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Evaluating a New Payment System for a Processing Cooperative

by

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This paper examines the potential benefits of introducing a new payment scheme in a sugarcane processing cooperative. Findings suggest that a use-value payment system would increase individual and total members' net returns significantly over a sugar-based system. The proposed payment system would change the incentive structure so varieties with higher processing quality would become more appealing. In addition, the cooperative plant would be used more uniformly throughout the processing season and payments to members would be more consistent with their contribution to cooperative surplus.

Given the current farm crisis, the changing structure of the U.S. food industry, and a reduction in government intervention in agricultural markets, there is pressure for increased efficiency in cooperatively organized farm businesses through improved organization and coordination among members (Duft; Kraenzle; Torgerson and Ingalsbe). In addition to increasing efficiency, the method of organization and coordination can affect the equity with which the cooperative treats its members relative to one another. Member conflicts about operation of the cooperative plant may arise over issues of cross-subsidization, the quality of raw products, and the use of limited plant capacity.

Among cooperative arrangements that shape efficiency and equity is the manner by which members are compensated for their deliveries (charged in a supply cooperative), i.e., the payment system. As shown by Lopez and Spreen (1984), alternative payment systems for cooperative members may generate substantial differences in cooperative performance.

Zusman; Lopez and Spreen (1985); and Sexton show that optimal (maximum total members' profits) cooperative operation is not attainable under members' price-taking behavior. These studies, however, base their analyses on product homogeneity, which ignores the complexities embodied

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in alternative payment systems in cooperatives. Other studies on pooling schemes for members' products have not incorporated members' production response to changed payment schemes. This naively assumes payments will not change members' production choices (see Buccola and Subaei).

The purpose of this paper is to provide an empirical framework for evaluating payment systems in cooperative organizations while incorporating members' strategic behavior to changed payment systems. The model is demonstrated using Florida sugarcane processing cooperatives as a case study. Although this paper draws on the work of Lopez and Spreen (1984), several new features are introduced. In particular, this paper presents additional results, including sensitivity analysis of solutions to parametric changes in cooperative membership structure and raw product quality, and more accurate solutions. In addition, the paper illustrates the network flow solution procedure used, links the problem to the more general class of pooling problems, and gives a substantial discussion of payment systems adoption beyond the allocative efficiency (total members' net returns) criterion.

Payment Systems and Members' Production Choices

Payment systems refer to the computation of payments to members for their deliveries. The objective in selecting a payment scheme is to provide incentives to members, who individually may be attempting to maximize profits, and to treat them equitably.

The first step in establishing a payment system is the determination of the basis for patronage, i.e., what unit or rule is to be used as the criterion to allocate payment to members (or charge in a supply cooperative). To do so, a marketing or processing cooperative must first identify the raw product characteristics that affect the "actual" contribution of each member. Some of these characteristics are: (1) volume delivered, (2) quality of products delivered, (3) time of delivery, (4) producer location, and (5) services required from the cooperative. Ideally these factors should be taken into account for payment to members. In one extreme, a truly equitable method of payment may prove disadvantageous to members because of high implementation costs and may result in increased risks. On the other hand, a complete pooling in favor of a flat price for the raw product may distort the price signal sent to members and ultimately result in inefficiency in the cooperative operation.

Cooperatives often resort to pooling, a process of averaging costs and returns, in establishing payments. The degree of pooling, then, refers to the extent of boundaries in characteristic space in which average costs and returns are applied, thus establishing a price for products within given quality boundaries. Commonly, grades are established in marketing cooperatives for payment purposes (Sosnick; Buccola and Subaei). This paper discusses a particular illustration of the pooling problem that is pervasive in agricultural cooperatives. In essence, although pooling may be an administratively convenient way to arrange financing, it may send inappropriate price signals to growers and engender cross-subsidization among them. The problem is most obvious for cooperatives that market or process multiple commodities, but it also is important when there are quality differentials for a single commodity as in the case examined in this paper. A major shortcoming of previous work on pooling is that it has ignored members' supply response when alternative pooling schemes were considered (see Buccola and Subaei).

To illustrate the problem, consider the case of sugarcane processing cooperatives, which provides a classical example of processing cooperatives.[1] Florida sugarcane cooperatives process and convert members' sugarcane into sugar. The decisions and tasks to be performed by the grower and the cooperative are as follows. The grower has control over preharvest decisions such as variety selection, planting, and other agronomic activities. The cooperative is responsible for harvesting, transporting the cane from the field to the mill, processing, and selling the jointly produced sugar.

In the payment system currently used by Florida cooperatives, cooperative surplus (cooperative revenues minus cooperative costs excluding members' payment) is divided by the total amount of sugar giving a "price" per ton of sugar.[2] At the end of the harvest season, a cooperative's revenues from the sale of sugar are totaled. Cooperative costs accrue from the operation of the mill, harvesting, and transportation of the cane. The payment to an individual grower is determined by the product of sugar tons delivered by that grower times the price per ton of sugar.[3]

In the current payment system, all processing, harvesting, and transportation costs incurred by the cooperative are pooled. One perspective is that costs should be shared by grower-members in proportion to the sugar tons delivered by individual members. Another perspective is that, although this system appears to be fair, it may not promote efficient utilization of the resources of the cooperative. For example, certain varieties of sugarcane possess superior milling qualities while others are high in fiber content and cost the cooperative more to process. Under the current payment system, a grower is not directly rewarded for selecting a readily millable variety.

Meade and Chen suggest an alternative payment system based on "use value."[4] With a use-value payment system, all costs that can be assigned to a particular field are deducted from the payment for the cane delivered from that field. To figure the payment to a particular delivery, the yield of sugar is multiplied by the price of sugar received by the cooperative and the costs of harvesting, processing, and transporting the cane are subtracted. The net figure gives the "use value" of that delivery. Processing costs could be estimated by the time required to process the cane for each field. Harvest costs would be estimated as before, and transportation costs would depend on the volume of cane and distance from the mill. Other costs of the cooperative, such as administration, plant and equipment repairs, and interest, would be shared in some equitable manner, as on the basis of tons of sugar delivered or acreage, or they could be prefixed by arrangement. In other words, additional accounting and administrative costs are not a major constraint to implementing a use-value payment system in this case.

A Model of Processing Cooperatives

The effect of a new payment system will depend on how the system affects the production choices of individual members and collective utilization of the processing plant. Analysis of the problem must entail simultaneous consideration of both levels. An appropriate methodology for this situation is a multilevel programming problem (Candler, Fortuny-Amat, and McCarl). At the lower level, individual members seek maximum net returns given a payment system and their individual delivery quotas. At another level, the cooperative schedules the harvest to maximize the total net returns of all members given variety selection by individual growers has been completed.

In the case of sugarcane cooperatives, there are a number of alternative varieties a grower may select for planting. Different varieties imply different strategies available to the grower with varying effects on the performance of the individual and the cooperative. There are at least four reasons for variation in the value-added (surplus) generated by each variety. Varieties differ by: (1) tons of cane produced per acre, (2) sugar content, (3) time required for processing, and (4) growing cost. Furthermore, cane yield and sugar content vary throughout the processing season.

When one considers other crops that involve processing cooperatives, the production alternatives available to the grower may take different forms. In dairy farming, for instance, it may be a choice among different breeds of cows that involves varying production of raw milk, fat content, and costs. Choices may involve entire systems of production.

Define Y_{iftv} as the amount of sugarcane delivered by member i, from field f, in processing period t, planted with variety v, where i, f, t, and v are finite. Given a payment system k (e.g., use-value or sugar-based), the member's problem is to select a variety so that

$$\pi^k_{ift} = \text{Maximum}(PAY^k_{iftv}, -C_{ifv}), \tag{1}$$

where PAY^k_{ift} denotes payment to the members from delivery of Y_{iftv}, C_{ifv} is the grower's cost of producing Y_{iftv}, and π^k_{ift} is the maximum attainable net revenue to a field from selecting a variety. Let Y^*_{ift} denote the solution to the problem in equation (1). In the second step of the model, after varieties have been chosen by members for each field and delivery period, the cooperative maximizes net returns to members.

Like other processing cooperatives, sugarcane processing cooperatives face the problem of determining the best use of limited processing capacity.[5] Hence, members' delivery quotas (herein referred to as "members' quotas"), in effect throughout the processing season, are imposed to ensure equitable use of the cooperative plant. The need for members' quotas is increased by the way members currently are paid. Because members are paid according to sugar delivered and sugar content is greatest at the end of the season, members would attempt to deliver their cane as late as possible in the absence of members' quotas. Perishability of the raw product and limited processing capacity make this situation undesirable from the cooperative's perspective.

In short, members' quotas constrain members to send deliveries in such a way that total deliveries during the processing season are scheduled proportionately across members and over time. Two types of quotas are needed. First, minimum quantity requirements are necessary to protect the cooperative from high operating costs due to inadequate volume. Second, upper bounds in members' deliveries may be necessary to ensure that members' volume will not exceed the cooperative plant capacity. For the sake of simplicity, members' quota arrangements are taken as given in this paper.

Define the processing plant upper and lower capacity as M_t^u and M_t^l and member i's upper and lower quotas as Q_{it}^u and Q_{it}^l. To avoid redundancy, define quotas such that $M_t^u = \Sigma_i Q_{it}^u$ and $M_t^l = \Sigma_i Q_{it}^l$. Then the cooperative problem is to maximize

$$\Sigma_i \Sigma_f \Sigma_t d_{ift} \pi_{ift}^k \quad \text{Total Members' Profits} \tag{2}$$

subject to:

$$Q_{it}^l \leq \Sigma_f d_{ift} Y^*_{ift} \leq Q_{it}^u \quad \text{Members' Quotas and Mill Capacity} \tag{3}$$

where d_{ift} is a choice variable that equals one if field f of member i is harvested in time t and is zero otherwise. Further, if d_{ift} is zero for all t, that field is left idle because it is unprofitable and unnecessary for filling quota requirements. In summary, the set of d_{ift} in the solution of the problem will specify a harvesting schedule for the current processing season, varieties grown, and area of cane planted by each of the members. The processing cooperative model in equations (2) and (3) is a constrained optimization problem. The objective of the model is to maximize total members' profits subject to the limitation of milling capacity and delivery quotas. Deliveries are evaluated according to the payment system instituted by the cooperative, assuming individualistic behavior by members in equation (1).

Data and Solution Procedure

To make this model operational, its parameters must first be estimated. These parameters consist of the price of sugar (the finished commodity), sugar yields (percent recoverable sugar [PRS] and cane tons per acre), cooperative (processing, transporting, harvesting, and fixed) and members' production costs, and parameters concerning the structure of the cooperative such as members' sizes and productivities, a measure of processing capacity and usage, and the relevant processing and payment arrangements among members. Data sources and parameter estimates used in this paper relied primarily on a study by Lopez.

Primary data on varieties, fields of cane, size of the cooperative, and processing capacity were obtained from a cooperative operating in southern Florida. Statistical models were used to predict sugar content and tons of cane per acre on a field basis for the different varieties, processing periods, and members of the cooperative. The field data used to estimate sugar and cane yields consisted of 4,500 cross-section and time-series observations.

The processing season was divided into five periods, each comprising four weeks, within which the growers' quotas and mill capacity were defined. The cooperative under study had a capacity of one million tons of cane per season. To simplify the structure of the problem, membership of the cooperative was assumed to consist of five randomly selected growers, each owning 160 fields. The total tonnage that accrues to each member was divided by the number of harvest periods to obtain a point estimate for the delivery quota. A ±20 percent interval was used to specify the upper and lower members' quotas.

The price of sugar was set at its 1980–82 average of $480 per ton (U.S. Department of Agriculture). Harvesting costs per ton and transportation costs were taken from the accounting books of the cooperative for its 1981–82 harvest season. Estimates of variable and fixed processing costs per ton were obtained from the U.S. Department of Agriculture. Total fixed cooperative cost was obtained by multiplying the fixed cost per ton times the mill capacity. The variety indices computed by Miller and James for southern Florida were used to estimate the processing cost per variety of cane. Some noncooperative mills in the area used these indices to adjust payment to independent growers of sugarcane. A total of five varieties were used in the model. A summary of average costs and yields for these varieties is presented in table 1.

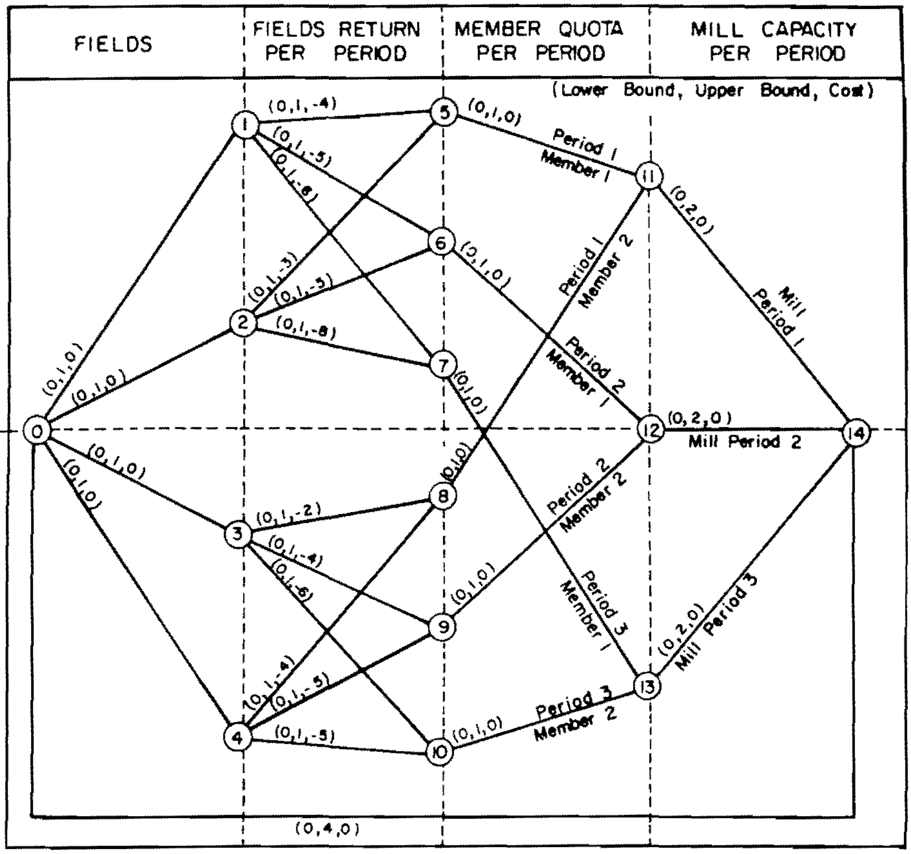
The problem represented by equations (2) and (3) was solved as a network flow problem (Hu). To illustrate the problem, consider the following example. Assume a cooperative with two members where each member has two fields of sugarcane; the fields' values differ during three processing periods. Also assume that members' net returns for each delivery possibility are determined according to an already chosen use-value or sugar-based payment system. The network flow structure of the problem is illustrated in figure 1. Let N_i ($i = 0, \ldots, 14$) denote the set of nodes (circles in figure 1) and X_{ij} the arc between nodes N_i and N_j. The cooperative's problem is to maximize total net returns from sending flows (deliveries) from a source node (N_o) to a sink node (N_{14}) while satisfying the arc ca-

Table 1.—Processing Costs, Growing Costs, Cane Tons Per Acre, and Percent Recoverable Sugar (PRS) for Five Varieties of Sugarcane

Variety	Processing Cost Per Ton	Growing Cost Per Ton	Cane Tons Per Acre	PRS[a]
A	$7.59	$436.50	49	9.3
B	7.72	360.00	37	10.0
C	8.37	315.00	37	9.1
D	8.37	495.00	36	9.3
E	6.54	450.00	34	9.6

[a]PRS shown is the average for the processing season. PRS varies with period of harvest.

Figure 1.—Network of the Example Problem



pacities between them (mill capacity and delivery quotas). The values in parentheses next to each arc represent its lower and upper bounds and net returns to the arc.

The problem of Florida sugarcane cooperatives was solved using 800 fields, 5 members, and 5 harvest periods—hence 832 nodes and 4,831 arcs—using an out-of-kilter algorithm (Ford and Fulkerson). The algorithm was written in FORTRAN code for the DEC VAX-11/780 computer and used 31 minutes of central processing unit time for a typical run. Solution results and implications are presented in the following section.

Implications of the Proposed Payment System

Table 2 presents some performance measures computed from the solution of the problem presented in equations (1), (2), and (3). A use-value payment system leads to greater total net returns for members and, in this case, greater net returns to each individual member. Payment based on

Table 2.—Some Performance Measures for Sugar-Based and Use-Value Payment Systems in Florida Sugarcane Cooperatives[a]

Performance Criterion	Optimum Solutions Assuming	
	Sugar-Based Payment	Use-Value Payment
Totals:		
Net Returns	$ 2,308,997	$ 4,213,630
Cooperative Surplus	15,482,104	19,273,596
Cooperative Costs	13,173,107	15,059,966
Tons of Cane	906,080	952,751
Tons of Sugar	88,228	93,096
Payment Per Ton of Cane	$ 17.09	$ 20.23
Payment Per Ton of Sugar	175.48	207.03
Varieties of Cane (Percent of Area)	C (100)	C,B (74,26)
Individual Member's Net Returns:		
Member 1	$ 397,870	$ 640,317
Member 2	337,592	764,724
Member 3	549,921	1,090,173
Member 4	105,013	334,125
Member 5	918,601	1,384,291
Processing Plant Use (Tons of Sugarcane):		
Period 1	166,415	199,894[u]
Period 2	160,301ℓ	198,362[u]
Period 3	180,496	199,465[u]
Period 4	199,666[u]	174,049
Period 5	199,202[u]	180,981

[a]Upper and lower mill capacities of 200,000 and 160,000 tons of sugarcane were used for each processing period. A "u" or "ℓ" denotes binding upper or lower bound in terms of processing cane from an additional field (an integer unit) rather than an infinitesimal amount of cane.

sugar leads to total net returns of approximately $2.3 million while a use-value payment system increases members' total net returns 82 percent to approximately $4.2 million. The amount of both raw product (sugarcane) and finished product (sugar) is higher for the use-value system.

Table 2 also shows utilization of processing capacity throughout the processing season under both payment systems. Under the current payment system, members have an incentive to deliver cane as late as possible, as argued by Alvarez et al. In this case, lower quotas are necessary at the beginning of the season to ensure a viable processing volume for the co-operative plant. However, under a use-value payment system, this is not the case. A use-value payment system leads to greater capacity use at the beginning of the processing season and a steadier pattern of deliveries.

Higher total net returns to the members under a use-value payment system are due to a greater consistency of harvesting, planting scheduling, and variety selection. Table 2 shows that under a use-value payment system, members have an incentive to increase deliveries of sugarcane in the earlier part of the processing season. Also, variety B becomes profitable under a use-value payment system. As shown in table 1, variety B is cheaper to process but is more expensive to grow than variety C. Thus the extra benefits and costs of delivering variety B are explicitly taken into account in the use-value system.

In table 2, the net returns of all members increase under a use-value payment scheme. In other cases, there could be both gainers and losers from implementation of a use-value payment system. In these situations, the problem becomes more complicated, whether or not further payment schemes can be devised to compensate losers and still have surplus left for the gainers. Members' approval of a new payment system becomes a group decision-making exercise. Sexton; Zusman; and Staatz present theoretical discussions of cooperative decision making in analogous situations. The empirical decision framework developed by Buccola and Subaei is not applicable in this case because it does not include members' supply response and is based primarily on price risk of commodities, which is not an issue for cooperatives dealing with a single commodity such as sugar or milk where government intervention stabilizes the price.

As a case in point, it may be advantageous for a cooperative to pool transportation charges to ensure deliveries and the loyalty of members located far from the processing plant. If the cooperative is a locational monopoly, it might logically choose to absorb some of the transportation costs of distant members who might find it advantageous to switch to a sugar mill that waives transportation charges.

Sensitivity Analysis

The preceding section leaves questions regarding the sensitivity of performance to the structural parameters of the cooperative. In an attempt to address these empirical questions, selected scenarios were examined under alternative membership structures, variety selection, and processing cost indices. The model specifications are essentially the same as in the baseline case except for the parameters where change is specified.

Membership Homogeneity

Members were homogenized by making them equally productive. That is, members' coefficients in the yield and PRS prediction equations were made equal to those of member 1. To ensure homogeneity of sugarcane fields, all characteristics of a field that influence yields and costs were set equal to their sample averages (e.g., distance to the plant). Other parameters remained the same. The performance results for this scenario are presented in table 3.

The new payment system would enhance total members' net returns even if members were identical. The use-value payment solution generated approximately $4.6 million in total net returns while the sugar-based payment solution generated $3.2 million, which represents a comparative

Table 3.—Sensitivity Analysis Results for Alternative Membership and Raw Product Quality Parameters

Performance Criterion	Identical Members		New Cane Variety		Homogeneous Processing Quality	
	Sugar-Based Payment	Use-Value Payment	Sugar-Based Payment	Use-Value Payment	Sugar-Based Payment	Use-Value Payment
Totals:						
Members' Net Returns	$ 3,199,336	$ 4,544,406	$ 1,534,942	$ 4,764,032	$ 2,970,688	$ 4,214,334
Cooperative Surplus	15,071,260	19,119,933	12,455,166	20,050,680	16,360,727	19,421,480
Tons of Cane	933,205	987,090	921,922	1,002,033	919,142	988,227
Tons of Sugar	94,480	94,790	84,288	96,839	89,491	96,268
Payment Per Ton of Cane	$ 16.15	$ 19.37	$ 13.51	$ 20.01	$ 17.80	$ 19.65
Payment Per Ton of Sugar	169.82	210.63	147.81	207.03	182.83	201.74
Varieties of Cane (Percent of Area)	C (100)	C (100)	E (100)	E,C (81,19)	C (100)	C,B (85,15)
Individual Members' Net Returns:						
Member 1	$ 639,867	$ 913,281	$ 249,647	$ 744,216	$ 527,647	$ 762,981
Member 2	639,867	913,281	216,686	859,082	472,363	745,199
Member 3	639,867	913,281	376,777	1,190,640	685,145	1,009,766
Member 4	639,867	913,281	28,146	394,489	215,043	387,844
Member 5	639,867	913,281	633,688	1,575,606	1,070,590	1,308,544

aggregate loss of approximately $1.4 million. Production choices were the same across members, and they attained the same level of net returns with the same number of fields.

Alternative Quality Possibilities

The example varieties used in the model possess values consistent with the objective of the growers under the current payment system. However, when considering a new payment system, one should consider the possibility of a somewhat different selection of sugarcane varieties. Further, in the long run, a new payment system may encourage research in developing varieties more consistent with that payment system. As an inquiry into the sensitivity of performance of cooperatives to the spectrum of quality choice possibilities, two major modifications were introduced.

The first part of the inquiry focused on the introduction of a high-tonnage, low-sugar content variety compared with those in table 1. The new variety was introduced as a substitute for variety E, which was not selected in the previous solutions. For the new variety E, the PRS in table 1 was increased by 0.9 to 10.5, its growing cost was decreased by 30 percent to $315 per acre, and cane yield was decreased by 2 tons to 32 tons per acre. In other words, variety E was made less expensive to grow than before while producing the same amount of sugar. The results of these modifications are presented in table 3.

Note that the impact of a use-value payment system is magnified when variation in quantity-quality choices increases. The use-value payment generated approximately $4.7 million in total members' net returns. Payment based on sugar delivered generated total net returns of approximately $1.5 million, which represents a loss of nearly $3.2 million compared with the use-value payment solution. This loss is $1.3 million greater than in the baseline results.

The second part of the analysis of sensitivity of performance to the quality choice spectrum dealt with an alternative processing cost structure. Processing cost was assumed to be the same across varieties, thus implying no processing quality differentials. Processing cost was set such that the use-value payment solution yielded approximately the same level of total net returns as in the baseline results. Table 3 shows the results of setting processing costs equal across varieties.

In the case of less quality differential among the varieties, in terms of equal processing quality, the use-value payment scheme made less of an impact. A cooperative utilizing a use-value payment system achieved total net returns of approximately $4.2 million, $1.7 more than under a sugar-based payment system. In general, these results suggest that as quality differentials among varieties disappear, the impact of a use-value payment system on cooperative performance decreases.

Concluding Remarks

If these are representative results, why have sugar processing cooperatives not adopted use-value or similar payment systems? Two reasons are likely. First, because of government price support programs, there has not been as much pressure for efficiency in sugar cooperatives in the past.

This pressure is now increasing as government support for sugar declines. Under all sugar price support options currently being considered by Congress, the projected national average cost of producing cane sugar will exceed the support rate after 1987 (Womach). Institutions producing sugar, including cooperatives, will be viable in the long run only if they can reduce costs to below the support rate.

The second reason sugar processing cooperatives may not have adopted use-value payment systems is because of the accounting and administrative costs of implementing them. Computerized accounting has lowered the cost differences from implementing alternative payment schemes (Buccola and Subaei). As the cost of information technology decreases, the cost of monitoring and implementing a more sophisticated payment scheme also will decrease, thereby encouraging its adoption.

Notes

1. In many agricultural processing cooperatives, the role performed by the cooperative is the extraction of some substance from the raw product supplied by the members. Some examples are the extraction of raw sugar from sugarcane, oil and meal from soybeans, fat from milk, and juice from citrus crops.

2. Sugar is the product of percent recoverable sugar (PRS) times the tons of sugarcane delivered. The cane delivered is weighed before milling. During milling, the juice from the cane delivery is sampled for sucrose content to determine the PRS. Based on that result, the tons of cane are converted to "standard tons," which is the base for payment in Florida sugarcane cooperatives. One standard ton yields approximately 182 pounds of sugar (Meade and Chen).

3. Cooperatives pay an initial amount to patrons for deliveries and later refund the rest (patronage refunds) when the cooperative net savings have been determined. Although this and other types of financial arrangements are important, especially if members have strong liquidity preferences, they are not taken into account in this paper. VanSickle and Ladd, and Knoeber and Baumer address the implications of alternative financial structures.

4. A third payment system, which is common in many countries such as India (Meade and Chen), is based solely on the weight of sugarcane delivered. This payment system does not recognize sugar content or any other attribute of the cane that affects net savings of the cooperative and, hence, performance.

5. Polopolus and Lester report that limited processing capacity is pervasive in citrus processing cooperatives. Youde and Helmberger point out that 70 percent of surveyed cooperatives that restricted membership did it because of restricted plant capacity. Dairy cooperatives face a similar problem due to seasonality of production that results from climate and forage availability. If no member production quotas are imposed, the handling facilities must be of sufficient size to handle milk delivered during the peak production season, which may be cost prohibitive.

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