A STUDY ON THE ROLE OF FUTURES PRICE INFORMATION IN THE ACREAGE RESPONSE ANALYSIS

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I. Introduction

The purpose of this study is to investigate the role of futures price information in supply response analysis. The futures price has been used as a proxy variable of one period lagged cash prices because the futures contract price for next year reflects the market's estimation of next year's cash prices and the expected prices of producers at the time when production decisions are being made. The spring time price of the harvest time contract is useful as a reasonable forecast of the subsequent harvest time price when futures markets are efficient[1].

However, because futures markets for some commodities or under some conditions are not efficient, applying the futures price in supply analysis is a rather controversial issue. According to previous research, there are two basic questions concerning the role of futures price information: (1) Can futures price be used as a proxy variable for specific price expectations?, (2) If this is not true in general, which commodities, or under what specific economic situations can the futures price be used instead of the cash price?

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[1] According to Tomek and Gray(1970), efficiency of the futures market depends on: (1) the nature of commodity market, perennial or annual crop, degree of uncertainty in annual production variations, supply and demand elasticities, and the natures of stocks or inventory cost function; (2) the quality of information about past and forthcoming economic conditions and the ease of predicting these values; and (3) the nature and degree of intervention by governments or international agencies in the free market price determination mechanism. Thus, the market efficiency is determined by commodities, government programs, and quality of information.

Gardner (1976) suggested that the futures price can be a proxy variable of one-period-lagged cash prices in supply response analysis for agricultural products, including livestock. In agreement with this suggestion, Morzuch, et al.(1980) applied the futures price in a study of wheat acreage response with farm programs and reached more concrete conclusions on the role of futures price information as: "Futures prices appear to merit consideration as an alternative to using distributed lags in modeling price expectations for economic research (p.37)".

Gardner's suggestions are rejected by Chavas, et al.(1983), and Burt and Worthington (1988). According to Chavas et al., "the use of futures prices as proxy for expected prices in supply response models appears to be justified only in the absence of government programs(p. 32)". Furthermore, they questioned whether the futures price are efficient for the formation of non-storable commodity price expectations even in the absence of government programs.

These studies indicate that no consensus has been reached regarding the role of futures prices in determining supply response in areas characterized by non-storable commodities and government programs. The purpose of this paper is to identify the usefulness of futures price information through: (1) market efficiency test of futures prices in comparison with lagged cash prices for different commodities; and (2) estimation of a soybean acreage response that incorporates the futures price and government program variables.

Although the study periods are not long enough, and the applied models are simple, this paper addresses the relative effectiveness of futures price information in forming price expectations. Thus, it may provide a more concrete foundation for incorporating the futures price in supply analysis as a proxy for the expected price.

II. Model Specifications

The model specification in this study consists of two parts: the analysis of relative effectiveness of futures price information through (1) the market efficiency test[2] for the commodities which have

[2] According to Fama (1970), an "efficient market" has been described as "one in

different storable characteristics, and (2) the soybean acreage estimations with or without government programs. Both models are eventually focused on the investigation of the role of futures price information in supply analysis.

For a comparison of relative effectiveness of the futures prices to the one-period-lagged cash prices, the market efficiency test method is applied as shown in equation (1) and equation (2). Since both equations are established to forecast cash price at time t with one period lagged cash price(t-1) and futures price, comparison of the forecasting results of these two equations provides information on the relative effectiveness of the two price variables: lagged cash price and futures price.

$$P_{1t} = a + bP_{t-1} + u_t \quad \cdots\cdots \quad (1)$$
$$P_{2t} = \alpha + \beta F_t + \varepsilon_t \quad \cdots\cdots \quad (2)$$

where,

P_{it} = cash price at time t, the last delivery day (Nov. for soybean, Dec. for Corn contract) closing price, where i=1 predicted from lagged cash price and i=2 predicted from futures price

P_{t-1} = cash price at time t-1

F_t = futures price at time t-1 for t, (Apr. 30th closing price for relevant contracts)

u_t, ε_t = disturbance terms

In the market efficiency test with the hypothesis that a particular price series behaves as a simple stochastic process, if the intercept (α) is zero and the slope (β) is unity, then the market is efficient. In addition, the r^2 can be used as a measure of market performance in this

which prices always fully reflect all available information". Out of three different market efficiencies -- weak form, semi-strong form, and strong form market efficiency - the weak form efficiency which is defined as "efficient if the current price always completely discounts the information contained in past market" is commonly applied. Market efficiency tests with the weak form efficiency hypothesis for various commodities are done by Tomek and Gray(1970) and Kofi (1972).

model.[3] For these model settings, comparison of the values of intercept, slope, and r^2 of these equation (1) and (2) may provide an indication of the relative effectiveness of price information.

For the purpose of analyzing relative usefulness of the price information in general, various commodities such as soybean, corn, and potatoes which have different storable characteristics are examined. Soybeans and corn are produced seasonally, and stocks are carried continuously throughout the year. Potatoes are also produced seasonally, but stocks are not carried continuously. For this reason, expected price formation for these crops are different. However, it is difficult to incorporate government programs in this model.

To examine the usefulness of the futures price information with government programs, soybean acreage responses are estimated with alternative price variables; lagged cash price and futures price, and government program variables.

Acres planted to a crop are determined by: (1) price of the crop itself and of relevant competing crops, (2) related government programs, (3) production costs including the prices of input for the crop production, and (4) other factors such as lagged acreage, stocks, technology, weather, etc. This relationship can be formulated as the following general acreage response model;

$$A = f(P, G, C, Z) \quad \cdots\cdots\cdots\cdots \quad (3)$$

where,

A = acres planted
P = prices of relevant crops
G = government programs
C = production cost
Z = other variables

The expected prices (P) of the crop and of competing crops might be basic explanatory factors for determining acreage. For soybean acreage response, many previous studies[4] have employed soybean and corn prices as price expectation variables. Usually one

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[3] See Tomek and Gray(1970, P.375) and Kofi(1972, P.585).
[4] See Heady and Rao(1969) and Ryan and Abel(1973), etc.

period lagged cash price, or futures price are usually applied as proxy of these expected price variables. To identify the relative usefulness of futures price, two price variables are incorporated alternatively.

Farm programs (G) for the crop and its competitive crops also have strong influences on acreage decisions. Although the soybean loan rate itself does not seriously bind on the decisions of soybean acreage, various policy programs for corn such as target price, support price, loan rate, and diversion payment rate, etc. may indirectly affect soybean acreage decisions. However, this paper incorporates government programs by "the effective support prices[5]".

The Nerlovian partial adjustment model is applied for the analysis of the U.S. soybean acreage response with or without government policy variables. For the purpose of comparison of the relative usefulness of the futures prices, four different models are constructed.

<Model 1> and <Model 2> do not incorporate policy variables. To capture the usefulness of futures prices in acreage response, one period lagged cash farm prices are used in <Model 1> and futures prices are used in <Model 2>. To avoid multicollinearity problems and to simplify the model specification, some variables such as indices of variable production cost, competing crop price, and effective support prices are alternatively used as deflators[6].

<Model 3> and <Model 4> incorporate government programs to the previous acreage response equations. The classification of <Model 3> and <Model 4> are specified to capture the relative effectiveness of the lagged cash prices and futures prices, respectively.

$$\text{Model (1)}: A_{1t} = a_1 + a_2(CPS_{t-1} / IVPCS_{t-1}) + a_3(CPC_{t-1} / IVPCC_{t-1}) + a_4A_{t-1} + a_5IS_{t-1} + E_{1t}$$

$$\text{Model (2)}: A_{2t} = b_1 + b_2(FPS_t / IVPCS_{t-1}) + b_3(FPC_t / IVPCC_{t-1}) + b_4A_{t-1} + b_5IS_{t-1} + E_{2t}$$

[5] Houck and others (1976) collapsed the price support level with the program acreage restriction requirement into one composite explanatory variable termed "effective support price". Also in a similar manner diversion payment and acreage reduction were reduced to a composite variable called an "effective diversion payment".

[6] The relative effectiveness of futures price, lagged cash price, and effective support price in forming price expectations might be simultaneously compared in the same model specification.

Model (3): $A_{3t} = c_1 + c_2(CPS_{t-1} / IVPCS_{t-1}) + c_3(CPC_{t-1} / IPCC_{t-1}) + c_4A_{t-1} + c_5IS_{t-1} + c_6\{(EPS_t / IVPCS_{t-1}) / (EPC_t / IVPCC_{t-1})\} + E_{3t}$

Model (4): $A_{4t} = d_1 + d_2(FPS_t / IVPCS_{t-1}) + d_3(FPC_t / IVPCC_{t-1}) + d_4A_{t-1} + d_5IS_{t-1} + d_6\{(EPS_t /IVPCS_{t-1}) / (EPC_t / IVPC_{t-1})\} + E_{4t}$

where,

A_{it}	=	soybean planted acreage in time t, i = 1, 2, 3, and 4
FPS_t	=	soybean futures prices, Nov. contract closing prices at Apr. 30
CPS_{t-1}	=	one period lagged cash farm prices for soybeans
FPC_t	=	corn futures prices, Dec. contract closing prices at Apr.30
CPC_{t-1}	=	one period lagged cash farm prices for corn
A_{it-1}	=	soybean planted acreage in time t-1
IS_{t-1}	=	total ending stock of soybeans in time t-1
$IVPCS_{t-1}$	=	index of variable production cost of soybeans in time t-1, (1980 = 100.00)
$IVPCC_{t-1}$	=	index of variable production cost of corn in time t-1, (1980 = 100.00)
EPS_t	=	effective support price for soybeans
EPC_t	=	effective support price for corn
E_{it}	=	disturbance terms

With these alternative model specifications, soybean acreage response is analyzed by the ordinary least squares method using data from 1966 to 1985. All the own prices and lagged acreage are expected to have positive effects while price variables of competing crops are expected to have negative effects on the acreage decisions.

The estimated acreage are then compared with actual values from 1986 to 1989. The MSE and the Theil's inequality coefficients that are provided in equation (4) and equation (5) are applied to test forecasting performance. Although those statistics do not prove absolute advantage of the models, the relative usefulness of incorporated variables can be identified through comparison of the MSE and the Theil's coefficients.[7]

[7] See Leuthold(1975, P.344)

$$MSE = \frac{1}{T} \sum_{i=1}^{T} (P_i - A_i)^2 \cdots\cdots\cdots\cdots\cdots\cdots \quad (4)$$

$$U_1 = \frac{\sqrt{MSE}}{\sqrt{(1/T)\Sigma P_i^2} + \sqrt{(1/T)\Sigma A_i^2}}, \quad U_2 = \frac{\sqrt{MSE}}{\sqrt{(1/T)\Sigma A_i^2}} \cdots\cdots \quad (5)$$

where,

T = number of years forecasted
P_i = predicted value
A_i = actual value
U_1, U_2 = Theil's coefficients, $o \leq U_1$ 1, $0 \leq U_2 < \infty$ when U_1 and $U_2 = 0$, then the forecast is perfect

If the MSE of models; 1 and 3 are greater (or the values of U_1 and U_2 are greater) than those of models; 2 and 4, this would imply futures price in the soybean acreage plays a larger role than the one period lagged cash price in forming expected prices.

III. The Data and Empirical Results

Most of the data were obtained from the data files provided by the Food and Policy Research Institute (FAPRI) of USDA in March 30, 1989 including: (1) the soybeans-planted acreage (mil.acre), (2) the previous cash prices (average price received by farmers; $/bu), (3) the effective support prices ($/bu), (4) variable production costs of soybeans and corn ($/acre), and (5) total ending stocks(Aug 31, mil. bu) of soybeans from 1966 to 1985. In addition, the actual soybean acreage data published by the FAPRI on December 30, 1990 are used for the comparison with forecasts for 1986-1989.

Futures prices from 1957 to 1989 are obtained from the Wall Street Journal. Since serial potato futures prices are not available since 1978, the futures prices of soybeans and corn in 1957-1987, and that of potatoes in 1957-1978 are applied for the market efficiency test. In addition, study periods were separated 1957-1971 and 1957-1978 because those crop prices changed dramatically in 1971.

Soybean, corn, and potato production decisions are made in the spring and harvest takes place in the fall. The first available futures contract after harvest is the December contract for corn, and the November contract for soybeans and potatoes on the Chicago Board of Trade. Therefore, the data selected are the closing prices for the respective November and December contracts. The closing prices on the last day of April of each year for the post harvest contracts represent the behavior of forward prices provided by these futures markets at planting time. The closing prices of the contracts on their expiration dates illustrate the behavior of immediate post-harvest cash prices[8].

According to the results of the market efficiency test, the futures prices play larger role than one-period-lagged prices in forming price expectations for soybean and corn which have similar storable characteristics. The intercept of futures price models are quite smaller than that of lagged cash prices (i.e., relatively close to zero) and the slope of futures price larger than that of lagged cash price (i. e., relatively close to one). Furthermore, the market performance

TABLE 1. Estimated Relationships Between the Cash Price and the Prior Futures Price for Soybean and Corn: 1957-1987

Unit; $ / bu

	INT	CPS_{t-1}	FPS_t	CPC_{t-1}	FPC_t	MSE	r^2	D.W
CPS_{1t}	0.9284	0.8127	-	-	-	1.3978	0.6759	2.477
	(0.5113)	(0.1064)						
CPS_{2t}	0.4383	-	0.9118	-	-	0.8614	0.8006	2.451
	(0.3995)		(0.0845)					
CPC_{1t}	0.4637	-	-	0.7632	-	0.2689	0.5999	2.009
	(0.2391)			(0.1178)				
CPC_{2t}	0.2242	-	-	-	0.8603	0.1823	0.7271	1.677
	(0.2015)				(0.0979)			

( ) standard error

[8] Throughout the test of efficient market hypothesis, the "cash price" of a commodity is taken to be the closing futures price on the last day of trading of the delivery month. For detailed discussion on this point, see Tomek and Gray (1970, p.374) and Kofi (1972, p.585).

measurement, r^2, of the futures prices are greater than that of the lagged cash prices for soybean and corn acreage forecasting (see Table 1).

The forecasting price efficiency of the storable commodity is higher than that of the non-storable commodity. Since storage of soybeans is easier than storage of potatoes, forecasting price efficiency of the soybean is higher than that of the potato. According to <Table 2>, the intercepts are not significantly different from zero, and the slope coefficients are not very different from unity for soybeans. However, the intercepts are significantly different from zero and the slops are quite different from unity for potatoes.

In addition, the forecasting price efficiency depends on the time periods that are investigated. The market efficiency of both commodities for 1957-1978 is higher than that for 1957-1971 as shown in <Table 2>. The improvement of forecasting price efficiency for the recent periods are due to the improvement of the storage and processing technology, and quality of information in soybean and potato markets.

TABLE 2. Estimated futures market efficiency for Soybean and Potatoes: 1957-1978

Unit; $ / bu (soybean) & $ / lb (potatoes)

Period	Intercept		Slope		r^2		D.W	
	Soybean	Potato	Soybean	Potato	Soybean	Potato	Soybean	Potato
1957 - 78	0.0828 (0.3480)	0.8530 (0.5174)	1.0459 (0.0949)	0.7716 (0.1506)	0.8584	0.5677	2.642	2.454
1957 - 71	0.5714 (0.4425)	2.8854 (1.5335)	1.2748 (0.1747)	2.9942 (0.6482)	0.7919	0.4722	1.776	2.312

( ) standard error

These results imply that the soybean market is more efficient than the potato market, and the springtime futures prices are better forecast of the harvest period cash prices for both commodities. The results are similar to the conclusions of the Gardner(1976) and

Morzuch, et al.(1980), and answering to the Chavas, et al.'s question (1983) that even the futures prices of non-storable commodity can be used as proxy variables in the supply analysis when government programs are not considered.

For the purpose of further investigation of the roles of futures prices with policy programs, four alternative regression models are run on the U.S. soybean acreage response for 1966-1985, and the results are presented in <Table 3>.

With the assumption that policy variables do not affect the soybean acreage decision, <Model 1> incorporates the lagged soybean and corn cash prices which are deflated by variable production cost index, previous soybean acreage and inventories, and <Model 2> incorporates the deflated futures prices rather than the deflated lagged prices.

Although the r^2 in <Model 1> based on the lagged cash prices are slightly greater than those of <Model 2> based on the futures prices, overall estimated results in <Table 3> are quite similar. These results are similar to the previous market efficiency test that futures prices can be used as proxy variables for expected cash prices without government programs.

To examine the role of futures prices with government programs in the acreage function, two different models are constructed additionally. That is, <Model 3> and <Model 4> incorporate the

TABLE 3. Soybean Acreage Response Without Policy Programs

Models	INT	$^*CPS_{t-1}$	$^*FPS_t$	$^*CPC_{t-1}$	$^*FPC_t$	$A_{i,\,t-1}$	IS_{t-1}	r^2
			($/bu)	($/bu)	($/bu)	($/bu)	(mil.acre)	(mil.bu)
Model 1	5.8814	2.3315		-4.9932		0.9479	-0.0175	0.9580
	(4.5064)	(0.6948)		(1.3175)		(0.0773)	(0.0107)	
Model 2	5.7415		1.7256		-3.6004	0.9814	-0.0219	0.9382
	(6.3482)		(0.8880)		(1.6254)	(0.0948)	(0.0136)	

* CPS_{t-1} = previous soybean cash price, deflated by variable soybean production cost index
* FPS_t = futures soybean price, deflated by variable soybean production cost index
* CPC_{t-1} = previous corn cash price, deflated by variable corn production cost index
* FPC_t = futures corn price, deflated by variable corn production cost index
( ) standard error

deflated effective support price ratios to the deflated lagged prices of soybean and corn, respectively. The regression results except the policy variables are similar to previous models as shown in <Table 4>.

Although including policy programs improved the explanatory power of the models, the government policy variables (RS^i) are not significant at the 5% significance level[9]. Since the loan rate for soybeans is the only policy program in soybean production, it was used as an effective support price. But the soybean loan rate is much lower than any market prices in most years, and it does not represent the price movement accurately.

The relative support price ratios are difficult to interpret because both prices are changing inconsistently. For example, increase in the ratio (relatively higher increase for soybean support price than corn support price) favors soybean producers, thus, soybean acreage may be expected to increase. However, the sign of this variable RS^i appeared negative because the increase of effective support price for corn was relatively higher than that of soybean during the study periods.

TABLE 4. Soybean Acreage Response with Government Programs

Models	INT	$^*CPS_{t-1}$	$^*FPS_t$	$^*CPC_{t-1}$	$^*FPC_t$	$A_{i,\,t-1}$	IS_{t-1}	RS^i	r^2
		(\$/bu)	(\$/bu)	(\$/bu)	(\$/bu)	(mil.acre)	(mil.bu)	(%)	
Model 3	14.0821	2.0539		-5.2704		0.9255	-0.0191	-1.5375	0.9631
	(7.3532)	(0.7034)		(1.2942)		(0.0767)	(0.0104)	(1.1082)	
Model 4	12.0684		1.7501		-4.1758	0.9507	-0.0205	-1.3430	0.9438
	(8.2418)		(0.8767)		(1.6766)	(0.0972)	(0.0135)	(1.1365)	

RS^i : $RS^1 = {}^*ESP_t \,/\, {}^*ECP_t$, deflated by variable production cost index
$RS^2 = ESP_t \,/\, ECP_t$, (not deflated)
( ) standard error

[9] Lower soybean support prices might be one reason why the policy variables failed to get significant results. Since the soybean support price is lower than market price, this government policy program cannot affect the soybean acreage response.

The soybean acreage forecasting results from 1986 to 1989 and test statistics are provided in <Table 5>. The MSE of <Model 1> which incorporated lagged cash prices is larger than that of <Model 2>, which incorporated futures prices, and the values of U_1 and U_2 of the <Model 1> are greater than that of <Model 2>. This means that the forecasting performance of the futures prices is better than that of lagged cash prices for the soybean acreage prediction without government programs.

When considering government programs, the MSE and Theil's coefficients of <Model 3>, which incorporated lagged cash prices, is larger than that of <Model 4>, which incorporated futures prices too. This implies that the model which incorporated futures prices performs better than the model which incorporated lagged cash prices, both with and without government programs.

TABLE 5. Soybean Planted Acreage Forecasting Results

Unit; million acre

	1986	1987	1988	1989	MSE	U_1	U_2
Actual	60.385	57.955	58.870	61.325			
Model 1	58.809	61.298	61.275	64.950	8.146	0.012	0.023
Model 2	59.085	59.663	56.016	63.798	4.717	0.009	0.018
Model 3	65.624	62.202	61.565	65.011	16.583	0.017	0.032
Model 4	60.190	60.709	62.309	64.139	6.842	0.011	0.021

Thus, it can be concluded that futures price information can be utilized as proxy variables in supply response analysis, and the futures price information works better than lagged cash price information in soybean acreage response even with government programs.

IV. Summary and Conclusions

This paper addresses the role of futures price information in supply response analysis. According to the analysis on the relative effectiveness of one period lagged cash prices and futures prices through the market efficiency test, the futures prices generally play a larger role than lagged cash prices in forming price expectations for corn, soybeans, and potatoes in the study periods.

This implies that the futures price can be applicable even for non-storable commodities(i.e., potatoes), a practice questioned by Chavas, et al., although the market efficiencies for these commodities are less than those of storable commodities.

The role of futures price information are further investigated through four alternative models for soybean acreage forecasting. The futures price performed as well as the lagged cash price without government policy program variables. Furthermore, the forecasting performances of futures price of the model (3) and (4) which incorporate government programs are also quite similar to the model (1) and (2) which do not incorporate government programs.

This analysis, as a whole, supports Gardner's suggestion and partly replies to Chavas,et al.'s questions. That is, futures price information can be used as proxy variables of lagged prices, and also as an important explanatory variable in supply analysis for corn, soybeans, and potatoes in the study periods.

These results are derived from the following reasons: Since price formation in the futures markets at any point in time is the result of expert appraisal of past conditions, currently available information, and expectations on supply and demand, futures prices contain more information than the simple lagged price alone. In addition, improvement of the quality of information and storage capability in general enhance the usefulness of the futures price information in supply response analysis.

REFERENCE

Burt,O.R. and V.E. Worthington, "Wheat Acreage Supply Response in the United States", *Western Journal of Agricultural Economics*, 13(1), pp.100-111, 1988.

Chavas,J.P., R.D. Pope, and R.S. Kao,"An Analysis of the Role of Futures Prices, Cash Prices and Government Programs in Acreage Response", *Western Journal of Agricultural Economics*, 8(1), pp.27-33, 1983.

Fama, E., "Efficient Capital Markets: A Review of Theory and Empirical Work." *Journal of Finance*, 25, pp.383-417, 1970.

Gardner, B.L., "Futures Prices in Supply Analysis", *American Journal of Agricultural Economics*, 58(1), pp.81-84, 1976.

Heady,E.O. and V.Y. Rao, "Acreage Response and Production Supply Functions for Soybeans", *Research Bulletin* No.555 (9), pp.1033-1055, Iowa Agricultural Experiment Station, 1969.

Houck,J.P., M.E.Abel, M.E.Ryan, P.W.Gallagher, R.G.Hoffman, and J.B. Penn, *Analyzing the Impact of Government Programs on Crop Acreage*, USDA, ERS Tech. Bulletin No. 1545, 1976.

Kofi, T.A., "A Framework for Comparing the Efficiency of Futures Markets", *American Journal of Agricultural Economics*, 55(4), pp. 584-593, 1972.

Leuthold, Raymond M., "On the Use of Theil's Inequality Coefficients", *American Journal of Agricultural Economics*, 57(2), pp.344-346, 1975.

Morzuch, B.J., R.D. Weaver, and P.G. Helmberger, "Wheat Acreage Supply Response Under Changing Farm Programs", *American Journal of Agricultural Economics*, 62(1), pp.29-37, 1980.

Nerlove,M., "Estimates of the Elasticities of Supply of Selected Agricultural Commodities", *Journal of Farm Economics*, 38(2), pp.496-509, 1956.

______,"The Dynamics of Supply: Retrospect and Prospect", American *Journal of Agricultural Economics*, 61(5), pp.874-888, 1979.

Ryan, M.E. and E. Abel, "Supply Response of U.S. Sorghum Acreage to Government Programs", *Agricultural Economics Research*. 25(2), pp. 45-55, 1973.

Tomek, W.G. and W. Gray, "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles", *American Journal of Agricultural Economics*, 52(3), pp.372-380, 1970.