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It is a common practice of agricultural processing and marketing cooperatives to operate pools. Pooling involves combining returns from sale of a number of growers' products and prorating these returns among growers according to a prearranged formula. A pooling rule is principally characterized by two aspects: (a) the number and identity of products included within the pool (its "structure") and (b) the method used to allocate the pool's net returns among growers (its "share valuation").

The principal objective of the present study is to analyze choice of an optimal pooling rule by risk averse cooperative members. Alternative pooling rules were formulated by utilizing different combinations of pool structures and share valuation methods. In all, five pooling rules were evaluated: multiple

pools (M), a farm-price-based single pool (S_F), farm-price-based grouped pools (G_F), a profitability-based single pool (S_p), and profitability-based grouped pools (G_p).

Data were obtained from a processing and marketing cooperative. The cooperative's membership was represented by ten distinct classes of farm enterprises, each with a characteristic crop mix. Yearly profits that would have resulted from employing each rule during the period 1960-1980 were calculated for each enterprise class.

Decision analysis techniques used included second-degree stochastic dominance (SSD), stochastic dominance with respect to a function (MSD), mean-Gini analysis (MG), and mean-variance analysis (MV). These techniques compare aspects of profit distributions associated with alternative rules, then identify sets of rules that are undominated for all decision makers in a specified category.

Results showed that undominated rules vary among enterprise classes and across risk aversion levels. Thus, interest conflicts among the cooperative membership are highlighted. Generally, MSD and MG resulted in smaller undominated sets than did SSD or MV.

To find a collectively optimal rule, three voting schemes were used: (a) one-person-one-vote, (b) voting based on a valuation of each member's pool contributions, and (c) a combination of these two. For all three schemes and for most risk aversion levels, the collectively optimal choice was G_F. Rule S_F, presently employed by the cooperative, was not collectively optimal at any risk aversion level studied.

Alternative Market Pools for Agricultural Cooperatives: A Decision Analysis Framework

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Alternative Market Pools for Agricultural Cooperatives: A Decision Analysis Framework

I. INTRODUCTION

A marketing pool is a means of combining the returns from sale of a number of growers' products and allocating these returns among growers according to a prearranged formula. The products might consist of different product species, varieties, and grades as well as grown in different geographic areas.

Roy [p. 397] argues that "In selling goods through cooperatives, growers nearly always participate in some sort of pooling arrangement. Pooling may include a pool of products, operating expenses and sales receipts. It is a distinctively cooperative procedure, and is not usually found among private marketing agencies."

The alternative to pooling is to keep individual accounts and hence maintain the identity of each individual grower's deliveries. Individual accounts are impractical for most processing and marketing cooperatives because efficient processing requires commingling of individual grower's deliveries and sometimes of different products.

According to Roy [p. 397], pooling consists of three main steps. The first is the mingling of products delivered by different individual producers into a collective lot in which the identity of each producer's deliveries is lost. The second step is pooling operating expenses and allocating them against the pooled products. The third and final step is prorating the returns from the sale of the pooled products among the producers contributing to the pool.

The Problem

The major problem addressed by this study is the choice of a pooling rule by members of an agricultural processing and marketing cooperative. The probability distribution of each member's net revenues generally is dependent on the pooling rule employed by the cooperative. Hence, evaluation of any pooling rule and comparisons among different pooling rules may be achieved by considering the distributions of members' net returns under each pooling rule.

If cooperative members are risk neutral, they should choose the pooling rule maximizing the expected value of net revenues. If members are expected utility maximizers and risk averse, their choice of a pooling rule should be based on the expected utility associated with each rule. This includes consideration of higher moments of net revenue distributions.

Pooling rules differ mainly in two aspects: the number and identity of products included in each pool and the method used to allocate net returns among members. Both aspects affect the probability distributions of members' net reveneus. In selecting a rule, cooperative members may consider various combinations of products and net revenue allocation procedures. That is the approach taken in the present study.

Another issue addressed below is the variable effect on decision results of alternative decision techniques. The following procedures will be independently applied to the same data and their results compared: (i) second-degree stochastic dominance (SSD); (ii) second degree stochastic dominance with respect to a function, or Meyer's stochastic dominance (MSD); (iii) mean-Gini analysis (MG); and (iv) mean-variance analysis (MV), sometimes referred to as EV analysis.

Data for the study were obtained from the records of a centralized processing and marketing cooperative for the period 1960-1980.

Alternative pool designs or strategies considered in the study are discussed in the following chapter. In Chapter III the different decision techniques used to analyze pooling rules are explained. Data used in the study are discussed in Chapter IV, and results presented and discussed in Chapter V. More general conclusions are provided in Chapter VI.

II. POOLING RULES AND ACCOUNTING FRAMEWORK

The design of any market pooling rule or "pooling strategy" depends on two main criteria: (a) the number and identity of products included in the pool, that is, its pool structure, and (b) the method used to determine each member-grower's share in the net revenue from sale of the pooled products.

Pool Structure

A processing and marketing cooperative that handles a number of products can operate a separate pool for each raw product and even for each grade and variety of each raw product it handles. This will be referred to as a multiple pool structure. A multiple pool represents the narrowest pool structure possible. On the other hand, a cooperative could include all the products it handles in a single pool. Such an arrangement represents the broadest pool structure. Between these two extreme arrangements falls a number of possible alternative pool structures; these could be referred to as grouped pools as they include groups of products from within the range of products the cooperative handles.

Thus, three general pool structure categories can be identified: multiple pools, a single pool, and grouped pools. With multiple pools, revenues from sale of the final processed products and associated processing costs are kept separate for each product. Under a single pool arrangement, revenues from sale of all processed products are added together and processing costs of all products deducted to obtain the pool's net revenue. Grouped pools contain subsets of products handled by the cooperative. When the number of subsets (i.e., number of grouped pools) is equal to the number of products the cooperative handles, we have a multiple pool arrangement. When the number of subsets is equal to one, that is, when there is one subset equal to the set of all products, then a single pool arrangement results. Intermediately, a large number of grouping possibilities arise.

Share Valuation Method

When a processing cooperative combines or pools members' products, it is necessary to find a method of determining the fractional share of net revenue payable to each member-grower. Pool fractional shares are usually determined on the basis of contributions made to the pool by each grower, be it in terms of the physical quantities delivered, the "estimated" dollar value of such deliveries, or any other agreed method. Determination of pool fractional shares on the basis of physical quantities delivered is inappropriate to the extent raw product unit values differ greatly among products, as is often the case.

The most common allocation method among cooperatives that practice pooling is to assign a per-raw-unit dollar value to each of the several types of raw products delivered to the cooperative [Buccola, 1982]. The fractional share of each grower is, then, based on the assigned dollar value of the products he delivers to the cooperative during a certain time period relative to the total dollar value assigned to all deliveries made to the cooperative by all growers during that same time period. Sometimes, per-raw-unit values are assigned to products in rough proportion to their expected processing returns and hence to their relative contributions to the pool net revenue.

Practically speaking, determination of per-raw-unit values is usually based on farm level market prices and/or on assigned "quality indexes." However, both methods have drawbacks. Local market volume of some products is typically insufficient for reliable determination of market values, especially where cooperative processors have a large share of the local market. Quality indexes, on the other hand, typically fail to provide dependable market value estimates unless a variety of quality factors are taken into consideration. The method most often used to avoid these problems is to assign "established" or "economic" raw product values based on distant market information, private processors' prices, and board members' value judgments.

Alternative Pooling Rules

Any pooling rule is completely described by the dual criteria of pool structure and share valuation method. A pool's total net revenue depends on the first criterion, while a member's fractional pool share and cooperative payment are dependent on both criteria.

Let I be the number of grower-members of a cooperative which processes and markets J farm products. The combination of products each member delivers is variable and can include a minimum of one product, several products, or all the products handled by the cooperative. A_{ij} is the i^{th} grower's acreage of the j^{th} product, Y_{ij} is the j^{th} product yield realized by the i^{th} grower in raw units per acre, and C_{ij} is the per-acre farm production cost for the j^{th} product and the i^{th} grower. Let P_j be the per unit (e.g., per ton) dollar valuation assigned by the cooperative to the j^{th} raw product and R_j be the per-unit revenue from sale of j in processed form minus its per-unit processing cost. Hence, processing net revenue from the sale of all of processed product j is $R_j \sum_i A_{ij} Y_{ij}$.

Multiple Pools

Under a multiple pool arrangement, a payment to the i^{th} grower for his deliveries of the j^{th} raw product will be

$$(2\text{-}1) \qquad F^m_{ij} = \left[\frac{A_{ij} Y_{ij} P_j}{\sum_i A_{ij} Y_{ij} P_j} \right] R_j \sum_i A_{ij} Y_{ij}$$

$$= A_{ij} Y_{ij} R_j$$

The first right-hand term of equation (2-1) is the fractional share valuation of the i^{th} member's deliveries of the j^{th} product expressed as the ratio of the value of his delivery relative to the total value of the deliveries of all the growers who produce j. The second right-hand term of equation (2-1) is pool net revenue. Because a multiple pool arrangement represents the narrowest pool breadth (i.e., each product is a separate pool), only revenues from the sale of product j are included in these net revenues. In the share valuation term of equation (2-1), per-raw-unit valuation P_j is the same in both numerator and denominator. Hence they cancel, leaving the share equivalent to the proportion of the physical quantity of the $j^{\underline{th}}$ product delivered by the $i^{\underline{th}}$ member.

Following from the above, the $i^{\underline{th}}$ member's total profit from all products he delivers to the cooperative is

$$(2\text{-}2) \qquad \pi_i^m = \sum_j (F_{ij}^m - A_{ij}C_{ij}) = \sum_j (A_{ij}Y_{ij}R_j - A_{ij}C_{ij})$$

$$= \sum_j A_{ij} (Y_{ij}R_j - C_{ij})$$

where $A_{ij} = 0$ for products the member does not produce.

<u>Single Pool</u>

Under a single pool arrangement, the payment to the $i^{\underline{th}}$ member for his delivery of the $j^{\underline{th}}$ product is

$$(2\text{-}3) \qquad F_{ij}^s = \left[\frac{A_{ij}Y_{ij}P_j}{\sum\limits_{ij}\sum A_{ij}Y_{ij}P_j}\right] \sum_{ij}\sum A_{ij}Y_{ij}R_j$$

The share valuation part of equation (2-3) (first term on the right side) gives the valuation of the $i^{\underline{th}}$ grower's deliveries of the $j^{\underline{th}}$ product ($A_{ij}Y_{ij}P_j$) relative to the valuation of all members' deliveries of all products ($\sum\limits_{ij}\sum A_{ij}Y_{ij}P_j$). Here, because of the summation over all products, per-raw-unit valuations P_j

do not cancel, making the member's payment dependent on relative per-raw-unit valuations P_j as well as on pool net revenues R_j.

Summing over all j porducts and deducting farm production costs, the i^{th} member's profit from all the proudcts he delivers to the cooperative is

$$(2\text{-}4) \qquad \pi_i^s = \sum_j (F_{ij}^s - A_{ij}C_{ij})$$

$$= \sum_j \left[\left[\frac{A_{ij}Y_{ij}P_j}{\sum\sum_{ij} A_{ij}Y_{ij}P_j} \right] \sum\sum_{ij} A_{ij}Y_{ij}R_j \right] - \sum_j A_{ij}C_{ij}$$

$$= \sum_j A_{ij} \left[\frac{Y_{ij}P_j \sum\sum_{ij} A_{ij}R_j}{\sum\sum_{ij} A_{ij}Y_{ij}P_j} - C_{ij} \right]$$

Grouped Pools

Let the number (J) of products handled by the cooperative be divided into K mutually exclusive and jointly exhaustive subsets, and let a given subset be the k^{th}. If K is equal to the number of grouped pools operated, K must be between 1 and J ($1 \leq K \leq J$). A multiple pool situation results when K = J and a single pool situation results when K = 1. Let the sequence of products be 1, ..., J_1 in the first pool; $(J_1 + 1)$, ..., J_2 in the second pool; and $(J_{k-1} + 1)$, ..., J_k in the k^{th} pool. Then the first grouped pool contain J_1 products, the second pool $(J_2 - J_1)$ products, and the k^{th} pool $(J_k - J_{k-1})$ products.

In a grouped pool structure, a grower-member participates only in pools that contain the product(s) he delivers. The i^{th}

member's payment for the $j^{\underline{th}}$ raw product he delivers to the $k^{\underline{th}}$ pool is

$$(2\text{-}5) \quad F^g_{ijk} = \left[\frac{A_{ij}Y_{ij}P_j}{\sum_i \sum_{j=J_{k-1}+1}^{J_k} A_{ij}Y_{ij}P_j} \right] \left[\sum_i \sum_{j=J_{k-1}+1}^{J_k} A_{ij}Y_{ij}R_j \right]$$

The member's total payment for all the products he delivers to the cooperative is obtained by summing his payments across all the grouped pools that include his products, or equivalently by summing his payments across all the grouped pools such that payments are zero from pools in which he does not participate. Denoting by $\sum_{j(k)}$ the summation over j from $(J_{k-1} + 1)$ to J_k and deducting farm production costs, we get the grower-member's total profit

$$(2\text{-}6) \qquad \pi^g_i = \sum_k \sum_{j(k)} F^g_{ijk} - \sum_j A_{ij}C_{ij}$$

$$= \Sigma_k \left[\frac{\sum_{j(k)} A_{ij}Y_{ij}P_j \sum_i \sum_{j(k)} A_{ij}Y_{ij}R_j}{\sum_i \sum_{j(k)} A_{ij}Y_{ij}P_j} \right] - \sum_j A_{ij}C_{ij}.$$

Equation (2-6) reduces to the multiple pool case (2-2) if K = J and to the single pool case (2-4) if K = 1.

The different pool structures discussed above and their relationships to pool breadth and share valuation method are depicted in figure 2.1 below.

The Accounting Framework of a Single Pool Cooperative

The cooperative investigated in this study currently operates a single pool. The share valuation method followed by the cooperative is to assign per-raw-unit "established" or "economic" dollar values to the different products it handles. Determination of raw product established values is usually based mainly on prices paid by private processors to farmers in the region in which the cooperative operates. However, the local market for processing fruits and vegetables in the region continues to decrease as private processors close down operations. Thus, the cooperative was forced to rely on raw product market price quotations from distant markets together with value judgment concerning the reliability of this information and the future profitability of each product. This situation has led the cooperative to consider changing its pool structure and/or the raw product valuation method it has employed.

Accounting Procedures of the Cooperative

The cooperative processes (cans, freezes, and brines) nine principal fruit and vegetable products grown by about 190 members. Some of the cooperative's product lines involve the commingling

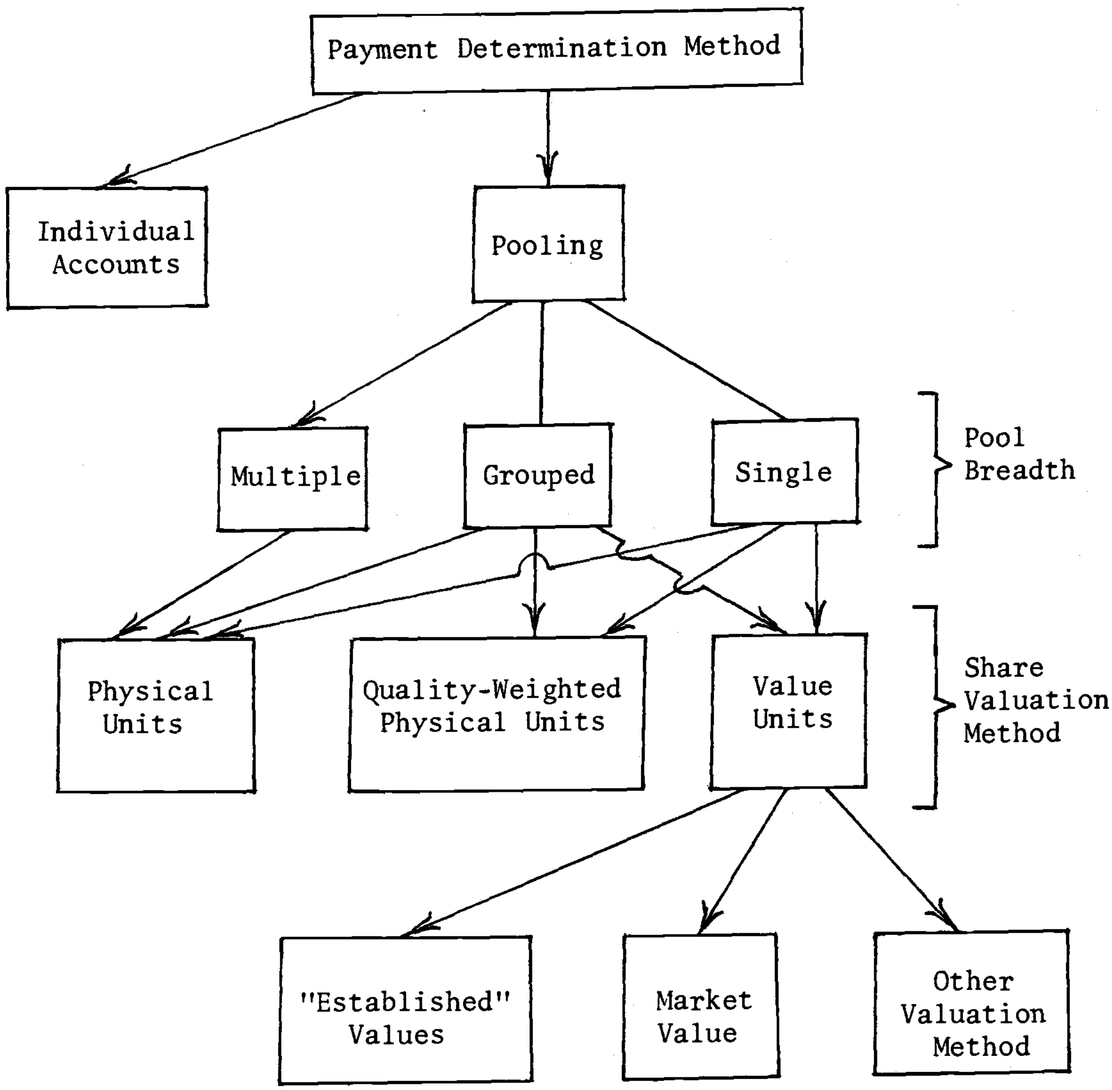

Figure 2.1. Pool accounting structure.

of individual products, e.g., fruit cocktail or mixed vegetables. All involve commingling of individual members' deliveries.

Accounting Period and Pool Closing

The cooperative's fiscal year is from April 1 to March 31. The single pool accounting period is two years; that is, the pool that began April 1, 1978 was closed March 31, 1980. The harvest season for the nine products grown by the cooperative's members extends between mid-May to the end of August. Processing (canning and freezing) starts during the harvest season and sales of processed products begin immediately. Usually about half of the processed product is left unsold at the end of the first fiscal year (March 31 of the year following the harvest season). Sales continue through the second fiscal year, at which time any product left in inventory is transferred to the succeeding pool. Estimates of the sales value of transferred products are credited to the pool that is closed. In summary, a pool's total sales receipts are obtained by adding receipts from sales in the first fiscal year, receipts from sales during the second year, and estimated dollar values of products left in inventory. Due to the two-year accounting period, the cooperative always handles two pools simultaneously: one that is proceeding through its first fiscal year and the other continuing during its second year.

Cost Allocation

Despite the single pool strategy used by the present cooperative, individual accounts are kept for each raw product handled. These accounts require, besides separate sales revenue figures for each product, the allocation of processing and marketing costs by product. Factory burden is allocated among products based on the percentage share of each product in total variable costs. General overhead, including administrative and selling costs and interest payments, is assigned on the basis of the final sales revenue of each product. Freight and distribution costs are allocated according to the number of cases of canned goods shipped and the weights of frozen goods shipped.

Member Payment Calculations

In calculating members' payments in the single pool, the cooperative follows a two-step procedure. Consider the definitions of terms used in the above discussion of alternative pool structure. The cooperative pools sales revenues of all final products and deducts all costs associated with handling, processing, and marketing to obtain single-pool net revenue $\sum_j A_{ij}Y_{ij}R_j$. The next step in the payments calculation is to express total pool net revenue as a percentage of the pool's raw product valuation. This percentage, call it ratio R, shows by what proportion a pool's net revenue is over or under its total raw product valuation, and consequently, what the payment of any raw product will be relative to its raw value:

(2-7) $$R = \frac{\sum\limits_{ij}\sum A_{ij}Y_{ij}R_j}{\sum\limits_{ij}\sum A_{ij}Y_{ij}P_j} \cdot 100.$$

Next, ratio R is multiplied by the total raw value of each product ($\sum\limits_i A_{ij}Y_{ij}P_j$, all j) to obtain the total amount of pool net revenue payable to the respective product. For product j, the latter amount is

(2-8) $$F_j^s = \left[\frac{\sum\limits_{ij}\sum A_{ij}Y_{ij}R_j}{\sum\limits_{ij}\sum A_{ij}Y_{ij}P_j}\right] \sum_i A_{ij}Y_{ij}P_j$$

which is equivalent to the summation of payment F_{ij}^s, equation (2-3), over all I growers.

The payment to each member-grower for the $j^{\underline{th}}$ product he delivers is calculated by multiplying the number of tons of the $j^{\underline{th}}$ product he delivers by that product's per-ton F_j^s, that is, by $F_j^s/\sum\limits_i A_{ij}Y_{ij}$. Such payments are then summed over all products the grower delivers to arrive at the cooperative's total obligation to each grower.

The entire such obligation is not paid in cash. Rather, part of the payment is made in the form of capital retains or revolving fund certificates [Knoeber and Baumer]. These capital retains are usually withheld by the cooperative for funding or payment of any capital obligation, redemption of capital stock, and refunding or redemption of capital retains or patronage capital equities. The retains are not redeemable for a number of years; the cooperative does not make interest payments on them. Further, the part of a member's payment that is made in cash is not paid immediately upon delivery. Rather, it is made in installments, again without interest on the delayed payments. Although interest costs of capital retains and delayed cash payments could be incorporated in this study, it is not necessary to do so because these costs would not be expected to vary by pooling method.

Alternative Pooling Rules Considered

The alternative pool structures considered in this study are: (a) multiple pools (one for each product); (b) a single pool for all products; and (c) two grouped pools (one for all vegetables and one for all fruits).

Pooling ordinarily involves distinguishing products by species, variety, and grade. In relatively broad pools ($K < J$), this is needed in order to assign raw product valuations. In multiple pools it is needed to identify the pool divisions themselves. For the present study some varieties were aggregated (three bean varieties were aggregated and, likewise, three cherry varieties were aggregated) as will be discussed in Chapter IV. Also, different grades of each product were included as a single product. However, because of the high positive correlation among raw product valuations, yields and net revenues of a given product, these aggregations do not represent a significant departure from actual pooling practices. It is clear from the pool structure discussion above that under multiple pools, member payments would be unaffected by share valuation methods. Instead, a member's fractional pool share would depend on the weight of his deliveries as a proportion of total deliveries by all members in a given year. In other words, the same multiple pool structure results irrespective of the method used to value raw product. In contrast, pool fractional shares under single and grouped pools depend on the per-raw-unit valuation method employed, meaning that a distinct pooling rule results from each raw product valuation method considered.

Due to dissatisfaction with the "established" or the farm-price-based raw product valuation method presently used by the cooperative, an alternative procedure is also tested in the present study. According to the alternative, each product's raw value is determined on the basis of its estimated expected contribution to total pool net revenue: $P_j = E(R_j)$. This method will be referred to as the "profitability" method. The expected contribution to pool net revenue, $E(R_j)$, in year t was estimated by a three year-moving average of previous per-ton net revenues:

$$(2\text{-}9) \qquad E(R_j)_t = [R_{j,t-3} + R_{j,t-2} + R_{j,t-1}]/3, \text{ all } j.$$

Equation (2-9) is a simple net revenue forecasting model. More rigorous forecasting mechanisms might provide better forecasts at added computational cost. However, the procedure has the advantabe of being easy to apply and uses data readily available to cooperative staff.

Thus, five pooling rules — resulting from employing all possible combinations of pool breadths and share valuation methods shown in Table 2.1 — are analyzed in this study:

(1) Multiple pools (M);

(2) Single pool using "established" raw product values based on farm-level market prices (S_F);

(3) Grouped pools (one for vegetables and one for fruits) utilizing "established" raw product values based on farm-level market prices (G_F);

(4) Single pool using profitability-based raw product values (S_p);

(5) Grouped pools (one for vegetables and one for fruits) using profitability-based raw product values (G_p).

Table 2.1. Aspects of a Pooling Rule

	Pool Breadth		
Share Valuation Method	$K = J$	$1 < K < J$	$K = 1$
Farm Price Basis	M	G_F	S_F
Profitability Basis	M	G_p	S_p

Hypothesized Effects of Alternative Pooling Rules

The literature on cooperative market pooling mostly identifies effects expected to be associated with pooling versus individual accounting [Roy, Abrahamsen, Bakken and Schaars; and McKay and Lane]. The literature says little about pool choice and the effect of different pool structures. An exception is Sosnick's "Optimal Cooperative Pools for California Avocados," wherein the author divided effects of pool breadth or structure into four categories: savings, risk spreading, inequity, and disincentives.

Savings in "the amount of labor, equipment, and supplies for recording, calculation and reporting," Sosnick argued, "are expected to increase as a pool becomes broader, that is, as the number of consolidations of commingling categories increases." However, computerized accounting has rendered accounting costs fairly homogeneous for different pool breadths, and hence the savings effect associated with different pool structures were ignored in the present study. Further, inequity and disincentive effects are considered as one category because they both relate to the effect of a pool choice on the cooperative's income distribution among its members.

Effects associated with any pooling rule are a consequence of the unique combination of structure and share valuation method characterized by that pooling rule. Whereas structure affects the variability (or risk) of a pool's net return through the number and identity of products included in the pool, share valuation method affects risk via its effect on the variability of the share valuation (first right-hand) term in equation (2-5). Both the structure and share valuation method of a pooling rule affect the expected distribution of cooperatives' income among its members.

Risk Effects

To the extent that pooling is an averaging process, one expects broader pools to be associated with lower variance. Markowitz [p. 108] argues: "Even though expected returns may vary, increasing diversification brings increasing certainty when returns are uncorrelated and variances are identical." Even among positively correlated returns, one would expect the variance to decrease with broader portfolios as long as the returns are not perfectly positively correlated. Anderson, Dillon, and Hardaker [p. 193] argue that "... if the prospects are not perfectly correlated, diversification always reduces variability of total returns." They also argue [p. 195] that "Just as diversification reduces variance, it also tends to reduce skewness. In general, people seem to prefer positive skewness (i.e., a long tail to the right) and to dislike negative skewness; we would therefore expect a lesser desire to diversify where the returns are positively skewed and a greater desire to diversify where skewness is negative, other things being equal." However, because of the statistical dependence that often would be encountered between yields, net revenues, and raw product values, and because of the nonlinearity of equation (2-6), the expression of even the variance of member net returns under pooling is intractable. Thus, it is difficult to show analytically what effect marginal changes in pool breadth would have on the variance and higher moments of pool income.

Income Distribution Effects

Under multiple pool arrangement, a grower delivering product j receives exactly j's per unit revenue over processing cost times the number of units of j delivered. Hence a multiple pool arrangement could be considered the most equitable pooling rule.

As pools became fewer and broader (i.e., as $K \rightarrow I$), growers' expected shares in cooperative net returns, and consequently members' expected income distributions, become dependent on the cooperative's share valuation method. Also, the number and identity of products included in a pool affect member payments through discrepancies between raw produce valuations and corresponding contributions to pool net returns. If a profitable product is included in a pool with an unprofitable one, growers of the former will subsidize the latter as long as the latter's raw product valuation is not negative. More generally in non-multiple-pool frameworks, products with relatively high profitability subsidize those with low profitability as long as raw product valuations are not proportionate to expected profitability.

A generally unique expected cooperative income distribution results from employing any pooling rule. The effect a particular pooling rule has on "member equity" may be obtained by considering the difference between a member's expected payment under that rule and his expected payment under a multiple pool arrangement. The closer the expected income distribution of a particular rule is to that under a multiple pool, the more equitable is the former rule.

Sosnick [p. 61] defines disincentives as "disparity among lots in the relation between the value assigned them by the association and their potential net resale value." This definition seems more consistent with inequity than with "disincentive." Indeed, it is identical to the notion of inequity used above if "potential net resale value" is the same as "expected profitability," which appears to be the case. Disincentives more properly would be the effects of this inequity on members' behavior. Under an inequitable pooling rule, growers who subsidize others may have a disincentive to produce the "high valued variety, or to take the pain for the higher grade" [Sosnick, p. 61]. Moreover, growers who deliver relatively low-profit products or grades would not have an incentive to improve their products or grades because they receive higher payments, on the average, than the resale value of their deliveries.

In summary, the effects of adopting a pooling rule are complex. They depend on the pool structure and share valuation method particular to the pooling rule; on probability moments of processing net revenues, farm production costs, and raw product valuations of the products included in the pool; and on the statistical relationships among these variables. The effect of a given pooling rule on risk and expected member income distribution (equity) may be observed by examining the variance, higher moments, and mean of the profit distribution for each grower resulting from employing that rule.

In the following chapter, decision techniques used to analyze and compare the five alternative pooling rules will be discussed.

III. THEORETICAL FRAMEWORK: DECISION THEORY AND EFFICIENCY ANALYSIS

Decision theory involves choice among alternative strategies or policies. The basis for such choice depends on the objective function of the policy maker as well as on the outcomes that may result from alternative decisions. In a risk-free world the decision problem is often cast as one of maximizing expected value. In the present context a cooperative member would choose the pooling strategy that produces the highest individual mean returns.

However, the world definitely is not risk free, especially for agricultural producers who continually face, among other things, uncertain weather conditions (and hence yields) and uncertain input and output prices. Risk would be expected to be an argument in such an individual's objective function. According to Anderson, Dillon and Hardaker [p. 11] "Decision analysis is a logical procedure for making risky choices. It is a mechanism for bringing together all the pertinent aspects of a decision environment. Most important, it fully recognizes the personal element in decision making — personal benefits about the risk involved and personal preferences for possible consequences."

Among the different methods for modeling single-attribute risky decisions are those called efficiency analysis procedures.

Both stochastic dominance and mean variance (MV) analysis belong to this category [Anderson, 1979, pp. 44-45].

Stochastic Dominance

Stochastic dominance analysis provides a means for comparing alternative strategies (e.g., alternative pooling rules) when information about decision makers' preferences is restricted. The validity of stochastic dominance, hence, depends on the validity of the behavioral assumptions made about the decision maker in question. Unlike economic optimization techniques, which provide complete ordering of alternative decisions and hence yield a unique optimal decision, stochastic dominance analysis identifies a set of stochastically efficient or undominated decisions. The size of the efficient set depends on how restrictive the assumptions made about preferences are: the more restrictive the assumptions, the smaller the efficient set.

Stochastic dominance analysis proceeds by identifying a group of agents with a specific preference structure. This is done through specifying an upper and a lower bound on the degree of risk aversion,[1/] i.e., putting restrictions on the Pratt coefficient $r(X) = -U(X)/U'(X)$ (where $U(X)$ is a utility function defined on income or wealth) [Meyer, 1977a, p. 328]. Thus a certain group of agents would be identified as $U(r_1(X), r_2(X))$, that is as having expected utility function $U(X)$ such that

$$r_1(X) \leq \frac{-U''(X)}{U'(X)} \leq r_2(X) \quad \text{for all X.} \tag{3-1}$$

After identifying groups of agents in this manner, pariwise comparisons of the cumulative density functions (CDFs) of probability distributions resulting from employing each strategy are made. Given two probability density functions f(X) and g(X) that resulted from employing strategies F and G, their cumulative density functions (CDFs) are defined as

$$F_1(X) = \int_a^x f(X)\, d(X) \tag{3-2}$$

and

$$G_1(X) = \int_a^x g(X)\, dX, \qquad \text{for all X.} \tag{3-3}$$

According to the expected utility theorem, F(X) then dominates G(X) if and only if

$$\int_o^1 U(X)\, dF(X) \geq \int_o^1 U(X)\, dG(X) \tag{3-4}$$

with at least one strict inequality (i.e., > holds for at least one value of X in the range of 0 - 1). Equivalently,

$$\int_o^1 [G(X) - F(X)]\, U'(X)\, dX \geq 0 \tag{3-5}$$

with at least one strict inequality.

Hence, the stochastic dominance problem may be summarized as finding necessary and sufficient conditions for F(X) to be preferred to G(X) by all agents in the group U $(r_1(X), r_2(X))$.

Second Degree Stochastic Efficiency

Stochastic efficiency concepts are characterized by the assumptions made about decision makers' preferences. First-degree stochastic dominance (FSD) is based on the Bernoullian assumption of monotonically increasing utility function [Anderson et al., p. 282]. This means that if X is a measure of the outcome of a prospect (such as profits), then decision makers prefer more of X to less. Hadar and Russell solved the FSD problem by giving necessary and sufficient conditions for F(X) to be preferred to G(X) by all decision makers in the group $U(-\infty, +\infty)$. That is F(X) is preferred to G(X) by all such agents if and only if

$$[G(X) - F(X)] \geq 0 \tag{3-6}$$

for all X in the interval (0,1) and with at least one strict inequality. Typically, however, FSD eliminates only few distributions because it includes all decision makers and because CDFs usually cross one another.[2/] Smaller efficient sets could be obtained, however, by imposing more restrictive assumptions about decision makers' preferences, such as under second degree stochastic dominance.

Second degree stochastic dominance (SSD) is based on the additional behavioral assumption that decision makers are averse to risk. This requires that the second derivative of the utility function be negative. Thus, for SSD,

$$U'(X) > 0 \tag{3-7}$$

and

$$U''(X) < 0.$$

These two conditions insure that the utility function is monotonically increasing and concave over the relevant region of X.

The assumption that decision makers are risk averters could be imposed by restricting the Pratt coefficient $r(X)$ to lie between zero and positive infinity, that is $0 < r(X) < +\infty$. The stochastic dominance problem for this group of agents was solved by Hadar and Russell. They proved that $F(X)$ is preferred to $G(X)$ by all agents in the set $0 < r(X) < +\infty$ [i.e., $U(0, +\infty)$] if and only if

$$\int_0^y [G(X) - F(X)]\, dX \geq 0 \tag{3-8}$$

for all y in the interval (0,1) with at least one strict inequality.

Anderson et al. [p. 285] depicted the SSD problem by using second-degree cumulative functions defined as

$$F_2(R) = \int_a^R F_1(X)\ dX \tag{3-9}$$

where F_1 is the cumulative density function (CDF). Then for F to dominate G, its second-degree cumulative function must lie nowhere to the left of the second-degree cumulative function of G. This means that the area behind the CDF of F must be greater than that behind the CDF of G, and is illustrated by figure 3.1 (notice that area A is greater than area B). Second-degree stochastic dominance in terms of second-degree cumulative functions is depicted in figure 3.2. F dominates G, but not Z, because the second-degree cumulative function for F and Z (i.e., F_2 and Z_2) cross. Both figure 3.1 and 3.2 are due to Anderson et al. [p. 285].

Strategies that are dominated in the second degree, such as strategy G in figures 3.1 and 3.2, will never be preferred by risk-averse utility maximizers. However all undominated strategies, such as F and Z in figure 3.2, remain in the second-degree efficient set and without further information none of them can be shown to be preferred to another. Identification of an optimal choice from within an efficient set requires more knowledge about perference than is provided by the mere assumption of risk aversion. As will be discussed in the next section Meyer narrowed the class of decision makers considered within the stochastic dominance framework.

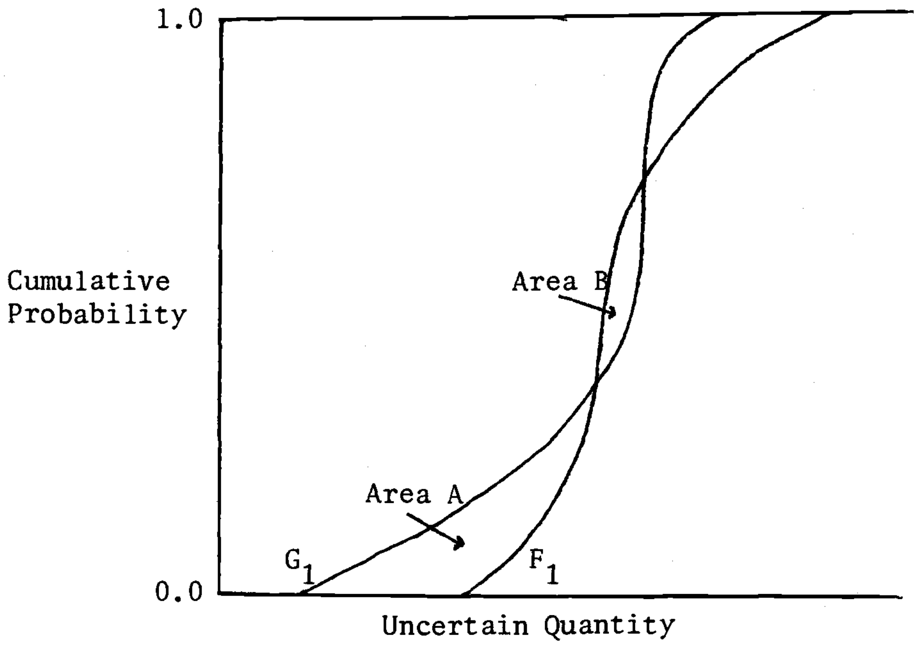

Figure 3.1. Second degree stochastic dominance using CDFs.

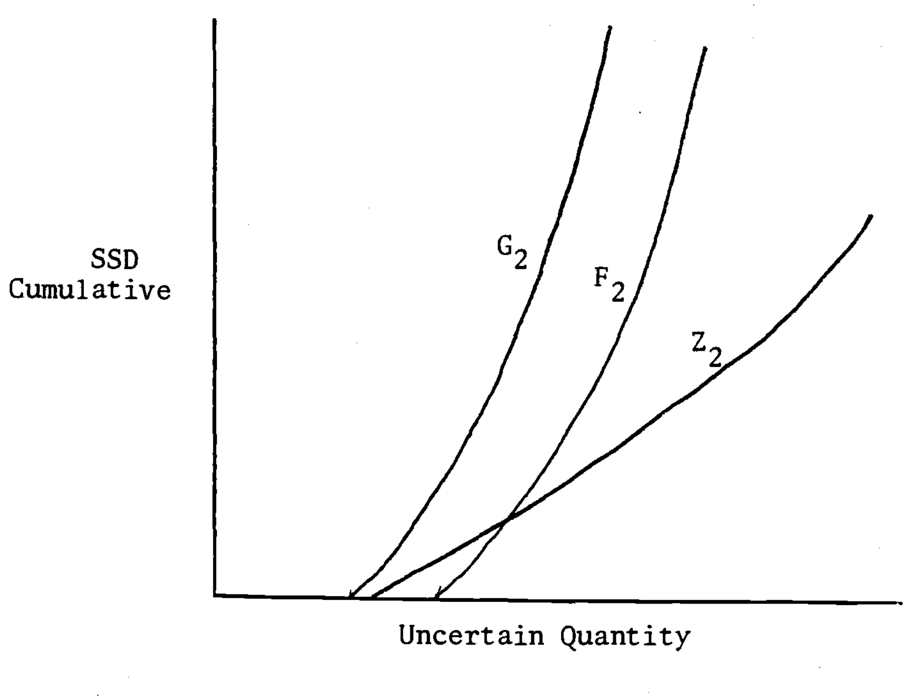

Figure 3.2. Second degree stochastic dominance using second degree cumulative functions.

Stochastic Dominance with Respect to a Function

Meyer [1977b] succeeded in narrowing the risk aversion range by introducing the concept of second degree stochastic dominance with respect to a function, which he denotes by SSD(k). I will alternately refer to SSD(k) as Meyer's stochastic dominance or MSD. In general, F MSD G will signify that F stochastically dominates G in the sense of Meyer's second-degree dominance [Meyer, 1977b, p. 479].

MSD is based on identifying an arbitrary lower and upper bound on the absolute risk aversion [Pratt] coefficient, hence limiting the group of decision makers to those whose risk aversion levels fall within the interval considered.

Meyer established a lower bound on the risk aversion coefficient by identifying a utility function k(X), then considering a set of utility functions U(X) that are more risk averse than k(X). That is,

$$\text{(3-9)} \qquad \frac{-k''(X)}{k'(X)} \leq \frac{-U''(X)}{U'(X)} \qquad \text{for all } X.$$

Then Meyer proved the following theorem for cumulative distributions F(X) and G(X): the weak inequality

$$\text{(3-10)} \qquad \int_0^y [G(X) - F(X)]\, dk(X) \geq 0 \qquad \text{for all } y \in [0,1]$$

holds if and only if $\int_0^1 U(X)\, dF(X) \geq \int_0^1 U(X)\, dG(X)$

for all $U(X) \in U\left(\frac{-k''(X)}{k'(X)}, \infty\right)$. This says that "F(X) stochastically dominating G(X) in the second degree with respect to k(X) is equivalent to F(X) being preferred or indifferent to G(X) by all agents more risk averse than an agent with utility function k(X)" [Meyer, 1977b, p. 480].

The above theorem's strength is that if a decision maker's risk aversion coefficient is known only to be greater than a specified level, then MSD provides a basis for predicting such decision maker's choice between two risky prospects F(X) and G(X). Conversely, starting from a pair of risky prospects F(X) and G(X), MSD could be used to find a k(X) that satisfies the condition F(X) MSD G(X).

Similar to the establishment of a lower bound, Meyer also established an upper bound of risk aversion. Consider the set of utility functions k(X) that contains all decision makers less risk averse than a specific function k(X); that is,

$$(3\text{-}11) \qquad \frac{-U''(X)}{U'(X)} \leq \frac{-k''(X)}{k'(X)} \quad \text{for all } X.$$

For cumulative distributions F(X) and G(X),

$$(3\text{-}12) \qquad \int_0^y [G(X) - F(X)]\, dk(X) \leq 0 \quad \text{for all } y \in [0,1]$$

if and only if $\int_0^1 U(X)\ dF(X) - \int_0^1 U(X)\ dG(X) \leq 0$ for all

$$U(X) \in U\left(-\infty,\ \frac{-k''(X)}{k'(X)}\right).$$

The interpretations of this theorem are analogous to (3-10).

Hence, Meyer improved the flexibility of the dominance problem by varying both the lower and the upper bounds on the measure of risk aversion. Researchers henceforth can limit the group of decision makers considered to include only those within the desired risk aversion interval. When MSD includes a smaller risk aversion set than SSD, it is expected to yield smaller efficient sets than the latter. This is because unanimous rejection of a given strategy is more likely to occur as the set of decision makers is restricted.

Mean-Gini Analysis

Mean-Gini analysis provides yet another decision technique that may be categorized as an efficiency analysis method. In this method, the variability or risk embodied in the outcome of a certain prospect is reflected by a function of its mean absolute difference. The coefficient of mean difference is due to Gini [1912] and one-half this coefficient is called the "Gini coefficient."[3/] The latter essentially is one-half "the average difference of all possible pairs of variate values, taken regardless of sign." [Kendall and Stuart, pp. 46-47]. Letting Δ be the mean absolute difference, the Gini coefficient is

$$(3\text{-}14) \qquad \Gamma_F \equiv \Delta/2 \equiv \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |X - Y| \, dF(X) \, dF(y)$$

where $F(X)$ is the cumulative density of random variable X.

Kendall and Stuart [p. 47] note that, "the mean difference has a certain theoretical attraction, being dependent on the spread of the variate values among themselves and not on the deviation from some central value." An example of the latter would be the mean absolute deviation. The Gini coefficient (Γ_F) for distribtuion F could equivalently be written as:

$$(3\text{-}15) \qquad \Gamma_F = \int_a^b F(X) \; [1 - F(X) \; dX$$

$$= \int_a^b [1 - F(X) \; dX - \int_a^b [1 - F(X)]^2 \; dX$$

$$= \mu_F - a - \int_a^b [1 - F(X)]^2 \; dX.$$

Equation (3-15) was obtained by integrating equation (3-14) with respect to F(y) [Gastworth, p. 307; Kendall and Stuart, p. 50].

The usefulness of the Gini coefficient as a criterion for decision analysis was clarified by Yitzhaki in a recent paper. Consider the SSD rule given by equation (3-8), which may be rewritten as

$$\text{(3-16)} \qquad \int_a^t F(X)\, dX \leq \int_a^t g(X)\, dX,$$

where the strict inequality holds for at least one value of t. Yitzhaki shows that a necessary condition of (3-16) is

$$\text{(3-17)} \qquad \int_a^b [1 - F(X)]^n\, dX \geq \int_a^b [1 - G(X)]^n\, dX$$

for all positive integer values of n, with strict inequality for at least one n. Expressed differently,

$$\text{(3-18)} \qquad \lambda_n = \int_a^b [1 - F(X)]^n\, dX - \int_a^b [1 - G(X)]^n\, dX \geq 0,$$

$$n = 1, 2, 3 \ldots$$

is a necessary condition for second-degree stochastic dominance. Setting n = 1, we have

$$\text{(3-19)} \qquad \lambda_1 = \int_a^b [1 - F(X)]\, dX - \int_a^b [1 - G(X)]\, dX$$

$$= \mu_F - \mu_G \geq 0.$$

Setting n = 2 and using (3-15) we get [Yitzhaki, p. 180]:

$$\text{(3-20)} \qquad \lambda_2 = (\mu_F - \Gamma_F) - (\mu_G - \Gamma_G)$$

$$= \int_a^b [1 - F(X)]^2 \, dX - \int_a^b [1 - G(X)]^2 \, dX$$

$$\geq 0.$$

The interpretation of equation (3-20) is that if distribution F dominates distribution G by SSD, then the mean minus Gini coefficient of F is not less than the mean minus Gini coefficient of G.

Equations (3-19) and (3-20) characterize the mean-Gini efficiency criterion (MG). Distribution F dominates distribution G by MG if both (3-19) and (3-20) hold, with at least one holding as a strict inequality.

Discriminatory Power of Alternative Criteria

Generally, the weaker the conditions required for dominance by a certain criterion, the smaller is the efficient or undominated set. As (3-19) and (3-20) are only necessary conditions for SSD (3-16), they are easier to satisfy than SSD. Hence, the efficient set under MG is expected to be at most as large as the efficient set under SSD.

This concludes the review of decision methods used to analyze the alternative pooling strategies discussed in Chapter II. In the next chapter, the data used in the study will be considered.

IV. DATA SOURCES AND ADJUSTMENTS

The centralized processing cooperative investigated here was formed in 1971 by a merger of two smaller cooperatives. Data were available from only one of the original cooperatives for the period 1960-1970, but these data included most of the products presently handled. Information for 1971 was incomplete and omitted. Thus, twenty years of data were used, the first eleven years from one of the original cooperatives (1960-1970), and the remaining nine years from the merged cooperative (1972-1980). As would be expected, the two cooperatives differed in number of members and product acreages. Fortunately, these differences do not represent a serious limitation since the analysis is conducted on a per-acre basis, abstracting from both size and number of growers.

Price and Revenue Data

The merged cooperative handles (processes and markets) nine major horticultural products. Listed in order of average net processing revenue for the period 1972-1980, the products are: bush beans, sweet corn, table beets, cherries, carrots, strawberries, rhubarb, squash, and blackberries. In addition to these products, the cooperative periodically handles a number of minor products. The latter are ignored in this study.

Data for all variables and terms defined in Chapter II were obtained for all 20 years for each of the nine products. These included data on processing net revenues R_j, acreages A_j, yields Y_j, and raw product valuations or "established values" P_j. All money data were expressed in constant dollars using the consumer price index (CPI) (1982 = 100).

Data Problems

Several problems were encountered in data compilation. One problem was that squash, a relatively important product for the merged cooperative was not grown by members of the original cooperative. Thus, data on squash were available only for the nine years following the merger, 1972-1980. Two alternatives were considered, the first being to omit squash from the study and the second to construct data for the earlier eleven years. The second alternative was taken, mainly because of the importance of squash to the present cooperative and because this importance has been increasing over time. Data on net revenue R_j, acreage A_j, yield Y_j, and established values P_j for the missing years were developed for squash as follows: (a) the available nine observations in constant dollars were replicated for the period 1960-1968; (b) for 1969, the average of 1967 and 1968 values were used: and (c) for 1970, the average of 1972 and 1973 values were used.

The assumptions implicit in these procedures were that the variability of each squash variable in the 1972-1980 period forms a reasonable estimate of its variability during the 1960-1968 period, and that the average values of the two preceeding years and the two succeeding years were reasonable estimates for the data for 1969 and 1970, respectively.

For convenience, data for very similar products were combined. For example, three types of bush beans are grown by cooperative members: green, yellow wax, and Romano (Italian). These are included as a single product. Similarly, Royal Ann, dark sweet, and red tart cherries were treated as one product. Per-acre net revenues of such products behave similarly and the research cost of treating them separately couldn't be justified.

Randomness Tests

Graphs of per-acre net processing revenues (R_j) and established values (P_j) of individual products (including the three kinds of beans and the three kinds of cherries) were examined in constant dollars. There were apparent downtrends in green beans, Romano beans, squash, and dark sweet cherries for the entire twenty-year period. Corn and carrot data showed downtrends during the last nine years only. Existence of downtrends, suggesting nonrandom behavior, together with the desire to examine whether the time series data were truly random in other ways, made it necessary to perform randomness tests on R_j's and P_j's of all individual products.

Many nonparametric tests have been developed that make no assumptions about the true form of the underlying probability density function. These tests belong to the family of distribution-free statistical methods. Among nonparametric tests are those for the randomness of a sample. Several such tests make it possible to judge the randomness of observed data on the basis of the order in which the observations were obtained. The particular test used here is based on the theory of runs, where a run is a succession of identical symbols that denote a certain feature of the data (e.g., good quality) followed and preceeded by different symbols that denote a different feature (e.g., bad quality) or no symbols at all [Freund, p. 352]. For example, consider testing the randomness of a sample of a certain product produced by a machine, and let the order of good (g) and bad (b) pieces produced be as follows:

g g g b b b b g g b g g g g g b b b b g g b b g

The first run is the first three g's, the second run, the second four b's, the third run the second string of g's, and so on. The number of runs relative to the number of observations is usually a good indicator of random or nonrandom behavior. Too many runs might indicate the presence of a repeated alternating pattern, and too few runs could imply some grouping or clustering in the data [Freund, p. 352].

This same procedure may be applied to test the randomness of a series of numerical observations by denoting observations that fall above the median with the same sign (+) and those below the median with another sign (-). Freund has shown that when the number of runs is ten or more, the smapling distribution of the number of runs (u) may be approximated by the two moments of a normal distribution. Thus, denoting the number of runs above the median by (a) and runs below it by (b), we have:

$$E(u) = \frac{2ab}{a+b} + 1$$

$$Var(u) = \frac{2ab(2ab - a - b)}{(a+b)^2 (a+b-1)}$$

and hence the value of the standard normal deviate

$$Z = \frac{U - E(u)}{\sqrt{Var(u)}}$$

is used to test the null hypothesis of randomness. That is, if $|Z| \geq Z\alpha/2$, the null hypothesis is rejected [Freund, p. 354]. On the other hand, if the number of runs is small (≤ 10), tests of the null hypothesis of randomness are based on specially constructed tables [Owen]. A computer program utilizing similar information to that provided by these tables was used in the present study to test the null hypothesis of randomness against the alternative hypothesis [Hadlai and Nie, SPSS Update 7-9].

The tests were applied to per-acre net revenue data (R_j) and per-acre established values (P_j) of the individual products. In the present case, with sample sizes of twenty, the null hypothesis of randomness was not rejected if the number of runs fell between the critical values of 6 and 16 runs [Siegel and Owen].

Results of the runs tests showed that the number of runs generally fell near the lower critical value, and below this value for green beans, Romano beans, squash, and dark sweet cherries (Table 4.1).

The coincidence of the downtrend and the below-critical-value number of runs for green beans, Romano beans, squash, and dark sweet cherries suggests that nonrandomness in these cases was attributable to the presence of the downtrend. For the sake of consistency, the procedures used to eliminate trend were applied to all products rather than only to those products with nonrandom time series. Per-acre net revenue data (R_j) and the per-acre established values (P_j) were linearly detrended by fitting trend lines with ordinary least squares (OLS), then adding deviations from the trend line to the most recent nine-year mean of each product series. These adjustments were consistent with cooperative management's expectations regarding the behavior of the different series for the coming decade. Per-acre net revenues (R_j) and established values (P_j) were expected to be trendless with means equal to those prevailing after the

Table 4.1 Runs Test Results, Per-Acre Net Processing Revenues

Per-Acre Net Processing Revenues	
Product	Number of Runs
green beans	2
yellow wax beans	10
Romano beans	5
corn	7
beets	9
carrots	8
squash	3
D.S. cherries	3
R.A. cherries	10
R.T. cherries	9
rhubarb	10
strawberries	7
blackberries	8

merger, that is, between 1972-1980. No differences between the 1960-1980 period and the coming decade were perceived in cooperative risks.

After detrending per-acre net revenues and established value data, adjusting their means, and combining the several bean and cherry varieties, randomness tests again were conducted. These showed that eliminating trend eliminated the nonrandomness problems but it also introduced nonrandomness in corn and blackberries series as can be seen in Table 4.2.

For two reasons, no further manipulations were performed to correct for the nonrandomness perceived in these two products. First, individual per-acre net revenue (R_j) and established value (P_j) series were utilized to construct models of mixed-crop farms (see below), and farms containing corn and blackberries were found to have random net revenues when applying the runs test. Second, it would be inconsistent to apply a procedure (such as computing first differences) to correct for randomness in corn and blackberries series without applying it also to the other products. Since all the latter were random and first difference series would not have the same intuitive content as the original series, it was best to leave the data in their present form.

Farm Production Costs

As discussed in Chapter II, the analysis in this study proceeded by comparing the distributions of farm profits of each grower type or class under each pooling rule. That is, cooperative

Table 4.2. Runs Test Results for Detrended Data

Per-Acre Net Processing Revenues	
Product	Number of Runs
beans	7
corn	6
beets	9
carrots	13
squash	8
cherries	9
rhubarb	12
strawberries	7
blackberries	5

net revenue payments minus farm production costs were compared among the different pooling rules considered. Per-acre farm production costs were obtained from Extension Service enterprise efficiency studies.[4/] These provide itemized accounts of per-acre farm production costs (C_j) including overhead, land, and mangement, for a range of possible yields for each product. Unfortunately, the variability of farm production costs across the twenty-year period could not be obtained from these studies, as they give cost information only for particular years. Because of this limitation, farm production costs were assumed to be fixed during the twenty-year sample period. Cost estimates quoted for years prior to 1982 were inflated using the producer cost index for U.S. farmers (1982 = 100).[5/]

Acreage Data

The cooperative investigated had 189 active members in 1980. About one-half the members delivered only beans and sweet corn, only beans, or only sweet corn to the cooperative. Thirty-three members delivered only cherries, while others delivered different combinations of fruits and vegetables.

The wide diversity of products delivered by cooperative members was represented in the present study by ten farm enterprise classes. These classes were identified from a 1980 grower profile in which each member's cooperative-contracted acreage is determined for each product. Use of 1980 data in this regard was dictated by lack of data on grower product mixes and acreages for earlier years. However, 1980 data are reasonably representative of the previous years because contracted acreage changes are usually pro-rated across growers according to current contracted acreage.

Farm Enterprise Classes

Ten farm enterprise classes were modeled by grouping together growers with similar product mixes and representing each group by a particular enterprise combination. For example, those who grew only beans were represented by a grower (enterprise class) that grows one acre of beans and delivers his total product to the cooperative. Those who grew a number of similar products were assigned to an enterprise class with the same proportional mix of product acreage. Designation of growers to enterprise classes was accomplished without difficulty in most cases; however, a few growers did not exactly fit into any of the ten enterprise classes modeled. The latter were assigned to enterprise classes they most closely resembled.

The ten farm enterprise classes and their proportional acreage mixes, together with the number of growers assigned to each class, are given in Table 4.3.

Profit Distributions of Farm Enterprise Classes

Cooperative members' profits were simulated for each enterprise class for each of the five pool structures discussed in Chapter II. This was done by applying the proportional product mix of each farm enterprise class (Table 4.3) to the per-acre

Table 4.3. Member Farm Enterprise Classes[a/]

Class	Number of Growers	Product								
		Beans	Beets	Corn	Carrots	Squash	Rhubarb	Cherries	Blackberries	Strawberries
I	45	.51		.49						
II	41	1.0								
III	33							1.0		
IV	16			1.0						
V	14	.27		.27			.13	.14	.06	.13
VI	10	.52	.12	.26	.10					
VII	10		.24	.64	.12					
VIII	10	.48	.29		.23					
IX	7	.52	.12	.26		.10				
X	3							.42	.19	.39

a/ Row numbers represent fractions of an acre and sum to 1.00.

profit of the appropriate product(s) for each of the five pool structures. Such procedure was equivalent to calculating profits of the ten farm enterprise classes using equation (2-2), then using (2-4) and (2-6) with both farm-price-based and profitability-based raw product valuations.

Fifty profit distribtuions, each a 20-year series, were obtained in this manner, one for each of the five pooling rules for each of the ten farm enterprise classes (Appendix).

In the following chapter, the five profit distributions, corresponding to the five alternative pooling rules, are evaluated for each farm enterprise class using mean-variance analysis stochastic dominance, and mean-Gini analysis.

V. RESULTS

The five pooling rules discussed in Chapter II were evaluated for each of the ten enterprise classes by comparing the distributions of profits that resulted from employing each rule. Profit distributions were compared using each of the four decision analysis procedures discussed in Chapter III, namely second degree stochastic dominance (SSD), [Meyer's] stochastic dominance with respect to a function (MSD), mean-Gini analysis (MG), and mean-variance analysis (MV).

Profit Distributions and Their Moments

Estimates of the first three moments of profit probability distributions for each enterprise class, that is sample means, standard deviations, and cube roots of third central moments (reflecting skewness) are shown in Table 5.1. These results may be understood most clearly by considering the product-specific moments given in Table 5.2.

Mean Per-Acre Profits

Mean per-acre profits in Table 5.2 are substantially higher for rhubarb, blackberries, squash, and beets, and lower for corn, carrots, and cherries, than for other products the cooperative handles. Hence, one would expect those producing much of the former and little or none of the latter to subsidize the rest of the growers under a farm-price-based single pool (S_F). This

Table 5.1. Estimated Probability Moments of Pooling Rules, by Farm Enterprise Class a/

		Pooling Rule				
			Farm Price Basis		Profitability Basis	
Enterprise Class	Moment	Multiple (M)	Single (S_F)	Fruit-Veg (G_F)	Single (S_p)	Fruit-Veg (G_p)
	Mean	219	283	295	189	193
I	S. D.	266	267	277	253	250
	Skew.	229	146	182	122	-70
	Mean	365	441	455	272	279
II	S. D.	394	470	480	321	323
	Skew.	-256	-321	293	-106	-163
	Mean	-68	-32	-154	-120	-104
III	S. D.	492	593	445	389	404
	Skew.	-222	465	315	378	209
	Mean	68	118	129	102	105
IV	S. D.	258	205	217	254	247
	Skew.	235	157	155	136	75
	Mean	542	529	471	511	547
V	S. D.	380	409	341	419	470
	Skew.	-190	232	-94	339	392

(continued)

Table 5.1. Estimated Probability Moments of Pooling Rules, by Farm Enterprise Class (continued)

Enterprise Class	Moment	Multiple (M)	Farm Price Basis: Single (S_F)	Farm Price Basis: Fruit-Veg (G_F)	Profitability Basis: Single (S_p)	Profitability Basis: Fruit-Veg (G_p)
	Mean	318	378	393	313	317
VI	S. D.	297	290	301	257	248
	Skew.	182	156	187	177	170
	Mean	267	268	283	357	358
VII	S. D.	299	257	273	356	344
	Skew.	317	219	214	245	281
	Mean	442	491	509	480	484
VIII	S. D.	358	314	327	392	381
	Skew.	171	198	212	338	361
	Mean	436	323	337	424	429
IX	S. D.	250	306	315	277	267
	Skew.	-105	-100	124	169	141
	Mean	307	599	390	256	354
X	S. D.	581	856	614	757	1063
	Skew.	-187	557	-322	714	1017

a/ Estimates shown are, in descending order: mean, standard deviation ($m_2^{0.5}$) and cube root of third central moment ($m_3^{0.33}$), in dollars per acre.

subsidy may be seen from Table 4.1. Growers in enterprise classes V and IX — who grow many of the high-mean-return products — would experience higher mean profits if the cooperative were to employ multiple pools (M) than if it were to employ a farm-price-based single pool (S_F). On the other hand, those belonging to enterprise class III (all-cherries) would experience lower mean returns under multiple pools because they would lose the long-run subsidy that would be enjoyed under a farm-price-based single pool.

Second and Third Moments

As may be seen from Table 5.1, moving from a broader pool to a narrower pool would not necessarily increase the per-acre profit variance for all enterprise classes. Whereas profit variance of growers in VI, VII, and VIII increased when switching from a farm-price-based single pool (S_F) to a multiple pool (M), that of growers in classes II, III, V, IX, and X decreased when making the same switch. Variance of those in class I remained about the same.

Per-acre profit variance of the typical fruit is much higher than that of the typical vegetable (Table 5.2). Thus, although vegetable growers would forego the superior diversification of a single pool when operating under a grouped pool arrangement, they also would avoid the high variance of annual fruit profits. As one would expect, therefore, enterprise classes III and X (fruit producers) faced higher variance under a profitability-based grouped fruit pool than under a profitability-based single pool. Although, analogically, we would expect the latter growers to face

Table 5.2. Means, Standard Deviations, and Skewness Coefficients of Alternative Pooling Rules, by Product a/

Product Category	Pooling Rule: Multiple (M)	Farm Price Basis: Single (S_F)	Farm Price Basis: Fruit-Veg (G_F)	Profitability Basis: Single (S_P)	Profitability Basis: Fruit-Veg (G_P)
Bush Beans	365	441	455	272	279
	394	470	480	321	323
	-0.27	-0.32	-0.23	-0.04	-0.13
Sweet Corn	68	118	129	102	105
	258	205	217	254	247
	0.75	.45	.36	0.15	0.03
Table Beets	944	531	552	1229	1225
	521	343	365	1159	1153
	0.98	0.35	0.27	0.81	0.91
Cherries	-68	-32	-154	-120	-104
	492	593	445	389	404
	-0.09	0.48	0.36	0.92	0.14
Carrots	-30	545	567	-30	-24
	560	443	459	304	307
	0.27	1.03	0.87	0.54	0.67

(continued)

Table 5.2. Means, Standard Deviations, and Skewness Coefficients of Alternative Pooling Rules, by Product (continued)

Product Category	Multiple (M)	Farm Price Basis: Single (S_F)	Farm Price Basis: Fruit-Veg (G_F)	Profitability Basis: Single (S_P)	Profitability Basis: Fruit-Veg (G_P)
	118	863	616	141	287
Strawberries	707	1074	836	934	1301
	1.25	0.84	0.42	1.00	0.69
	2529	1409	1440	2530	2544
Rhubarb	1463	566	601	865	852
	0.91	0.32	0.32	0.29	0.24
	1150	- 3	4	1085	1094
Squash	967	472	472	593	590
	0.50	0.75	0.72	0.27	0.14
	1523	1454	1128	1324	1503
Blackberries	1763	2118	1797	1914	2478
	-0.05	0.27	0.12	0.39	0.87

a/ Numbers shown are, in descending order: mean, standard deviation, and coefficient of skewness, in dollars per acre.

higher variance under a farm-price based grouped pool than under a farm-price based single pool, profit variability in fact fell under such a swith. This seemingly inconsistent behavior results from negative correlations between established values of fruits and of the principal vegetables, producing negative correlations between numerator and denominator of the share valuation term in equation (2-3). This increases the variability of fractional shares and hence increases profit variability under a farm-price-based single pool (S_F).

The task of explaining cross-pool differences in third moments would be much more difficult than it is for variances. Table 5.1 shows that, on average, third moment estimates are algebraically greater in profitability-based than in farm-price-based pools, and lowest of all in multiple pools.

Comparisons Among Ranks of Profit Distribution Moments

The varying effects on the first three profit moments of adopting each of the five pooling rules may be observed more clearly for each enterprise class by ranking moments within each enterprise class (Table 5.3).

Enterprise classes I, II, and VI experience qualitatively similar mean effects across the five pooling rules; that is, the highest means are obtained under farm-price-based grouped pools, followed by a farm-price-based single pool, then multiple pools, then profitability-based grouped pools, then a profitability-based single pool. But variance and skewness rankings tended to vary

Table 5.3. Ranks of Moments of Pooling Rules, by Farm Enterprise Class a/ b/

Enterprise Class	Pooling Rule				
	Multiple	Farm Price Basis		Profitability Basis	
	(M)	(S_F)	(G_F)	(S_p)	(G_p)
	3	2	1	5	4
I	3	2	1	4	5
	1	3	2	4	5
	3	2	1	5	4
II	3	2	1	5	4
	3	5	4	1	2
	2	1	5	4	3
III	2	1	3	5	4
	5	1	3	2	4
	5	2	1	4	3
IV	1	5	4	2	3
	1	2	3	4	5
	2	3	5	4	1
V	4	3	5	2	1
	5	3	4	2	1
	3	2	1	5	4
VI	2	3	1	4	5
	2	5	1	3	4

Table 5.3. Ranks of Moments of Pooling Rules, by Farm Enterprise Class (continued)

Enterprise Class	Pooling Rule: Multiple (M)	Farm Price Basis (S_F)	Farm Price Basis (G_F)	Profitability Basis (S_p)	Profitability Basis (G_p)
	5	4	3	2	1
VII	3	5	4	1	2
	1	4	5	3	2
	5	2	1	4	3
VIII	3	5	4	1	2
	5	4	3	2	1
	1	5	4	3	2
IX	5	2	1	3	4
	5	4	3	1	2
	4	1	2	5	3
X	5	2	4	3	1
	4	3	5	2	1

a/ Entries in the table are, in descending order: rank of the mean, rank of standard deviation, and rank of the third central moment.

b/ Ranks are in descending order such that the highest value is assigned the rank of 1. and the lowest the rank of a 5.

among these enterprise classes. Enterprise class II gives an interesting case; in this class, means and variances are ranked similarly across pooling rules such that the highest mean is associated with the highest variance, the second highest mean with the second highest variance, and so on. No mean-variance dominance was to be expected among the five pooling rules for this class.

Stochastic Dominance Results

As discussed previously, stochastic dominance is a means of testing for stochastic efficiency among alternative strategies. Second-degree dominance (SSD) involves pairwise comparisons among the cumulative density functions of the sample distributions of each strategy (see Chapter III). An example of such CDF's (for enterprise class I) is given in figure 5.1. Meyer's stochastic dominance (MSD) involves, in addition, consideration of the upper and lower risk aversion bounds. Member-growers of the cooperative investigated here were assumed to be risk averse based on interviews with cooperative management. The assumption may not be strictly true; some members may be risk neutral or risk seeking. But it would be unlikely for growers to operate in the risk neutral or risk seeking portions of their utility functions when faced with such a significant decision as that of a pooling rule. A computer program designed by Meyer and modified by James Richardson and Edward Reister was used to implement both SSD

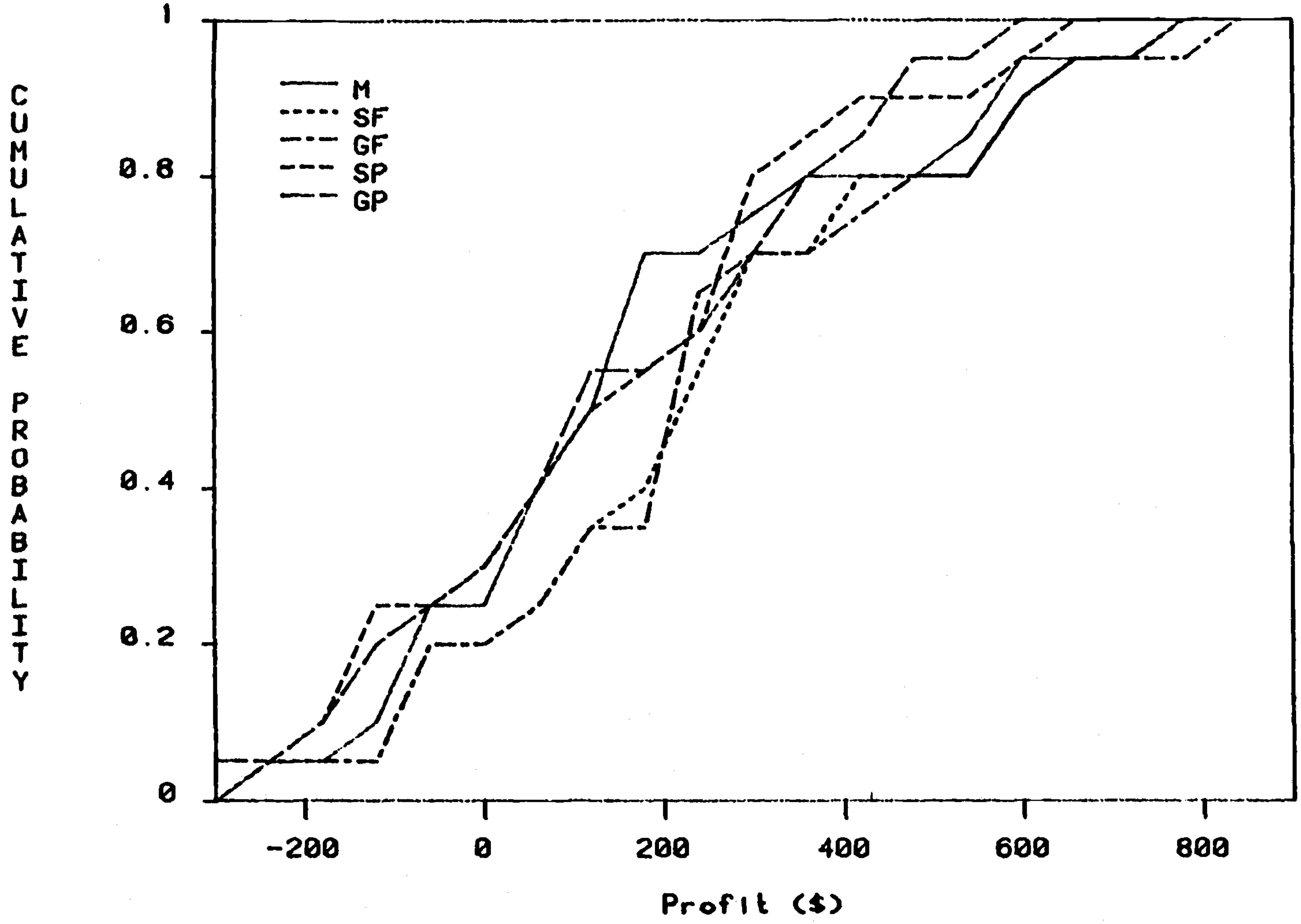

Figure 5.1. Enterprise class I, CDFs of pooling rules.

MSD. Table 5.4 shows second-degree stochastic dominance results and the results of Meyer stochastic dominance for three risk aversion intervals.

Discussion of Stochastic Dominance Results

As Table 5.4 makes clear, bean-corn (class I) growers with absolute risk aversion falling between 0.0 and 0.015 unanimously prefer G_F pooling rule over the other four rules. When class I growers with higher risk aversion levels are included (that is, when the upper limit is increased to $+\infty$), the multiple pool arrangement ceases to be dominated by farm-price-based grouped pools (G_F). Such a change may be explained by considering the moments of class I's profit distributions in Table 6.1. It has been shown that as risk aversion rises, the expected utility importance of the second moment increases relative to that of the mean and the importance of the third moment increases relative to that of the variance [Tsiang, p. 357]. Tsiang also has shown [p. 359] that all risk averters except those with very increasingly risk averse utilities (who probably are few in number) prefer algebraically high third central moments to low ones. Since, for class I growers, multiple pools have lower variance and higher positive skewness than do farm-price-based grouped pools, the former are presumably preferred to the latter by very risk averse members of this class. Thus, M and G_F do not dominate each other when all risk averters are considered as a group.

Table 5.4. Undominated Pools, by Risk Aversion Interval and Farm Enterprise Class a/

Enterprise Class	All Risk Averters	Absolute Risk Aversion b/ 0-0.005	0.005-0.010	0.010-0.015
I	M, G_F	G_F	G_F	G_F
II	M, G_F, S_P, G_P	M, G_F, S_P, G_P	S_P	S_P
III	M, S_F, S_P, G_P	M, S_F, S_P, G_P	S_P	S_P
IV	S_F, G_F	G_F	S_F, G_F	G_F
V	M, S_F, G_F, S_P, G_P	M, S_P, G_P	S_P	S_P
VI	G_F, G_P	G_F	G_F, G_P	G_P
VII	M, S_F, G_F, S_P, G_P	S_P, G_P	G_P	M, G_P
VIII	S_F, G_F	G_F	G_F	G_F
IX	M, S_P, G_P	M	M, G_P	G_P
X	M, S_F, G_F	M, S_F, G_F	M	M

a/ Symbols used are defined in the heading of table 5.1.

b/ Absolute risk aversion is defined as $-U''(X)/U'(X)$, where $U(X)$ is utility of X.

Although, for enterprise classes II and III, a profitability-based single pool (S_p) has the lowest and the second lowest mean, respectively, S_p still is undominated in the (0.005 - 0.010) and (0.010 - 0.015) risk aversion intervals. The reason is that S_p has the least variance in both classes, algebraically the highest skewness in class II, and algebraically the second highest skewness in class III.

Dominated and Undominated Pools

For corn (class IV) growers, multiple pools (M) and both single and grouped profitability-based pools (S_p and G_p) were rejected in all risk aversion intervals considered. Such effect may be explained by the low expected rewards and the high variances associated with these pooling rules for class IV growers. Profitability-based single (S_p) and grouped (G_p) pools were rejected by growers in enterprise classes I, VIII, and X in all risk aversion levels. Class IX growers rejected the farm-price-based single (S_F) and grouped (G_F) pools in all risk aversion levels considered.

Generally, undominated pooling rules vary among enterprise classes and across risk aversion intervals. Each of six enterprise classes (I, II, III, V, VIII, and X) did have the same undominated pools in both (0.005 - 0.010) and (0.010 - 0.015) risk aversion intervals. Further, each of three classes (II, III, and X) had the same dominance results for the all-risk-averter group as for the (0.0 - 0.005) interval. But, with one exception, unanimous agreement on undominated or rejected pools could not be detected among enterprise classes at any given risk aversion level.[6/] Hence, even if cooperative management knew the risk preferences of members in each of the ten enterprise classes, it would still be impossible to find a pooling rule that was optimal for everyone. Unless some weighting scheme is employed to find a group optimum, Table 5.4 is only helpful in pointing out the interest conflicts among enterprise classes for a given risk aversion level.

Mean-Gini Results

As shown in Chapter III, mean-Gini analysis eliminates any strategy that simultaneously has a lower mean and a lower mean-minus-Gini-coefficient than some other strategy.

Mean-Gini analyses were conducted on per-acre-profit data to compare the five pooling rules for each of the ten enterprise classes (Chapter IV). To accomplish this, equation (3-15) was estimated for each of the fifty profit distributions. Table 5.5 shows estimates of the mean (μ), Gini coefficient (Γ), and (μ-Γ), respectively, for each of the five pooling rules.

Mean-Gini Efficient Set

Identification of the mean-Gini undominated pools was done by first ranking estimates of (μ-Γ), as given in the third of each set of rows of Table 5.5, for each enterprise class. The mean of the first-ranked strategy — i.e., the one with the highest

Table 5.5. Mean, Gini Coefficient, and Mean Minus Gini Coefficient by Enterprise Class and Pooling Rule a/

	Pooling Rule				
Enterprise Class	M	S_F	G_F	S_p	G_p
I	219.35	282.50	295.25	188.95	193.40
	144.45	147.00	149.55	139.725	137.175
	74.90	135.50	145.70	49.225	56.225
II	365.00	440.8	454.65	272.4	278.7
	205.012	256.594	263.681	177.712	175.612
	159.988	184.206	190.969	94.688	103.088
III	- 68.05	-32.10	-153.65	-120.15	-104.35
	264.45	322.80	237.90	204.30	223.80
	-332.5	-354.9	-391.55	-324.45	-328.15
IV	68.00	117.80	129.30	101.95	104.55
	136.65	112.05	116.25	141.15	137.55
	- 68.65	5.75	13.05	- 39.20	- 33.00
V	542.80	528.90	471.20	511.10	547.25
	204.625	220.00	183.875	227.50	251.75
	338.175	308.90	287.325	283.60	295.50
VI	317.80	378.15	392.95	312.60	316.80
	161.363	161.688	165.263	140.563	135.525
	156.437	216.462	227.687	172.037	181.275
VII	266.55	268.10	283.15	356.75	358.15
	151.60	127.50	147.70	193.00	182.80
	114.95	140.60	135.45	163.75	175.35
VIII	442.05	490.90	508.65	480.35	483.50
	190.913	173.25	185.40	209.475	203.175
	251.137	317.65	323.25	270.875	280.325
IX	435.70	323.30	336.65	424.15	428.60
	137.80	165.994	173.144	152.588	145.275
	297.90	157.306	163.506	271.562	283.325
X	306.80	599.25	390.10	256.35	353.85
	323.00	470.00	334.00	404.00	547.25
	- 16.20	129.25	56.10	-147.65	-193.40

a/ Extimates shown are, in descending order, mean, Gini coefficient, and mean minus Gini coefficient.

(μ-Γ) — was then compared to the means of the rest of the pooling rules, and any rule with a lower mean than the first was discarded from the efficient set. Rules that remained in the set were next compared with the rule that had the second-highest (μ-Γ), and any rule with a lower mean than the latter was also rejected. This was repeated until all pool pairs were compared. The set of mean-Gini undominated pooling rules was thus obtained when no more eliminations were possible, that is, when no pool remaining in the set had a lower (μ-Γ) and a lower mean than any other pool in the set. Undominated pooling rules obtained by the above procedure are given for each enterprise class in Table 5.6.

Discussion of Mean-Gini Results

Results in Table 5.6 may be explained by considering the mean (μ) and mean-minus-Gini coefficient (μ-Γ) estimates provided in Table 5.5. For example, G_F is the only undominated pool for enterprise class I because, although it has the highest Γ of any rule, it also has the highest mean. Further, its (μ-Γ) estimate is the highest of any pooling rule for this enterprise class.

With the exception of classes III and V, only one undominated pooling rule remained for each enterprise class. For enterprise class III, only G_F was eliminated; it had the lowest mean and the lowest (μ-Γ) among the five pooling rules. However, none of the remaining four pools could be eliminated as each of them had a higher mean or a higher (μ-Γ) than one of the other three. In enterprise class V, the multiple pooling rule had a lower mean

Table 5.6. Mean-Gini Undominated Pools, by Enterprise Class

Enterprise Class	Undominated Pooling Rules
I	G_F
II	G_F
III	M, S_F, S_p, G_p
IV	G_F
V	M, G_p
VI	G_F
VII	G_p
VIII	G_F
IX	M
X	S_F

but higher (μ-Γ) than G_p, and hence was not eliminated. But rules S_F, G_F, and S_p were eliminated because they had both lower means and lower (μ-Γ) estimates than M, the multiple pooling rule.

Enterprise classes I, II, IV, VI, and VIII had the same undominated pooling rule, G_F. The undominated rule was G_p for class VII, M for class IX and S_F for class X. Generally, mean-Gini undominated pools vary across enterprise classes, indicating that a method for weighting the preferences of each enterprise class must be used in order to find a group optimum.

Comparisons of Stochastic Dominance, Mean-Gini and Mean-Variance Results

Mean-variance analyses also were conducted for the profit distributions that resulted from employing each of the five pooling rules for each of the ten enterprise classes. Mean-variance efficient sets were obtained by imposing two conditions for F to dominate G, viz. F dominates G iff $\mu_F \geq \mu_G$ and $\sigma_F^2 \leq \sigma_G^2$, with at least one of these two conditions holding with strict inequality [Tobin, 1958]. For purposes of comparison with mean-variance and mean-Gini results, Meyer's stochastic dominance tests were applied holding the lower risk aversion bound at zero and gradually increasing the upper bound. This included increasingly risk averse decision makers in successive Meyer-type tests. Comparative results from Meyer stochastic dominance, second-degree stochastic dominance, and mean-Gini analysis are shown in Table 5.7.

Table 5.7. Undominated Pools, by Enterprise Class and Dominance Criterion

Enterprise Class	Stochastic Dominance (MSD)			Mean-Variance (MV)	mean-Gini (MG)
	0.0 - 0.0015	0.0 - 0.0045	0.0 - ∞ (SSD)		
I	G_F	G_F	M, G_F	M, S_F, G_F, G_P	G_F
II	G_F	M, S_P, G_F, G_P	M, S_P, G_F, G_P	M, S_F, S_P, G_F, G_P	G_F
III	M, S_F, S_P, G_P	M, S_F, S_P, G_P	M, S_F, S_P, G_P	M, S_F, S_P, G_P	M, S_F, S_P, G_P
IV	G_F	G_F	S_F, G_F	S_F, G_F	G_F
V	M, G_P	M, S_P, G_P	M, S_F, S_P, G_F, G_P	M, G_F, G_P	M, G_P
VI	G_F	G_F	G_F, G_P	S_F, G_F, G_P	G_F
VII	G_P	S_P, G_P	M, S_F, S_P, G_F, G_P	S_F, G_F, G_P	G_P
VIII	G_F	G_F	S_F, G_F	S_F, G_F	G_F
IX	M	M	M, S_P, G_P	M	M
X	S_F	M, S_F, G_F	M, S_F, G_F	M, S_F, G_F	S_F

Two interesting relationships are clear from Table 5.7. The first is that the number of undominated pools under mean-variance analysis (MV) or under second-degree stochastic dominance (SSD) is at least as large as that under mean-Gini analysis (MG). Furthermore, the mean-Gini undominated set is a subset of the undominated pools in SSD or MV. That is

$$MV \supseteq MG$$

$$SSD \supseteq MG,$$

where MV, SSD, and MG are undominated sets under the respective criteria and $\supseteq$ means "contains." These results confirm the hypothesis proposed in Chapter IV concerning the discriminatory power of the three techniques.

The second interesting result in Table 5.7 is that the set of mean-Gini undominated pools is identical to the undominated set under Meyer's stochastic dominance (MSD) for the risk aversion interval (0.0 - 0.0015). Comparing Tables 5.7 and 5.1 one finds that, for all enterprise classes except III and V, all undominated pools in interval (0.0 - 0.0015) are the ones with the highest expected return. This suggests that decision makers represented by the (0.0 - 0.0015) interval and by mean-Gini analysis are weakly risk averse.

Group Optima

Group-optimal rules for each risk aversion interval were found by simulating three voting schemes: (a) where each member-grower is given one vote (one person - one vote); (b) where votes are assigned in proportion to the 1980-1982 mean established raw product value delivered by each member; and (c) where one vote is assigned per member plus one vote for each $5,000 of 1980-1982 mean raw product established value delivered (with a maximum of 19 votes on the latter basis). Voting scheme (c) is the one actually used by the cooperative under investigation.

In cases where more than one pooling rule were undominated for a certain member class in a certain risk aversion interval, votes were divided equally among the undominated pools. This procedure may be inconsistent with the actual distribution of preferences within a risk aversion interval. However, stochastic dominance analysis does not indicate, with a risk aversion interval, the proportions of decision makers having strict preference for each undominated pooling rule.

Voting Procedures

The three voting schemes described above were each applied by two different methods. In the first method, votes were added across all enterprise classes and the pooling rule with the highest number of votes in each risk aversion interval was considered the group choice in that interval. This method will be referred to as "one-round voting." The second application of the three voting schemes was to eliminate the pooling rule with the least number of votes in the first orund of voting and to rerun the stochastic dominance analysis for the remaining pooling rules. A second round of voting then was conducted and the pooling rule with the least number of votes again eliminated. These steps were repeated until a vote could be conducted bewteen just two pools in each risk aversion interval. The final vote yielded the group optimum for the risk aversion interval considered. This second voting method will be referred to as "elimination voting."

Voting Results

Results of both one-round voting and elimination voting are shown in Table 5.8. One-round voting results are given in the first row, and elimination voting results in the last row, for each risk aversion interval and voting method.

Voting results were the same using one-round voting and elimination voting except in the case of the per-value-delivered voting scheme in the (0.010 - 0.015) risk version interval. For the latter, G_F-pooling received the highest number of votes in the first round of voting. But after M and S_p were eliminated due to insufficient votes, all enterprise classes which had originally voted for either of them shifted their votes to G_p. In this way, G_p became group-optimal in the last round of voting.

Table 5.8. Voting Results by Risk Aversion Interval and Voting Method a/ b/

Voting Method	Absolute Risk Aversion	Voting Round	Pooling Rules M	S_F	G_F	S_P	G_P
Per Person Voting	0.0 - 0.005	1	16	5	49	15	15
		2	18	out	49	16	16
		3	31		69	out	out
	0.005 - 0.010	1	3	4	36	47	10
		2	out	2	40	46	12
		3		out	42	47	11
		4			47	53	out
	0.010 - 0.015	1	4	0	37	47	12
		2	out	1	38	47	14
		3		out	39	47	14
		4			47	53	out
	All Risk Averters	1	26	14	30	14	16
		2	34	out	41	out	25
		3	42		58		out
Per Value Delivered Voting	0.0 - 0.005	1	14	1	57	14	14
		2	14	out	60	13	13
		3	27		73	out	out
	0.005 - 0.010	1	3	3	43	30	21
		2	out	out	46	30	24
		3			59	41	out
	0.010 - 0.015	1	5	0	38	30	27
		2	out	out	38	30	32
		3			38	out	62
	All Risk Averters	1	23	12	35	11	19
		2	27	14	37	out	22
		3	29	out	46		25
		4	40		60		out

(continued)

Table 5.8. Voting Results by Risk Aversion Interval and Voting Method (continued)

Voting Method	Absolute Risk Aversion	Voting Round	Pooling Rules				
			M	S_F	G_F	S_P	G_P
Combination Voting	0.0 - 0.005	1	16	1	55	14	14
		2	17	out	55	14	14
		3	30		70	out	out
	0.005 - 0.010	1	3	3	43	34	17
		2	out	out	46	34	20
		3			55	45	out
	0.010 - 0.015	1	5	0	41	34	20
		2	out	out	42	34	24
		3			55	45	out
	All Risk Averters	1	25	13	34	12	16
		2	29	15	36	out	20
		3	31	out	46		23
		4	41		59		out

a/ Votes cast are expressed on a percentage basis. Rows sum to 100.

b/ The "outs" refer to the pooling rule with the least votes at a particular round, and which will be eliminated from the analysis in the next round.

As may be seen from Table 5.8, the farm-price-based grouped pool (G_F) is group-optimal under voting schemes (b) and (c) for all risk aversion intervals used. Under voting scheme (a) — per-person voting — G_F is the group optimum only for the (0.0 - 0.005) risk aversion interval. For the remaining intervals, the profitability-based single pool (S_p) becomes group optimal under per-person voting. The farm-price-based single pool (S_F), presently employed by the cooperative investigated here, received the least number of votes for all risk aversion intervals and all voting schemes. This is consistent with the cooperative's expressed dissatisfaction with its present pooling arrangement.

VI. CONCLUSIONS

The main objective of this study has been to analyze choice of marketing pool by risk averse cooperative members. The study involved formulating alternative pooling rules that utilized different combinations of pool breadths and share valuation methods. In general, the number of possible pooling rules is equal to the number of all possible combinations of feasible pool breadths and share valuation methods.

Although the number of pooling rules investigated in the present study was limited to five, enough generality was allowed with respect to pool breadth and share valuation method to demonstrate the choice of pool in a risky environment. Pool breadths modeled in the study included the two extreme cases of single and multiple pools as well as the intermediate case of grouped pools. The two share valuation methods employed demonstrated how to implement alternative formulae for allocating cooperative income among members.

Pool Choice

Choice of an optimal pooling rule depends on the risk preferences of cooperative members as well as on the schemes used to weight individual choices. Because risk aversion may vary both within and among enterprise classes, one would not expect members to agree on the best pooling rule. Further, any weighting scheme used to summarize group preferences may favor certain member groups over others. The value of decision analysis in this context is to highlight individual interests and the conflict among such interests.

For each of the weighting or voting schemes employed in the present study, the group-optimal choice usually was to operate separate fruit and vegetable pools and to value raw products on a farm-price basis. The exception was that, under per-person voting, a profitability based single pool was group-preferred in the (0.005 - 0.015) risk aversion interval. The farm-price-based single pool, presently employed by the cooperative studied, fared worst of all. For no enterprise class or risk aversion interval was it the only stochastically undominated pool and only in classes IV, VIII, and X was it stochastically undominated at all. More importantly, the farm-price-based single pool tended to receive the fewest votes regardless of voting criterion. Given the correctness of the assumptions made about members' risk attitudes and other factors, the implication is that the cooperative should change the pooling rule it is presently employing.

Decision Analysis Methods

The risk aversion assumptions implicit in the alternative decision techniques used in this study significantly affected results. Application of mean-variance (MV) and second-degree stochastic dominance (SSD) analysis tended to result in rather large undominated sets, while Meyer stochastic dominance (MSD) and mean-Gini (MG) analysis resulted in smaller sets.

Whether the tendency of mean-Gini to produce a relatively small undominated set, and to represent relatively weakly risk averse decision makers, is desirable depends on the situation investigated. When it is justifiable to assume low risk aversion, mean-Gini would appear superior to second-degree stochastic dominance because the latter represents strongly as well as weakly risk averse decision makers. Computationally, mean-Gini is easier to apply than either SSD or MSD since mean-Gini utilizes parameter estimates only. By contrast, SSD and MSD involve comparisons of cumulative density functions along their entire net return domains. Finally, mean-Gini, like SSD and MSD and unlike mean-variance analysis, is not limited to situations where prospects are normally distributed, utilities quadratic, or variances small relative to means.

Suggested Research Extensions

As emphasized in Chapter II, calculation of net returns for profitability-based pools has been based on a particular net revenue forecasting formula (2-9). Other forecasting models could be employed for this purpose and choice of forecasting model would be expected to affect pools' stochastic efficiency. Investigation of the impact of alternative forecasting models will be left for future research.

An important aspect of calculating member returns for any pooling arrangement narrower than a single pool is the method of allocating fixed costs. In the present study, administrative and other fixed costs were allocated among products mainly on the basis of sales revenue of each product line (see Chapter II). Different allocation methods are possible and group pool preference may vary according to the allocation procedure adopted.

Finally, different pool designs might also have been investigated. One possibility is to include in a given pool a number of products whose returns are thought to be negatively correlated. This would tend to reduce overall income variance. Another suggestion is to operate more than one pooling rule at the same time. For example, a cooperative might simultaneously operate a single pool and a set of multiple pool where (say) half the deliveries of each grower-member go to the former and half to the latter. Such possibilities currently are being tried in practice but have not as yet been investigated in a research setting.

ENDNOTES

1/ Pratt and Arrow's absolute risk aversion coefficient, r(X), in the negative of the ratio of the second derivative to the first derivative of the utility of wealth (or profits) U(X):

$$r(X) = -U''(X)/U'(X)$$

The Pratt coefficient is positive for risk aversion, zero for risk neutrality, and negative for risk seeking preferences. Many economists argue that absolute risk aversion typically is a decreasing function of wealth or profits, that is, $r'(X) < 0$ [e.g., Arrow, p. 96]. If instead, $r'(X) > 0$, then an individual would decrease the amount of risky assets he holds as he becomes wealthier. The latter condition, which seems unreasonable, is a characteristic of quadratic utility functions.

For more discussion of expected utility theory and risk aversion see Anderson et al., Arrow, Deaton and Meullbauer, Layard and Walters, Arrow, and Pratt.

2/ Anderson et al. [p. 284] argue that "a related consideration is that it tends to be the rule rather than the exception that CDFs from different families and indeed CDFs from the same family intersect at least once, thereby predisposing against the chance of identifying any FSD.

3/ Conventionally, the Gini coefficient has been used as a measure of the inequality of income distribution and is defined as the area between the Lorenz curve and the 45° line. Another application of the coefficient is in economic welfare theory. Dorfman [p. 146] attributes the increased interest in the Gini coefficient in the 1970s to "a debate about its significance as a measure of economic welfare." An example of such application is provided by Sen [1976] where the Gini coefficient was transformed "from the measurement of inequality to that of poverty" [p. 226] in an effort to provide an ordinal measure of poverty.

The use to which the Gini coefficient is put here is a different one, namely as a measure of the variability of a cooperative member's net retruns. Dorfman [p. 147] notes that "Gini himself proposed the coefficient that now bears his name as a measure of the variability of any statistical distribution or probability distribution. Specifically he based his coefficient on the average of the absolute differences between pairs of observations, and defined it to be the ratio of half of that average to the mean of the distribution."

4/ The enterprise efficiency studies were prepared by Oregon State University Extension Service. However, production cost estimates were not available for rhubarb. Production costs for rhubarb were obtained from the cooperative investigated by the study.

5/ Indices for prices paid by U.S. farmers were obtained from "Agricultural Prices," Crop Reporting Board, ESCS, USDA. The base year was changed from 1977 to 1982.

6/ The exception was that S_F was rejected by all enterprise classes in the risk aversion interval (0.010 - 0.015). See Table 5.4.

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APPENDIX

Profit Distributions of Enterprise Classes

for the Five Pooling Rules ($/Acre)

Table A-1. Enterprise Class I

Year	M	SF	GF	SP	GP
1960	-451	-622	-615	-238	-250
1961	182	151	223	168	181
1962	357	480	468	207	207
1963	249	413	416	537	507
1964	403	576	564	126	169
1965	964	1057	1095	492	481
1966	1095	1230	1342	758	718
1967	894	1127	1130	852	744
1968	504	853	851	514	479
1969	403	668	655	538	757
1970	427	655	630	578	625
1972	51	-186	-185	-230	-244
1973	334	- 42	- 20	- 79	- 84
1974	405	687	685	440	479
1975	-425	-134	-141	-191	-166
1976	35	87	90	11	- 20
1977	550	412	444	145	125
1978	638	638	689	399	399
1979	555	522	523	320	298
1980	130	244	249	132	169

Table A-2. Enterprise Class II

Year	M	SF	GF	SP	GP
1960	96	207	233	69	53
1961	183	235	305	161	172
1962	-149	50	43	- 47	- 26
1963	-323	-114	-113	-221	-233
1964	- 75	- 20	- 26	- 92	- 64
1965	287	159	177	173	165
1966	519	368	429	606	572
1967	360	152	153	369	297
1968	- 95	- 13	- 14	203	178
1969	-190	- 67	- 72	138	279
1970	-172	- 53	- 65	60	87
1972	- 73	83	84	-291	-301
1973	78	346	375	-202	-205
1974	706	645	643	252	282
1975	198	62	54	- 5	23
1976	122	114	116	182	149
1977	113	225	249	440	417
1978	77	272	307	491	490
1979	-130	4	5	53	38
1980	-172	-299	-297	-300	-282

Table A-3. Enterprise Class III

Year	M	SF	GF	SP	GP
1960	-183	-216	-199	- 88	-102
1961	182	192	263	165	177
1962	109	269	260	67	93
1963	- 31	155	157	166	144
1964	169	284	275	19	55
1965	632	617	645	336	326
1966	813	808	895	684	646
1967	632	649	651	615	525
1968	210	429	427	362	332
1969	112	308	299	342	523
1970	133	308	389	324	361
1972	- 10	- 54	- 53	-260	-272
1973	209	148	174	-139	-143
1974	552	666	664	348	382
1975	-120	- 38	- 45	-100	- 73
1976	78	100	103	95	63
1977	336	320	348	290	268
1978	363	459	502	444	444
1979	219	268	269	189	171
1980	- 18	- 22	- 19	- 80	- 52

Table A-4. Enterprise Class IV

Year	M	SF	GF	SP	GP
1960	- 97	9	-126	-199	- 96
1961	- 61	286	- 75	1	- 66
1962	-669	-707	-681	-582	-663
1963	-336	-290	-331	-711	-345
1964	-597	-640	-605	-399	-575
1965	-152	39	-158	-239	-157
1966	470	839	455	247	436
1967	688	697	685	- 6	622
1968	673	653	672	- 58	616
1969	-523	-572	-523	324	-494
1970	-196	-390	-205	167	-181
1972	645	-417	-437	-477	-137
1973	- 55	- 23	-339	1	106
1974	184	- 90	- 55	995	159
1975	-707	-797	-697	-189	-581
1976	-191	-110	-131	-458	-129
1977	272	592	187	-114	226
1978	334	1267	340	132	136
1979	9	-129	-142	-528	-155
1980	-1052	-859	-907	-310	-809

Table A-5. Enterprise Class V

Year	M	SF	GF	SP	GP
1960	- 43	22	50	34	13
1961	548	483	588	491	510
1962	337	418	405	283	322
1963	213	242	245	262	234
1964	288	447	435	258	313
1965	750	843	880	681	668
1966	1016	1002	1111	904	856
1967	561	811	814	777	663
1968	551	619	617	457	419
1969	598	545	533	80	255
1970	495	512	486	245	287
1972	36	202	204	705	668
1973	495	489	528	1087	1075
1974	1140	1157	1154	1457	1531
1975	-161	15	5	- 78	- 43
1976	218	270	274	191	149
1977	529	698	740	677	644
1978	938	582	637	553	553
1979	433	434	435	558	530
1980	-101	27	32	- 15	23

Table A-6. Enterprise Class VI

Year	M	SF	GF	SP	GP
1960	222	338	372	170	149
1961	486	438	532	439	456
1962	73	170	161	153	184
1963	- 95	- 42	- 40	-103	-120
1964	67	105	96	123	167
1965	409	336	360	488	476
1966	696	520	597	821	778
1967	387	290	291	536	444
1968	188	133	132	317	286
1969	167	119	111	- 57	78
1970	109	112	95	5	35
1972	- 7	251	253	492	463
1973	282	569	608	798	788
1974	1156	967	964	1139	1200
1975	194	83	73	20	55
1976	213	222	225	268	227
1977	316	484	518	752	720
1978	545	382	426	630	630
1979	108	133	134	358	335
1980	-185	-248	-245	-214	-188

Table A-7. Enterprise Class VII

Year	M	SF	GF	SP	GP
1960	-100	-298	-282	- 19	- 36
1961	348	193	268	413	429
1962	512	318	307	296	331
1963	431	234	237	350	323
1964	411	319	309	280	330
1965	663	671	701	757	744
1966	856	864	957	927	882
1967	690	819	821	822	715
1968	637	544	542	426	392
1969	402	453	442	337	528
1970	360	335	315	409	451
1972	144	- 64	- 62	230	206
1973	366	158	185	443	435
1974	893	687	685	880	933
1975	115	- 67	- 75	21	54
1976	213	86	88	201	164
1977	499	367	398	553	525
1978	628	488	534	655	655
1979	448	344	345	473	448
1980	198	15	18	29	63

Table A-8. Enterprise Class VIII

Year	M	SF	GF	SP	GP
1960	-139	-133	-112	- 45	- 61
1961	334	313	398	299	314
1962	214	341	330	160	192
1963	82	204	206	221	197
1964	227	367	356	122	166
1965	695	733	765	484	473
1966	910	909	1007	776	735
1967	610	740	742	692	591
1968	366	529	528	406	373
1969	331	425	414	242	422
1970	299	410	388	303	343
1972	10	48	50	142	120
1973	335	284	315	372	365
1974	791	876	874	814	865
1975	-154	- 19	- 28	- 96	- 66
1976	135	172	175	130	94
1977	424	485	519	443	417
1978	615	518	566	484	483
1979	320	350	351	348	325
1980	- 49	11	15	- 45	- 12

Table A-9. Enterprise Class IX

Year	M	SF	GF	SP	GP
1960	433	374	311	491	529
1961	472	575	446	536	514
1962	233	225	236	146	128
1963	117	48	30	- 27	146
1964	357	327	350	192	124
1965	737	899	774	733	780
1966	1073	1427	1243	1475	1600
1967	995	838	834	1053	1446
1968	703	624	632	465	824
1969	521	366	400	517	302
1970	535	393	511	763	593
1972	483	310	296	- 58	131
1973	378	828	615	122	162
1974	1089	693	710	1051	720
1975	- 24	-142	- 81	205	30
1976	711	531	518	394	604
1977	1161	1060	831	735	913
1978	857	1023	628	1050	1052
1979	279	376	369	349	542
1980	-254	-197	-229	30	-195

Table A-10. Enterprise Class X

Year	M	SF	GF	SP	GP
1960	178	653	402	63	240
1961	37	737	149	171	66
1962	-604	-362	-305	-634	-770
1963	-402	-443	-502	-921	-340
1964	117	201	295	-218	-530
1965	646	1350	904	535	709
1966	1166	2453	1695	2295	2774
1967	1110	900	882	1280	2716
1968	1110	902	929	342	1514
1969	477	331	459	324	-801
1970	654	297	703	840	213
1972	328	332	286	-319	293
1973	124	1238	514	-270	-136
1974	5	154	211	1146	29
1975	-474	-727	-525	- 91	-714
1976	1155	944	897	184	919
1977	722	1847	1071	336	949
1978	433	1730	418	875	882
1979	11	198	175	-479	169
1980	-657	-750	-856	-332	-1105