Cooperative pricing and scale efficiency: The case of Korean rice processing complexes

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Abstract

Unlike most investor-owned enterprises, cooperatives often have freedom to choose among a variety of firm objectives. Using 2002–2008 plant- and province-level data, we ask in the present article which of several alternative maximands a Korean cooperative rice processing firm pursues. In contrast to earlier studies, farmer-member supply functions are incorporated into the cooperative’s optimization framework. We show that only large cooperative firms have operated at efficient scale, while small and medium-sized ones have been scale-inefficient. Because the latter operate where scale returns are increasing, mergers of small and medium-sized cooperatives likely would be cost-reducing and member-return-enhancing.

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\textit{Keywords:} Cooperatives; Firm objectives; Pricing efficiency; Scale efficiency

1. Introduction

Cooperative membership often has been shown to boost farmer prices, particularly when markets are scattered or weak (Bernard et al., 2008; Wollni and Zeller, 2007). More generally, private or investor-owned (IOF) farm-product buyers exhibit pricing behavior distinct from those in cooperatives or other collective organizations (Buccola, 1994; Cobia, 1989; Helmberger and Hoos, 1962; LeVay, 1983a, 1983b; Royer, 1987; Staatz, 1987). The cooperative is a business owned by the firm’s users, in the processing-cooperative case by the farmer-owners supplying the raw product. Because it is controlled by, and allocates net revenues to, raw-product suppliers, the cooperative normally is assumed at least to try to minimize the cost of such nonraw-product processing inputs as labor and energy at given raw-product volume. However, it need not try maximizing the return to raw product itself, as that may interfere with, for example, membership size goals.

Conjectures about whether a cooperative goes beyond the presumed allocative efficiency of its nonraw-product inputs to achieve pricing or scale efficiency thus depend on conjectures about the cooperative’s principal objective. Many objectives have been proposed, including: (i) maximizing the price paid to members per unit of raw product delivered, (ii) maximizing total member income, and (iii) accepting all quality-acceptable raw product delivered. During the past several decades, cooperatives have faced substantial changes in market conditions and structure, especially in much stiffer competition (Cook, 1995; Harris et al., 1996; Juliá and Mari, 2002; Merrett and Walzer, 2004). These changes complicate efforts to identify a cooperative’s objectives on the basis of theoretical analysis alone.

In the present study we assess the pricing and scale efficiency of Korean cooperative rice processing complexes (RPCs) and explore options for their improvement. Unlike previous studies, we incorporate raw-product cost and supply considerations in our analysis. Rice is Korea’s most important farm commodity, considered either as a staple food or as a source of farm income, accounting for 54% of urban household food grain...
expenditures in 2007 (Korea National Statistics Office). In 2008, rice farms covered about 60% of Korea’s farm land, 70% of farm households, and 47% of farm income (Korean Ministry for Food, Agriculture, Forestry and Fisheries).

Operating under an open-membership policy, cooperatives play an important part in Korean agriculture and its rice industry in particular. Approximately 1,200 agricultural cooperatives are currently owned by 2.4 million farmer-members, estimated to be about 90% of Korean farm households. Of these, 166 have combined into rice processing complexes, representing about 60% of rice processing firms in Korea. These facilities accept raw rice from farmer-members; store, process, and polish it; and sell it in consumer markets. At delivery, members initially are paid a transfer price determined by the board of directors. If a positive net return eventually is realized, additional payment is made in the form of patronage dividend.

Cooperative and IOF processors are so numerous in Korea that little pricing power likely is present in either the raw or finished rice market. However, a number of researchers have argued that cooperatives perform poorly relative to investor-owned firms. And by the turn of the 21st century, cooperatives faced rising domestic and international competition from the investor-owned sector (Lamprinakis and Fulton, 2011). Major U.S. cooperatives recently have faced bankruptcy, including Farmland Industries and Tri Valley Growers (Cross et al., 2009). The Uruguay Round Agreement on Agriculture (URAA) in 1995 similarly has created a competitive environment for Korean rice producers and cooperative processing centers. Fifty years of domestic rice price supports were gradually curtailed, and finally eliminated in 2005. Since 1995, foreign rice imports have risen under the influence of the World Trade Organization’s Minimum Market Access provisions of the URAA. With the diversification of Korean dietary habits, per-capita annual rice consumption has had the same time fallen from 106.5 kg in 1995 to 75.8 kg in 2008 (Korea National Statistics Office). Because consumption has dropped more quickly than production, domestic supplies have piled up, stiffening the competition among domestic producers. Analysis of cooperative efficiency thus is critical to Korea’s as well as other nations’ adjustment to the changing world market environment.

2. Economic theory of cooperatives

Efficiency assessments alternatively focus on technical, allocative, pricing, or scale efficiency. Distinctions among these four are best understood in the context of the four most common cooperative relationships: net revenue product (NRP), net marginal revenue product (NMRP), net average revenue product (NARP), and farmer-member raw-product supply (S). NRP is total revenue less total processing cost (exclusive of raw-product value) at given raw product quantity R. Its role in cooperative theory is analogous to an IOF’s profit function. In the single-output case, for example, NRP is

\[
NRP(P, W, R) = Pf(X, R) - WX, \tag{1}
\]

where \( P \) is the price the cooperative receives from selling its good (after processing and handling) in the final-product market; \( W \) is the vector of processing input prices excluding raw-product price; \( f(X, R) \) is quantity of final good sold, which in turn is a function of the vector of resources \( X \) used in processing and of the quantity \( R \) of raw product delivered by members; and \( WX \) is the cost of resources, excluding raw product, used in processing.

We will suppose the cooperative utilizes labor and other resources optimally to maximize \( NRP \) at given \( R \). In other words, the cooperative is technically efficient (operates on its technical frontier) and allocatively efficient in the use of its \( X \) inputs. \( NRP \) so maximized with respect to nonraw-product inputs \( X \) is:

\[
NRP = \text{Max}\{Pf(X, R) - WX, \forall R\}, \tag{2}
\]

of which the first-order optimization conditions are

\[
\frac{P\partial f(X, R)}{\partial X} = W. \tag{3}
\]

\( NMRP \) is the change in \( X \)-maximized \( NRP \) induced by an additional raw product unit \( R \):

\[
NMRP = \frac{\partial NRP}{\partial R} = \frac{\partial [Pf(X, R)/WX]}{\partial R} = \frac{P\partial f(X, R)}{\partial R} - \frac{\partial WX}{\partial R}. \tag{4}
\]

The interpretation of this expression in terms of conventional marginal revenue and cost requires assuming a relationship between output and raw-product input. As the principal material in an assembly-line environment, raw-rice volume \( R \) can be reasonably assumed to hold a fixed proportion to finished rice output \( f \). It follows that, up to a multiplicative constant, \( \frac{P\partial f(X, R)}{\partial R} \) in (4) is marginal revenue and \( \frac{\partial WX}{\partial R} \) is marginal processing cost exclusive of raw product.

In contrast, \( NARP \) is \( NRP \) per unit \( R \):

\[
NARP = \frac{NRP}{R} = \frac{Pf(X, R) - WX}{R} = \frac{Pf(X, R)}{R} - \frac{WX}{R}. \tag{5}
\]
where by the same reasoning as above, $\frac{P(X, R)}{R}$ is—up to a multiplicative constant—average revenue and $\frac{W X}{R}$ is average processing cost, again excluding raw product. Finally, $S(R)$ facing the cooperative is the horizontal sum of farmer-members' marginal costs of producing quantity $R$ of raw product. $S(R)$ thus represents, at given $R$, the farm cost of producing one more unit of the raw commodity.

Figure 1 shows prototypical $NMRP(R)$, $NARP(R)$, and $S(R)$ functions, the latter represented at two of several potential positions. Even if average revenue $P$ falls as raw-product volume rises, $NARP$ initially may rise if there are scale economies, that is if average processing cost declines with greater volume. If input fixities such as management skill are either specified in the model or present in the data—so that scale diseconomies eventually are encountered—$NARP$ thereafter would decline in the face of the rising average processing costs. $NARP$ equals $NMRP$ at maximum $NARP$ because average equals marginal processing cost when average cost is a minimum.

### 2.1. Possible equilibria in marketing cooperatives

An immediate consequence of the member-owned raw input’s fixed proportionality to final output is that questions about the allocative efficiency of raw-input use are not meaningful, as raw input cannot be varied at fixed output. Rather, we can speak only of the raw good’s pricing or scale efficiency, satisfied if and only if those same efficiencies are satisfied in the output domain. The output-price-taking cooperative is price-efficient when raw product quantity equates $NMRP$ with farm marginal cost, and scale-efficient when $NARP$ is a maximum.

In particular, note that $NARP$ defines the greatest break-even unit payment—including any advance plus final patronage dividend—the cooperative can make to members at given raw-product volume $R$. The cooperative equilibrium suggested by Helmberger and Hoos (1962) is motivated by assuming the cooperative allows unlimited raw-product deliveries and pays the break-even price for each unit. As Sexton et al. (1989) show, that equilibrium occurs at such a point as D in Fig. 1, where the unlimited raw-product supply $S(R)_2$ intersects $NARP$ and the corresponding unit raw-product payment is HD. Because this equilibrium does not equate marginal processing return to marginal farm cost, it cannot be price-efficient; nor in general is it scale efficient. It does maximize the quantity of raw product delivered consistent with nonnegative farm-plus-processing income, and often is associated with open-membership cooperatives.

If the cooperative instead employs a restricted-intake policy, the raw-product supply curve it faces generally will lie to the left of $S(R)_2$, as some members who might have sought membership are excluded. An equilibrium consistent with that idea, associated with restricted-membership cooperatives and first suggested by Clark (1952), can be characterized at point B in Fig. 1, where $S(R)_1$ intersects the maximum $NARP$ point. This solution—both pricing and scale efficient—is motivated by assuming the cooperative wants to earn the highest return possible per unit of raw product, including its returns to farm and processing inputs. To do so, the cooperative will restrict membership or intake-per-member so that, behaving as individual raw-product price-takers, the aggregate membership will wish to deliver the $NARP$-maximizing volume. The cooperative’s break-even condition is satisfied because member price received, FB, is the cooperative’s full per-unit net return. Thus, the cooperative objective defined by Clark (1952) is to maximize price paid to members per unit of raw product delivered.

Another possible solution, first offered by Ohm (1956) and later endorsed by LeVay (1983b), is that the cooperative set its equivalent raw-product price at $NMRP$ point C in Fig. 1. This can be considered the first-best optimum in that it maximizes member welfare for a given function $S(R)$. But it cannot generate the break-even condition because $NMRP$ is unequal to $NARP$ except at maximum $NARP$. And, although it is pricing efficient, it is not scale-efficient. Buccola (1994) argues the Ohm-LeVay solution is socially optimal in the short run. In the long run, however, per-unit patronage dividend EC in this equilibrium, namely full price EG less initial transfer price CG in Fig. 1, renders delivery quantity OG unstable because the positive dividend encourages members to deliver OJ rather than OG.

Sexton’s (1986) game theory model of cooperation rejects the Ohm-LeVay solution, predicting cooperatives instead will operate close to the Clark solution, where $NARP$ is maximized. Sexton et al.’s (1989) examination of California cotton ginning cooperatives supports the game-theory prediction. However,
Boyle’s (2004) study of Irish dairy cooperatives suggests instead that cooperative raw-product pricing is similar to a profit-maximizing firm’s. In support of the Ohm-LeVay hypothesis, he finds raw-milk prices to occur where $S(R)$ intersects $NMRP$ but not at maximum $NARP$.

The variety of observed cooperative pricing solutions suggests none is universal. Royer and Smith (2007) insist a cooperative’s ability to pursue a variety of objectives implies that judgments about its performance should not be drawn from theoretical arguments alone. The feasibility and optimality of a cooperative’s equilibrium appear to depend on context. In their review paper, Soboh et al. (2009) argue also that empirical studies typically fail to employ clear theoretical frameworks when testing alternative cooperative objectives. New studies are needed to not only identify possibilities for improved performance but to spur further development of the theory of collective organizations.

2.2. Comparing cooperative and investor-owned equilibria

A key difference between the cooperative and the competitive investor-owned firm is that, in the face of given factor prices, the IOF chooses raw-product volume $R$ along with processing inputs $X$, while in the cooperative, $R$ may be determined either centrally by the board or individually by the members. The IOF’s profit function can be expressed as:

$$\pi(P, W, r) = Pf(X, R) - WX - rR,$$

where $r$ is raw-product price. Its decision problem then is:

$$\text{Max } \pi = \{Pf(X, R) - WX - rR\}. \tag{7}$$

The first-order condition of the solution to (7) can be decomposed into optimal choices of $X$ and $R$, namely:

$$\frac{\partial Pf(X, R)}{\partial X} = W \quad \text{and} \quad \frac{\partial [Pf(X, R) - WX]}{\partial R} = r. \tag{8}$$

The first condition in (8) corresponds to a cooperative’s maximization of $NRP$ at given $R$—as in Eq. (3). It is allocatively efficient in the disposition of its $X$ inputs. The second condition sets per-unit raw product payment $r$ at the $NMRP$, in turn determined by the quantity $R$ of raw product delivered. That is,

$$NMRP = \frac{\partial NRP}{\partial R} = \frac{\partial [Pf(X, R) - WX]}{\partial R} = r. \tag{9}$$

Solution (9) is pricing efficient if farmer-members’ marginal raw-product cost functions intersect at the same point. Provided raw-product supply coincides with that marginal cost function, the IOF thus performs the same optimization that Ohm-LeVay call for when they equate $NMRP$ with marginal farm cost $S(R)$—point C in Fig. 1.

Another possible IOF equilibration constraint is the long-run zero-profit condition under free entry:

$$\pi(P, W, r) = Pf(X, R) - WX - rR = 0. \tag{10}$$

Since, from Eq. (1), $NRP(P, W, R) = Pf(X, R) - WX$, Eq. (10) is expressed for the cooperative as

$$NRP(P, W, R) - rR = 0. \tag{11}$$

Differentiating $NRP$ with respect to $R$ and dividing by $R$ gives

$$NMRP = \frac{\partial NRP}{\partial R} = r = \frac{NRP}{R} = NARP. \tag{12}$$

This condition occurs at maximum $NARP$, where $NMRP$ equals $NARP$. Thus, requiring zero profit in the IOF competitive equilibrium produces a result equivalent to Clark’s scale-efficient cooperative solution. That is, if the cooperative achieves the Ohm-LeVay or Clark equilibrium, it is efficient in employing processing inputs and pricing raw product.

3. Methods

3.1. Specifying the $NRP$ and farm cost function

We now identify the cooperative’s equilibria by explicitly incorporating marginal farm cost $S(R)$ into its $NMRP$ and $NARP$ system. This enables a more general assessment than heretofore possible of a marketing cooperative’s pricing and scale efficiency. We assume $NRP$ takes the translog form. Maintaining quadratic symmetry, and linear homogeneity by normalizing inputs prices with output price $P$, we obtain:

$$\ln NRP_{it} = a_0 + a_1 \ln w_{it} + a_2 \ln v_{it} + a_3 \ln e_{it} + a_4 \ln s_{it} + a_5 \ln e_{it} + \frac{1}{2} a_{ij} \ln w_{it}^2 + \frac{1}{2} a_{ik} \ln v_{it}^2 + \frac{1}{2} a_{rl} \ln e_{it}^2$$

$$+ a_{lt} \ln s_{it} + a_{it} \ln w_{it} \ln v_{it} + a_{it} \ln w_{it} \ln s_{it} + a_{it} \ln s_{it} \ln e_{it} + a_{it} \ln e_{it} \ln s_{it} + a_{it} \ln s_{it} \ln e_{it} + a_{it} \ln s_{it} \ln e_{it}$$

$$+ a_{it} \ln s_{it} \ln e_{it} + \gamma_j D_j,$$  \(13\)

where $NRP, w, v, e,$ and $s$ are $P$-normalized net revenue product, wage rate, capital price, energy price, and other-service price respectively, and $R_{it}$ is quantity of raw-rice members deliver to cooperative $i$ at time $t$. Provincial dummies ($D_j, j = 2, \ldots, 8$) are included to account for province-specific fixed effects. These fixed effects add a short-run character to (13) despite capital’s variability. Other inputs that are unaccounted for, such as management skill, presumably carry fixity as well, allowing size diseconomies.

Logarithmically differentiating Eq. (13) with respect to the normalized input prices gives the optimal shares of processing inputs $X$:

$$S_i = a_1 + a_{it} \ln w_{it} + a_{it} \ln v_{it} + a_{it} \ln e_{it}$$

$$+ a_{it} \ln s_{it} + a_{it} \ln R_{it},$$  \(14\)
\[ S_k = a_k + a_{it} \ln w_{it} + a_{it} \ln v_{it} + a_{ke} \ln e_{it} + a_{ks} \ln s_{it} 
+ a_{et} \ln R_{it}, \] (15)

\[ S_e = a_e + a_{it} \ln w_{it} + a_{et} \ln v_{it} + a_{ee} \ln e_{it} + a_{es} \ln s_{it} 
+ a_{et} \ln R_{it}, \] (16)

\[ S_s = a_s + a_{is} \ln w_{is} + a_{es} \ln v_{is} + a_{es} \ln e_{is} + a_{ss} \ln s_{is} 
+ a_{sr} \ln R_{is}. \] (17)

We estimate \( NRP \) Eq. (13) jointly with system (14)–(17) by Zellner’s seemingly unrelated regression (SUR). Twenty-four linear constraints are employed to maintain the cross-equation parametric identities.

To derive raw-product supply function \( S(R) \), we first specify a translog farmer cost, maintaining quadratic symmetry and normalizing input prices by capital price to maintain input-price linearity:

\[ C_j = \beta_0 + \beta_1 \ln l_j + \beta_m m_j + \beta_g g_j + \beta_e e_j + \beta_l \ln R_j 
+ 1/2 \beta_{11} \ln l_j^2 + 1/2 \beta_{mm} m_j^2 + 1/2 \beta_{gg} g_j^2 
+ 1/2 \beta_{el} \ln l_j \ln e_j + 1/2 \beta_{lg} \ln l_j \ln g_j 
+ \beta_{mg} \ln m_j \ln g_j + \beta_{ml} \ln m_j \ln l_j + \beta_{mr} m_j \ln R_j 
+ \beta_{gr} \ln g_j \ln R_j + \sum_{j} \delta_j D_j. \] (18)

Here \( C, l, m, \) and \( g \) are normalized cost, farm wage rate, farm materials price, and land rental rate, and \( R \) is quantity of farm good delivered to the cooperative in province \( j \) at time \( t \). As in the \( NRP \) function, provincial fixed effects \( (D_j, j = 2, \ldots, 8) \) are included. Optimal farm input demands are derived by successively log differentiating normalized cost with respect to normalized input prices:

\[ S_l = \beta_1 + \beta_{ll} \ln l_j + \beta_{mm} m_j + \beta_{lg} g_j + \beta_{re} e_j + \beta_{rl} \ln R_j; \] (19)

\[ S_m = \beta_m + \beta_{mm} m_j + \beta_{mg} g_j + \beta_{ml} l_j + \beta_{mr} \ln R_j; \] (20)

\[ S_g = \beta_g + \beta_{mg} m_j + \beta_{lg} g_j + \beta_{lg} l_j + \beta_{gr} \ln R_j. \] (21)

Supply equation system (18)–(21) is estimated with SUR, maintaining 15 cross-equation parameter constraints. The capital share equation is recovered through the linear homogeneity condition requiring cost shares to sum to one, that is, \( \beta_1 + \beta_k + \beta_m + \beta_g = 1, \sum_i \beta_{ij} = 0, \) and \( \sum_j \beta_{ij} = 0, \) in which \( i, j = l, k, m, \) and \( g \) (Greene, 2008). Employing these specifications, we now examine the following hypotheses about how cooperatives make raw-product pricing and volume decisions.

3.2. Hypothesis (1): Equilibrium occurs where farm supply intersects maximum \( NARP \) (Clark)

Such equilibrium, point \( B \) in Fig. 1, also maximizes the IOF’s profit under long-run free-entry situations (Clark, 1952). In this sense, it is a reasonable standard for fully efficient raw-product pricing in a cooperative.

To test Hypothesis (1), we rearrange Eq. (12) to express the condition that the \( NRP \)’s elasticity with respect to raw-product volume \( R(\varepsilon_{NRP}) \) be unity (Sexton et al., 1989). That condition holds at maximum \( NARP \), where \( NMRP = NARP \), so that:

\[ \frac{\partial NRP}{\partial R} = \frac{NRP}{R}. \] (22)

Since \( \frac{NMRP - \bar{R}}{NMRP} = \varepsilon_{NRP} - 1 \) at this point, it can be tested by specifying the null hypothesis that the \( NRP \) elasticity be unity, where \( t = (\varepsilon_{NRP} - 1)/\sigma \) and \( \sigma \) is standard error. To do so, we log differentiate the normalized \( NRP \) function with respect to \( R \):

\[ \left( \frac{\partial \ln NRP}{\partial \ln R} \right)_{jt} = \hat{\alpha}_c + \hat{\alpha}_{cr} \ln R_{jt} + \hat{\alpha}_{le} \ln w_{jt} + \hat{\alpha}_{kr} \ln v_{jt} + \hat{\alpha}_{ge} \ln e_{jt} + \hat{\alpha}_{ge} \ln s_{jt}, \] (23)

then evaluate it at every data point to generate the sample for obtaining the standard error. Failure to reject the null implies the cooperative’s equilibrium occurs where \( S(R) \) intersects maximum \( NARP \). If the null is rejected, we must search for another equilibrium. Because Korean cooperative rice processing complexes vary substantially in size, we conduct the \( NRP \) elasticity test successively for small, medium, and large complexes, distinguished—as discussed at Eq. (29) below—according to the quantity of raw rice processed.

3.3. Hypotheses (2) and (3): Equilibrium occurs where farm supply intersects \( NMRP \) (Ohm-LeVay) or \( NARP \) (Helmberger-Hoos)

Rejecting Hypothesis (1) implies equilibrium can occur at the intersection of either \( S(R) \) and \( NMRP \)—point \( C \) in Fig. 1—or \( S(R) \) and \( NARP \), point \( D \). To test these two possibilities, we may compare sample mean raw-product deliveries \( R \) with the means defined by the two alternative equilibria, respectively \( R_{S(R)=NMRP} \) (Hypothesis 2) and \( R_{S(R)=NARP} \) (Hypothesis 3). The null of Hypothesis 2 is that \( \hat{R} \) and \( R_{S(R)=NMRP} \) differ nonsignificantly from one another, and of Hypothesis 3 that \( \hat{R} \) and \( R_{S(R)=NARP} \) differ nonsignificantly. Each is testable through difference-in-means tests.

The first step in deriving \( R_{S(R)=NMRP} \) and \( R_{S(R)=NARP} \) is to compute the farm marginal costs associated with cost function (18). Given fitted normalized farm cost \( C_j = \exp(\ln C_j) \) in province \( j \) at time \( t \), marginal cost \( MC_j = S(R)_j \) is derived as

\[ MC_j = \left( \frac{C_j}{R_j} \right) \left[ \hat{\beta}_c + \hat{\beta}_{cr} \ln R_{jt} + \hat{\beta}_{le} \ln w_{jt} + \hat{\beta}_{kr} \ln v_{jt} + \hat{\beta}_{ge} \ln e_{jt} + \hat{\beta}_{ge} \ln s_{jt} \right], \] (24)

where the term in the square brackets is cost elasticity with respect to \( R \). The next step is to derive \( NMRP_{jt} \) and \( NARP_{jt} \).
from the normalized NRP estimate, Eq. (13). Using the fitted NRP, that is $NRP_{jit} = \exp(\ln NRP_{jit})$ at cooperative $i$ in province $j$ at time $t$, we have

$$NMRP_{jit} = \left(\frac{NRP}{R}\right)_{jit} [\alpha_x + \alpha_{tr} \ln R_{it} + \alpha_{wtr} \ln w_{it} + \alpha_{lt} \ln v_{it} + \alpha_{sr} \ln e_{it} + \alpha_{sr} \ln s_{it}]. \quad (25)$$

$$NARP_{jit} = \left(\frac{NRP}{R}\right)_{jit}. \quad (26)$$

The first term on the right side of (25) is NARP, and the square-bracketed term is the NRP elasticity with respect to $R$. Thus, (25) is equivalent to $NMRP_{jit} = [NARP_{jit}][\{\epsilon_{NRP}, R\}_{jit}]$. We compute the raw-rice quantity $R$ at which $S(R)$ intersects $NMRP$ (or NARP) at each observation by equating $MC_{jit}$ to $NMRP_{jit}$ (or $NARP_{jit}$) as

$$(R_{S(R)=NMRP})_{jit} : MC_{jit} = \left(\frac{NRP}{R}\right)_{jit} \{\epsilon_{NRP}, R\}_{jit} \quad (27)$$

and

$$(R_{S(R)=NARP})_{jit} : MC_{jit} = \left(\frac{NRP}{R}\right)_{jit}. \quad (28)$$

Evaluating (27) and (28) at each data point allows deriving the mean and standard deviation of $R_{S(R)=NMRP}$ and $R_{S(R)=NARP}$. Hypotheses (2) and (3) are tested for the full sample as well as separately for the three cooperative size subsamples.

4. Estimation approach and data

Tests of these hypotheses are ideally conducted with cooperative-specific NRP and member-specific farm cost data. The former are available to us but, as in most countries, farm-level observations are not. Fortunately, they are accessible as annual provincial means. And because the cooperatives to which most farmers deliver their rice are domiciled in the farmer’s own province, we can represent the observation-specific matches in (27) and (28) as explicit, stable pairings of cooperatives and their members. As indicated above, province fixed effects are used in both the NRP and farm cost function to represent provincial differences in otherwise unaccounted-for processing and farm resources.

Any aggregation bias of using provincial rather than individual-farm cost data to estimate (18) likely is small because most farmers in a given Korean province appear to face largely the same raw-rice prices as do IOF processors, with whom cooperative members also conduct business and to whose prices they presumably would equate their marginal production cost in order to maximize profit. Intra-province commonality of farmer marginal cost in turn is sufficient for unbiased aggregation in the neighborhood of farmers’ current operations.

For the NRP function, we use 2002–2008 data on the 166 cooperative Regional Rice Processing Complexes (RPCs) provided by the National Agricultural Cooperative Federation of Korea. Each rice complex’s NRP is computed as the difference between its gross revenue and total processing cost exclusive of raw-rice cost. Gross revenue is deflated by the Korean consumer price index (2005 = 100). Output price $P$ is computed as the ratio of gross revenue to processed-rice volume. Processing inputs consist of capital ($K$), labor ($L$), energy ($E$), and other services ($S$), measured as follows.

Capital expenditure is measured as the opportunity cost of (interest on) and depreciation of capital stock. Capital stock is obtained by the perpetual inventory method: $K_t = I_t + (1 - \theta_t)K_{t-1}$, where $K_t$ comprises buildings and machinery, $I_t$ is investment, and $\theta_t$ is depreciation rate at cooperative $i$ in time $t$. For most cooperatives, asset service lives ($T$) of buildings and machinery are assumed, respectively, to be 20 and 8 years. Hence, respective depreciation rates $\theta = 1/T$ are 5% and 12.5%. Capital stock is deflated by the national gross fixed capital formation deflator (2005 = 100). Capital expenditure is then obtained by multiplying stock by the weighted-average loan rate, deflated by the CPI (Bank of Korea).

Labor compensation includes wages and other benefits. CPI-deflated wage rate is total labor compensation divided by the annual hours worked by full and part-time RPC employees. Unlike in other Korean manufacturing, rice cooperatives face a mixed price system for energy (electricity and oil) use. Electricity prices depend on the production process in which the electricity is used. General-manufacturing price rates apply to the milling process, while lower prices apply to the storage process. Because oil is used in storage, its price is exempted from tax. Annual electricity and oil prices are respectively obtained from the Korean Electric Power Corporation and the Korean Ministry of Food, Agriculture, Forestry, and Fisheries. We compute energy price by combining per-kW-hour (kWh) electricity and oil rates and deflating with the producer price index (PPI, 2005 = 100). Per-liter oil prices are converted to an hourly basis assuming the average quantity of oil (24 l) used per hour.

Prices of other processing and handling services, such as packing materials, maintenance, transportation, insurance, and related services, are measured as an aggregate rate per worker hour. For this we divide the services’ expenditures, deflated by the CPI (2005 = 100), by annual hours worked by full and part-time employees. NRP’s and input costs are measured in (million) Korean won, and each input share is computed by dividing each deflated input cost by the deflated NRP.

Mean annual province-level 2002–2008 rice farming cost and factor price estimates are provided by the Korean National Statistics Office for the eight provinces in which processing complexes are located. Farm input prices consist of farm wage rate ($l$), interest and depreciation rates on depreciated capital ($k$), farm materials price ($m$), and rental rate of farm land ($g$). Wage rate is computed for both self- and hired labor.

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5 Korean agricultural cooperatives are exempt from some or all taxes on fixed assets. We thus use only interest and depreciation rates to specify capital prices.
Materials consist of seeds, fertilizers, pesticides, and other chemicals. Input prices are deflated by the index of prices paid by farmers (2005 = 100), which includes household-consumption commodities, farm production materials, and farm wages. Area-based total costs and input prices are converted to a per-ton-yield basis using mean per-hectare yield rates reported by the Korean National Statistics Office.

5. Results and discussion

5.1. NRP and farmer cost function estimates

Table 1 provides summary statistics of the variables used in the estimation of normalized NRP and rice farm cost functions. Estimates of the normalized NRP function and associated cooperative input demand shares, Eqs. (13)–(17), are reported in Table 2. Most estimates are statistically significant and model explanatory power is high ($R^2 = 0.99$). Significance of the $\alpha_{rr}$ parameter implies returns to scale are non-constant. Significance of $\alpha_{tr}$, $\alpha_{tv}$, $\alpha_{tr}$, $\alpha_{sr}$, implies, from (14) to (17), that rice processing technology is nonhomothetic. On the basis of a Breusch-Pagan Lagrange multiplier (B-P LM) test [$\chi^2(10) = 4,616.80$], we reject, at 1% significance, the null hypothesis that the disturbances of the NRP and input demands are independent of one another. Joint estimation of NRP and factor demand shares therefore is asymptotically efficient. Fitted input shares of the normalized NRP estimates are positive at every observation, implying the monotonic property is satisfied. Determinant of the NRP Hessian $\|\partial^2\text{NRP}/\partial w_i \partial w_j\|$ and its principal minors, are all positive at data means, ensuring convexity in normalized input prices at least at the centroid (Table 4).

Table 3 shows estimates of the corresponding normalized rice farm cost function and associated farm factor demands, Eqs. (18)–(21). Most parameters are, as with the NRP, statistically significant and model explanatory power is high. The B-P LM test [$\chi^2(10) = 39.92$] suggests disturbances of the cost and input share equations are correlated with one another, implying the FGLS (SUR) estimator is asymptotically efficient. Fitted input shares (19)–(21) are positive at each observation, implying the monotonicity property is satisfied.
Table 5a
Test results for cooperative equilibrium at maximum NARP (Hypothesis 1)

<table>
<thead>
<tr>
<th>Processing size (percentile)</th>
<th>Elasticity (1)</th>
<th>Mean (2)</th>
<th>Maximum</th>
<th>OBS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall</td>
<td>Small (below 30)</td>
<td>Medium (30–70)</td>
<td>Large (above 70)</td>
</tr>
<tr>
<td>Elasticity (1)</td>
<td>1.0239***</td>
<td>1.0495***</td>
<td>1.0239***</td>
<td>0.9981</td>
</tr>
<tr>
<td>Mean (2)</td>
<td>0.9170</td>
<td>0.9672</td>
<td>0.9431</td>
<td>0.9170</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.1800</td>
<td>1.1800</td>
<td>1.0827</td>
<td>1.0807</td>
</tr>
<tr>
<td>OBS</td>
<td>1272</td>
<td>381</td>
<td>510</td>
<td>381</td>
</tr>
</tbody>
</table>

Note: Row (1) elasticities are evaluated at data means. Numbers in the parenthesis are standard errors and test statistics (null hypothesis: $e_{NRP,R} = 1$), respectively.

** Asterisks denote rejection of null hypothesis at 1%, 5%, and 10% levels, respectively. The farm cost curvature properties are thus satisfied at least at data means.

5.2. Testing for pricing and scale efficiency

Table 5a reports NRP elasticities with respect to raw-rice volume $R$, both for the entire sample and for small, medium, and large rice processing complexes. The overall elasticity, evaluated at data means via Eq. (23), is 1.024 and the null hypothesis that $e_{NRP,R} = 1$ is rejected at the 1% significance level (upper-tail test, $t$-statistic = 2.40). Thus, overall NRP elasticity statistically exceeds unity. If and only if $NMRP$ exceeds $NARP$ to the left of maximum NARP (Fig. 2) does the NRP elasticity exceed unity:

$$\frac{\partial NRP}{\partial R} > \frac{NRP}{R} \quad \text{so that} \quad \frac{\partial NRP}{\partial R} \times \frac{R}{NRP} = e_{NRP,R} > 1. \quad (29)$$

In the representative or average-sized cooperative, equilibrium thus appears to occur to the left of maximum NARP.

Identical tests were conducted for the small-, medium-, and large-cooperative subsets, in which—for the simplicity of using equal-interval categories—the lowest 30% is regarded as small, the 30th to 70th percentile as medium-sized, and the 70th to 99th as large. Estimated NRP elasticities in small and medium-sized cooperatives were 1.050 and 1.024, respectively (Table 5a). In both, the null hypothesis of unitary NRP elasticity is rejected at 1% significance (upper-tail test, $t = 3.47$ and 2.41, respectively). Hence, and again following the logic of Eq. (29), we can conclude that small and medium-sized cooperatives operate, like the average one, to the left of maximum NARP as depicted at point F in Fig. 2.

In large cooperatives, however, we fail to reject the null hypothesis of unitary NRP elasticity ($t = -0.11$), suggesting, as in Clark’s (1952) result, that only large entities achieve the efficient equilibrium indicated in Fig. 2’s point H. This large-cooperative equilibrium is the same as IOF profit-maximizing behavior under free-entry long-run conditions. Provided they use nonraw-rice processing inputs optimally, large processing centers therefore operate at an efficient scale as well as price, maximizing the full price paid farmers. Such result is consistent with Ariyaratne et al. (2000), who find large Great Plains grain marketing and supply cooperatives to be more scale efficient than smaller ones are. Sexton et al. (1989) suggest California cotton ginning cooperatives similarly operate near maximum NARP, their NRP’s mean elasticity with respect to raw cotton volume being almost unitary at 1.0095.

That small and medium cooperatives and, unexpectedly, the average one operate to the left of maximum NARP, and that large cooperatives are found at the maximum itself, have a common implication: the Ohm-LeVay and Helmberger-Hoos equilibria—Hypotheses (2) and (3)—are rejected. Korean agricultural cooperatives, including those working together to operate rice complexes, do maintain the open-membership policies normally thought conducive to an Ohm-LeVay or Helmberger-Hoos solution. On the other hand most Korean rice farmers do not, as the Helmberger-Hoos model supposed, deliver their entire output to one cooperative. They sell to others in the province.
is concave. We test this as-
exceeds
in our data, namely whether point I in Fig. 2 involves
at given
is upsloping and
(A) and (B) are rejected at 1% significance in a two-tail test. Asterisks
= mean
= (C) is rejected at
= (ton) (B) 9,581.30 (5,263.02) 5,074.37 (1,626.06) 8,598.27 (1,824.01)
=equals
= (D) are rejected at, respectively, 10% and 1% significance in a lower tail test. Asterisks
NARP
= (C) 11.66
= (D) 27.71
= (ton) (D) 9,717.34 (3,385.13) 8,671.43 (2,870.76) 9,669.78 (2,990.33)
= Rows (A), (B), (C), and (D) show mean raw-product deliveries, where parenthesized numbers are standard deviations. Asterisks
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−46.63∗∗∗
−41.27∗∗∗
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1–4, and means difference tests in rows 5–9, of Table 5b.
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5.3. Interpreting cooperative scale inefficiency

These results collectively imply that the mean Korean cooperative rice processing complex—and small and medium-sized ones in particular—do not succeed in minimizing unit cost. The inoptimality is tied to their underutilization of raw rice, likely because of their failure to adequately adjust to the decline in rice production and consumption during the past two decades. Rice processing complex construction began in 1991 and almost 70% of the centers were in operation by 1995. Their capacity at the time of construction probably coincided with current demand. For instance, average consumption and production during the three years prior to rice complex construction (1988–1990) were, respectively, 5.134 and 5.852 million tons. Since then, consumption has fallen by about 30% and production by 20%. In particular, consumption during the 2007–2009 period was only 3.673 million tons and production only 4.722 million tons (Korean National Statistics Office, Korean Ministry of Food, Agriculture, Forestry, and Fisheries). The average rice-processing complex thus appears to be suffering from over-capacity.

In contrast, the larger complexes have processed the equilibrium rice quantities depicted at OJ in Fig. 2. In particular, we fail to reject the null hypothesis of no difference between a large cooperative’s mean actual deliveries \( \bar{R} \) and equilibrium \( R_{\text{NARP}} \) (Table 6). Hence, only large cooperatives appear to employ a processing-cost-minimizing volume of raw rice and to pay a raw-rice price that would call forth such quantity.

5.4. Policy implications

Consider now the small and medium-sized cooperatives, which operate to the left of maximum \( NARP \). The up-sloping \( NARP \) curve these firms face implies a down-sloping average processing cost curve. That is, unexploited scale economies are present because average processing cost falls as raw-rice quantity rises. The interest-free short-term loans granted these cooperatives to buy members’ raw-rice serves, as we have said, to shift their \( NARP \) functions upward. Thus we can assume that our estimated \( NARP \) function rests, in Fig. 2’s low-maximum, clearly are not eliminated. That LR test suggests cooperative equilibrium occurs where \( S(R) \) intersects \( NARP \) to the left of maximum \( NARP \) (see Appendix).

### Table 6

<table>
<thead>
<tr>
<th>Processing size (percentile)</th>
<th>Overall</th>
<th>Small (below 30)</th>
<th>Medium (30–70)</th>
<th>Large (above 70)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual ( \bar{R} ) (tons) (1)</td>
<td>6,690.26</td>
<td>3,391.35</td>
<td>5,911.46</td>
<td>11,031.65</td>
</tr>
<tr>
<td>Equilibrium quantity (tons) (2)</td>
<td>( R_{S=R=\text{NARP}} )</td>
<td>( R_{S=R=\text{NARP}} )</td>
<td>( R_{S=R=\text{NARP}} )</td>
<td>( R_{\text{NMRP}=\text{NARP}} )</td>
</tr>
<tr>
<td>( t )-statistic (3)</td>
<td>-41.27***</td>
<td>-27.37***</td>
<td>-38.92***</td>
<td>0.79</td>
</tr>
<tr>
<td>OBS</td>
<td>1,272</td>
<td>381</td>
<td>510</td>
<td>381</td>
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</tbody>
</table>

Note: Rows (1) and (2) give mean values; numbers in the parenthesis are standard deviations. Row (3) is the test statistic of the difference between the means in rows (1) and (2). The null hypothesis is (1) = (2). ***Alternative hypothesis, namely (1) < (2), is accepted at 1% significance in a lower tail test.

6 The falling-short of actual below predicted raw rice deliveries suggests the raw-rice supply intercept estimate in Table 3 is negatively biased, namely that mean marginal farm cost is greater than what Table 3 represents. Some marginal farm costs—such as of owner effort—appear to be missing from our data. Had they been available, our conclusion that small- and medium-sized cooperatives undershoot the efficiency-maximizing equilibrium would have been even stronger than we presently draw.

7 Mergers reduced the number of cooperative RPCs, from 200 in 2002 to 166 in 2008.
after the merger \( \varepsilon_{NRP,R} = 0.997, t = -0.16 \). Moreover, on the basis of a lower-tail test \( (t = -18.76) \), pre-merger actual deliveries \( R \) were significantly lower than at the observed equilibrium \( (R_{SR} = NARP) \). Yet we fail to reject the null that actual deliveries equaled \( R_{NM} = NARP \) after the merger \( (t = 1.44) \). In sum, evidence suggests that promoting mergers effectively improved overall cooperative efficiency.

6. Summary and conclusions

The objective of this study has been to assess raw-rice pricing and scale efficiency in Korean cooperative rice processing complexes and, where appropriate, to identify ways of improving such efficiency. For this purpose, we used 2002–2008 revenue and cost data in 166 processing cooperatives to estimate net revenue product functions, and 2002–2008 farm cost data in eight provinces to estimate farmer-member rice cost functions. Combining net revenue product with farm supply information, we then tested alternative cooperative equilibria by comparing actual deliveries with those deduced from the farm marginal cost, net average revenue product \( (NARP) \), and net marginal revenue product \( (NMRRP) \) functions. The comparisons were conducted separately for small, medium, and large cooperative processing operations.

On the basis of their observed behavior, large cooperative rice processing complexes appear strongly to operate at the Clark equilibrium—where marginal farm cost intersects maximum \( NARP \)—and hence to be efficient raw-product pricers. Small and medium-sized cooperatives, and the average one in our sample, on the other hand resist both the Clark and Ohm-LeVay equilibria, attracting rice supply quantities that equate farm marginal cost to \( NARP \) at the left of the \( NARP \) maximum.

Because they undershoot rather than overshoot the \( NARP \) maximum, these latter solutions resist the Helmberger-Hoos equilibrium as well, despite equating farm supply with \( NARP \) as Helmberger and Hoos postulated. In any event, only the large cooperatives appear to employ their members’ raw products efficiently.

Wollni and Zeller (2007) and Bernard et al. (2008) show cooperative membership can boost farmer output prices. Assuming, nevertheless, that Korean rice cooperatives are output price takers, their operation below the maximum of an upward-sloping \( NARP \) function implies the presence of unexploited processing scale economies. Small and medium firms thus operate, on average, at inefficient scale, depressing implicit raw-product prices below what they might have been. Improving that efficiency will require reducing capacity and rationalizing the number, sizes, and locations of their processing and handling facilities. Much of that rationalization will involve retiring excess capacity or re-allocating it to such specialized uses as drying or storage.

As government economic policy has become more market-oriented and preferential treatment of cooperatives curtailed, Korean rice markets have become increasingly competitive. Rice imports under the URAA minimum-market-access provisions have expanded and rice demand simultaneously fallen, inducing excessive rice supplies. Cooperative mergers targeted toward more efficient raw-rice use and scale appear to be the only effective way of meeting this competitive challenge from the noncooperative sector. We do in fact find evidence that post-merger rice processing complexes have moved in the direction of an efficient equilibrium, where net average revenue product is maximized.

Cooperative efficiency depends upon, in addition to operating volume, such structural factors as member delivery contract terms, capital subscription and retirement plans, and the distribution of voting rights (e.g., Cook, 1995). We have not examined these important questions. But it is worth noting that a transition from small to large cooperative operations tends to increase the diversity of member farm sizes and structures and of member ages and financial incentives. Such heterogeneity may create its own strains on cooperative efficiency, possibly dampening the benefits of cooperative merger.

Appendix: Robustness Test for Aggregate Scale Efficiency

The following procedure was used to check for robustness of our finding that the full-sample cooperative equilibrium occurs away from the \( NARP \) maximum. This robustness test is motivated by noting that, if raw-product volume \( R \) is selected in the way an IOF would optimally do, it should be included as one of the shares in Eqs. (14)–(17). We examine whether the mean cooperative treats raw product as a share along with labor, capital, energy, and materials by conducting a log-likelihood ratio test, following Boyle’s (2004) application in Conrad and Unger (1987). For this test, we specify two different systems. The first
is an NRP-maximizing system for competitive firms and the other an ad hoc one (Boyle, 2004). If cooperatives maximize NRP by setting raw-rice price \( r \) optimally as competitive IOFs do under free entry, raw-rice share

\[
\frac{R}{\text{NRP}}_{jlt} = a_r + a_{lr} \ln (w)_{lt} + a_{sr} \ln (v)_{lt} + a_{er} \ln (e)_{lt} + a_{sr} \ln (s)_{lt} + a_{rr} \ln R_{lt}
\]  

(A.1)

can be added to NRP system (13)–(17) because, by Hotelling's lemma, it constitutes one of the NRP-maximizing input demands.

As noted earlier, cooperatives buy raw rice at a transfer price approved by their boards of directors and initially pay that price to members. Thus, raw-rice cost \( rR \) is measured as each cooperative's expenditure for rice purchases, deflated here by the Korean index of prices received by farmers (2005 = 100).8 As the alternative to the above null hypothesis, we replace (A.1) in the estimation system with

\[
\frac{R}{\text{NRP}}_{jlt} = \gamma_r + \gamma_{lr} \ln (w)_{lt} + \gamma_{sr} \ln (v)_{lt} + \gamma_{er} \ln (e)_{lt} + \gamma_{sr} \ln (s)_{lt} + \gamma_{rr} \ln R_{lt}
\]  

(A.2)

The resulting alternative system, which we will call the unrestricted one, thus consists of Eqs. (13)–(17), and (A.2).

Parameters in (A.2) are independent of parameters \( \alpha \) in (13)–(17) and (A.1). The number of parameters is 28 in the restricted system and 34 in the unrestricted system because cross-equation linear parametric restrictions are applied to (A.1) but not to (A.2). Based on SUR estimates of the two systems, we conduct an LR test in which \( \chi^2 (n = 6) = -2[\ln L(r) - \ln L(ur)] \), where \( n \) is the number of restrictions and \( \ln L(r) \) and \( \ln L(ur) \) are the log-likelihood values of the restricted and unrestricted estimates, respectively. If we reject the null, aggregate cooperative pricing occurs where \( S(R) \) intersects NARP away from the NARP maximum.

Table A1 reports the estimation results of the two systems. Parameter estimates are mostly significant and model explanatory power is high (\( R^2 = 0.99 \)) in each. FGLS estimators in the restricted and unrestricted systems are each asymptotically efficient because in the B-P LM test \( \chi^2 (15) = 3,932.50 \) and 5,154.22, respectively] we reject the null that disturbances in input-share equations are independent of one another. Monotonicity is satisfied, and convexity is satisfied at least at data means. The log-likelihood ratio \( \chi^2 (6) = 756.04 \) is high, rejecting the null hypothesis at 1% significance. Together with our test result for Hypothesis (1), this LR test thus confirms our finding that means cooperative volume is scale-inefficient.

Table A1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NRP-maximizing (restricted)</th>
<th>Arbitrary (unrestricted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_l )</td>
<td>-0.4068*** (0.0178)</td>
<td>-0.3732*** (0.0175)</td>
</tr>
<tr>
<td>( \alpha_k )</td>
<td>-0.2149*** (0.0166)</td>
<td>-0.2133*** (0.0147)</td>
</tr>
<tr>
<td>( \alpha_l )</td>
<td>-0.0382*** (0.0162)</td>
<td>-0.0464*** (0.0129)</td>
</tr>
<tr>
<td>( \alpha_s )</td>
<td>-0.2837*** (0.0206)</td>
<td>-0.2633*** (0.0209)</td>
</tr>
<tr>
<td>( \alpha_{lk} )</td>
<td>-0.0297*** (0.0011)</td>
<td>-0.0283*** (0.0010)</td>
</tr>
<tr>
<td>( \alpha_{ls} )</td>
<td>-0.0717*** (0.0010)</td>
<td>-0.0692*** (0.0008)</td>
</tr>
<tr>
<td>( \alpha_{lr} )</td>
<td>0.0043** (0.0002)</td>
<td>0.0007 (0.0001)</td>
</tr>
<tr>
<td>( \alpha_{sl} )</td>
<td>-0.0225*** (0.0014)</td>
<td>-0.0223*** (0.0012)</td>
</tr>
<tr>
<td>( \alpha_{sr} )</td>
<td>-0.0009 (0.0010)</td>
<td>0.0017* (0.0009)</td>
</tr>
<tr>
<td>( \alpha_{es} )</td>
<td>-0.0043*** (0.0010)</td>
<td>-0.0015*** (0.0007)</td>
</tr>
<tr>
<td>( \alpha_{tl} )</td>
<td>0.0053** (0.0010)</td>
<td>0.0042*** (0.0009)</td>
</tr>
<tr>
<td>( \alpha_{ts} )</td>
<td>0.0075*** (0.0019)</td>
<td>0.0016 (0.0015)</td>
</tr>
<tr>
<td>( \alpha_{ts} )</td>
<td>-0.0027*** (0.0010)</td>
<td>-0.0016*** (0.0009)</td>
</tr>
<tr>
<td>( \alpha_{lt} )</td>
<td>0.0007 (0.0009)</td>
<td>0.0009 (0.0007)</td>
</tr>
<tr>
<td>( \alpha_{rt} )</td>
<td>1.0799*** (0.1068)</td>
<td>1.5970*** (0.1420)</td>
</tr>
<tr>
<td>( \alpha_{tr} )</td>
<td>0.0286*** (0.0116)</td>
<td>-0.0350*** (0.0162)</td>
</tr>
<tr>
<td>( \alpha_{sr} )</td>
<td>0.0281*** (0.0013)</td>
<td>0.0264*** (0.0013)</td>
</tr>
<tr>
<td>( \alpha_{ls} )</td>
<td>0.0196*** (0.0011)</td>
<td>0.0176*** (0.0010)</td>
</tr>
<tr>
<td>( \alpha_{ls} )</td>
<td>0.0066*** (0.0011)</td>
<td>0.0051*** (0.0009)</td>
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<tr>
<td>( \alpha_{lr} )</td>
<td>0.0191*** (0.0015)</td>
<td>0.0171*** (0.0015)</td>
</tr>
<tr>
<td>( \gamma_{sr} )</td>
<td>4.4338** (0.2503)</td>
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</tr>
<tr>
<td>( \gamma_{lr} )</td>
<td>0.0280 (0.0179)</td>
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<tr>
<td>( \gamma_{sr} )</td>
<td>0.4062** (0.0717)</td>
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<tr>
<td>( \gamma_{lr} )</td>
<td>0.0400 (0.0212)</td>
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<tr>
<td>( \gamma_{sr} )</td>
<td>0.4874*** (0.0662)</td>
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<tr>
<td>( \gamma_{lr} )</td>
<td>0.0181 (0.0172)</td>
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<tr>
<td>Constant</td>
<td>2.7969*** (0.5139)</td>
<td>4.9143*** (0.6435)</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.9995</td>
<td>0.9995</td>
</tr>
<tr>
<td>Breusch-Pagan LM test ( \chi^2 (15) )</td>
<td>3,932.50</td>
<td>5,154.22</td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>17,507.3</td>
<td>17,885.3</td>
</tr>
<tr>
<td>Log-likelihood ratio: ( \chi^2 (6) )</td>
<td>756.04</td>
<td></td>
</tr>
</tbody>
</table>

Note: *, **, ***Statistical significance at 10%, 5%, and 1%. Parenthesized numbers are asymptotic standard errors. Null hypothesis in the Breusch-Pagan LM test is that equation disturbances are independent. For convenience, estimates of provincial dummy variables are not included in the table.

References


Clark, E., 1952. Farmers cooperatives and economic welfare. J. Farm Econ. 34, 35–51.


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8 Note that cooperative price \( r \) of raw rice is not generally the same as that paid by investor-owned firms.


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Ohm, H., 1956. Member behavior and optimal pricing in marketing cooperatives. J. Farm Econ. 38, 613–621.


