Pricing and investment under Uncertainty in a Duopoly: Evidence from Iowa Agricultural Marketing Cooperatives

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1 Introduction

An agricultural cooperative helps its independent member-producers earn a competitive return on their products by utilizing the economies of scale. Despite the economic advantages of cooperative formation, its unique organizational structure has constituted many internal and external challenges to the success of cooperative (Cook, 1995). Among these is the cooperative financial constraint hypothesis where the cooperative is faced with difficulty in accessing the external capital market to finance their investment. A number of empirical investigations have explored the existence and impact of financial constraints faced by cooperatives, particularly as compared with investor-owned firms (IOFs). Lerman and Parliament (1993) found that there was statistically indistinguishable difference of equity financing between cooperatives and national average of non-financial corporations in food-processing industries for 1973-1983, which was a contrary evidence to the cooperative equity constraint hypothesis. Chaddad (2005) et al examined the cooperative financial constraint hypothesis and showed internal funds had significant impact on investment behavior of cooperatives in food industry for 1991-2000, but not on comparable publicly traded corporations. On the other hand, overutilization of capital inputs was found in cotton-ginning cooperatives by Sexton et al (1989).

Although somewhat sensitive to data and model specifications, these works largely agree that cooperatives are less financially leveraged than investor owned firms. However, empirical evidence is diverging as to whether the cooperatives' lower financial leverage implies undercapitalization of cooperatives or whether they simply have lower investment needs than do their IOF counterparts. Also, many testable hypotheses in previous studies have been based on the implicit assumption of perfect information, which ignores the uncertain nature of the markets thus biases the results.

The goal of this paper is to derive and compare optimal capital investment and equilibrium prices of raw product for agricultural marketing cooperative and investor owned firm under demand uncertainty. The next section develops a mixed duopoly model based on price competition between cooperative and investor owned firm that offer price to buy crops from producers, then marketing and selling the crop in a competitive market. The business risk is assumed to be exogenous to firms under certain price condition. Producers are assumed to be rational that maximize their expected utility of sale by allocating their crop between cooperative and investor owned firm after observing the price offer. The essence of the model is that the producer faces a portfolio problem while investing in the cooperative because doing so is a decision that deepens his financial commitment rather than diversifying it (Staatz 1987).

2 Theoretical Framework

Following the owner-user principle of the cooperative, there is a unit mass of homogenous producers assumed to own (capitalize) and use the marketing cooperative. Thus, cooperative's objective is to maximize the expected return to producers' crop. Besides the production decisions of the cooperative, each producer also decides how to allocate their crop between the cooperative and the investor owned firm. Producers are risk averse and their utility is represented by a monotonically increasing and strictly concave Bernoulli utility function:

$$\max_{\delta} E(u(w)) = \max_{\delta} \int_x u(w_p(1-\delta) + (w_c + \beta\pi_c)\delta) dF(x) \tag{1}$$

where w_c and w_p are price paid for the crop by cooperatives and investor owned firm respectively; δ is how much crop the producer delivers to the cooperative and then $(1-\delta)$ is delivered to the investor owned firm; π_c is the cooperatives' profit which will not be realized until the year end; β is a discounting parameter (can be understood as the risk free interest rate) between 0 and 1 on future patronage refund.

Investor owned firm are assumed to be risk neutral and make decisions on capital investment and price strategies in order to maximize expected profit under uncertainty over demand (x) for the final product, a normalized random variable between 0 and 1 with symmetric CDF $F(x)$.

Cooperative and investor owned firm are assumed to have the same limitational production technology, meaning that the production is bounded by capacity. Following Sexton (1990), both firms are further assumed to employ a quasi-fixed proportions technology that requires two inputs, crop $(\phi)$and capital (k).There is no substitution between crop and capital. The production function in this paper is specified as:

$$q = \min(\phi/\lambda, f(k)) \tag{2}$$

where $\lambda \leq \phi/q$ indicates the convertibility from raw product to final product. $f(k)$ is concave and continuously differentiable. Thus the minimized cost function conditional on input prices and output $(q > 0)$ is specified as follows:

$$c(q, \overrightarrow{w}) = \lambda w_\phi q + m(q, w_k) \tag{3}$$

where $m(q, w_k)$ is positively convex in q and concave in capital price. In this paper, it is assumed $\lambda = 1$ and equation (3) can be rewritten as:

$$c(\phi, \overrightarrow{w}) = w_\phi \phi + m(\phi, w_k) \tag{4}$$

When the firm overproduces$(\phi > x)$, the remaining products have a salvage value a so we can write the profit function as:

$$\pi = px + a(\phi - x) - c(\phi, \overrightarrow{w}) \tag{5}$$

On the other hand if the firm under produces ($\phi < x$), the cost associated with shortage is d,

$$\pi = p\phi - d(\phi - x) - c(\phi, \overrightarrow{w}) \tag{6}$$

In inventory planning, the shortage cost is often referred to the penalty when firm cannot meet the required ordering. More broadly when firm under produces, it may just miss the potential profit or have to incur additional variable cost to satisfy the demand. Following equation (5) and (6), the objective function of investor owned firm is obtained as follows:

$$\begin{aligned} \max_{\phi,k} E(\pi) &= \max p \int_0^{\phi} x dF(x) + p \int_{\phi}^{1} \phi dF(x) - c(\phi, \overrightarrow{w}) \\ &\quad + a \int_0^{\phi} (\phi - x) dF(x) - d \int_{\phi}^{1} (x - \phi) dF(x) \end{aligned} \tag{7}$$

simplifying the equation (7):

$$\begin{aligned} \max_{\phi,k} E(\pi) &= \max pE(x) - c(\phi, \overrightarrow{w}) \\ &\quad + \underbrace{a \int_0^{\phi} (\phi - x) dF(x)}_{\text{expected excess}} - (p + d) \underbrace{\int_{\phi}^{1} (x - \phi) dF(x)}_{\text{expected shortage}} \end{aligned} \tag{8}$$

This leontif production function restricts the output to be no greater than capacity invested. As compared to the conventional limitational technology, this study allows for less structure on the production function to reflect the added value to final product from marketing. This expected profit function specification is "limitational" in a broader sense that production decision need to be made before demand is unveiled and any cost associated with unpredicted demand shock that requires adjustment of variable cost in the short run has been considered.

2.1 Producers' Decisions

This section analyzes the member-producers' allocation decisions of their crop and cooperative's production decisions. These results are compared to the decisions of investor owned firms in the next section. To simplify the following analysis, it is first assumed that $p - a - d = 0$ ($p, a, d > 0$), so firm would not want to either overproduce or under produce. This section also derived cooperative's production decision and shows that the cooperative will operate only if the expected return of producer's crop from investing in cooperative is higher than the return from selling crop to the investor owned firm (otherwise risk-averse producer will only patronize with investor owned firm). The difference is only marginal so to guarantee the interior solution. Pratt demonstrated that the expected utility function that measures the decision maker's local risk aversion can be approximated by

$$E(u(w)) = E(w) - \frac{1}{2}\rho\sigma^2 \tag{9}$$

where ρ measures the degree of absolute risk aversion. Thus the equation (1) can be rewritten as:

$$\max E(u(w)) = \max(1-\delta)w_p + \delta(w_c + \beta E(\pi_c)) - \frac{1}{2}\rho\sigma_\pi^2 \tag{10}$$

The σ_π^2 measures risk associated with investing in cooperatives which is a function of variance of cooperative's profit:[1]

$$\begin{aligned}\sigma_\pi^2 &= (\delta\beta)^2\{(p-a)\int_0^\phi x^2 dF(x) + d^2\int_\phi^1 x^2 dF(x) \\ &\quad -[(p-a)\int_0^\phi x dF(x) - d\int_\phi^1 x dF(x)]^2\}\end{aligned} \tag{11}$$

The equation (11) illustrates that the risk to producers' return is increasing with the volume of their business with cooperative. Combine equation (10) and equation (11):

$$\begin{aligned}\max E(u(w)) &= \max(1-\delta)w_p + \delta(w_c + \beta E(\pi_c)) \\ &\quad -\frac{1}{2}\rho(\delta\beta)^2\{(p-a)\int_0^\phi x^2 dF(x) + d^2\int_\phi^1 x^2 dF(x) \\ &\quad -[(p-a)\int_0^\phi x dF(x) - d\int_\phi^1 x dF(x)]^2\}\end{aligned} \tag{12}$$

First, when all input prices are exogenous, meaning the cooperative and investor owned firm are essentially paying the same mill price (i.e. competitive market), the producer's objective is a function of allocation decision and cooperative's production decision. Thus the first order condition for maximization of (10) with respect to δ is:

$$(w_c - w_p) + \beta E(\pi_c) - \rho\delta\beta var(\pi_c) = 0 \tag{13}$$

rearranging equation (13):

$$\delta^* = \frac{w_c + \beta E(\pi_c) - w_p}{\rho\beta var(\pi_c)} \tag{14}$$

That is, how much producer decides to patronize with the cooperative is determined by the risk adjusted difference in return between two alternative

[1] please see appendix for detail derivation

buyers. Examining the individual term in equation (14[redacted], the numerator is the expected difference in return between selling crop to the cooperative and investor owned firm. The denominator is the risk discounting factor that depends on risk free interest rate, producer's risk aversion level and business risk faced by cooperative. Ceteris paribus, larger the expected difference between the return from cooperative and investor owned firm, more the producer's willingness to do business with cooperative. As for the cooperative, the first order conditions for maximization of (12) with respect to ϕ :[2]

$$-(w_\phi^c + \frac{\partial m(\phi^c)}{\partial \phi^c}) + aF(\phi^c) + (p+d)[1 - F(\phi^c)] = 0 \qquad (15)$$

where $\phi^c(p, w)$ is the optimal output conditional on prices. The equality in (12) follows because $\frac{\partial var(\pi_c)}{\partial \phi} = 0$ based on assumption that selling price is equal to the sum of salvage value of unsold product and shortage cost. That is, the production decision has no effect on the total risk to the firm. Although somewhat counterintuitive at first sight, but in the context of fixed price with stochastic reasoning, the business risk is characterized by demand shock which is strictly exogenous to firms that act as a price taker in a competitive market. This implies that cooperative without competitive yardstick will behave risk neutral just like an investor owned firm and the expected profit is zero. So for a risk-averse producer, she will never invest in cooperative in this situation because the expected return to producers from patronizing with cooperative is the same as return from investor owned firm. The cooperative has zero market shares in this competitive market. So a necessary condition for cooperative to achieve a positive market share is to provide the producer with a higher expected return than does investor owned firm.

We now analyze behavior of producers in the context of mixed duopoly where cooperative's purchase decision of the raw product does influence the mill price. More importantly, the mixed duopoly enables the further strengthening of owner-user principle in the manner that producers internalize the production decision of cooperative, i.e. $\delta = \phi$ at raw product market clearing. Cooperative will maximize the members' welfare by choosing its optimal production decision evaluating at equilibrium, as a best reply function of price offered by investor owned firm:

$$[(w_c - w_p) + \beta E(\pi_c) - \rho\delta\beta var(\pi_c)] + \delta[\frac{dw_\phi^c}{d\delta} + \beta\frac{dE(\pi_c)}{d\delta}] = 0 \qquad (16)$$

To simplify the subsequent analysis, it is assumed that the supply function of raw product to cooperative is still characterized by equation (13), but in the duopoly context, producers no longer take the expected profit of cooperative as given. Rather the producer's allocation decision will affect the cooperative's

[2] the first order condition with respect q is derived as follows:
$-\hat{c}_q(q, \vec{w}) + aF(q) + (p+d)[1 - F(q)] - \frac{1}{2}\rho(\delta\beta)^2$
$*\{f(q)q(p-a-d)[p-a+d)q - 2[(p-a)\int_0^q xdF(x)$
$-d\int_q^1 xdF(x)]]\} = 0$

profit and there exists δ^* such that the equation (13) holds. So as a result of this assumption, the first term in (16) is zero and equation (16) can be expressed as:

$$J^c = \frac{d(w^c_\phi - w^p_\phi)}{d\delta} - \beta\frac{dw^c_\phi}{d\delta}\delta + \beta\{-w^c_\phi - \frac{dm(w^c_\phi)}{d\delta} + aF(\delta) + (p+d)[1-F(\delta)]\} = 0 \tag{17}$$

First notice in the duopoly, the expected profit of cooperative is no longer zero and price offer for the raw product may differ between cooperative and investor owned firm, thus at equilibrium the market share is positive for cooperative. $-w^c_\phi - \frac{dm(w^c_\phi)}{d\delta} + aF(\delta) + (p+d)[1-F(\delta)]$ is decreasing in δ with range $(-\infty, p+d]$. This can be interpreted as the difference between marginal cost and expected price per unit based on the choice of output level, which is zero under competitive market. Let ϕ^c be the solution to equation (15) and evaluating J^c at ϕ^c :

$$J^c|_{\delta=\phi^c(w_\phi)} = \frac{dw^c_\phi}{d\delta}(1-\beta\delta) - \frac{dw^p_\phi}{d\delta}|_{\delta=\phi^c(w_\phi)} > 0 \tag{18}$$

That is, in the duopoly context the cooperative would like to produce a higher output level than in the competitive market. When cooperative is the price taker in both input and output, the expected profit is zero. It implies the expected return to producers from patronizing with cooperative is the same as return from investor owned firm. For a risk-averse producer, she will never invest in cooperative in this situation and the cooperative has zero market share. So in order to achieve a positive market share in this duopoly model, cooperative must provides the producer with a higher expected return than does investor owned firm.

2.2 Investor owned firm's decision and Equilibrium

This section considers the problem of investor owned firm and discuss how cooperative may operate differently in comparison. Investor owned firm maximizes the expected profit when facing the cooperative price and producers' supply $1 - \blacksquare$. The objective function is specified in equation (8). Similarly to the cooperative's problem, the optimal production decision for the investor owned firm has to satisfy the following:

$$J^p = -(\frac{dw^p_\phi}{d\phi^p}\phi^p + w^p_\phi + \frac{dm(w^p_\phi)}{d\phi^p}) + aF(\phi^p) + (p+d)[1-F(\phi^p)] = 0 \tag{19}$$

where $\phi^p = 1-\delta$ is at market clearing for raw product. In comparison to the first order condition for maximizing profit under competitive market, the addition term the investor owned firm needs to take into account is $-\frac{dw^p_\phi}{d\phi^p}\frac{\phi^p}{w^p_\phi}$, which is the total mill price flexibility or the inverse of elasticity of the raw product supply. As for the price decision of cooperative embedded in equation (17), besides mill price flexibility, it also has to consider the total impact of raw product purchase on the relative coop-IOF price spread. Intuitively, the elasticity of raw product supply has a direct effect on firm's purchase decision thus affects the profitability. However, unlike the investor owned firm the cooperative tries to provide its member-producer with competitive returns. Since selling the raw product to coop/IOF is one of important sources of revenue to the producers, the cooperative has to consider the relative price spread to the competitor explicitly. Equation (14) gives producer's supply curve to cooperative and we can write the general form of inverse supply as:

$$w_\phi^c = w_\phi^c(\delta, w^p) \tag{20}$$

so,

$$\frac{dw_\phi^c}{d\delta} = \frac{\partial w_\phi^c}{\partial \delta} + \frac{\partial w_\phi^c}{\partial w_\phi^p}\frac{\partial w_\phi^p}{\partial \delta} \tag{21}$$

That is, the total marginal impact of increase in raw product purchase on price is an aggregate of direct partial effect $\frac{\partial w_\phi^c}{\partial \delta} > 0$ and indirect effects. $\frac{\partial w_\phi^p}{\partial \delta} < 0$ follows because increasing in δ implies the decreasing market share for investor owned firm. $\frac{\partial w_\phi^c}{\partial w_\phi^p}$ is the slope of cooperative's best reply curve, which can be obtained by applying the implicit function theorem on (14):

$$\frac{\partial w_\phi^c}{\partial w_\phi^p} = -\frac{\partial \delta / \partial w_\phi^p}{\partial \delta / \partial w_\phi^c} > 0 \tag{22}$$

the inequality follows because $\partial \delta / \partial w_\phi^p$ is negative but $\partial \delta / \partial w_\phi^c$ is positive as just discussed. That is, the best reply function of cooperative is positively sloped indicating that two prices are strategic complements. In other words, the more sensitive is the cooperative mill price offer to the counterpart's price offer, the less responsive is the total raw product supply to the price change. It is assumed that $\frac{\partial w_\phi^c}{\partial w_\phi^p} < 1$ to guarantee the uniqueness of the equilibrium[3]. Now we can study the pricing behavior of cooperative and investor owned firm by comparing and combining equation (17) and (19):

$$\frac{dw_\phi^c}{d\delta}(1 - \beta\delta) - \frac{dw_\phi^p}{d\delta}\delta + (F^p - w_\phi^p) + \beta(F^c - w_\phi^c) = 0 \tag{23}$$

where $F^p = -\frac{dm(\phi^p)}{d\phi^p} + aF(\phi^p) + (p+d)[1 - F(\phi^p)]$ and $F^c = -\frac{dm(\delta)}{d\delta} + aF(\delta) + (p+d)[1 - F(\delta)]$. Notice that $F^p - w_\phi^p$ and $F^c - w_\phi^c$ are the first order conditions of the maximization problems of the investor owned firm and cooperative under competitive raw market respectively, while in the context of mixed duopoly their magnitudes are dependent on the total marginal impact of raw crop purchase on mill price offer. Since both $F^p - w_\phi^p$ and $F^c - w_\phi^c$ have to be non-negative as they represent the expected profit per unit of final product sold, equation (19) implies that $dw_\phi^p/d\phi^p \geq 0$ and equation (17) implies $\frac{dw_\phi^c}{d\delta}(1 - \beta\delta) - \frac{dw_\phi^p}{d\delta} \leq 0$. Furthermore,

$$\frac{dw_\phi^c}{d\delta} = \frac{\partial w_\phi^c}{\partial \delta} + \frac{\partial w_\phi^c}{\partial w_\phi^p}\frac{\partial w_\phi^p}{\partial \delta} \leq 0 \tag{24}$$

[3] Uniqueness requires the absolute value of the slope of the best reply function of each firm to be less than one (Kreps and Scheinkman, 1983, pp. 328-329).

By assumption that $\frac{\partial w_\phi^c}{\partial w_\phi^p} < 1$, we have our price condition under which the raw product market is at equilibrium:

$$\frac{\partial \delta}{\partial w_\phi^c} > \frac{\partial (1-\delta)}{\partial w_\phi^p} \tag{25}$$

That is at equilibrium, the cooperative is faced with a more responsive raw product supply than investor owned firms. The intuition is straight forward that as compared to the mill price offer by investor owned firm, the change in cooperative's price will not only affect the revenue of producer from selling the raw product but also have an impact on the cooperative's profitability which is another source of income for the member-producer in the form of patronage refund in the future. In reality, cooperatives retain patronage refund due to capital needs and may not give it back to members until a long period of time and in some cases the producers may have little incentive to patronize with cooperatives. However, from the perspective of demand for raw product, equation (25) implies that the slope of input demand of cooperatives is less steeper than that of investor owned firms over the range of output observed. This is intuitive because one unit of increase in mill price offer will call for greater market share for the cooperative thus the quantity of raw product demanded is less affected as compared to investor owned firm. As for the capital investment, if two competitors split market equally, i.e. $\delta^* = 1/2$, then implied by the production technology, cooperative will just operate like investor owned firm and have same level of output and capital requirement. That means if cooperative ever operates like the investor owned firm, there exists price offers by both firms such that equation (23) holds. To check this condition we need to put more structure on the production function which is beyond the scope of this paper.

3 Econometric Methodology

3.1 Empirical Model

Despite the different objective between cooperative and the investor owned firm, they all minimize short run cost. Since the cost function provides the same information about the technology as the production function, we estimate the cost function using translog form which is flexible in producing price elasticities at different data point. Following Kim and Maksimovic (1990), the variable cost function is specified as:

$$VC = g(W, Y, k, t) \tag{26}$$

where W is a vector of prices of input purchases and Y is vector of output level. k appears as quantity in the variable cost function which is the size of fixed capacity that was determined before the variable inputs are chosen. t is the yearly time dummy variable. Represent the cost function in the translog form:

$$\begin{aligned}\ln VC^n &= \alpha_0 + \sum_f \lambda_f + \sum_T \rho_T + \sum_i \alpha_y \ln y_i + \sum_j \beta_j \ln w_j + \beta_k \ln k \\ &\quad \frac{1}{2}[\sum_j \sum_i \alpha_{ij} \ln y_i \ln y_j + A_{kk}(\ln k)^2 + \sum_j \sum_i A_{ji} \ln w_j \ln w_i] \\ &\quad + \sum_j \sum_i B_{ij} \ln y_i \ln w_j + \sum_i C_{ik} \ln y_i \ln k + \sum_j B_j \ln w_j \ln k \end{aligned} \tag{27}$$

where n stands for the type of a firm. The term λ_f and ρ_T capture the firm specific intercept and time effect respectively, because we use panel data that consists of cross-section of firms and time series. The input demand equations can be easily obtained using Shephard's Lemma, $x_i = \partial VC/\partial w_i$ and a set of input share equation can be expressed as:

$$\begin{aligned} S_i &\equiv \frac{w_i x_i}{VC} = \frac{\partial \ln VC}{\partial \ln w_i} \\ &= \beta_i + \sum_j A_{ji} \ln w_j + \sum_i B_{ij} \ln y_i + B_i \ln k \end{aligned} \tag{28}$$

So the equation system to be estimated are equation (27) and share equations in (28). The advantage to estimate the system of equations instead of a single equation is that we can impose cross function restrictions according to the standard properties of cost function, i.e. the following restrictions are imposed:

$$\sum_j \beta_j = 1, \quad \sum_i A_{ji} = 0, \quad \sum_i B_{ij} = 0, \quad \sum_i B_i = 0, \quad A_{ji} = A_{ij} \tag{29}$$

This system of equations are estimated using Three-stage least square regression technique and additive disturbance terms are appended to each equations to reflect nonsystematic errors in optimization (Sexton 1990). We examine and compare the input price flexibility between cooperative and investor owned firm in two ways. First, we estimate the the own price elasticity of input demands of both cooperative and investor owned firm and determine wether the differences are significant. The own price elasticity of demand is derived as the following:

$$\varepsilon_{ii} \equiv \frac{\partial x_i}{\partial w_i} \frac{w_i}{x_i} = \frac{A_{ii}}{S_i} + S_i - 1 \tag{30}$$

We can also study the effect of input prices on firm's input purchase decisions by examining the price elasticity of input share.

$$\frac{\partial \ln S_i}{\partial \ln w_i} = \varepsilon_{ii} + (1 - S_i) \tag{31}$$

Notice the sign of $\partial \ln S_i / \partial \ln w_i$ depends on whether the input demand is elastic and the magnitude of current input's share of total cost. This measure will allows to study how cooperative may differ from the investor owned firm operationally regarding relative size of input price elasticity and the mix of raw product purchase.

3.2 Result and Discussion

The panel data consists of annual accounting information of 100 agricultural grain marketing and supply coops and 50 IOFs in Iowa from 1992 – 1995 collected by survey in year. The sample was selected on the basis of type of ownership and product line. Featherstone and Al-Khearaiji (1995) provided a procedure to process the accounting information to suit for the cost function estimation. There are two categories of output in our dataset, grain sales and supply sales, which are converted to output volumes by dividing by 12-month moving averages of PPI (producer price indices[4]) that matches the prices series of firms' fiscal year. Data on inputs consists of raw product purchases (including grain and supply), and labor cost. Since the composition of product sales is not available, we use real prices of corn to represent the purchase prices of the firm[5]. Given the strong correlations among grain product prices in the history, the corn price should reflect much of the variation in prices over the products the firm is marketing. Real price of corn is calculated by dividing the nominal price by the CPI in order to reflect the impact of price movement on the agricultural grain marketing firms as buyers in the raw product market.

The State of Iowa average hourly earnings of manufacturing jobs[6] is used to represent the price of labor input. The capacity was measured as the book value of fixed asset divided by the GNP deflator and the price of capacity was measured as the six month commercial paper rate[7] which is also deflated to real rate. Finally, variable cost is constructed as total cost minus depreciation and interest expense. The price of all other input is assumed to follow the GNP deflator. Notice that not all firms in the dataset have either grain sale or supply sale so we need to adjust the zero output so it can be log transformed. Following Schroeder (1992), the zero output is set to 0.1. The descriptive statistics for cooperative and investor owned firm is summarized in table 1 and table 2 respectively. The mean variable cost is $1,610,354 for cooperatives and $671,507 for investor owned firm. On average, raw product purchases represent 59% of the variable cost for cooperatives and 60% for investor owned firms. It is obvious from our dataset that cooperatives are larger than investor owned firms on average in terms of both sales and capacity.

Three-stage least square regression with iteration was used to estimate the system of the cost function and share equations. Under seemingly unrelated regression, this iteration converges to maximum likelihood estimates. Bootstrapping technique with 100 times repetition is also used to calculate the standard errors on measures of elasticities and construct confidence interval. The parameters for the translog cost function of cooperatives and investor owned firms are reported in table 3 and 4 respectively. The estimated mean input share of raw product purchases is 0.628 for cooperatives and .586 for investor owned

[4]Source: US Department of Labor's *Producer Price Indexes* 1992-1995)
[5]Source: National Agricultural Statistics Service 1992-1995
[6]Source: Department of Labor's Employment and Earnings, 1992-1995
[7]Source:Federal Reserve Bulletin, 1992-1995

firm which is pretty consistent with our observations of sample means. The estimated short-run own price elasticities of input share of raw product purchases is -.7934 for cooperatives with 95% confidence interval from -1.145 to -0.439; and that of investor owned firm is -1.211 with 95% confidence interval from -1.250 to 0.1873. The fact that own price elasticities are negative is consistent with economic theory. The simple t-test using bootstrap standard errors was performed to test null hypothesis that there is no difference between the own price elasticities of cooperatives and investor owned firms. The null hypothesis was rejected at 5% significance level and we conclude the cooperatives are less sensitive to price change in raw product market than their counterparts.

Tests were also performed to investigate the impact of capacity on short run variable cost and input shares. Checking the corresponding estimates of second order coefficients in the translog cost function found little significant impact of capacity on input shares for either cooperatives or Investor owned firms. In addition, we observed an increase in marginal variable cost with respect to both grain and supply sales for the two types of organizations, but by examining the second order coefficient of grain sales and capacities, we found that capacity had an significantly positive effect on the ratio of marginal variable cost to average variable cost for investor owned firm, which is just the derivative of log of cost with respect to log of grain output, but the coefficient appeared to be negative in the cost function for cooperatives. In other words, cooperatives could potentially lower the short run variable cost by increase the capacity while investor owned firm needs to employee more variable inputs if it invests more. This observation naturally gives rise to the question wether the level of cooperative's capacity is at long run optimal. This will be my research focus at next step. Conrad and Unger (1987) has provided a statistical method to test the hypothesis but I believe there is still room in developing a theoretical understanding of the behavior of cooperatives.

Appendix

Table 1.

summary statistics of 100 Agricultural grain marketing and supply cooperatives, 1992-1995

Variable	Mean	Standard Deviation	Min	Max
Variable Cost	1,610,354.00	1,298,853.00	271,596.00	9,078,872.00
Grainsale	9,810,852.00	10,916,660.00	-	91,017,940.00
Supplysale	6,077,407.00	4,524,209.00	574,957.40	26,087,220.00
Wage	11.82	0.09	11.71	11.92
GNPdeflator	79.11	1.87	76.58	81.61
Capacity	2,706,524.00	2,467,030.00	271,020.70	24,949,360.00
Labor Share	0.61	0.07	-	0.81
Other input Share	0.39	0.07	0.19	1.00

Table 2.

summary statistics of 50 Agricultural grain marketing and supply IOFs, 1992-1995

Variable	Mean	Std.	Min	Max
Variable Cost	671,506.70	937,002.80	31,318.00	6,592,062.00
Grainsale	3,253,052.00	3,904,913.00	-	32,919,410.00
Supplysale	2,286,397.00	3,631,929.00	-	23,471,710.00
Wage	11.82	0.09	11.71	11.92
GNPdeflator	79.17	1.86	76.58	81.61
Capacity	725,538.60	1,249,800.00	33,251.44	9,381,480.00
Labor Share	0.40	0.20	-	0.85
Other input Share	0.62	0.24	0.15	1.00

Table 3.

Parameter Estimate for the Cost Function of Agricultural Grain Marketing And Supply Cooperatives

ln (variable cost)	Coef.	Std. Err	[95% Conf. Interval]	
βw	1.023882	0.003059	1.017886	1.029879
βg	0	(omitted)		
βk	-2.162324	6.952228	-15.7884	11.46379
αg	0.0914503	7.170103	-13.9617	14.14459
αs	-4.171292	15.91814	-35.3703	27.02768
αgg	0.0196263	0.004986	0.009853	0.0294
αsg	-0.2209863	0.042259	-0.30381	-0.13816
αss	0.0638548	0.025791	0.013306	0.114404
Agg	-24.55157	217.2995	-450.451	401.3477
Agw	9.638198	137.9826	-260.803	280.0792
Aww	-0.4974879	21.91639	-43.4528	42.45785
Akk	0.0171899	0.071012	-0.12199	0.15637
Bgk	0.104934	1.754796	-3.3344	3.544272
Bgs	0.3837247	1.94043	-3.41945	4.186898
Bgg	0.0031678	0.762342	-1.491	1.497331
Bws	2.066961	6.959359	-11.5731	15.70705
Bwg	0.1222514	3.073806	-5.9023	6.1468
Bwk	0.6880778	2.300205	-3.82024	5.196397
Cgk	0.0824562	0.023397	0.036598	0.128314
Csk	-0.0425303	0.04107	-0.12303	0.037965

Table 4.

Parameter Estimate for the Cost Function of Agricultural Grain Marketing and Supply Investor owned firms

ln (variable cost)	Coef.	P>|z|	[95% Conf. Interval]	
βw	0			
βg	0			
βk	1.000678	0.857	-9.86	11.85648
αg	0.0093274	0.995	-3.1	3.11905
αs	0.7208811	0.975	-44.9	46.34142
αgg	0.0217819	0	0.015	0.028637
αsg	0.0563405	0.043	0.002	0.111031
αss	0.1222561	0.087	-0.02	0.262485
Agg	0			
Agw	0			
Aww	2.361909	0.007	0.649	4.075302
Akk	-0.0223668	0.771	-0.17	0.128081
Bgk	0.6322295	0.621	-1.87	3.136337
Bgs	-0.5376899	0.806	-4.82	3.748059
Bgg	0.0137448	0.924	-0.27	0.296804
Bws	-0.4072268	0.967	-20	19.13793
Bwg	-0.0082568	0.99	-1.33	1.312009
Bwk	-0.2101766	0.911	-3.89	3.469865
Cgk	-0.0376719	0.009	-0.07	-0.009348
Csk	-0.0179773	0.775	-0.14	0.105569

Derive the variance of firm's profit.

$$E(x) = \int_0^1 x dF(x)$$
$$E(g(x)) = \int_0^1 g(x) dF(x)$$

Let $g(x) = \begin{cases} px + a(q-x) - \hat{c}(q, w_\phi, w_k), & x \le q \\ pq - d(\mathrm{x} - q) - \hat{c}(q, w_\phi, w_k), & x > q \end{cases}$,

Also, let $\mathrm{f}(x) = \begin{cases} (p-a)x, & x \le q \\ -dx, & x > q \end{cases}$,

Notice that $\mathrm{f}(x)$ and $g(x)$ have the same variances.

So $E(f(x)) = \int_0^1 f(x) dF(x) = (p-a)\int_0^q x dF(x) - \mathrm{d}\int_q^1 x dF(x)$

$$E(f(x))^2 = \int_0^1 [f(x)]^2 dF(x) = (p-a)^2 \int_0^q x^2 dF(x) - \mathrm{d}^2 \int_q^1 x^2 dF(x)$$

Then

$$Var[g(x)] = Var[f(x)] = E(f(x))^2 - [E(f(x))]^2$$
$$= (p-a)^2 \int_0^q x^2 dF(x) + \mathrm{d}^2 \int_q^1 x^2 dF(x) - [(p-a)\int_0^q x dF(x) - \mathrm{d}\int_q^1 x dF(x)]^2$$

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