Northeast Soybean Acreage Response Using Expected Net Returns

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Expected prices and expected net returns from cropping activities are used to estimate soybean acreage response in the Northeast. Futures prices and lagged cash prices constitute proxies for price expectations. Expected net returns appear as good or better than expected prices for estimating acreage response. Short-run and long-run elasticities of soybean acreage with respect to expected net returns from soybeans are estimated as 0.5 and 1.6 for the northeast region. Soybean acreage appears less responsive to changes in expected net returns than to expected changes in prices.

Estimates of acreage response elasticities for major crops are useful to policy makers that design legislation, agribusinesses that supply crop inputs and market output (including storage and transportation), and the U.S. Department of Agriculture (USDA) and others who analyze and forecast agricultural production. Soybeans are an important crop in all major farming regions east of the Great Plains, including the northeastern United States.

Northeast acreage of soybeans has increased faster than the area of grains since 1970 and now ranks second to corn grain in acreage among major field crops (Figure 1). Soybean production in Delaware, Maryland, New Jersey, and Pennsylvania more than tripled from 10.6 million bushels in 1970 to 37.7 million in 1989, doubling the region's share of U.S. production from 1% to 2%.

Most previous research on soybean acreage response used crop prices as explanatory variables in acreage response equations. For example, Gardner used corn and soybean futures prices and the previous (lagged) season-average prices as proxies for expected prices in soybean acreage response equations. Shideed, White, and Brannen used conditional expected prices of corn and soybeans, deflated by the variable cost of production per bushel. Other studies have used variations and combinations of cash prices, futures prices, and support prices as explanatory variables.

Farmers, however, consider more than expected prices when forming planting strategies to maximize profits. Other considerations include expected yields, production costs, and noncrop land-use options. While percentage changes in U.S. corn and soybean prices and variable production costs may be similar over the past ten to fifteen years, percentage increases in corn yields more than double those in soybeans. This disparity in yield growth favors expected net returns over expected prices as an explanatory variable for planted acreage. Multiple-commodity simulation models have used expected net returns rather than prices (Collins and Taylor; Taylor). Also, Crowder estimated soybean response functions using expected net returns for the United States and the six major producing regions, but not the northeast region.

Figure 2 shows relative movements of cash prices and market returns for northeast soybeans during 1961–89. The graph illustrates the degree to which prices and returns move together. There is no discernible relationship between prices and returns during the 1960s. They tracked fairly closely from the early to late 1970s before a price spike in 1980 when net returns fell. During the 1980s they moved in the same direction. It is apparent that in some years price does not serve as a proxy for net returns. Because farmers seek to maximize profits (net returns) from their cropping activities, expected net returns are anticipated to provide better estimates of soybean acreage response than will expected prices.

Our objectives are to (a) construct expected-net-returns and expected-price variables using cash prices

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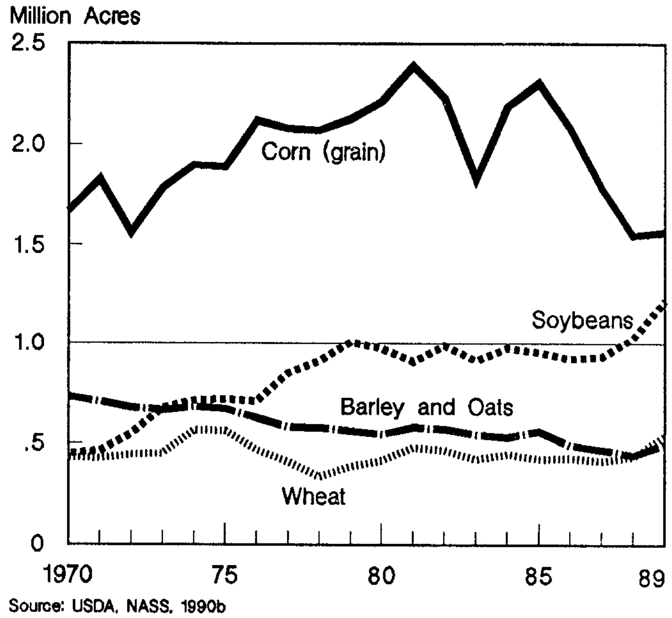

Figure 1. Northeast Harvested Acres (DE, MD, NJ, PA)

and futures prices; (b) compare estimates of northeast soybean acreage response using expected net returns and expected prices; and (c) forecast northeast soybean acreage.

Price and Income Expectations

Because farmers must choose their crop mix without knowing the cash prices they will receive for their crops, they may use lagged cash prices, futures prices, or both in their planting decisions. The use of a lagged cash price follows the fundamental theorem of the cobweb model—supply, or acreage, of a commodity is a function of the price in the preceding time period, in this case the previous year.

Futures markets, however, indicate realized and anticipated changes in current-year market conditions. Anticipated changes in production and trade factors such as weather, currency exchange rates, trade subsidies and tariffs, and demand, are integrated in futures prices. Therefore, futures prices provide farmers current information about harvest-time cash prices before planting time. However, futures prices are volatile and can vary dramatically between the time of the planting decision and harvest, as happened during the drought of 1988.

Farmers typically evaluate price information available prior to planting time, including futures prices, previous season-average prices, and current cash prices. After looking at their yield experiences for alternative crops and current costs for purchased inputs, farmers can formulate budgets to determine which crops may provide the greatest net returns within production constraints and goals, such as satisfying farm feed requirements, crop diversification for risk management, and labor availability.

Complicating farmers' planting decisions is the option of participating in government programs where price supports and acreage restrictions usually vary from year to year. Producer participation in crop programs, particularly in feed grains that compete with soybeans, varies from state to state and from year to year. Consequently, estimating acreage response equations with farm-program variables should give better results than equations without such variables.

Model Specification

Soybean acreage planted (SA, 1,000 acres) is estimated as a function of lagged acreage, expected net returns per acre (equation 1) or deflated expected price (equation 2) for soybeans and corn, and a dummy variable:[1]

$$(1) \quad SA = a_0 + a_1 SA_{t-1} + a_2 XNR_s + a_3 XNR_c + a_4 XNR_c * D + e,$$

$$(2) \quad SA = b_0 + b_1 SA_{t-1} + b_2 DXP_s + b_3 DXP_c + b_4 DXP_c * D + e,$$

[1] Specification with expected net returns to winter wheat did not produce wheat net-return coefficients significant at the 10% level.

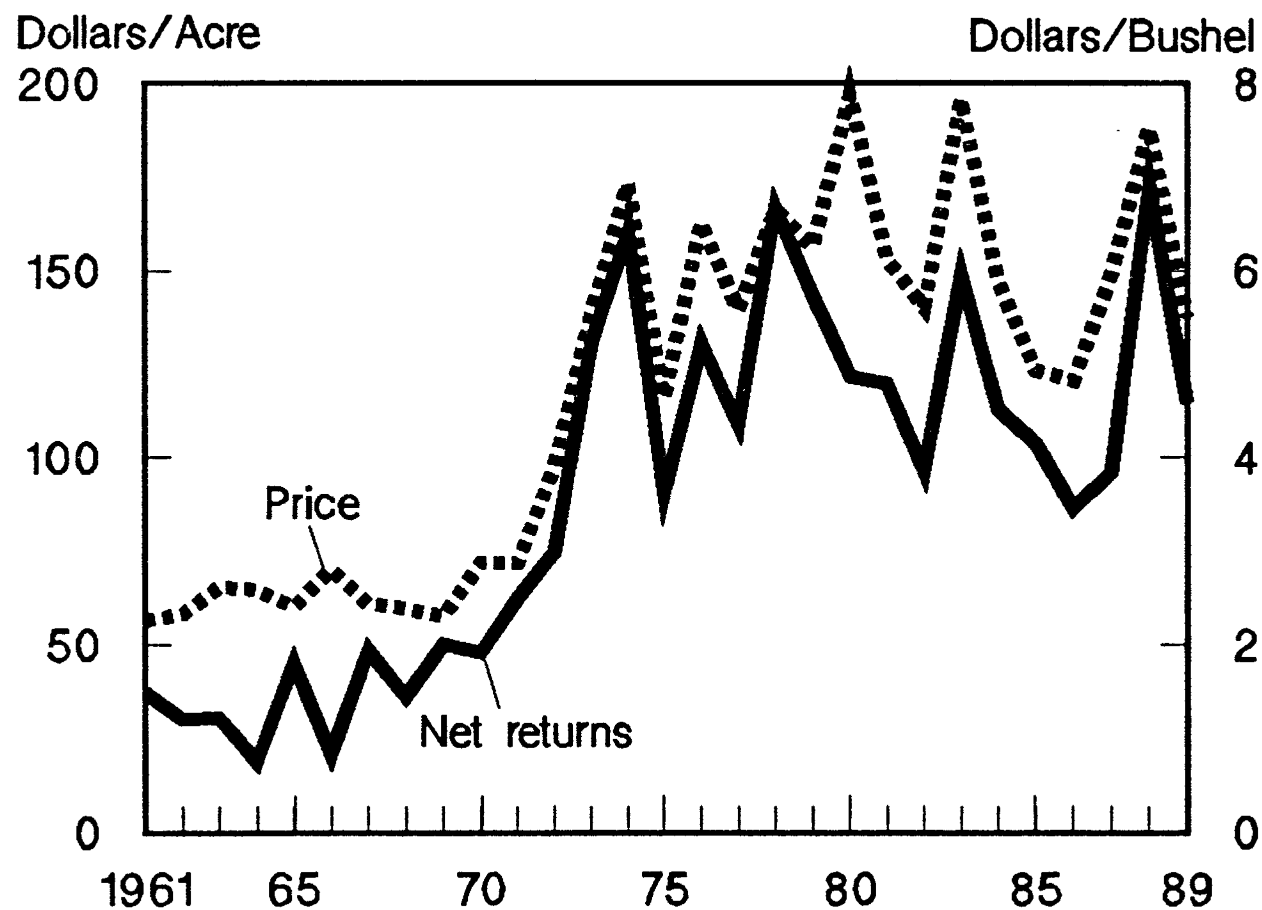

Figure 2. Northeast Soybean Prices and Net Returns Per Acre

where SA_{t-1} is the soybean acreage planted the previous year; XNR_s equals the expected net returns per acre from soybeans; XNR_c equals the expected net returns per acre from corn; D is a dummy variable that is one during 1982–89, zero during 1961–81; e is a stochastic error term; DXP_s is the deflated expected price for soybeans; and DXP_c is the deflated expected price for corn.

Changes in agricultural legislation every four to five years can substantially alter farmers' production decisions and thus affect supplies and prices received for various crops. Changes in base-acreage provisions in the Agricultural and Food Act of 1981, which were continued in the Food Security Act of 1985, penalize farmers for diverting corn (or other program crop) acreage to soybeans. Reduced planting of program crops reduces the farmer's base acreage, which would reduce future program payments. As a result, rising cash prices for soybeans (relative to corn) in recent years accompanied *declining* soybean acreage in the Corn Belt, where participation in the corn program is high relative to other regions (Glauber).

In the Northeast, where corn acreage and program participation rates are substantially lower than in the Corn Belt, one could expect soybean acreage to be more responsive to an increasing cash price (relative to the cash corn price). We modify the regional expected net returns from corn (XNR_c) to check for structural changes in soybean acreage response since the Agricultural and Food Act of 1981. We multiply XNR_c by a dummy variable ($D = 1$ during 1982–89, $D = 0$ otherwise).

In the same fashion, we checked for evidence of changes since the Food Security Act of 1985 ($D = 1$ for 1986–89, $D = 0$ otherwise). The structural-change variables indicated significant change since 1981, but not since 1985 in the northeast region. Consequently, we include this structural-change variable ($XNR_c * D$, $D = 1$ for 1982–89, $D = 0$ otherwise) in all equations for the region and the individual states. We use the specification in equation (1) to compare two proxies for expected prices and to compare net-return variables with and without government-program variables.

Soybean Acreage Response without Program Variables

Expected net returns (XNR) per acre for a given crop are the expected price (XP) per bushel (futures price minus basis or lagged cash price) times the expected yield (XY, bushels per acre), minus the variable costs (VC) of production per acre:

$$(3) \qquad XNR = (XP * XY) - VC.$$

The deflated expected price per bushel of a given crop (DXP) is the expected price (XP) per bushel (futures price minus basis or lagged cash price) deflated by variable cost per bushel (VC_{bu}):

$$(4) \qquad DXP = XP/VC_{bu}.$$

Soybean Acreage Response with Government-Program Variables

Producers participating in the government price-support loan program for soybeans can sell their soybeans at the cash price or receive the soybean loan rate. Because participation requires no costs, such as limited planting or diverted acres, we assume 100 percent eligibility in the program. Consequently, we calculate the expected net returns per acre from soybeans as the larger of the expected price or the loan rate for soybeans times the expected yield, minus the variable production costs:

$$(5) \qquad XNR_s = \max(XP_s, L_s) * XY_s - VC_s,$$

where XNR_s equals the expected net returns from soybeans (dollars per acre); $\max(XP_s, L_s)$ equals the greater of expected soybean price (XP_s) or loan rate (L_s) (dollars per bushel); XY_s is the expected soybean yield (bushels per acre); and VC_s is the variable cost (dollars) per acre of soybean production.

Expected net returns per acre from corn are the weighted (by program participation rate) average expected net returns per acre in and outside the government corn program. Expected net returns from corn in the program consist of expected deficiency payments plus the market value of corn, minus variable costs. Expected deficiency payments are the difference between the target price and the larger of the expected price or loan rate times the percentage of corn acreage planted (one minus acreage reduction requirement) times the program yield. The expected market value of program corn is the larger of the expected price or loan rate times the percentage of cropland planted times the expected yield. Variable costs are production costs on planted acreage plus costs of soil conservation practices on idled acres times the fraction of cropland idled or set-aside.

Expected net returns per acre from corn outside the program are the expected price times the expected yield minus variable costs. The equation for expected net returns from corn (XNR_c) is

$$(6) \qquad XNR_c = PART_c * \{[(TP_c - \max(XP_c, L_c)) * (1 - S_c) * PY_c]$$

$$+ [\max(XP_c, L_c) * (1 - S_c) * XY_c] - [VC_c * (1 - S_c)] - [VCIDLE * S_c]\} + (1 - PART_c) * [(XP_c * XY_c) - VC_c],$$

where $PART_c$ is the percentage (as a decimal) of corn acreage planted in the corn program; TP_c is the target price for corn (dollars per bushel); $\max(XP_c, L_c)$ is the greater of expected price (XP_c) or current-year loan rate (L_c) for corn (dollars per bushel); S_c is the percent (as a decimal) of corn acreage base set aside in an acreage reduction program as a condition for program participation; PY_c is corn program yield (bushels per acre); XY_c is the expected crop yield for corn (bushels per acre); VC_c is the variable cost (dollars) per acre of corn production; and $VCIDLE$ is the variable cost per acre of idled cropland (assumed $0.2 * VC_c$).

Participation rates for the corn program in the northeast region are calculated as the sum of the acres planted in the corn program in Delaware, Maryland, New Jersey, and Pennsylvania, divided by the acres harvested for grain in those states.

Deflated expected-price variables were constructed from the expected-net-return variables by adding the variable cost per acre (to get expected gross returns per acre) and dividing by the expected yield. Then, this expected gross price per bushel was deflated (divided) by the variable production cost to make the deflated expected-price variables comparable with the expected-net-return variables. The difference between the expected-net-return variables and the deflated expected-price variables is the expected yield, contained in the expected-net-return variables, and the use of variable-cost data.

Data

We compare two proxies for expected price, the cash price lagged one year and the futures price. Expected prices using futures prices are calculated as follows. We assume planting decisions for corn and soybeans are made in April. Average daily futures prices for March are used for the contract closest to the time of harvest for each crop: November (Chicago Board of Trade (CBT)) for soybeans, and December (CBT) for corn (*Wall Street Journal*). Then we subtract the annual season-average price received by farmers for the respective crop in the northeast region to determine the basis. Annual basis calculations were averaged for 1961–89. The average basis (six cents per bushel for soybeans and negative twelve cents for corn) was subtracted from the average March futures price to approximate the farmers' expected price each April.

Soybean acreage for the Northeast is the sum of soybean acreage in Delaware, Maryland, New Jersey, and Pennsylvania, the only northeast states for which USDA reports soybean data (USDA/NASS 1990b). Crop-yield (USDA/NASS 1990b) and cash price data (USDA/NASS 1990c) for each of these states are weighted by production and summed to obtain data for the regional equation. Farm-program data are published USDA/ASCS data (USDA/ASCS 1989, 1990, Langley).

Expected yields are the average of actual yields for the preceding three years. Variable costs of production are USDA estimates for 1975–88 (McElroy et al.; USDA/ERS). Variable costs for 1960–74 and 1989 are generated by deflating (inflating) the 1975 (1988) cost with USDA's index of producer prices paid by farmers for production items (USDA/NASS 1990a), which we projected to rise 3.6% in 1990.

Results and Discussion

Equations (1) and (2) for soybean acreage in the northeast region were estimated by ordinary least squares first as linear combinations of the variables, then as log-log (Table 1). The log-log estimations produce higher adjusted R^2s and allow direct estimation of elasticities. Coefficients on expected-net-return and deflated expected-price variables are short-run elasticity estimates.

Expected-net-returns equations using government-program variables have essentially the same adjusted R^2 (and similar elasticities) as the equations without program variables, reflecting the relatively low program participation rates in the Northeast. However, acreage estimation using program variables produces higher t-statistics than the equations without program variables. Although equations with futures prices are quite similar to those with lagged cash prices, the program variable equation produces higher t-statistics with lagged cash prices than with futures prices.

Estimation using deflated expected-price variables, derived from the government-program expected-net-return variables, produced adjusted R^2s comparable to the expected-net-return equations. However, most of the t-statistics were higher in the government program expected-net-return estimation. The effects of expected crop yields, contained in the expected-net-return estimations, improve the test statistics of the regression equations. Consequently, we use the log-log government program expected-net-return variable specification with lagged cash prices to estimate soybean acreage for Delaware, Maryland, New Jersey, and Pennsylvania (Table 2).

Table 1. Log-Log Estimation Results for Soybean Acreage Response Using Expected Net Returns (NR) or Expected Prices, Northeast Region, 1961–89

Acreage Estimation with	Constant	Lagged Acreage[a]	Elasticity wrt Expected NR or Expected Prices: Soybeans	Elasticity wrt Expected NR or Expected Prices: Corn	Structural-Change Variable	Durbin h	Adj. R^{2b}
Expected market returns using							
Futures prices	1.98**[c] (5.65)	.559** (7.39)	.446** (8.64)	−.232** (−5.08)	.013* (2.03)	.270	.985
Lagged cash prices	1.58** (4.27)	.653** (8.27)	.432** (7.64)	−.266** (−5.24)	.014* (2.19)	.517	.982
Government-Program equations using							
Expected net returns with							
Futures prices	1.86** (5.84)	.594** (8.55)	.469** (9.97)	−.280** (−6.13)	.015* (2.75)	−.247	.988
Lagged cash prices	1.46** (5.02)	.684** (10.86)	.479** (10.57)	−.332** (−7.54)	.017** (3.31)	.375	.989
Expected deflated prices with							
Futures prices	.663* (2.54)	.831** (16.91)	.678** (7.41)	−.534** (−4.99)	.149* (2.41)	.826	.981
Lagged cash prices	.453* (2.07)	.878** (22.15)	.708** (8.60)	−.705** (−7.04)	.129** (2.69)	1.343	.985

[a]Lagged acreage = soybean acreage planted in previous year.
[b]Adj. R^2 = R^2 adjusted for degrees of freedom.
[c]Significance levels (two-tailed test): * = 5%, ** = 1%, t-statistics in parentheses.

Table 2. Log-Log Estimation Results for Soybean Acreage Response Using Expected Net Returns, by State, 1961–89

Soybean Acreage in	Constant	Lagged Acreage[a]	Elasticity wrt Expected Net Returns from: Soybeans[b]	Elasticity wrt Expected Net Returns from: Corn[b]	Structural-Change Variable	Durbin h	Adj. R^{2c}
Delaware	1.27**[d] (3.35)	.657** (7.34)	.286** (6.85)	−.154** (−4.19)	.008 (1.42)	.440	.954
Maryland	1.92** (5.84)	.518** (6.74)	.488** (10.76)	−.301** (−8.75)	.033** (5.69)	.721	.979
New Jersey	.098 (.53)	.805** (11.09)	.309** (2.99)	−.109 (−1.19)	−.026** (−2.71)	.702	.973
Pennsylvania	−.050 (−.23)	.717** (5.97)	.574** (3.75)	−.283 (−1.98)	.036 (1.49)	−1.069	.981

[a]Lagged acreage = soybean acreage planted in previous year.
[b]Using lagged cash prices in government-program variables.
[c]Adj. R^2 = R^2 adjusted for degrees of freedom.
[d]Significance levels (two-tailed test): * = 5%, ** = 1%, t-statistics in parentheses.

Nerlove's coefficient of adjustment on the lagged dependent variable indicates that the previous year's soybean plantings exert a stronger influence on soybean acreage than expected net returns from either soybeans or corn (Tables 1 and 2). This result is consistent with Crowder's estimates for other regions and the United States.

Short-run elasticities indicate the average responsiveness of soybean acreage with respect to expected net returns in the same year. Long-run elasticities indicate responsiveness over many years to a long-term shift in expected net returns among crops. The lagged dependent variable allows calculation of the long-run elasticities following Nerlove's partial-adjustment hypothesis. Both short-run and long-run elasticity estimates vary somewhat from state to state (Table 3).

Short-run elasticity estimates of soybean acreage with respect to deflated expected price and expected net returns from soybeans (own returns) are inelastic for the whole region and all four states. Long-run elasticity estimates are elastic for the region, New Jersey, and Pennsylvania, and near 1.0 for Delaware and Maryland.

The short-run and long-run elasticities of soybean acreage with respect to expected net returns from soybeans in the northeast region (short-run = 0.48, long-run = 1.55) are more elastic than Crowder's estimates for most other regions and the United States (0.18 and 1.08, U.S. short-run and long-run, respectively). Participation rates in corn and other crop programs in the Northeast are substantially lower than the U.S. average. For example, preliminary corn-program participation for 1990 is 48% for these four northeastern states, compared with 76% for the total United States. This allows northeast farmers greater flexibility to shift acreage among crops in response to changes in expected returns. Short-run and long-run elasticity estimates of soybean acreage with respect to expected net returns from soybeans are more elastic than with respect to expected net returns from corn.

The structural-change variable is significant in the regional equations and two of the state equations. The positive sign is consistent with low participation rates in the corn program in the northeast region, indicating an increase in soybean acreage in response to rising prices (relative to corn). The elasticity estimate carried a negative sign for New Jersey, where participation in the corn program in recent years was higher than in the other three states.

Elasticities of soybean acreage response with respect to expected net returns are lower than those with respect to expected price (Table 1), indicating that northeast farmers adjust their soybean acreage less to changes in expected net returns than they do to proportional changes in expected prices. In other words, stable returns to soybeans and competing crops may lead to greater stability of soybean acreage in the Northeast, even in the presence of volatile prices.

Policies and market signals that stabilize farmers' net returns would encourage greater production stability for soybeans and other crops. Such stability includes farmers receiving higher (lower) prices for their crops when yields decline (increase) or when costs of production increase (decline). An efficient commodities market, in the absence of government distortions, provides market discipline at the cost of unstable prices and net returns. Government policies are meant to stabilize farm income by providing price floors and deficiency payments (income support) for farmers growing program commodities. However, these policies distort commodity markets and may create incentives for farmers to switch crops from year to year. Such policies have external effects beyond destabilizing production and incomes, such as environmental degradation and reduced farm diversification.

Table 3. Elasticities of Soybean Acreage Response with Respect to Expected Net Returns or Expected Prices for Soybeans and Corn

	Northeast Region		Expected Net Returns			
	Expected Prices	Expected Net Returns	Delaware	Maryland	New Jersey	Pennsylvania
Short-run elasticity estimates[a]						
Soybeans	.71	.48	.29	.49	.31	.57
Corn	−.70	−.33	−.15	−.30	−.11	−.28
Long-run elasticity estimates[b]						
Soybeans	5.78	1.52	.83	1.01	1.59	2.03
Corn	−5.76	−1.05	−.45	−.62	−.56	−1.00

[a]Estimated short-run elasticity (E_s) from government-program equations with lagged cash prices in Tables 1 and 2.
[b]Estimated long-run elasticity = $E_s * [1/(1-b_1)]$ where b_1 is the coefficient on lagged acreage (Nerlove).

This study demonstrates that expected net returns can be used to estimate crop acreage response. Expected-net-return elasticities can be used to evaluate a wide range of farm policies that affect farm incomes and acreage response, such as acreage reduction or retirement programs, deficiency payments, loan rates, mandatory program participation and cross-compliance, program base acreage and yields, and others geared toward affecting not only prices but farm incomes. While these policies can also be analyzed using expected-price equations, expected-net-return variables not only save degrees of freedom in regression equations, they also directly and more fully reflect the factors that farmers consider in making crop planting decisions.

Forecasting Soybean Acreage

We forecast soybean acreage out of sample for 1988–90. Government-program participation rates in each forecast year are assumed the same as those for the last year in the sample. The forecasts from the four government-program specifications in the northeast region plus the state forecasts are shown in Tables 4 and 5. Equations are estimated with 1961–87 data to forecast 1988 acreage, 1961–88 data to forecast 1989 acreage, and 1961–89 data to forecast 1990 acreage. For the region, the expected-net-returns equation with futures prices forecasts better than the other equations.

The regional and state equations correctly forecast rising soybean acreage in the region and all four states for 1989. The sum of the state forecasts projects a 5% decline in regional soybean acreage for 1990, while the four regional equation forecasts range from a 1% decline to a 1% increase. Actual plantings reported 9 August 1990 indicate a 12% drop from 1989.

Conclusions

Expected-net-return variables were used to estimate soybean acreage response in the Northeast. All net-return expectations that were tried—lagged cash prices and futures prices with and without government-program variables—produced high adjusted R^2s and coefficients that were highly significant. Both futures prices and lagged cash prices were shown to be reasonable proxies for expected prices. However, expected-net-return variables that included government-program variables produced higher t-statistics.

Expected net returns were as good or better than expected prices for estimating soybean acreage response. Elasticities of soybean acreage response with respect to expected net returns were less than those with respect to expected prices. A change in expected net returns will cause less fluctuation in northeast soybean acreage than a proportional change in expected price.

Elasticity estimates were similar for each of the regional specifications. Own-return elasticities for

Table 4. Forecasts of Soybean Planted Acreage, Northeast Region, 1988–90

Soybean Acreage Planted	Planted Acreage 1988	1989	1990[a]	Theil Inequality Coefficient[b]	MAPE[c]
	– – – –	*1,000 Acres*	– – – – –		*Percent*
Actual	1,050	1,250	1,095		
Forecasts					
Government-Program equations using					
Expected net returns with					
Futures prices	1,080	1,254	1,244	.038	5.6
Lagged cash prices	1,040	1,316	1,241	.040	6.5
Expected deflated prices with					
Futures prices	1,076	1,231	1,262	.042	6.4
Lagged cash prices	1,050	1,323	1,264	.045	7.1

[a]Soybean plantings for Delaware, Maryland, New Jersey, and Pennsylvania, released 9 August 1990 (USDA/NASS 1990b).
[b]Theil inequality coefficient: 0 = perfect forecast, 1.0 = worst-possible forecast (Theil, pp. 26–35).
[c]MAPE is the mean absolute percent error of 1988–90 forecasts, one year beyond sample.

Table 5. Forecasts of Soybean Planted Acreage by State, 1988–90, Using Government-Program Expected Net Returns with Lagged Cash Prices

Soybean Acreage Planted	Planted Acreage 1988	1989	1990[a]	Theil Inequality Coefficient[b]	MAPE[c]
	– – – – – *1,000 Acres* – – – – – –				*Percent*
Delaware					
Actual	230	255	200		
Forecast	249	262	252	.067	12.3
Maryland					
Actual	465	570	505		
Forecast	457	614	514	.025	3.7
New Jersey					
Actual	105	115	110		
Forecast	114	118	114	.026	4.9
Pennsylvania					
Actual	250	310	280		
Forecast	226	315	304	.035	6.6
Total					
Actual	1,050	1,250	1,095		
Forecast	1,046	1,309	1,184		

[a]Soybean plantings for Delaware, Maryland, New Jersey, and Pennsylvania, released 9 August 1990 (USDA/NASS 1990b).
[b]Theil inequality coefficient: 0 = perfect forecast, 1.0 = worst-possible forecast (Theil, pp. 26–35).
[c]MAPE is the mean absolute percent error of 1988–90 forecasts, one year beyond sample.

the Northeast ranged from 0.43 to 0.48, while cross-return elasticities with respect to corn ranged from −0.23 to −0.33. Elasticities were somewhat lower when futures prices were used to construct expected net returns. Incorporating government program effects in expected-net-return variables slightly increased elasticities relative to specifications without government program effects.

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