An Analysis of the Role of Futures Prices, Cash Prices and Government Programs in Acreage Response

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An integrated investigation of futures price, cash price, and government programs is presented in the context of an econometric model of acreage supply response for U.S. corn and soybeans. The analysis refines the role of different sources of price information in the farmers' acreage decision. It is found that the government corn support price program plays a major role in corn and soybean production decisions. Also, the results indicate that futures prices are not good proxies for expected future cash prices in the presence of government programs. This raises questions about the informational efficiency of futures prices when government intervenes in the market place.

Many econometric analyses have been developed for investigating crop acreage response (e.g., Houck and Ryan; Houck and Subotnik; Gallagher; Gardner). In such models, acreage decisions are specified as a function of the expected output price. In the Nerlovian tradition, the expected price may be determined from past market prices (Houck and Ryan; Houck and Subotnik; Gallagher). More recently, by considering that futures prices are expected spot prices in the future, Gardner has argued in favor of using the futures price in supply response. However, while Peck, Gardner, Telser and Morzuck et al. view futures prices as expected prices, the evidence on the quality of futures prices as forecasts is somewhat mixed. On the one hand, Just and Rausser have shown that futures prices forecast relatively well compared to econometric forecasts, sug-

gesting that acreage decisions could be based on futures prices. On the other hand, Working argued four decades ago that futures prices are not price predictions. Also, under rational expectations (Muth), Grossman and Stiglitz, and Bray have presented theoretical arguments suggesting that it may be unrealistic to assume that futures prices perfectly reflect all the information available in the market. Finally, empirical work by Tomek and Gray and by Stein questions whether futures prices are price forecasts. For example, Stein (p. 231) states that "Prior to four months to maturity, the futures price is a biased and worthless estimate of the price at maturity." Thus, it may be that both cash markets and futures markets provide useful information in the formulation of farmers' price expectation. However, none of the previous studies of supply response appear to consider that acreage may depend on both lagged cash prices and futures prices.

Furthermore, government programs are expected to affect producers' price expectation. Although futures prices likely play an important role in the formulation of price expectations, this role could potentially be altered if the government intervenes in the market. For example, farmers

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participating in government programs may find the government support price more relevant for their acreage decision than the futures price. Thus, there is a need to empirically analyze how government programs influence the formulation of farmers' price expectations.

The objective of this paper is to investigate the role of futures prices as well as cash prices and government programs in supply response. This is done by estimating the acreage-response functions for two major substitute crops: corn and soybeans. This paper extends previous research (Houck and Subotnik; Brown; Houck and Ryan; Kenyon and Evans; Gallagher) by considering how the support price, cash price, and futures price can interact and affect corn and soybean production decisions. Comparing the results for corn and soybeans will prove particularly instructive since government programs historically had a stronger impact on corn acreage than they had on soybean acreage. This will provide some evidence on how government programs influence the farmers' price expectation formulation.

The Model

A general economic model of acreage response is

$$A = f(FP, CP, G, C), \qquad (1)$$

where A is crop acreage planted, FP and CP represent, respectively, the futures prices and cash prices of the relevant crops, G measures government programs (prices support, loan rates, and acreage diversion payments), and C is production cost. In this specification, FP, CP, and G all have some influence on the formulation of the farmers' price expectation.

The biological characteristics of the crops play a crucial role in the specification of the futures price (FP) in the supply function (1). In the Midwest, the planting times of corn and soybeans are from April 20 to May 30 and May 15 to June 1, re-

spectively. The crops are harvested from October to November of the same year. Producers can observe the price of futures contracts which expire right after harvest time and use this information to formulate price expectation. On the Chicago Board of Trade, the first available futures contracts after harvest are December for corn and November for soybeans. Thus, the December contract for corn and the November contract for soybeans are used in the supply specification (1).

Although the futures price used in the analysis should be the one observed at the time of the acreage decision, it is not clear exactly when such decisions are made. Because of the time required for the procurement of all the necessary inputs, one may expect the farmers to decide how many acres to plant several weeks before planting. On this basis, the weekly average futures price during the week of March 15 was chosen in the analysis for both corn and soybeans.

Concerning spot prices (CP in (1)), yearly average cash-market prices lagged one year are used in the acreage supply response. This simple specification has been successfully employed in most previous research (e.g., Houck and Ryan; Houck and Subotnik; Gardner). It implies that the average cash price of the previous year reflects most of the relevant price information provided by the cash market.

The policy variables (G) included in the model are diversion payment for corn and effective support prices of the two crops. The effective support price is essentially a weighted average of target price and loan rate. The policy variables used in this study are those constructed by Houck *et al.* and updated by Gallagher.

Market prices and effective support prices are deflated by variable production costs as reported in the "Costs of Producing Selected Crops in the United States" by USDA. Seed, fertilizer, lime, chemicals, custom operations, labor, fuel and lubrication, repairs, drying, and interest are

included in the variable production cost for corn. The drying cost item was left out for soybeans. These costs were adjusted by an index of prices paid by farmers to generate production costs from 1957 to 1977.

Finally, in order to take into consideration dynamic response, the acreage function (1) is specified as a partial adjustment model (Griliches) by introducing lagged acreage as an explanatory variable in the model. Thus, the acreage function for corn or soybeans (1), specified as linear in the variables, becomes

$$
\begin{aligned}
A_t = a_0 &+ a_1[b_1 FPC_t + b_2 CPC_{t-1} \\
&+ b_3 SPC_t] \\
&+ a_2[c_1 FPS_t + c_2 CPS_{t-1} \\
&+ c_3 SPS_t] + a_3 A_{t-1} + \ldots
\end{aligned} \quad (2)
$$

Equation (2) defines expected prices as a weighted average of deflated futures (FP), cash (CP), and support (SP) prices for corn (C) and soybeans (S), where the weights are parameters which satisfy the restrictions $b_1 + b_2 + b_3 = 1$, $c_1 + c_2 + c_3 = 1$, $0 \le b_i \le 1$, and $0 \le c_i \le 1$ (i = 1, 2, 3). These weights have the advantage of providing a direct measure of the importance of futures, cash, and support prices in the formulation of farmers' price expectations.

Results

The model for U.S. corn and soybean acreage is estimated by non-linear least squares, using yearly data for the period 1957–77. The results are presented in Table 1 for corn and in Table 2 for soybeans.

In the corn equation ((1) in Table 1), the estimated short-run elasticities of acreage with respect to the expected corn price (.441) and the expected soybean price (−.206) have the expected signs and are significantly different from zero at the 5 percent level. Diversion payments have a negative and significant impact on corn acreage. Also, the coefficient on lagged acreage is positive but very small and not significantly different from zero, indicat-

ing that the economic adjustments in corn acreage are rapid.

The estimates of the weights in the price expectation formula indicate that support prices play a major role in the acreage decision. In particular, the hypothesis that the weights for support prices in the corn-acreage equation are equal to zero ($b_3 = c_3 = 0$) is rejected at the 5 percent significance level. This indicates that policy variables have a major effect on farmers' price expectations and on corn planted acreage. This result is not surprising since the government corn price support program has been in effect during most of the study period.

The estimated results for corn acreage do not give a clear answer concerning the role of futures and cash markets in the formulation of farmers' expectations. In Table 1 (equation 1), the weights for the cash price of corn and the futures price of soybeans are zero, while they are positive for the futures price of corn and the cash price of soybeans. In order to further investigate the role of these prices, the acreage equation was reestimated by restricting the weights of the cash prices (equation 2, Table 1) or of the futures prices (equation 3, Table 1) to be zero. The results confirm the importance of support prices in the corn-acreage decision. They also indicate that the futures price and the cash price may play a similar role since substituting one for the other appears to make little difference in the empirical results. This supports Gardner's conclusion that futures prices perform as well as lagged prices in supply-response specification.

The soybean equation ((1) in Table 2) exhibits significant short-run response. The elasticities of acreage with respect to the expected soybean price (.590) and the expected corn price (−.584) are both significantly different from zero at the 5 percent level. The large and significant influence of the lagged dependent variable (.8862) indicates important dynamic

TABLE 1. Acreage Response for Corn (AC_j). [a,b]

Equa-tion	INT (a_0)	Expected Corn Price (a_1)	Expected Soybean Price (a_2)	DPC_t	AC_{t-1}	FPC_t (b_1)	CPC_{t-1} (b_2)	SPC_t (b_3)	FPS_t (c_1)	CPS_{t-1} (c_2)	SPS_t (c_3)	R^2
(1)	60,258 (11,292)	1,430,751 (412,362) [.441]	−154,959 (80,556) [−.206]	−35,337 (9,457) [−.052]	.0396 (.1065)	.3652 (.1748)	0 (0)	.6348 (.1748)	0 (0)	.4682 (.2573)	.5318 (.2573)	.9207
(2)	58,671 (12,191)	1,366,929 (459,357) [.421]	−127,029 (82,034) [−.169]	−33,822 (9,904) [−.049]	.0516 (.1137)	.3077 (.1960)	—	.6923 (.1960)	.4449 (.3873)	—	.5551 (.3873)	.9135
(3)	58,702 (15,292)	1,423,039 (542,850) [.439]	−150,472 (84,611) [−.200]	−27,930 (11,265) [−.041]	.0683 (.1174)	—	.2261 (.1635)	.7739 (.1635)	—	.3455 (.2629)	.6545 (.2629)	.9126

a Standard errors are presented in parentheses, below the parameter estimates. Elasticities evaluated at sample means are in brackets.
b AC_t = acreage of corn (acres); DPC_t = diversion payment of corn; FPC_t = weekly average futures price of the week of March 15 for corn on December contract, deflated by variable production costs; CPC_{t-1} = yearly average cash price of corn lagged one year, deflated by variable production costs; SPC_t = effective support price of corn deflated by variable production costs; FPS_t = weekly average futures price of the week of March 15 for soybeans on November contract, deflated by variable production costs; CPS_{t-1} = yearly average cash price of soybeans lagged one year, deflated by variable production costs; SPS_t = effective support price of soybeans deflated by variable production costs.

TABLE 2. Acreage Response for Soybeans (AS_j). [a,b]

Equation	INT (a_0)	Expected Corn Price (a_1)	Expected Soybean Price (a_2)	AS_{t-1}	FPC_t (b_1)	CPC_{t-1} (b_2)	SPC_t (b_3)	FPS_t (c_1)	CPS_{t-1} (c_2)	SPS_t (c_3)	R^2
(1)	2,728 (5,837)	−946,907 (357,603) [−.584]	221,859 (61,749) [.590]	.8862 (.0942)	0 (0)	.5970 (.2252)	.4030 (.2252)	.2902 (.4875)	.7198 (.4875)	0 (0)	.9601
(2)	4,729 (4,556)	−989,987 (342,016) [−.611]	209,399 (56,497) [.557]	.9025 (.0878)	—	.6603 (.1862)	.3397 (.1862)	—	1 (0)	0 (0)	.9592
(3)	540 (6,091)	−918,581 (454,610) [−.566]	227,897 (66,360) [.606]	.9433 (.1328)	.6841 (.3468)	—	.3159 (.3468)	1 (0)	—	0 (0)	.9543

a Standard errors are presented in parentheses, below the parameter estimates. Elasticities evaluated at sample means are in brackets.
b Variable definitions are the same as in Table 1.

TABLE 3. Futures Price Equations.[a,b]

	INT	FPC$_t$	CPC$_{t-1}$	SPC$_t$	FPS$_t$	CPS$_{t-1}$	SPS$_t$	R^2
FPC$_t$	.0029	—	.5971	.0482	.1423	−.0672	−.0130	.8909
	(.0054)		(.1493)	(.1107)	(.0487)	(.0488)	(.0329)	
FPS$_t$	.0110	2.548	−2.2079	.1699	—	.7346	.0408	.9109
	(.0232)	(.8723)	(.7069)	(.4692)		(.1096)	(.1394)	

[a] Standard errors are in parentheses below the parameter estimates.
[b] Variable definitions are the same as in Table 1.

adjustment in acreage. As a result, short-run and long-run supply response for soybeans differ sharply.

The estimated weights are zero for the futures price of corn and the support price of soybeans. They are positive for the other prices. This suggests that public policy influences soybean production only through the farmer's price expectation for corn. This is an expected result since the two crops are substitutes and government programs during the study period have been targeted more heavily at corn than at soybeans.

Again, the estimated coefficients in the soybean acreage equation do not provide definite information on the role of futures and cash prices. For example, the weight of either the soybean futures price or the soybean cash price, although positive, is not significantly different from zero at the 5 percent level. However, the hypothesis that the weights of both futures and cash prices are equal to zero ($b_1 = b_2 = c_1 = c_2 = 0$) is rejected. This suggests that futures prices and cash prices may reflect similar information and that the information provided by either of the two is crucial in the formulation of price expectations. To further analyze the role of these prices, the soybean supply function was reestimated by restricting the weights of the futures prices (equation 2, Table 2) or of the cash prices (equation 3, Table 2) to be zero. The results support our earlier statements. First, policy variables influence soybean production mainly through the formulation of corn price expectations. Second,

the supply elasticity estimates hardly change as the futures price is substituted for the cash price (or vice versa). This provides additional evidence that futures prices and cash prices may reflect similar market information.

This close relationship between the futures price (FP) and the lagged cash price (CP$_{t-1}$) can be further investigated. The correlation coefficient between these two prices is high: .87 for corn and .90 for soybeans during the study period. This suggests that estimating supply equations as a function of both futures and cash prices will likely give rise to multicollinearity problems. This high correlation also suggests that a strong informational component of futures prices is the market price of the previous year. This is confirmed by the regression estimates of futures prices on other relevant price variables, reported in Table 3. For both corn and soybeans, the most significant variable explaining futures price variations (Table 3) is the average market price lagged one year. Also, it is found that the effective support price has a non-significant influence on futures prices, indicating that futures markets do not reflect the effects of government programs. This suggests that futures prices for corn and soybeans may not be informationally efficient. Such results provide added support for our earlier finding: when government intervenes in the market place (as it has been doing in the case for corn), futures prices do not appear to reflect government actions, implying that farmers want to rely on sources

of information (such as support prices) other than futures prices in the formulation of their price expectations.

Concluding Remarks

An integrated investigation of the futures price, the cash price, and government programs has been presented in the context of acreage-supply response for corn and soybeans. It generates evidence on how farmers formulate expectations about product prices. In particular, it refines the role of different sources of price information in the acreage decision.

Our estimates support the following conclusions. First, policy variables play a major role in the corn production decision, reflecting the strong influence of the government corn support price program in the last few decades. They also play a role in the soybean acreage decision, but only indirectly through the formulation of the expected corn price. Given the limited involvement of government in the soybean market, this illustrates the effect of policy decisions on expectations and economic adjustments in related markets.

Second, as argued by Gardner, the futures price appears to be a good substitute for the cash price lagged one year in supply analysis. This is the case for corn and soybeans because these two prices are highly correlated and appear to reflect similar market information. As a result, using both futures and cash prices in supply equations may lead to multicollinearity problems, while deleting one of the two appears to make little empirical difference in the estimates of supply elasticities.

Third, our results raise questions about the informational efficiency of futures prices. In particular, futures prices do not seem to reflect the effects of government decisions, implying that the use of futures prices as a proxy for expected prices in supply response models appears to be jus-

tified only in the absence of government programs. When the government intervenes in the market place, the futures price is found to be only a part of the information component of farmers' expectations.

Finally, it remains unclear whether the futures prices are informationally efficient for the formulation of price expectation in the absence of government intervention. In agreement with Gardner, futures prices do appear to perform relatively well in modeling supply response without government programs, as illustrated by our soybean acreage function. However, this does not necessarily mean that futures prices are good predictors of future cash prices (Stein). It may be that for continuously stocked commodities such as corn or soybeans, the futures markets have as their main function storage coordination over time rather than price discovery. This problem needs more detailed research before any conclusions may be drawn.

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