# Pool Payment Equity in Agricultural Marketing Cooperatives

by

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# Pool Payment Equity in Agricultural Marketing Cooperatives

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Marketing cooperatives often commingle farm products in a common payment pool. A member's receipts from a pool depend upon the method the cooperative uses for valuing raw product patronage. The present article examines alternative patronage valuation methods with particular regard to their effect on the distribution of pool income. Principles of distributive equity are discussed and conditions shown under which a valuation rule would be equitable in the senses defined. The discussion is illustrated with a pool consisting of snap beans and sweet corn. It is shown that valuation rules differ in the mean and variance of subsidies that they induce across products.

In an agricultural marketing cooperative, the service-at-cost principle implies members should receive the final-product value of their goods net of processing and handling cost. Cooperatives that physically segregate members' products during processing, or that operate a separate payment pool for each type and grade of raw product, can apply service at cost to each member once a method has been determined for allocating overhead expenses. However, few U.S. marketing cooperatives attempt to segregate members' products or to organize a separate payment pool for every homogeneous class of raw product. Most operate on a pooling basis, either by combining all products into a single payment pool or by conducting a group of pools (Davidson; Buccola 1982).

## Reasons for Pooling

Allocating net returns on a pool basis is especially convenient if the pooled products are commingled on the assembly line, as with feed mixes or vegetable blends. Pooling is useful also because it is a way of diversifying member risk. Since a pool's patronage refund rate varies with returns to all the pool's products, payments to each product vary with the income of every other product. Unless such returns are highly positively correlated with one another, individuals' income risks tend to be smaller than they would be in an unpooled accounting framework. Finally, pooling permits

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greater marketing flexibility because the cooperative need worry less about a single transaction's impact on a particular member group (Abrahamsen, pp. 370-1).

### Pooling and Service at Cost

It would seem, strictly speaking, that pooling violates the concept of service at cost: a pool cooperative cannot each year guarantee each member the net final-product value of his goods. Yet the spirit of cooperative organization—and federal tax law in particular—imposes no such literal compensation requirement. Section 521 of the 1951 Revenue Act requires for federal tax exemption that a cooperative turn back to members "the [net] proceeds of sales . . . on the basis of either the quantity or the value of the products furnished by them," leaving the cooperative to select the class of product returns from which a given product's payments are to be periodically calculated. Inasmuch as returns vary randomly, a reasonable service-at-cost principle for a pool cooperative is that each raw product receive its net sales proceeds on average. That is, risk diversification should not prevent each member from receiving, on average, his products' contribution to total pool return.

Frequent complaints that certain pool products "subsidize" others essentially are appeals to this generalized notion of the service-at-cost principle. In fact, the principle appears to embody the fundamental equity norm against which one may evaluate alternative pool allocation or payment systems. "Subsidy" problems often threaten a cooperative's existence or membership stability (Zusman; Staatz). Further, they probably represent an inefficient use of resources from society's standpoint. For these reasons, it is worthwhile exploring how and why violations of the service-at-cost principle arise in pools.

The present article examines alternative pool payment formulae with particular attention to the subsidy problem. The first section looks more carefully at pool payment structure and at ways of valuing raw product patronage. The second section discusses a pool's service-at-cost principle in more detail and outlines conditions under which the principle is or is not violated. The third section illustrates results by simulating various pool payment systems in a fruit and vegetable processing cooperative.

## Determining Pool Payments

Consider a pool consisting of J raw products, which the cooperative processes and sells. Let $R_j$ be the $j^{th}$ product's unit net return, that is, final product price less unit variable processing cost and an allocated share of factory burden and overhead cost. Costs debited from $R_j$ do not include raw product value, so "net return" or "return" in this paper signifies returns to raw product. If $Q_j$ is the quantity of the $j^{th}$ raw product members deliver to the cooperative in a given pool period, the pool's total net return is NR = $\Sigma R_jQ_j$ (unless otherwise noted, $\Sigma$ means $\sum_{j=1}^{n}$). Returns are not finally determined until the entire pack has been sold.

## Pool Payment Structure

The requirement (expressed for example in the 1951 Revenue Act) that such net returns be allocated according to patronage implies the cooperative must value or weight each unit of raw product delivered. Let $P_j$ be such a unit valuation—sometimes termed "economic" or "established" value—of the $j^{th}$ raw product. Then the share $S_j$ of net returns NR to be allocated to the $j^{th}$ raw product is:

$$S_j = \frac{P_jQ_j}{\Sigma P_jQ_j} \qquad (1)$$

A raw product's fractional pool share in equation (1) is the total established value of the product relative to the total established value of all products delivered during the pool period.

Eventual member payment $G_jQ_j$ for all the $j^{th}$ raw product delivered to the cooperative is the product's fractional pool share times total pool return:[1]

$$G_jQ_j = (S_j)\ (NR) = \frac{P_jQ_j}{\Sigma P_jQ_j} \Sigma R_jQ_j \qquad (2)$$

Often, the right-hand side of equation (2) is expressed in the form $(P_jQ_j)$ $(\Sigma R_jQ_j/\Sigma P_jQ_j)$, where $P_jQ_j$ is the $j^{th}$ product's patronage and $\Sigma R_jQ_j/\Sigma P_jQ_j$ is the rate at which net returns are refunded to all J products per dollar of patronage. Summing equation (2) over all J products gives $\Sigma G_jQ_j = \Sigma R_jQ_j$, implying the pool's net returns are completely allocated to members. Dividing equation (2) by $Q_j$ gives $G_j = (P_j/\Sigma P_jQ_j)\ (\Sigma R_jQ_j)$, showing that the $j^{th}$ raw product's unit payment depends not only on total pool returns but on the product's valuation $P_j$ relative to the valuations of the pool's other raw commodities.

## Raw Product Patronage Valuation

The latter fact underscores the importance of finding suitable ways of valuing a pool's raw product patronage. A survey by Buccola (1982) indicates horticultural processing cooperatives use one of three ways to determine patronage or established values $P_j$. Perhaps the most common method in pooling-type firms is to weight raw product deliveries by an estimate of their current "market price." A second method is to employ weights reflecting the raw products' identified characteristics such as color, sugar content, or size. Relationship between each characteristic and corresponding patronage values presumably is determined on the basis of the characteristic's mean impact on pool returns. The third method is to weight all products equally, that is, to apportion total pool returns according to physical mass or volume delivered. In addition, some cooperatives weight patronage partly on the basis of estimated unit cost of farm production (Hinkle).

Differences in valuation methods may be explained by differences in the numbers of pools the cooperatives operate, heterogeneity of their raw products, degree of external competition, and amount of information available. The more numerous the proprietary competitors or the more competitive the raw product, the stronger might be the case for market price weighting. The more stable and identifiable the relationship between a raw product's characteristic and its contribution to total net return, the greater is the incentive for quality weighting. The larger the number of pools, the more similar the products in a given pool tend to be and thus the greater might be the argument for equal weighting. If none of these methods adequately compensate key members or motivate them to participate in the pool, weights $P_j$ might be determined according to the goods' mean unit farm production costs.

Patronage valuation schemes useful for retaining key cooperative members are not necessarily the same as those that would satisfy a generalized service-at-cost principle. The balancing act cooperatives often undertake simultaneously to retain membership and to satisfy an equity ideal is influenced by members' market power and by the opportunities they perceive outside the cooperative. We concentrate here on the equity of alternative pool payment systems in light of the service-at-cost principle. Such equity is important in its own right as well as in its possible impacts on membership stability and composition.

## Service-At-Cost Equity Principles

Equation (2) shows that once a pool's product composition is known, the rule for allocating pool returns to individual products depends entirely on the method of valuing raw product patronage. It is natural to ask whether one could value patronage such that the service-at-cost ideal is always satisfied. Assuming pool net returns $\Sigma R_jQ_j$ are random and thus unknown at raw product delivery time, there actually is a weaker and stronger version of the service-at-cost principle. The weaker version is that each raw product receive, in the long run, the expected net proceeds attributable to it, namely, the product's expected contribution to pool net return:

$$E(G_jQ_j) = E(R_jQ_j) \tag{3}$$

all j.

Although this criterion ensures no product will subsidize another on average, it does not ensure the no-subsidy requirement will be satisfied over a given time horizon. Because returns are random, average payments to a product over a particular time interval also are random and cannot be guaranteed always equal to the product's expected net return. A member might, in other words, be assured there is no long-run subsidy without knowing he will live long enough to avoid a subsidy in practice. The stronger service-at-cost principle accounts for such risk by requiring that a sample average of a product's payments not deviate too far from the product's own expected net returns. Letting t be a given year and $n^o$ a selected number of years, the latter criterion requires that:

$$\sum_{t=1}^{n^o} G_{jt}Q_{jt}/n^o = E(R_jQ_j) \tag{4}$$

hold approximately for each commodity in the pool.[2] This criterion is consistent with the notion of pool inequity put forward by Sosnick. Either criterion (3) or (4) is contingent on the procedure for allocating the pool's overhead costs among individual products. Hence, neither is an adequate equity standard unless members accept the cooperative's overhead allocation practices.

## Satisfying Absolute Equity Standards

The strong equity criterion is perfectly satisfied by waiting until net returns $R_j$, $j = 1, \ldots, J$, are realized, then retroactively weighting each unit of raw product delivered according to its actual subsequent net return. To see this, set $P_j = R_j$ and substitute into equation (2), obtaining:

$$G_jQ_j = \frac{R_jQ_j}{\Sigma R_jQ_j} \; \Sigma R_jQ_j = R_jQ_j \tag{5}$$

A product's payment in a given year would, with this procedure, equal its actual net proceeds that year; hence, any sample average of payments always would correspond to the product's expected income. The problem is this would undermine pooling; it is equivalent to the practice of operating a separate payment account for every homogeneous group of raw products. Small wonder pool-type cooperatives have not resorted to retroactive weighting to solve their product subsidy problems.

Equation (5) does illustrate that a pool cooperative cannot guarantee a product will be paid its actual pool contribution $R_jQ_j$ in any arbitrary short run. Risk sharing requires one product benefit from another product's income in certain years. Criterion (4) defines over what time horizon $n^o$ the cooperative is willing to tolerate such subsidies on average. Clearly, as the horizon becomes large, the stronger criterion approaches the weaker one and criterion (4) protects member equity no better than does criterion (3). As the horizon becomes small, the cooperative must be able to forecast more accurately each product's net return contribution.

Inasmuch as a pool cooperative cannot value members' deliveries just on the basis of actual subsequent net returns, it must value deliveries according to forecasts of these returns. Indeed, the schemes discussed above for determining patronage weights $P_j$ essentially are ways of forecasting the products' subsequent contributions $R_j$ to pool income. This is not surprising, since generally speaking a good's commercial value is the expectation of returns it later will generate. The important issue for pool design is how the accuracy of such forecasts affects the equity of pool payments that derive from them.

The following theorem is particularly useful in this regard. Suppose that quantities $Q_j$ of all raw products delivered to the cooperative are known, or that these quantities are uncorrelated with one another and with unit net returns $R_j$. Then each product's pool payment on average will equal its contribution to pool net returns [satisfying weak equity criterion (3)] if and only if per-unit return forecasts used to formulate patronage values $P_j$ all are unbiased or are biased in the same proportion (Buccola 1987). A key aspect of this statement is that biased forecasts do not impair equity as long as each product's forecast tends to bear the same proportion to expected return as does every other product's forecast. The zero-sum nature of pool payments guarantees that only relative patronage values matter.

The condition in the preceding paragraph that delivery quantities be known or uncorrelated with one another and with unit returns is sometimes realistic. Delivery quantities are known when the cooperative assigns patronage weights $P_j$ if (1) the weights are assigned after harvest or (2) member delivery contracts are expressed on a tonnage rather than on an acreage basis. Even if contracts are expressed on an acreage basis or patronage weights are assigned before harvest, product delivery volumes would have no effect on unit returns if the cooperative's unit cost function is flat and it sells into a competitive final product market. Of course, these latter conditions are often violated and, when they are, equal proportionate biases in unit return forecasts do not guarantee even weak equity. Bias does not take into account differences among products in the correlation between unit return and delivery quantity; these correlations affect raw products' net return contributions.

## Satisfying Relative Equity Standards

The relation between proportionate forecast bias and weak equity explains partly why cooperatives traditionally have weighted raw product deliveries by their current market prices. In a competitive and efficient market, a raw product's market price $P_j^m$ is an unbiased, efficient forecast of its net return $R_j$. To see this, note that processor unit profit net of raw product cost is $\pi_j = R_j - P_j^m$. For processor profit to average zero in a competitive industry, $E(\pi_j) = E(R_j - P_j^m) = E(R_j) - P_j^m = 0$, requiring $P_j^m = E(R_j)$. Market price weighting may serve not only to help the cooperative meet its proprietary competition but also to value raw products according to their expected net returns and hence expected pool contributions. This in turn ensures equitable payments as long as the raw product market is competitive and deliveries and unit returns are mutually independent.

Unfortunately, cooperatives operate increasingly in raw and processed product markets that are thin or imperfectly competitive (Hayenga). A local raw product market may not in some cases be said to exist at all. In either event, market price patronage weighting does not necessarily provide the greatest equity in either the weak or strong sense. Other return forecasting methods, including univariate and econometric approaches, may generate more equitable pool allocations. It may be that no approach satisfies equity criterion (3) or (4) to the cooperative's complete satisfaction. Members then must judge the relative equity of alternative payment rules, which involves formulating a loss function for deviations between products' pool payments and their expected pool contributions.

A useful approach to this problem is to assume that loss (or the cooperative's utility) varies with the square of deviations between a product's pool payments and its expected returns—the standard quadratic loss function of statistical decision theory. It is easy to show that in this case the inequity L of a given pool payment or patronage valuation rule is:

$$L = \Sigma \{E[G_jQ_j - E(R_jQ_j)]\}^2 + \Sigma \operatorname{Var}[G_jQ_j - E(R_jQ_j)] \qquad (6)$$

That is, the inequity of a payment system is the sum across products of the squares of the expected subsidies plus subsidy variances. The cooperative could alter this measure in a number of ways, such as by emphasizing one product's subsidies more than another's. However, equation (6) has the advantage of being easily understood and calculated and of reflecting—through the variance terms—the notion of strong service-at-cost equity. Using equation (6), we simulate below the equity performance of alternative payment rules in a multiple product, single pool processing cooperative.

## Pool Payment Simulations

The 200-member cooperative investigated operates in a one-state area and processes 12 to 14 fruit and vegetable products, many of which are further subdivided by grade. Grower contracts call for members to deliver the entire yield produced on specified acreage. Processed products are sold—primarily under private label—in a national market. To calculate patronage, the cooperative weights raw product deliveries according to estimates of their market prices. However, few proprietary processors operate in the cooperative's vicinity, so this weighting procedure may not result in the most equitable payment system.

Several alternatives to market price weighting were tested. All involved weighting each unit of raw product with a forecast of the per-unit return from that product in the coming pool year. Forecasts were based on: (1) a simple three-year moving average of previous net returns from the product; (2) a double exponential smoothing equation, which employs weighted averages of past net returns; and (3) an econometric model, which utilizes information about previous production and incomes as well as net returns. The equity performance of these methods was compared to that of weighting deliveries according to raw product market prices.

To perform the comparison, we calculated what each product's net return forecasts would have been under each method for each year from 1976 through 1985. The forecasts were used to form delivery weights $P_j$; total payments for each product and year then were determined from equation (2). Relative equity of the four weighting methods was judged according to equation (6). Exponential smoothing and econometric forecasts for the 1976 pool year utilized data from 1960 through 1975. The moving average forecast for 1976 employed data from 1973 to 1975. Models were updated and re-estimated as forecast years progressed, incorporating any information that would have become available to the cooperative in the new year.

The analysis is limited to snap beans and sweet corn, which together account for the majority of the cooperative's business. Table 1, column (1), shows 1976-85 means and standard deviations of unit net returns $R_j$ from snap bean and sweet corn processing. Corresponding statistics on unit net return forecasts $P_j$ and per-acre delivery quantities $Q_j$ are given in columns (2) and (3). To be treated equitably in the weak sense, bean growers on average should receive the expected net returns from bean processing and corn growers should receive expected corn net returns. If we adopt a

**Table 1.—Net Returns, Pool Payments, and Per-Acre Subsidies: Simulated Statistics for 1976–85**

| Payment Rule (Forecast Model) | Product | Statistics[a] | (1) Per-Ton Net Return ($R_j$) | (2) Per-Ton Net Return Forecast ($P_j$) | (3) Per-Acre Yield (Delivery Volume) ($Q_j$) | (4) Per-Acre Payment ($G_jQ_j$) | (5) Per-Acre Net Return ($R_jQ_j$) | (6) Per-Acre Subsidy $G_jQ_j - E(R_jQ_j)$ |
|---|---|---|---|---|---|---|---|---|
| Moving Average | *beans* | mean | 124 | 137 | 5.0 | 592 | 593 | −1 |
| | | sd | 61 | 59 | 0.6 | | | 121 |
| | *corn* | mean | 64 | 69 | 8.2 | 519 | 518 | 1 |
| | | sd | 14 | 6 | 0.6 | | | 125 |
| Exponential Smoothing | *beans* | mean | 124 | 142 | 5.0 | 609 | 593 | 16 |
| | | sd | 61 | 48 | 0.6 | | | 134 |
| | *corn* | mean | 64 | 69 | 8.2 | 502 | 518 | −16 |
| | | sd | 14 | 8 | 0.6 | | | 112 |
| Econometric Model | *beans* | mean | 124 | 180 | 5.0 | 613 | 593 | 20 |
| | | sd | 61 | 68 | 0.6 | | | 131 |
| | *corn* | mean | 64 | 91 | 8.2 | 498 | 518 | −20 |
| | | sd | 14 | 36 | 0.6 | | | 140 |
| Raw Product Market Price | *beans* | mean | 124 | 163 | 5.0 | 659 | 593 | 66 |
| | | sd | 61 | 15 | 0.6 | | | 143 |
| | *corn* | mean | 64 | 68 | 8.2 | 452 | 518 | −66 |
| | | sd | 14 | 6 | 0.6 | | | 79 |

[a] sd refers to standard deviation.

10-year time horizon, this implies the 1976-85 sample mean of per-acre payments ($G_jQ_j$) should equal the 1976-85 sample mean of returns ($R_jQ_j$) for each product.

The extent to which this would have occurred for the various valuation methods is indicated by subtracting the means in column (4) from those in column (5). Column (6) shows means and standard deviations of per-acre subsidies generated. A mean in column (6) is just the difference between the corresponding means in columns (4) and (5), whereas a standard deviation in column (6) reflects the variation of payments around expected net return. Subsidy standard deviations provide, for a given time horizon, information about the reliability of the mean subsidies shown and hence about the likelihood of encountering similar mean subsidies in other years. Table 1 assumes delivery volumes are random and unknown when patronage weights are computed.

Comparison of columns (1) and (2) indicates all four methods tended to overforecast snap bean and sweet corn returns. Econometric models performed the worst in this regard, followed by market prices. The moving average model produced the least bias (124 − 137 = −13) in bean forecasts, but its corn forecast bias (64 − 69 = −5) was about the same as that of the exponential smoothing and market price models. Moving average biases were roughly proportionate to mean forecasts, so the mean subsidy to corn growers under the moving average rule was only −1.[3] Market price weighting, in contrast, generated the highest mean subsidy of any method: sweet corn acreage subsidized snap bean acreage at the average annual rate of $66 per acre. Between 1980 and 1983, mean subsidy for beans was $188 per acre.

Every model's net return forecasts were negatively correlated with per-acre yields; correlations ranged from −0.05 to −0.88. On that basis, one might have doubted that even equal proportionate biases in products' moving average forecasts could have resulted in low subsidies since the conditions for the theorem in the previous section are not strictly fulfilled. The fact that several of the payment rules' mean subsidies were low suggests that return-yield correlations sometimes do not count for much. Mean subsidies were little changed when yields were held constant to reflect known delivery quantities.

In order to judge the strong-form equity of these payment rules, we need to take subsidy variances into account as well. The application of equation (6) for this purpose is shown in table 2. Column (1) of the table gives for each payment rule the sum of the two commodities' squared mean subsidies, and column (2) the sum of the commodities' subsidy variances (all expressed in square roots for convenience). Column (3) gives the square root losses, that is the square root sums of squares of columns (1) and (2). The payment rule providing the lowest loss and hence highest equity is that in which each product's patronage weight is based on a moving average of the product's previous net returns. The rule employing exponential smoothing follows close behind. The current practice of valuing patronage at market prices ranks third, and use of the econometric model is a distant fourth. It is interesting that the moving average approach not only is the most equitable but is the simplest of the four to compute.

**Table 2.—Relative Equity of Alternative Pool Payment Rules**

| Payment Rule | Sum of Squared Mean Subsidies[a] | Sum of Subsidy Variances[a] | Sum of Mean Squared Subsidies[a] | Equity Rank |
|---|---|---|---|---|
| Moving Average | 1 | 174.0 | 174.0 | 1 |
| Exponential Smoothing | 22.6 | 174.6 | 176.1 | 2 |
| Econometric Model | 28.3 | 191.7 | 193.8 | 4 |
| Raw Product Market Price | 93.3 | 163.4 | 188.1 | 3 |

[a] Values shown as square roots.

## Summary

Allocating net returns according to patronage is a fundamental element of cooperative organization. Frequently, however, a wide variety of member payment systems can qualify as patronage-based. In order to determine patronage, one must weight every unit of raw product that members deliver. There are numerous ways of formulating weights, and each way generally will result in a different allocation of the cooperative's income.

As a matter of distributive equity, a product should over a reasonable time horizon be paid its long-run contribution to pool net returns. This requires not only that expected payment equal expected contribution, but that random deviations between payment and contribution be small enough for the time horizon to be acceptable. In practice, a payment rule may be deficient in both regards.

It is useful to recognize that raw product patronage weights act as relative forecasts of the products' eventual per-unit returns. If delivery quantities are uncorrelated with unit returns and all products' unit return forecasts are biased in the same proportion, no product can subsidize another in the long run. However, since deliveries and unit returns sometimes are correlated, equal proportionate forecast biases will not always prevent long-run subsidies.

In the present application, weighting raw product deliveries with simple three-year averages of their previous returns resulted in lower mean subsidies and more equitable income allocation than did use of an exponential smoothing model, raw product market prices, or an econometric model. Together, the simpler methods (moving averages and exponential smoothing) far outperformed the more complicated econometric approach and ranked well above the cooperative's current practice of weighting patronage by raw product market prices.

Results such as these depend upon the character of the markets in which a cooperative is engaged. For example, since competitive market prices summarize a great deal of information about future market conditions, they usually are effective forecasters of future net returns. Thus, valuing patronage on the basis of raw product market prices is appropriate if all the cooperative's raw products are traded in highly competitive markets. Many raw product markets are, however, locally thin, unreliable, or nonexistent. Market competitiveness varies greatly from one product and period to the next, and each cooperative must assess alternative member payment plans in the light of these circumstances.

Future research on return allocations might explore, perhaps along the lines of Sporleder's recent article, the relation between pool payments and raw product marketing contracts. Members' delivery rights have equity implications that may affect the distributive impact of a pool payment rule. Research also might consider interactions between payment plans and the cooperative's capital subscription and retirement programs.

## Notes

1. Part of this payment ordinarily is made in revolving fund certificates (Knoeber and Baumer; Junge and Ginder). We do not consider the equity effects of various capital subscription and retirement plans.

2. In Lopez and Spreen's model of a sugarcane processing cooperative, unit returns $R_j$ and delivery quantities $Q_j$ are nonrandom. Equation (4) implies under these conditions that the cane use-value payment system is the equitable one: each unit of sugar delivered should receive its known final product price less processing cost.

3. The ratio of bias to mean forecast in the moving average model is $(137 - 124)/124 = 0.11$ for beans and $(69 - 64)/64 = 0.08$ for corn. These proportionate biases are relatively similar considering that the forecast bias of one product easily could have been positive and the other negative.

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