3	15.2	11.2
Domestic crush (mil. bu.)	-0.3	-26.0	-10.9	-15.4	-16.3
U.S. exports (mil. bu.)	-0.3	3.7	10.5	7.5	6.5
Stocks (mil. bu.)	0.6	9.6	23.7	23.1	21.0
$Acreage_{t+1}$ (1000 acres)	-442.3	453.3	-279.8	-399.5	-438.3
Price (Decatur) (¢/bu.)	1.6	100.4	68.3	81.1	83.2
Margin (¢/bu.)	0.1	3.6	4.9	4.9	4.8
U.S. Meal:					
Supply (1000 tons)	-6.6	-611.4	-261.0	-369.7	-392.3
U.S. consumption (1000 tons)	-2.4	-187.5	-11.8	-81.7	-71.0
Comm. exports (1000 tons)	-4.2	-423.9	-272.8	-288.0	-321.3
Price ($/ton)	0.10	30.32	21.73	25.76	25.30
U.S. Oil:					
Supply (mil. lbs.)	-3.1	-276.5	-160.3	-186.7	-188.9
U.S. consumption (mil. lbs.)	-7.0	-156.0	-89.4	-98.5	-102.4
Comm. exports (mil. lbs.)	0.3	14.2	2.1	-7.1	-0.6
P.L. 480 exports (mil. lbs.)	-3.8	-94.8	-56.7	-68.4	-76.3
Stocks (mil. lbs.)	7.5	-39.9	-16.3	-12.7	-9.6
Price (¢/lb.)	0.13	3.0	1.9	2.2	2.5
Iowa beans:					
Iowa production (mil. bu.)	0	0.1	0.3	3.9	6.4
Iowa crush (mil. bu.)	0.03	1.7	2.8	4.0	5.1
Iowa stocks (mil. bu.)	-0.1	6.9	10.0	8.6	7.5
Iowa net exports (mil. bu.)	-0.03	-1.6	-3.1	-7.9	-11.5
Iowa acreage (1000 acres)	4.4	-12.3	-106.2	-176.4	-257.0
Iowa net income (mil. $)	3.0	195.6	163.1	173.9	219.1
Iowa meal production (1000 tons)	0.7	39.4	59.0	95.3	123.6
Iowa oil production (mil. lbs.)	0.3	19.1	27.7	40.4	51.6

Implications

This model and the examples of impact analysis demonstrates a method for evaluating the impacts of national market shocks and policies on a particular state crop sector. This type of analysis may be of interest to commodity oriented groups. This procedure can also be expanded to encompass other commodities and to generate broader measures of economic impact on a state's agricultural sector and related industries. These broader measures would be of interest to state government, input dealers, and product handlers and processors.

As states are increasingly asked to take on more responsibility for financing development and services, the need for state level analytical tools is increasing. This type of model, while dependent on national level commodity models, provides a useful tool for state level analysis.

References

Ash, Mark S. "A Supply Response Model for Iowa Soybeans and Net Farm Income Implications." Unpublished M.S. Thesis, Iowa State University, 1984.

Baumes, H. and W. Meyers. "The Crops Model: Structural Equations, Definitions, and Selected Impact Multipliers." NED Staff Report. USDA, ESCS, Washington, D.C., March 1980.

Meyers, W. and D. Hacklander. "An Econometric Approach to Analysis of Soybean and Soybean Product Markets." NED Staff Report. USDA, ESCS, Washington, D.C., June 1979.