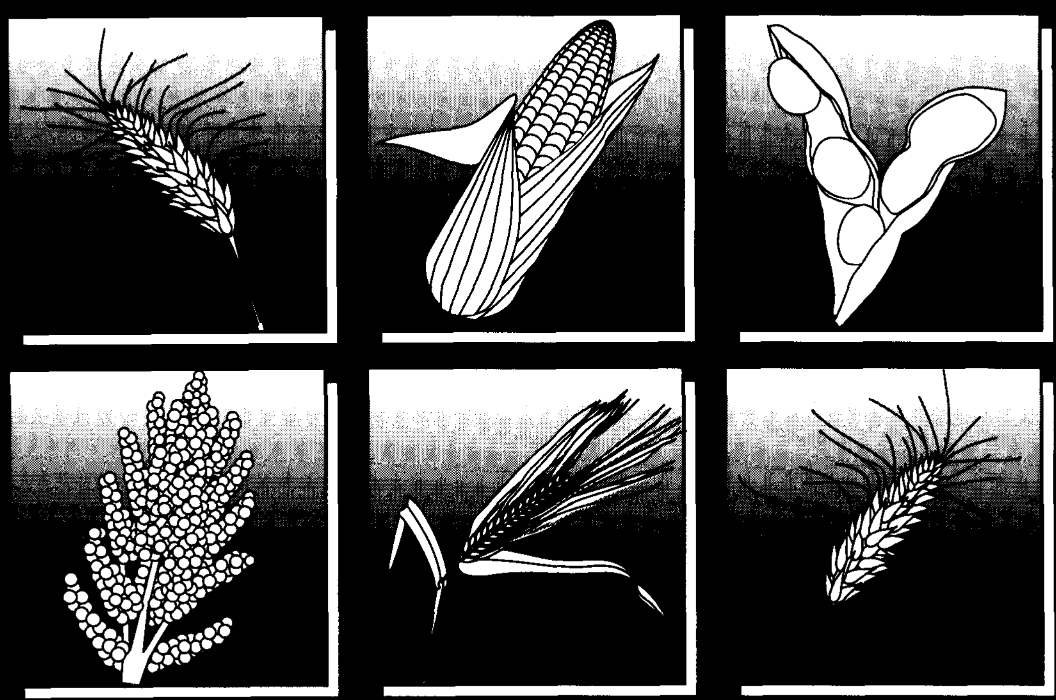
United States Department of Agriculture

Agricultural Cooperative Service

ACS Research Report 128

First-Handler Grain Cooperative Elasticities:

Output Supply, Factor Demands, and Factor Substitution, 1983-1991



Abstract

First-Handler Grain Cooperative Elasticities:
Output Supply, Factor Demands, and Factor Substitution, 1983-1991

Anthony C. Crooks
David E. Cummins
Agricultural Economists
Agricultural Cooperative Service
United States Department of Agriculture

This report is the first of a multi-part investigation that attempts to quantify the impacts of market and policy changes upon first-handler grain cooperatives in the United States The response of grain cooperatives to their changing market and policy environment from 1983 to 1991 is quantified.

An economic model is constructed to measure grain cooperative output supply response, changes in grain cooperative factor demands, and substitution rates among the factors of production employed by grain cooperatives in four major United States grain producing regions. The model assumes that grain cooperatives employ three basic factors of production (intermediate inputs, labor, and capital) to provide three services/products (grain sales or merchandising, grain storage, and farm supply sales). A discussion of the important findings of the model in the light of the events transpiring in the grain industry during the study period and important model implications is also included.

Keywords: Farmer cooperatives, grain, elasticities, policy analysis, duality, translog profit function

ACS Research Report 128

March 1994

Preface

This report is based on balance sheet and operating statement data from annual cooperative reports requested by USDA's Agricultural Cooperative Service (ACS) as part of an annual survey of grain marketing cooperatives. By ACS definition, grain cooperatives are those whose sales of grains and oilseeds account for more than half of total sales. Other types of information such as volume of grain handled and storage capacity were obtained directly from first-handler cooperatives.

Report estimates were obtained from local first-handler associations having $5 million or more in total sales during the study period, and four types: corn-soybean, wheat-sorghum, wheat-barley-oats, and wheat-barley. This group accounted for an estimated 90 to 95 percent of total grains and oilseeds sales by local grain cooperatives. Most cooperatives were diversified, also handling farm supplies. All provided related services.

Information for this report is based on condensed balance sheets and operating statements. Adjustments were made in financial reports to ensure data comparability because of variations in accounting, auditing practices, and terminology. Some detail was lost in the process.

Information in this report can help cooperative managers and boards make sound business decisions as they adjust to variations of old problems and consider the need for increased capital for improved or new facilities and/ or services. Information can be used to compare your cooperative with others of similar size.

Contents

Highlights

This report is the first of a multi-part investigation that attempts to quantify the impacts of market and policy changes upon first-handler grain cooperatives in the United States from 1983 to 1991.

- Varian's (1985) nonparametric test was performed for behavioral consistency with the hypothesis that grain cooperatives in the United States maximize net savings. The execution of Varian's test generated a failure rate of less than 0.6 percent among cooperatives within each region (provided in Table 2). The hypothesis of net savings rationality cannot be rejected, therefore, among first-handler grain cooperatives in the United States
- An economic model was constructed to measure grain cooperative output supply response, changes in grain cooperative factor demands, and substitution rates among the factors of production employed by grain cooperatives in four major grain producing regions in the United States, the Corn Belt (corn-soybeans), Northern Plains (wheat-barley-oats), Southern Plains (wheat-sorghum), and the Pacific Northwest (wheat-barley).
- Evidence of technical change and of factor reallocation were also examined. Technical change occurring in the Corn Belt region had a pronounced impact on the substitution of capital for labor. Evidence for the impact of technical change in the other three regions was inconclusive.

First-Handler Grain Cooperative Elasticities:
Output Supply, Factor Demands, and Factor Substitution, 19834991

Anthony C. Crooks, David E. Cummins
Agricultural Economists

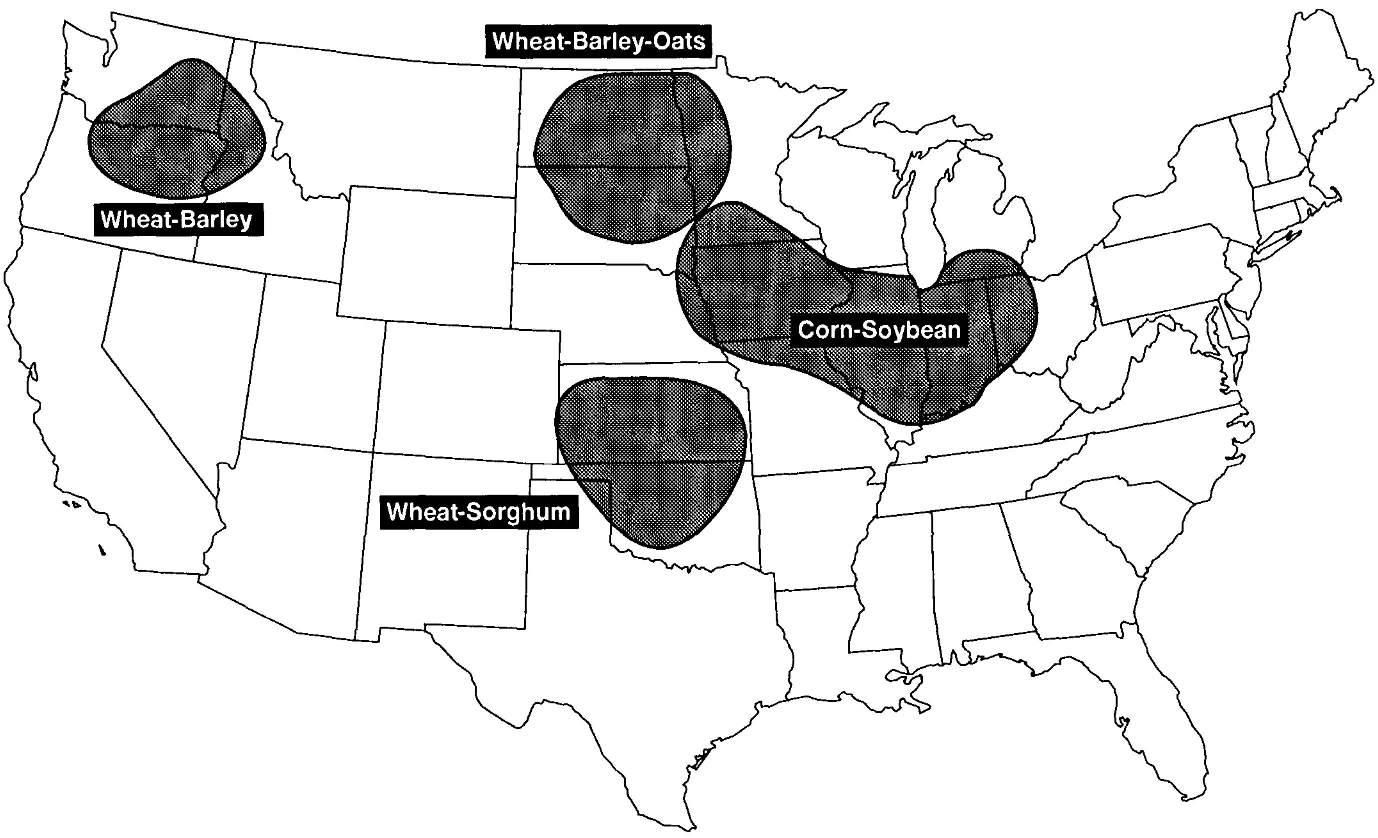
INTRODUCTION

This report is the first of a multi-part investigation that attempts to quantify the impacts of market and policy changes upon first-handler grain cooperatives in the United States This paper reports how grain cooperatives responded to their changing market and policy environment from 1983 to 1991. An economic model is constructed to measure grain cooperative output supply response, changes in grain cooperative factor demands, and substitution rates among the factors of production employed by grain cooperatives in four major grain producing regions in the United States (figure 1).

The model assumes that grain cooperatives employ three basic factors of production (intermediate inputs, labor, and capital) to provide three services / products (grain sales or merchandising, grain storage, and farm supplies sales). The estimation technique uses a flexible functional form approach to permit a more disaggregated analysis of the structural changes occurring among grain cooperatives during the study period and a way to measure the impacts of technological change upon factor use and factor substitution. The technique also has the feature of exploiting the duality relationship between the cooperative's production and net savings functions.

Figure 1

Location of Selected Types of First-handler Grain Cooperatives



The report provides a brief history and justification of the method of analyses used, a description of a procedure to test the hypothesis of net savings maximization among cooperatives, a description of the data set, the results of a nonparametric testing, a data exploration strategy for the cooperative net savings function, and model validation efforts. The third section reports empirical results for the econometric model. A discussion of the important findings of the model in the light of the events transpiring in the grain industry during the study period and important model implications follows in the fourth section. The fifth section provides a summary of results and important conclusions for first-handler grain cooperatives in the United States

MATERIALS AND METHODS

Measuring Cooperative Response to Market Changes: A Duality Approach

The application of duality theory to empirical analysis has long been appealing as a way to bring theoretical coherence to empirical estimation. The dual approach offers researchers a method of ensuring theoretical consistency of cross-commodity relationships. The practice has often been overlooked with non-dual approaches (Taylor, 1990). The application of duality also allows the empirical estimation of producers' output supply and factor demand functions. Without understanding these two aspects of producer response, any analysis of a policy regime or market structure change is critically hindered.

The first applications of duality to economic analysis were Hotelling (1932) and Roy (1942) for consumer demand, and Shephard (1953) and Samuelson (1953) for cost and production functions. McFadden (1973) generalized the work of Shephard to include net savings and revenue functions.

Another advantage of the dual approach is that it provides the researcher with a richer class of operational functional forms. Investigation of production in a multi-product and multi-factor framework was made possible with this framework. The work of Diewert (1971, 1973, 1974); Lau (1972); Lau and Yotopolous (1972); and Jorgensen and Lau (1973); to develop flexible functional forms permits a highly disaggregated analysis of production structure.

Traditional approaches required the aggregation of heterogeneous exogenous factors that may effect factor demands and output supplies differently. The combined use of duality theory with the flexible forms makes it possible to trace the impact of an array of environmental factors simultaneously (Sidhu and Banaante, 1981).

However, the dual approach is not without its "pitfalls" (Taylor, 1990). Duality results are obtained by applying the envelope theorem to the classical models of net savings maximization (Hotelling's lema) or cost minimization (Shephard's lema). And while the envelope theorem always holds for optimizing behavior, it has been demonstrated that the duality results may not. Lee and Chambers (1986) show this general failing in the case of constraints on net savings maximization. The general duality results are also shown to not hold in the cases of uncertainty (Pope, 1980, 1982a, 1982b) and stochastic dynamic problems (Taylor, 1984).

Furthermore, questions regarding the validity of the neoclassical maximization hypothesis have also been raised (MacCrimmon and Larson, 1979; De Alessi, 1983; Shoemaker, 1982). Because any empirical application of duality theory rests on the assumption of net savings maximization, suspecting the validity of the maintained hypothesis presents a more fundamental problem. If, however, the maximization hypothesis is testable, and there seems to be no consensus even on this point,[1] then perhaps some conclusions may be drawn as to the applicability of the duality approach to a particular empirical question.

[1] Consider the spirited debate between Boland (1981, 1983) and Caldwell (1983).

Several approaches for testing the net savings maximization hypothesis have been offered. These tests are both parametric (Dillon and Anderson, 1971) and nonparametric (Varian, 1984; Chavas and Cox, 1988; Fawson and Shumway, 1988) in nature.

Parametric testing is based on comparing marginal physical productivities to price ratios. These tests suffer from the same shortcoming faced by all parametric tests of being conditional on the selected functional form. Because neither theoretical nor biological relationships provide any criteria for the selection of functional form, the researcher is often left to his own device (intuition). Nonparametric testing has the advantage of allowing hypothesis testing without imposing any assumptions on functional form or the technology. However, nonparametric tests also have an heuristic base and can only determine whether or not observed behavior is consistent with the null hypothesis (Taylor, 1990).

It seems reasonable, therefore, to combine parametric and nonparametric tests. Information gained from both tests stands to be complementary and should provide the researcher with a stronger sense of the validity of the maintained hypothesis.

Testing the Hypothesis of Net Savings Maximization Among United States Grain Cooperatives

Following Varian (1984, 1985), a nonparametric test was performed for behavioral consistency with the hypothesis that grain cooperatives in the United States maximize net savings. In general, the Varian test is a pragmatic comparison of current period net savings against the net savings that would result from current year prices and wages with output and factor quantities of all other periods. More precisely, a production set Y is said to be net savings rational for the observed behavior if for a net-output price vector **P**

$$p^i y^i > p^i y^j \text{ for } i,j = 1, \ldots, n; \; p >> 0, \; y \geq 0.$$

The Data Set-This report is based on balance sheet and operating statement data from cooperatives' annual reports requested by ACS as part of an annual survey of grain marketing cooperatives. By ACS definition, grain cooperatives are those whose sales of grains and oilseeds account for more than half of total sales. Other types of information such as volume of grain handled and storage capacity were obtained directly from first-handler cooperatives.

Report estimates were obtained from local first-handler associations having $5 million or more in total sales during the study period, and four types: corn-soybean, wheat-sorghum, wheat-barley-oats, and wheat-barley. This group accounted for an estimated 90 to 95 percent of total grains and oilseeds sales by local grain cooperatives. Most cooperatives were diversified, also handling farm supplies. All provided related services. Information for this report is based on condensed balance sheets and operating statements.

Revenues and expenditures from grain sales and storage and farm supply sales, and grain volume data from farmer cooperatives designated as grain handlers (at least 60 percent of income in grain sales) from prominent grain regions from 1983 to 1991. This data set was employed for the nonparametric tests of the net savings maximization hypothesis and all parametric estimates. Descriptive statistics of the data set are provided by region and for all regions in table 1.

Nonparametric Test Results-The computer algorithm used to perform the nonparametric test for net savings maximization among grain cooperatives in the United States is provided in the appendix. The nonparametric test of Varian is distributed as an F-statistic with (n-k,n-k) degrees of freedom; a critical-F value of 1 for each region. Execution of Varian's test generated a failure rate of less than 0.6 among cooperatives within each region (table 2). Therefore, the hypothesis of cooperative net savings rationality cannot be rejected.

Table 1 **-Descriptive statistics for grain cooperative data set, by region**

Region	Number of Observations	Grain Income - $1000 -	Storage Income - $1000 -	Farm Supply Income - $1000 -	Grain Volume - 1000 bushels -
Corn Belt	1,169	11,780	597	3,470	3,496
Northern Plains	549	10,060	369	2,189	3,214
Southern Plains	327	10,520	774	3,617	3,598
Pacific NW	88	14,210	970	2,282	4,236
All	2,143	11,350	581	3,114	3,485

Table **2-Varian's test of the weak axiom of profit (net savings) maximization for U.S. grain cooperatives, by region, 1983-91**

Region	Number of Observations	Number of Failures	Number of Comparisons	Rate of Failures/ Comparisons (%)
Corn Belt	1,168	3,173	682,696	0.46
Northern Plains	548	719	150,426	0.48
Southern Plains	326	274	53,301	0.51
Pacific NW	87	22	3,828	0.57

Critical $F_{.05}(\infty, \infty) = 1.OO$

A Data Exploration Strategy for the Cooperative Net Savings Function

Just as the net savings function for cooperatives is more complicated than the analogous profit specification for the proprietary firm, estimation of the indirect net savings function for cooperatives is also more complex than a similar estimate for investor-owned firms. An estimate of cooperative indirect net savings must account for both total private profits (farmer-member profits) and collective profits (net savings) of the cooperative. Fortunately, the collective net savings of the cooperative may be incorporated into the estimate of an indirect net savings function in a relatively simple manner. From Royer (1978), the net savings function for a cooperative that maximizes the total net savings of all member patrons may be written as:

$$\pi = \mathbf{RY - PX\ t\ s'(RY - PX - FCC)}, \qquad (1)$$

where:
p is a vector of the expected net savings of a member patron,
R is a matrix of product prices,
Y is a matrix of total product quantities,
P is a matrix of factor prices,
X is a matrix of factor quantities,

FCC is the total fixed costs to the cooperative, and for s, the porportion of patronage refunds paid in cash, and
$s' = s + (l\text{-}s) / (1 + d)^t$,

where:
d is the member patron's discount rate, and
t is the number of years that (l-s) portion of patronage refunds is deferred. Because estimates of the indirect net savings function include only variable costs, the fixed costs to the cooperative term (FCC) may be excluded for econometric estimates such that (1) may be rewritten as:

$$\pi = (1 \text{ t } s')\, RY - PX, \qquad (2)$$

and s' becomes a constant for given values of s, d and τ.

Following Mountain and Hsaio (1989), a specification search for the "correct" functional form was performed beginning with the simplest flexible parametric specifications and proceeded in increasing order of complexity. When compared with the more popular general-to-specific approach this technique reduced the computational burden because in the former approach there could be many more different routes of imposing restrictions. To choose the most appropriate specification, we began by testing the most restrictive hypothesis. Thus, testing began with the Cobb-Douglas specification, proceeded with the translog, and culminated with the Fourier functional form. For all tests the alternate hypothesis was the homogeneous unrestricted functional form of equations (3) and (4), below.

$$\ln \pi = (1 \text{ t } a)\text{ a t } \Sigma_i \beta_i \ln P_i^* \text{ t } \Sigma_i \Sigma_j \beta_{ij} \ln P_i^* \ln P_j^* \qquad (3)$$
$$- 2\{\Sigma_i [\delta_i \sin(\ln P_i^*) + \phi_i \cos(\ln P_i^*)I)$$

$$S^*_i = (1+\sigma)(\beta_i + \Sigma_i \beta_{ij} \ln P^*_j \text{ t } 2\{\Sigma_i [\delta_i \sin(\ln p^*_i)$$
$$- \phi_i \cos(\ln p^*_i)]\}). \qquad (4)$$

For the above system to be derived from a viable net savings function, one of the following sets of restrictions must hold:

(a) constant (Cobb-Douglas) case, $\delta_i = \phi_i = \beta_{ij} = 0$, all i,j;.
(b) linear (translog) case, $\delta_i = \phi_i = 0$, $\beta_{ij} = \beta_{ij}$, all i,j; or
(c) Fourier case $\delta_i = -\delta_j$, $\phi_i = -\phi_j$, $\beta_{ij} = \beta_{ji}$, all i,j.

From the general function (1), the normalized flexible net savings function for grain cooperatives is specified:

$$\ln \pi^* = (1+\theta)\{\alpha + \beta_x \ln P^*_x + \beta_w \ln P^*_w + \beta_k \ln P^*_k \qquad (5)$$
$$\text{t } \tfrac{1}{2}\beta_{xx} \ln P^*_x \ln P^*_x \text{ t } \beta_{xw} \ln P^*_x \ln P^*_w \text{ t } \beta_{xk} \ln P^*_x \ln P^*_k$$
$$\text{t } \tfrac{1}{2}\beta_{ww} \ln P^*_w \ln P^*_w + \beta_{wx} \ln P^*_w \ln P^*_x + \beta_{wk} \ln P^*_w \ln P^*_k$$
$$+ \tfrac{1}{2}\beta_{kk} \ln P^*_k \ln P^*_k + \beta_{kx} \ln P^*_k \ln P^*_x \text{ t } \beta_{kw} \ln P^*_k \ln P^*_w$$
$$- 2[(\delta_x \sin \ln P^*_x \text{ t } \phi_x \cos \ln P^*_x) \text{ t } (\delta_w \sin \ln P^*_w \text{ t } \phi_w \cos$$
$$\ln P^*_w) \text{ t } (\delta_k \sin \ln P^*_k \text{ t } \phi_k \cos \ln P^*_k)]\}$$

where:
θ is a constant defined by the cash portion of patronage refunds and the discount rate (s' above);
π^* is normalized net savings with output price P_y as the numeraire, evaluated as total revenue per unit (bushel) of grain (sold and or stored);
P^*_x is the normalized intermediate inputs cost per bushel of grain;
P^*_w is the normalized wages expenditure per bushel of grain;
P^*_k is the normalized price of capital, i.e., interest expense per bushel of grain.

Following the development of (4), the S function for intermediate inputs (including grain purchases and storage), wages, and capital expenditures can be obtained by differentiating (5) with respect to P_x, P_w and P_k.

$$S^*_x = (1+\theta)\{\beta_x + \beta_{xx} \ln P^*_x \text{ t } \beta_{xw} \ln P^*_w \text{ t } \beta_{xk} \ln P^*_k \qquad (6)$$
$$\text{t } 2[\delta_x \sin \ln P^*_x - \phi_x \cos \ln P^*_x]\} \text{ t } \gamma_x Q \text{ t } \mathrm{E}T$$

$$S^*_w = (1+\theta)\{\beta_w + \beta_{ww} \ln P^*_w \text{ t } \beta_{wx} \ln P^*_x \text{ t } \beta_{wk} \ln P^*_k \qquad (7)$$
$$\text{t } 2[\delta_w \sin \ln P^*_w - \phi_w \cos \ln P^*_w]\} \text{ t } \gamma_w Q \text{ t } \mathrm{E}T$$

$$S^*_k = (1+\theta)\{\beta_k + \beta_{kk} \ln P^*_k + \beta_{kx} \ln P^*_x + \beta_{kw} \ln P^*_w + 2[\delta_k \sin \ln P^*_k - \phi_k \cos \ln P^*_k]\} + \gamma_k Q + \varepsilon T \quad (8)$$

where: $S^*_x = -P^*_{xx} / \pi^*$;

$S^*_w = -P^*_w X_w / \pi^*$;

$S^*_k = -P^*_k X_k / \pi^*$;

γ_i for $i = x, w$, and k, is a coefficient to estimate neutral and non-neutral efficiency differences in factor allocation; and

ε a coefficient to proxy technical change.

Following Binswanger, the model includes a coefficient (γ) to capture any factor reallocation that occurs during the study period and a proxy measure for technical change (ε). Binswanger described a non-neutral efficiency difference (in the sense of Hicks) as one in which the isoquant does not shift inward homothetically, i.e., the factor price ratio does not remain constant. In such an event g is significantly different from zero. If for example, the capital-labor ratio increased during the period, then estimates of $\gamma_k > 0$, and $\gamma_w < 0$, would be expected. Since the variable T is a simple linear trend (T=1, 2, ... 10), if its coefficient (ε) is significantly different from zero, then certain time periods contributed more to the outcome of the estimate than others. Such an outcome strongly suggests that technical change occurred during the period. When the results of γ and ε are combined, inferences may be drawn not only on the existence of technical change but also on impacts of such change upon factor reallocation among grain cooperatives.

Given the estimated parameters of equations (5) - (8), the elasticities of output supply and factor demands, evaluated at the simple mean of S_i, are linear transformations of the parameter estimates.

The own-price elasticity of demand (h_{ii}) for each factor becomes:

$$\eta_{ii} = (-S^*_i / (1+\theta)) - 1 - (\beta_{ii} / (S^*_i / (1+\theta))), \quad (9)$$

for inputs i = x, w, and k. Similarly, the cross-elasticity of demand (η_{ij}) for input i with respect to a l-percent change in the price of the jth input is:

$$\eta_{ij} = -S^*_j / (1+\theta) - (\beta_{ij} / S^*_i / (1+\theta)), \quad (10)$$

for i and j = x, w, and k; and $i \neq j$. The elasticity of demand for input i (η_{iy}) with respect to an output price, P_y, is:

$$\eta_{iy} = \Sigma_i S^*_i / (1+\theta) + 1 + \Sigma_j (\beta_{ij} / S^*_i / (1+\theta)), \quad (11)$$

for i = x, w, and k. The elasticity of output supply (ε_{yi}) with respect to the price of the input is given by:

$$\varepsilon_{yi} = -S^*_i / (1+\theta) - \Sigma_j \beta_{ij} / (1 + \Sigma_j S^*_j / (1+\theta)), \quad (12)$$

for i and j = x, w, and k. The own-elasticity of output supply (ε_{yy}) is:

$$\varepsilon_{yy} = \Sigma_i S^*_i / (1+\theta) + \Sigma_i \Sigma_j \beta_{ij} / (1 + \Sigma_j S^*_j / (1+\theta)), \quad (13)$$

for i and j = x, w, and k. Finally, the elasticity of substitution (σ_{ij}) is:

$$\sigma_{ij} = \eta_{ij} / S^*_j / (1+\theta), \quad (14)$$

for i and j = x, w, and k.

Each model was estimated by the iterative Zellner (1962) efficient technique. SAS® Proc SYSNLIN, SUR was employed for each regional estimate. Because the profit function is homogeneous of degree 1 in **P** and W, the share equations must also be homogeneous of degree 0 in **P** and W. This implies that while the profit function may be estimated using a constant term, the share equations may not. This condition is satisfied in each system of equations by the use of a matrix of linear restrictions. In addition to other previously mentioned imposed conditions, each price variable in the profit equation ($\mathbf{P}_x, \mathbf{P}_w, \mathbf{P}_k$) is forced to equal the constant term in its respective share equation.

Table 3—**Critical and Wald statistics for specification search procedure**

	Cobb-Douglas		Translog		Fourier	
Region	Critical Value	Wald Stat.	Critical Value	Wald Stat.	Critical Value	Wald Stat.
Corn Belt	$F_{.05(26,1695)} = 1.46$	1.41*	$F_{.05(18,1695)} = 1.87$		$F_{.01(12,1695)} = 2.18$	–
Northern Plains	$F_{.05(26,545)} = 1.48$	1.66	$F_{.05(18,545)} = 1.89$	1.81*	$F_{.01(12,545)} = 2.2$	
Pacific NW	$F_{.05(26,323)} = 1.47$	1.49	$F_{.05(18,323)} = 1.92$	1.47*	$F_{.01(12,323)} = 2.23$	
Southern Plains	$F_{.05(26,84)} = 1.94$	2.08	$F_{.05(18,84)} = 2.11$	1.99*	$F_{.01(12,84)} = 2.41$	–

*Accept Null Hypothesis that the given parametric specification conforms to the information contained in the data set. (Specification search stops upon acceptance of the Null Hypothesis.)

Model Validation

These estimates form the basis for deriving output supply elasticity estimates for grain sales, grain storage, and farm supplies sales and the associated factor demand elasticities for intermediate inputs, capital expenditures, and labor. All elasticities are evaluated at simple averages for S^*_i, the variable input price, and of the level of the fixed input.

The Wald statistic with an F-distribution was used for all statistical tests. To balance the desirability of not estimating an overparameterized model with the sensitivity of the procedure for rejecting a false null hypothesis, a monotonically non-decreasing significance level for the more restrictive null hypothesis was employed. Therefore, a 5 percent significance level was used for testing the Cobb-Douglas and translog specifications, and a 1 percent level of significance was used to test the Fourier specification. Once the null hypothesis could not be rejected for a particular specification, the search procedure stopped for that region.

The procedure is a joint test on the validity of imposing 26, 18, and 12 restrictions for the Cobb-Douglas, translog, Fourier specifications, respectively, to estimate jointly the net savings and three share equations. The critical F-test and computed Wald statistics are provided in table 3 for each specification and all regions. The Cobb-Douglas specification was accepted for the Corn Belt region, the translog specification for the Northern Plains, Southern Plains, and Pacific NW regions.

Following Lopez, and Siddhu and Baanante, validation tests were performed for symmetry, negative semi-definiteness of the function gradients, and convexity, to examine the specification's consistency with the properties of the underlying net savings function. The test of symmetry is a joint test on the validity of the symmetry and parametric constraints across the estimated net savings and share equations (Siddhu and Baanante). The null hypothesis is that the parameters of the share equations are equal to the corresponding shares of the net savings equation and that $b_{ij} = b_{ji}$ for all i,j.

The condition of negative semi-definiteness requires that the net savings function gradients be positive regarding output prices and negative with respect to factor prices (Lopez). And as in Lopez, this condition is satisfied at each sample point since the functional gradients are positive with respect to output prices and negative with respect to input prices.

The test for convexity is performed by examining the determinants of the principal minors of the Hessian matrix at each sample point (Lopez). Local convexity is established given that: 1) the matrix is convex at each sample observation; and 2) the net output supply equations show the expected signs for each own-price elasticity.

EMPIRICAL RESULTS

Corn Belt (corn-soybeans):

Parameter estimates of the net savings function and share equations for grain cooperatives in the Corn Belt region are provided in table 4. Nested hypothesis testing led to the selection of the Cobb-Douglas specification to estimate the Corn Belt region. Own-share relationship estimates are provided for three factors: intermediate inputs (B11), labor (B22), and capital(B33). All own-share parameter estimates are significant at the 0.0001 level.

The proxy coefficient for technical change (ET), significant at the 0.01 level, indicates the occurrence of technical change during the period. Furthermore, the factor share parameters (CQ2 and CQ3 significant at the 0.0001 and 0.05 level, respectively) suggest that at constant factor prices, the factor shares would have changed. Such an occurrence indicates that technical change was non-neutral or factor saving (in the sense of Hicks) for labor ($CQ2=-0.03<0$) and factor using for capital ($CQ3=0.01>0$). In other words, the efficiency gains brought by technical change were labor saving (labor's contribution toward the production of grain cooperative goods and services declined), and capital using (capital's share gained).

Derived output supply and factor demand elasticities for grain cooperatives in the Corn Belt states are listed in table 5. The Cobb-Douglas functional form, selected by search as the most representative specification for grain cooperatives in the Corn Belt, has the characteristic of unitary elasticity of substitution across all factors. This feature implies that the impacts of exogenous changes across the input demand functions of intermediate inputs, labor, and capital are symmetric. For example, in grain sales the change in the demand for intermediate inputs regarding a l-percent change in either the output price or any other factor (labor, capital) is the same, -0.449 percent. Furthermore, the supply response of each factor (intermediate inputs, labor, and capital) regarding a l-percent change in the output price is the same, 1.950 percent.

Northern Plains (wheat-barley-oats):

Estimated parameters for grain cooperatives in the Northern Plains are provided in table 6. The translog specification was selected in the search for the appropriate functional form to represent grain cooperatives in this region. Each of the own-share parameter estimates (e.g., B11, B22, and B33) is significant at the 0.0001 level. Two of the three cross-share parameter estimates (B13, and B23) were significant at the 0.05 level. However, the parameter capturing the interactive effects among intermediate inputs and labor (B12) was not significantly different from 0.

The proxy coefficient for technical change (ET), significant at the 0.20 level, slightly suggests the occurrence of technical change during the period. However, neither of the factor share parameters (CQ2 and CQ3) is significantly different from 0. So any technical change in the Northern Plains was diffused to such an extent that any realized efficiency benefits (economies of scale) were factor neutral, i.e., at constant factor prices, the factor shares did not change.

Derived output supply and factor demand elasticities for grain cooperatives in the Northern Plains are listed in table 7. Cooperative grain sales and farm supply sales were somewhat unresponsive to output and factor price changes. Cooperative grain storage however, was quite responsive to output price (i.e., Federal policies that established storage rates) changes and altered factor prices. Grain storage factor demand elasticities are greater than $|1|$ for all but the demand for labor regarding a change in capital prices.

Southern Plains (wheat-sorghum):

Parameter estimates and diagnostic statistics for grain cooperatives in the Southern Plains region are listed in table 8. One parameter estimate (B33) is significant at the 0.01 level.

Table **4-Estimated parameters of translog net savings model for grain cooperatives in the Corn Belt (corn-soybean) region, 1983-91**

Nonlinear SUR Summary of Residual Errors							
Equation	DF Model	Error	SSE	MSE	R-Square	Adj R-Sq	Durbin-Watson
Net Savings	4.5	1165	71352	61.27265	0.0421	0.0392	1.843
Int. Inputs	1.5	1168	40.5616	0.03474	0.0868	0.0864	1.914
Labor	3	1166	59.2043	0.05078	0.0660	0.0644	1.893
Capital	3	1166	124.2765	0.10658	0.3848	0.3838	1.969

Nonlinear SUR Parameter Estimates				
Parameter	Estimate	Approx. Std Err	‘T Ratio	Approx. Prob> ITI
A	4.218	0.3957	10.66	0.0001
B2	-0.317	0.0846	-3.75	0.0002
B3	0.044	0.0580	0.76	0.4455
B I I	0.059	0.0129	4.58	0.0001
B22	0.102	0.0118	8.69	0.0001
B33	0.082	0.0042	19.47	0.0001
CQ2	-0.030	0.0064	-4.79	0.0001
CQ3	0.011	0.0052	2.16	0.0309
ET	0.007	0.0027	2.72	0.0065

SAS® Proc SYSNLIN is employed for all parametric estimates.

Table 5—**Derived output supply and factor demand elasticities for grain cooperatives in the Corn Belt (corn-soybeans) region, 1983-91**

	Prices			
Stocks	output	Intermediate Inputs	Labor	Capital
Grain Sales				
output	0.950	-0.449	-0.291	-0.210
Int. Inputs	1.950	-1.449	-0.291	-0.210
Labor	1.950	-0.449	-1.291	-0.210
Capital	1.950	-0.449	-0.291	-1.210
Grain Storage				
output	0.218	-0.004	-0.057	-0.157
Int. Inputs	1.218	-1.004	-0.057	-0.157
Labor	1.218	-0.004	-1.057	-0.157
Capital	1.218	-0.004	-0.057	-1.157
Farm Supplies				
output	0.532	-0.311	-0.165	-0.056
Int. Inputs	1.532	-1.311	-0.165	-0.056
Labor	1.532	-0.311	-1.165	-0.056
Capital	1.532	-0.311	-0.165	-1.056

Table **6-Estimated parameters of translog net savings function for grain cooperatives in the Northern Plains (wheat-barley-oats) region, 1983-91**

Nonlinear SUR Summary of Residual Errors							
Equation	DF Model	DF Error	SSE	MSE	R-Square	Adj R-Sq	Durbin-Watson
Net Savings	4.5	544.5	22754	41.78945	0.0367	0.0305	1.854
Int. Inputs	1.5	547.5	18.6700	0.03410	0.1190	0.1182	1.858
Labor	3	546	25.8980	0.04743	0.0753	0.0719	1.860
Capital	3	546	52.6348	0.09640	0.6418	0.6405	1.957

Nonlinear SUR Parameter Estimates				
Parameter	Estimate	Approx. Std Err	'T' Ratio	Approx. Prob>ITI
A	6.415	0.5178	12.39	0.0001
B2	-0.028	0.1223	-0.24	0.8130
B3	-0.095	0.0447	-2.13	0.0338
B1 1	0.070	0.0155	4.53	0.0001
B12	0.010	0.0138	0.77	0.4425
B13	0.005	0.0022	2.33	0.0199
B22	0.093	0.158	5.93	0.0001
B23	0.004	0.0020	2.31	0.0214
B33	0.082	0.0034	23.69	0.0001
CQ2	0.007	0.0091	0.81	0.4203
CQ3	0.003	0.0041	0.78	0.4361
ET	0.003	0.0022	1.36	0.1733

Table **7-Derived output supply factor demand elasticities for grain cooperatives in the Northern Plains (wheat-barley-oats) region, 1983-91**

		Prices		
Stocks	output	Intermediate Inputs	Labor	Capital
		Grain Sales		
output	0.080	0.263	0.211	1.417
Int. Inputs	0.088	-0.460	0.294	-0.087
Labor	0.079	0.263	-0.372	-0.092
Capital	-0.262	0.177	0.207	-0.587
		Grain Storage		
output	0.152	-0.004	-0.119	0.033
Int. Inputs	2.312	-3.625	2.576	-1.373
Labor	-0.561	-4.477	4.250	0.671
Capital	3.434	-0.454	-0.163	-1.896
		Farm Supplies		
output	0.148	0.043	0.198	1.875
Int. Inputs	0.004	-0.256	0.257	-0.210
Labor	0.022	0.200	-0.347	-0.220
Capital	-0.174	0.041	0.063	-1.019

Table 8-Estimated parameters of translog net savings function for grain cooperatives in the Southern Plains (wheat-sorghum) region, 1983-91

Nonlinear SUR Summary of Residual Errors

Equation	DF Model	DF Error	Durbin SSE	MSE	R-Square	Adj R-Sq	Durbin-Watson
Net Savings	4.5	322.5	17861	55.38232	0.0374	0.0270	2.090
Int. Inputs	1.5	325.5	9.9014	0.03042	0.0783	0.0768	2.096
Labor	3	324	11.3061	0.03490	0.0732	0.0675	2.083
Capital	3	324	36.6437	0.11310	0.0371	0.0311	2.109

Nonlinear SUR Parameter Estimates

Parameter	Estimate	Approx. Std Err	'T Ratio	Approx. Prob> ITI
A	0.502	1.6715	0.30	0.7638
B2	-0.103	0.4496	-0.23	0.8176
B3	-0.670	0.2616	-2.56	0.0109
B1 1	0.060	0.0448	1.35	0.1778
B12	0.033	0.0412	0.82	0.4155
B13	-0.016	0.0170	-0.99	0.3215
B22	0.078	0.0532	1.48	0.1397
B23	0.063	0.0465	1.37	0.1718
B33	0.174	0.0608	2.87	0.0043
CQ2	0.038	0.0471	0.82	0.4116
CQ3	0.094	0.0330	2.85	0.0-046
ET	-0.001	0.0031	-0.36	0.7223

Three parameters (B11, B22, and B23) are significant at the 0.20 level, or better. The proxy coefficient for technical change (ET) is insignificantly different from 0. However, the factor share coefficient for capital (CQ3) is significant at the 0.005 level.

Derived output supply and factor demand elasticities are given in table 9. Grain sales and farm supplies sales elasticities are relatively inelastic. One exception for both was the change output related to a change in the price of capital; both have elasticities greater than 1 at 1.21 and 1.56 for grain sales and farm supplies sales, respectively. Grain storage output and factor use, however, are more responsive to relative price changes. The grain storage own-elasticity of demand for intermediate inputs and labor are quite elastic at 2.61 and 3.85, respectively.

Pacific Northwest (wheat-barley):

Table 10 lists parameter estimates for grain cooperatives in the Pacific Northwest. While the translog was selected to be the most appropriate specification, the relative fit of the estimate might be questioned. Only two of the parameter estimates (B1 1 and B22) have T-values greater than 1 and these estimates are significant at the 0.20 level only. The coefficient to proxy technical change (ET) was insignificantly different from zero (significant at 0.66), as were the factor share parameters (CQ2 and CQ3, significant at 0.66 and 0.49, respectively). These results may be the consequence of the relatively low number of observations available for this region.

Table 9—Derived output supply and factor demand elasticities for grain cooperatives in the Southern Plains (wheat-sorghum) region, 1983-91

Stocks	Prices: output	Intermediate Inputs	Labor	Capital
		Grain Sales		
output	0.291	0.449	0.291	1.210
Int. Outputs	0.084	-0.477	0.276	0.042
Labor	0.063	0.238	-0.274	0.039
Capital	-0.332	0.169	0.202	0.034
		Grain Storage		
output	0.210	0.004	-0.057	-0.157
Int. Inputs	-0.571	2.614	-0.910	-0.876
Labor	-4.555	0.500	3.850	0.458
Capital	2.009	-0.101	-0.033	-0.528
		Farm Supplies		
output	0.234	-0.311	0.165	1.556
Int. Inputs	-0.016	0.075	0.311	0.026
Labor	0.012	0.223	-0.235	-0.050
Capital	-0.230	0.026	0.075	-0.342

Table 1 O-Estimated parameters of translog net savings function for grain cooperatives in the Pacific Northwest (wheat-barley) region, 1983-91

Nonlinear SUR Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	R-Square	Adj R-Sq	Durbin-Watson
Net Savings	4.5	83.5	3864	46.27282	0.0525	0.0289	2.196
Int. Inputs	1.5	86.5	2.4717	0.02857	0.1723	0.1675	2.249
Labor	3	85	3.3508	0.03942	0.1006	0.0794	2.222
Capital	3	85	10.4020	0.12238	0.0068	0.0166	2.238

Nonlinear SUR Parameter Estimates

Parameter	Estimate	Approx. Std Err	'T Ratio	Approx. Prob> ITI
A	3.859	4.2909	0.90	0.3711
B2	0.376	0.6452	0.58	0.5610
B3	-0.692	0.5553	-1.25	0.2157
B I I	0.083	0.0590	1.41	0.1626
B12	-0.007	0.0571	-0.13	0.8961
B13	0.002	0.0276	0.08	0.9394
B22	0.090	0.0667	1.35	0.1794
B23	-0.008	0.0633	-0.13	0.8933
B33	0.086	0.1296	0.67	0.5055
CQ2	-0.026	0.0611	-0.44	0.6604
CQ3	0.049	0.0710	0.70	0.4886
ET	0.005	0.0119	0.44	0.6625

Table 1 **l-Derived output supply and factor demand elasticities for grain cooperatives in the Pacific Northwest (wheat-barley) region, 1983-91**

	Prices			
Stocks	output	Intermediate Inputs	Labor	Capital
		Grain Sales		
output	0.096	0.282	0.317	1.329
Int. Inputs	0.083	-0.391	0.239	-0.076
Labor	0.108	0.205	-0.389	-0.082
Capital	-0.286	0.176	0.210	-0.422
		Grain Storage		
output	0.257	-0.062	-0.077	-0.118
Int. Inputs	-4.148	1.070	3.186	-0.256
Labor	-1.879	1.150	0.824	-0.241
Capital	2.428	0.033	0.080	-1.617
		Farm Supplies		
output	0.148	-0.426	0.364	1.943
Int. Inputs	-0.016	-3.893	4.328	-0.332
Labor	0.021	2.726	-3.016	-0.396
Capital	-0.154	0.004	0.054	-1.220

Table **12-Elasticities of substitution for U.S. grain cooperatives, 1983-1991**

	Prices		
Stocks	Intermediate Inputs	Labor	Capital
		Corn Belt (corn-soybeans)	
Int. Inputs	-1 .oo	1.00	1 .oo
Labor		-1 .oo	1.00
Capital			-1 .oo
		Northern Plains (wheat-barley-oats)	
Int. Inputs	-1.43	0.92	-0.27
Labor		-0.72	-0.18
Capital			-2.06
		Pacific Northwest (wheat-barley)	
Int. Inputs	-1.82	0.78	-0.25
Labor		-0.81	-0.17
Capital			-1.62
		Southern Plains (wheat-sorghum)	
Int. Inputs	-2.10	1.20	0.07
Labor		-0.19	0.03
Capital			-1.09

Derived output supply and factor demand elasticities for grain cooperatives in the Pacific Northwest region are provided in table 11. These estimates should be used / viewed with caution given the relatively loose fit of the model used to derive them. Grain sales and farm supplies elasticities of factor demand were highly inelastic. However, grain cooperative use of intermediate inputs and of labor in grain storage was highly responsive to factor price changes.

Grain Cooperative Factor Substitution:

Table 12 presents elasticities of substitution for each of the four regions. Because the Corn Belt region was estimated using a Cobb-Douglas specification, the elasticities of substitution all have an absolute value of 1. In this case, the impact across all variable inputs of an exogenous price change is symmetric. On the other hand, the impact of a similar exogenous price change in the case of the translog specification varies across input demand equations. The own-elasticities of substitution have little economic meaning except that each must obey the constraint $\Sigma_j \Sigma^*_j \text{ x } \sigma_{ij} = 0$. Cross-elasticities of substitution are positive for substitutes and negative for complements. The elasticity of substitution of intermediate inputs, given a l-percent change in the price of labor, is unitary or approaches unity in each of the four regions. Labor and intermediate inputs appear, therefore, to be the best substitutes. Intermediate inputs and capital and labor and capital are complementary in both the Northern Plains and Pacific Northwest regions.

DISCUSSION

Model Implications

A variety of policy analyses are possible given these estimates of cooperative output supply and factor demand response to market changes by product and region. For example, a 1-percent reduction in the target price of wheat for grain cooperatives in the Northern Plains will simultaneously reduce grain sales by 0.08 percent, grain purchases by 0.09-percent, and labor by 0.08- percent, and increase capital use by 0.26-percent. In another example, suppose that loan rates are reduced by 1 percent, reflecting a 1-percent reduction in the cost of intermediate inputs. Considering the same region, grain cooperatives in the Northern Plains would then increase their demand for intermediate inputs by 0.46- percent and reduce their demand for labor and capital by 0.26- and 0.18-percent, respectively.

Additionally, policy analysts may, in this same manner, consider the impacts of minimum wage laws (so long as the proposed policy is effective to change wages paid), changing interest rates, or a wide array of instruments that affect the grain prices at the farmgate. Furthermore, it is also possible to trace and compare the relative impacts regarding grain cooperative products / services (grain sales and storage, and farm supplies sales) and across regions.

Historical Context

The dramatic changes of the past 20 years, endured by the United States grain industry in general, and grain cooperatives in particular, are well documented (Dahl, 1990, 1991a, 1991b; Warman, 1993). In the 1970s, regional grain cooperatives enjoyed almost a decade of export expansion. Increased marketing margins stimulated cooperatives to invest in the infrastructure — rail cars, storage, and port facilities seen then as necessary to meet widespread expectations of expanding markets (Dahl, 1991a).

However, just as these facilities were coming on line in the early 1980s, the grain industry hit a decade of declining export demand. Competition for the markets that remained squeezed marketing margins ever tighter (Dahl, 1991a). Because of the investment surge, export infrastructure was now in surplus. And given that this new capital was mortgaged at unusually high rates of interest, many grain cooperatives became increasingly stressed financially.

The grain industry adjusted to reduced export demand by major consolidations, transforming the way the industry in general and grain cooperatives in particular do business (Warman, 1993a).

Grain marketing is now highly decentralized, with the futures market as the basis for pricing cash grain. Grain is no longer bought and sold on a sample basis, but by forward cash contracts that specify price, grade, and quality premiums and discounts. Consignment marketing of grain has mostly disappeared (Dahl, 1991b).

Innovations in grain transportation contributed to the industry's restructuring. Because of the increased use of trucks and multiple-car railroad shipping rates, local elevators now ship grain directly to port and bypass subterminal and terminal markets. The Staggers Act (1980) deregulated railroad shipping rates and allowed them to be negotiated among grain handlers and shippers.

Although its broad powers were enhanced by other transportation legislation of the period (The Conrail Privatization Act of 1986), the Staggers Act encouraged the direct movement of grain from originator to final destination (Warman, 1993). The combined affect of these transportation innovations and railroad deregula tion was to hasten the decline of grain exchanges and terminal markets for cash grain (Dahl, 1991b).

Furthermore, the farm financial crisis coupled with United States farm policies accelerated the present restructuring of grain cooperatives. During the early 1980s, high interest rates coupled with depressed land values and low commodity prices forced many agricultural producers out of the industry.

Moreover, as Government policies shifted toward more market-oriented programs (e.g., lowering loan rates and target prices), grain producers and handlers were forced to operate as efficiently and cost-effectively as possible. Those producers who remained in the industry tended to be larger. More sophisticated operators managed their own marketing programs. Consequently, grain cooperatives not only lost membership but saw competitors (now producers as well as investor-owned firms) gain strength.

The impacts of this eventful period on grain cooperatives in the United States are reflected in the elasticity estimates of capital, particularly for storage income but also for grain sales and farm supplies sales. Payment made to elevators to store grain held by Commodity Credit Corporation (CCC) was a welcome additional source of income to cooperative elevators during a period of narrow margins.

About 4 percent of grain cooperative gross income was storage income during the 1983-90 period. However, these Government programs encouraged grain storage capacity expansion during a period of excess capacity and delayed a needed industry-wide consolidation (Gunn and Cobia). Given that lucrative storage and handling fees for Government-held grain are now greatly reduced, cooperative elevators are under pressure to substantially adjust capacity.

The impacts of other Government payment programs (Payment-In-Kind, Acreage Reduction Program, Conservation Reserve Program, PIK and roll) are also reflected in the grain cooperative elasticities. The PIK and roll program increased grain sales volume and encouraged managers to alter their method of acquiring grain. PIK and roll increased the use of cash purchases and the use of Delayed Price Contracts (DPC)[2] (Gunn and Cobia).

The impacts of changes in the rail transportation industry, also reflected in the grain cooperative elasticities, were somewhat offsetting in effect. The savings associated with unit-train rates encouraged elevators to add load-out capacity. However, rail line abandonment caused many cooperative elevators to loose business to their competitors (who retained rail shipping ability), to become supplemental storage units for elevators with rail, or even to exit the industry.

[2] A practice of grain acquisition in which the elevator takes possession of and title to the grain, but the price is not determined until a later date.

CONCLUSIONS

This study derived important economic information regarding the input and output responses to market changes for grain cooperatives in the United States The elasticity estimates are derived for output supplies, factor demands, and factor substitution, for three grain cooperative products/services (grain sales, grain storage, and farm supplies sales) and three factors, intermediate inputs, labor, and capital; and for the four major grain producing regions in the United States (Corn Belt, Northern Plains, Southern Plains, and Pacific Northwest). The existence and impacts of technical change upon cooperative input demand was also derived.

Although important in their own right, these estimates also make an array of policy analyses possible. Elasticities provide a way to trace the impacts of cooperative adjustments to market and policy changes. These estimates also provide a way of projecting grain cooperative response to anticipated market and policy changes.

The next report in this series will combine the elasticity estimates derived in this report with additional information to quantify the impacts of the significant market and policy changes that occurred during the 1980s.

REFERENCES

Boland, L.A. 1981. "On the Futility of Criticizing the Neoclassical Maximization Hypothesis." American Economic Review. 71(3):1031-1036.

__________. 1983. "The Neoclassical Maximization Hypothesis: A Reply." *American Economic Review*. 73(3):831-833.

Caldwell, B.J. 1983. "The Neoclassical Maximization Hypothesis: Comment." *American Economic Review*. 73(3):828-830.

Chambers, R. 1984. "Agricultural and Financial Market Interdependence in the Short Run." *American Journal of Agricultural Economics*. 66(1): *12-24.*

Chavas, J.P. and T.L. Cox. 1988. "Nonparametric Analysis of Agricultural Technology." *American Journal of Agricultural Economics*. 70(1):303-310.

Cochrane, D. and G.H. Orcutt. 1949. "Application of Least Squares Regressions to Relationships Containing Auto Correlated Error Terms." *Journal of the American Statistical Association*. 44(1):32-61.

Dahl, R.P. 1990. "Structural Change and Performance of Grain Marketing Cooperatives." Department of Agricultural and Applied Economics, University of Minnesota, Staff Papers Series, Staff Paper P90-54, October.

_______. 1991a. "Structural Changes in the United States Grain Marketing System." Department of Agricultural and Applied Economics, University of Minnesota, Staff Papers Series, Staff Paper P91-35, September.

_______. 1991b. "Structural Change and Performance of Grain Marketing Cooperatives." *Journal of Agricultural Cooperation*. 5:66-80.

De Alessi, L. 1983. "Property Rights, Transactions Costs, and X-Efficiency: An Essay in Economic Theory." *American Economic* Review. 73(1):64-81.

Diewert, D.L. 1971. "An Application of Shepherd Duality Theorem." Journal *of Political Economy.* 79(2):481-507.

_______. 1972. "Functional Forms for Profit and Transformation Functions." Journal *of* Economic Theory 5(1):

_____. 1974. "Applications of Duality Theory." In *Frontiers of Quantitative Economics, vol. 2.* ed. M.D. Intrilligator and D.A. Kendrick, Amsterdam: North-Holland Pub. Co.

Dillon, J.L. and J.R. Anderson. 1971. "Allocative Efficiency Traditional Agriculture, and Risk." *American Journal of Agricultural Economics.* 53(1):26-32.

Durbin, J. and G.S. Watson. 1950. "Testing for Serial Correlation in Least Squares Regression." *Biometriku.* 37(2):409-428.

_________. 1951. "Testing for Serial Correlation in Least Squares Regression." *Biometriku.* 38(1):159-178.

Fawson, C. and C.R. Shumway. 1988. "A Nonparametric Investigation of Agricultural Production Behavior for United States Subregions." *American Journal of Agricultural Economics.* 70(1):311-317.

Gunn, S.P. and D.W. Cobia. 1992. "Grain Marketing Cooperatives' Adjustments to Farm Programs." Department of Agricultural Economics, Agricultural Experiment Station, North Dakota University, Agricultural Economics Report No. 291, September.

Harvey, A.C. 1981. *The Econometric Analysis* of *Time Series.* Deddington: Philip Alan Publishers.

Hotelling, H. 1932. "Edgeworth's Taxation Paradox and the Nature of Demand and Supply Functions." *Journal of Political Economy.* 40(2):577-*616.*

Jeffreys, H. 1967. London: Oxford University Press.

Jorgensen D.W. and L.J. Lau. 1973. "The Duality of Technology and Economic Behavior." Discussion Paper No. 252, Cambridge HIER.

Judge, G.E., W.E. Griffiths, R.C. Hill, H. *The Theory and Prac* 2d Edition. New York: J and Sons.

Lau, L.J. 1972. "Profit Functions of Technologies *Review of Economics and S ta tis tics.* 54(2):281-289.

_________ and P.A. Youtopolos. 197 Supply and Factor Demand Functions." *American Journal of Agricultural Economics* 56(1):11-*18.*

Learner, E.E. 1983. "Let's Take the Con Out of *American Economic Rev* 78(1):31-43.

Lee, H. and R.G. Chambers. 1986. "Expenditure Constraints and Profit Maximization in U.S. *American Journal of Agri Economics,* 68(3):857-865.

Lopez, R.E. "Estimating Substitution and Expansion Effects Using a Profit Function *American Journal of Agri Economics.* 66(1984):358-367.

MacCrimmon K.R. and S. Larson. 199 *Expected Allais Paradox*. Allais and 0. Hagen, p. 33-409. Dordrecht Holla *Jour. of Agric Econ*. 14(1):200-212.

McFadden, D.L. 1973. “Cost, Revenue and Profit Functions.” In *An Econometric Approach to Production Theory,* D.L. McFadden ed., Amsterdam: North-Holland Pub. Co.

Mountain, D. and Cheng, H. 1989. “A Combined Structural and Flexible Functional Approach for Modeling Energy Substitution.” *Journal* of the *American Statistical Assoc.* 84(1):76-87.

Pope, R.D. 1980. “The Generalized Envelope Theorem and Price Uncertainty.” *Znternutionul Economic Review.* 21(1):75-85.

_________. 1982a. “Expected Profit, Price Change, and Risk Aversion.” *American Journal of Agricultural Economics.* 64(2):581-584.

_________. 1982b. “To Dual or Not to Dual.” *Western Journal of Agricultural Economics.* 7(1):337-*351.*

Roy, A. 1942. *“Del’ Utilitie: Contribution de La Theorie de Choix.”* Paris: Hermann, et Cie.

Royer, J.S. 1978. “A General Nonlinear Programming Model of a Producers Cooperative in the Short-Run.” Unpublished Ph.D. thesis, Iowa State University.

Samuelson, P.A. 1953. “Prices of Factors and Goods in General Equilibrium.” *Review of Economic Studies.* 2(1):1-20.

SAS Institute Inc. SAS/ETS™ User’s Guide, Version 5 Edition, Car, NC: SAS Institute Inc., 1984, pp 505-550.

Shapiro, S.S. and M.B. Wilks. 1965. “An Analysis of Variance Test for Normality (Complete Samples).” *Biometrika.* 52(2):591-611.

Shepard, R.W. 1953. *“Cost and Production Functions.”* Princeton: Princeton University Press.

Shoemaker, P.J.H. 1982. “The Expected Utility Model: Its Variants, Purposes, Evidence and Limitations.” *Journal of Economic Literature.* 20(2):529-563.

Siddhu, S.S. and CA. Banaante. 1981. “Estimating Farm Level Input Demand and Wheat Supply in the Indian Punjab Using a Translog Profit Function.” *American Journal of Agricultural Economics.* 63(1):237-246.

Taylor, C.R. 1984. “Stochastic Dynamic Duality: Theory and Empirical Applicability.” *American Journal of Agricultural Economics.* 66(2):351-357.

_________. 1990. “Duality, Optimization and Microeconomic Theory: Pitfalls for the Applied Researcher.” *Western Journal of Agricultural Economics.* 14(1):200-212.

Varian, H.R. 1984. “The Nonparametric Approach to Production Analysis.” *Econometrica. 52(3):579-597.*

_________. 1985. “Non-parametric Analysis of Optimizing Behavior with Measurement Error.” *Journal of Econometrics.* 30(2):445-458.

Warman, M. 1993. “Changing Grain Market Structure Poses Challenge to Cooperatives.” *Farmer Cooperatives* 59(10):4-8, January.

Wold, H. 1938. *“The Analysis of Stationary Time Series”,* 1st ed. Uppsala: Almquist and Wicksell.

Wu, De-Min. 1983. “Tests of Causality Predeterminedness and Exogeneity.” *International Economic Review.* 24(2):347-358.

Zellner, A. 1962. “An Efficient Method of Estimating Seemingly Unrelated Regression and Tests of Aggregation Bias.” *Journal of the American Statistical Association.* 57(2):348-375.

Appendix

(SAS code for Varian's non-parametric test of the profit maximization hypothesis.)

```
DATA WORK1 ; SET GRAINS.MASTER;
WHERE GRAINVOL GT 0 AND GRAINSLS GT 0
AND LABOREXP GT 0 AND NETINTRS NE.
AND TOTEXPNS GT 0 AND NETINCOM NE. ;
*
%MACRO WAPM(REG);
DATA WORK2; SET WORK1;
WHERE REGION=&REG;

*SET IMPLIED FACTOR PRICES;
*
PSALES = GRAINSLS / GRAINVOL;
PSTORE = SUM(GROSSINC,-GROSSMGN) / GRAINVOL;
PY = SUM(PSALES,PSTORE);
PW = LABOREXP / GRAINVOL;
PK = NETINTRS / GRAINVOL;
PX = (TOTEXPNS - SUM(LABOREXP,NETINTRS))/ GRAINVOL; PROC PRINT;

DATA WORK3;
SET WORK2 NOBS=TOTOBS;
IF _ERROR_=1 THEN ABORT ABEND;
FLAG=0; COUNT=O; TEST1 =O;
 DO I = 1 TO TOTOBS-1;
 SET WORK2 POINT=I;
 NSI=NETINCOM; PI=PY; YI=GRAINVOL;
 WI=SUM(PW,PK,PX);  L=TOTOBS-I;
   DO J = 1 TO L; K=J+I;
   SET WORK2 POINT=K;
   IF _ERROR_=1 THEN ABORT ABEND;
   NSK=NETINCOM; XK=GRAINVOL;
   IF NSI GT NSK AND PI*YI-WI*XK GT 0 THEN FLAG=FLAG+1;
   COUNT=COUNT+1;
   END;
 END;
PUT REGION TOTOBS FLAG COUNT; STOP;
%MEND WAPM;
*
%WAPM('CORN BELT');
%WAPM('NORTHRN PLA');
%WAPM('PACIFIC NW');
%WAPM('SOUTHRN PLA');
RUN;
```

U.S. Department of Agriculture
Agricultural Cooperative Service
P.O. Box **96576**
Washington, D.C. 20090-6576

Agricultural Cooperative Service (ACS) provides research, management, and educational assistance to cooperatives to strengthen the economic position of farmers and other rural residents. It woks directly with cooperative leaders and Federal and State agencies to improve organization, leadership, and operation of cooperatives and to give guidance to further development.

The agency (1) helps farmers and other rural residents develop cooperatives to obtain supplies and services at lower cost and to get better prices for products they sell; (2) advises rural residents on developing existing resources through cooperative action to enhance rural living; (3) helps cooperatives improve services and operating efficiency; (4) informs members, directors, employees, and the public on how cooperatives work and benefit their members and their communities; and (5) encourages international cooperative programs.

ACS publishes research and educational materials and issues *Fanner Cooperatives* magazine. The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs and marital or familial status. (Not all prohibited bases apply to all programs). Persons with disabilities who require alternative means for communication of program information (braille, large print, audiotape, etc.) should contact the USDA Office of Communications at (202) 720-7808 (TDD).

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, D.C. 20250, or call (202) 720-7327 (voice) or (202) 720-l 127 (TDD). USDA is an equal employment opportunity employer.