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Optimal Cooperative Pools for California Avocados

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Pooling is a method of allocating net revenues. Marketing cooperatives that adopt this method to determine members' returns face conflicting objectives when choosing a set of pools. Using numerous pools avoids inequity and maintains incentives, while using few pools achieves savings and spreads risks. This study proposes a method for selecting a reasonable compromise. From this viewpoint it appraises 31 possibilities in pooling California avocados.

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Optimal Cooperative Pools for California Avocados[1]

AGRICULTURAL MARKETING cooperatives usually must allocate their net revenues among members whose deliveries differ in handling cost and resale potential. Many cooperatives meet the problem by deferring valuation until deliveries have been resold, creating categories to group similar deliveries, valuing all deliveries within a category at the same price, setting the price just high enough to allocate the net revenues actually realized for the category, and then paying members according to their tonnage in each category.

The uniform-price categories, or pools, are potential sources of trouble. If the pools combine deliveries with markedly different values, they may violate members' standards of fair treatment, impair the ability of the association to compete for high valued lots, and weaken members' incentives to improve quality. On the other hand, an association which tried to reproduce the many differences in resale value might establish pools that were narrowly defined and numerous, and therefore expensive. The cost would reduce the net revenues available for all members. It might even reduce payments to the very members who delivered the highest valued lots and therefore would benefit from having numerous pools.

An optimal set of pools represents a compromise between these extremes. This study formulates a criterion of optimality, develops a procedure for determining an optimal set in practice, and applies the procedure to an illustrative case—California avocados. Attention centers on the number and kind of pools to adopt, taking as given the association's selling policies, method of determining pool revenues, cost allocations, and deductions from member payments.

Criterion for Optimal Pools

Development of a criterion for an optimal set of pools is fundamental to the analysis of pooling problems and is the principal innovation in this study. It may be helpful to outline the proposed criterion at this point.

The criterion involves two numerical concepts. One is the "total savings" associated with any pooling method, or the potential reduction in annual pooling costs from adopting that alternative instead of some very complex pooling method. The other concept is the "aggregate inequity" associated with an alternative, or the sum of a year's underpayments for members whose valuations would be smaller with that alternative than with the very complex alternative, neglecting these members' share of the total savings that also would result from the alternative.

The optimal alternative would be whichever of the following two had the larger total savings: (1) the alternative with the largest excess of total savings

[1] Submitted for publication November 29, 1962.

over aggregate inequity, or (2) the alternative with the largest total savings among those with which each member, after adding his share of total savings, receives at least as large a valuation as with the most complex alternative.

The criterion, as will be seen, passes a number of intuitively appealing tests for whether a decision reflects the preferences of members of a group. One of these tests is whether no change—no further simplification of the pooling structure—is available that would benefit some people and harm no one.

The criterion fulfills these standards while accomplishing a specific result that also is intuitively appealing. The optimal alternative goes as far in increasing total savings, and therefore the combined valuation of all members, as is possible without raising two objections simultaneously. One is the objection that some members will end up with a smaller valuation than they would receive with the very complex alternative. The other is the objection that pooling simplification has been carried so far that the cost (aggregate inequity) has increased by more than the benefit (total savings).

While no criterion can be demonstrated to be superior to all others, this one does seem to offer an impartial and sensible way to reconcile the conflicting objectives of savings and equity. It can reasonably be adopted by a cooperative unless (1) a different alternative appears preferable when risk-spreading and maintaining incentives (two additional but uncommensurable objectives) are also considered, or (2) the cost of changing from the existing pooling procedure would outweigh the gain in savings-minus-inequity because the gain would be small or short lived.

SETTING FOR THE STUDY

Sums Paid to Members—Initial Values and Refunds

The bylaws of a marketing cooperative usually distinguish two sums owed to member-patrons. One is the initial value (also called "market value") placed on members' deliveries. From these amounts are subtracted the fees for any services, such as harvesting, that are billed to members individually.

The other sums are patronage refunds determined following each fiscal year. The refunds apportion any net income that remains after deducting all costs, including the initial values, and after making (unallocated) additions to capital. Provision for such refunds is often regarded as essential if a commercial organization is to be called a "cooperative," a cooperative in this view being an organization that is owned by its patrons and that allocates any net income in proportion to patronage, not to investment or other criteria.

To determine initial values, cooperatives ordinarily employ one or more of three methods. Each method recognizes variation in resale value among deliveries in a different way.

Methods of Initial Valuation

One method of initial valuation is called "individual results." With it, the association, although it may take title to members' deliveries, determines initial values much as a proprietary commission merchant usually does. Each member's deliveries are sold separately, and for each delivery the association owes the revenues actually realized, minus separated costs (such as outfreight) and minus a deduction for common or unseparated costs (some of the amount owed perhaps being retained for a revolving capital fund). If the sum of a year's deductions for unseparated costs proves to be higher than necessary, net income will be positive.

A second method of determining initial values is called "immediate fixation." With it, the association, although it may not take title to deliveries, determines initial values much as a proprietary buyer usually does. For each delivery the association owes an amount that it specifies to, or negotiates with, the member-patron (some of which may be retained for a revolving fund). Ordinarily, every delivery is subdivided according to commodity characteristics, and a value is placed on each lot by referring to prices paid by other handlers. If the sum of a year's initial values is less than the net marketing income of the association, net income will be positive.

The third method is called "pooling." With it, the association, although it may neither take title nor commingle different deliveries, determines initial values much as a joint selling agent or a syndicate might. Every delivery is subdivided, and the association owes for each lot a proportion of the revenues actually realized from the sale of that and all "similar" lots delivered by other members, minus separated costs, minus a deduction (the operating retain) for unseparated costs (some of the amount owed perhaps being retained for a revolving fund). If the sum of a year's deductions for unseparated costs proves to be higher than necessary, net income will be positive.

Distinction Between Cost-Spreading and Pooling

It is sometimes said that all cooperatives pool since all combine and apportion costs. With each method of initial valuation, costs relating to a number of deliveries are indeed shared. When the method of individual results is used, a deduction is made to cover unseparated costs. With pooling, a deduction is made for unseparated costs, and separated costs are combined within each pool. With immediate fixation, the excess of revenues over total costs may be refunded uniformly.

Proprietary handlers, however, also spread costs. An agent's commission or a buyer's gross margin tends to include an allowance for depreciation and other expenses that relate to a number of deliveries. Since cost spreading is universal, it seems appropriate to confine the word "pooling" to cases where net revenues are apportioned.

Refund Pooling

On the other hand, there is some reason to use the word "pooling" to refer also to the usual method of calculating refunds. With this method, the refund for any lot of a commodity is determined by deciding that certain lots will receive the same refund and by making this refund just high enough to apportion the net income attributed to all lots in the category. This arrangement has the essential characteristic of pooling—apportioning combined net revenues.

At one extreme, the refund can be uniform per dollar of initial value for all lots. When combined with immediate fixation, this procedure successfully avoids any need to allocate common costs among different commodities, grades, and so forth. This case has been called "single pool accounting" (Mayhew, 1949; Mauser, 1961). It is, however, a combination of a single *refund* pool with immediate fixation, and it might be more revealing to call it such.

At the other extreme, refund pools can be so numerous that they nullify the prior determination of initial values by immediate fixation. For example, refunds may amount to 5 per cent of initial value for Grade A apricots and to 3 per cent for Grade B apricots; all Grade A apricots may have received the same initial value per pound (regardless of date delivered), and all Grade B apricots a lesser value; and the refund for each grade may represent the actual revenues for the grade, minus its initial values and assigned costs. Then the initial values do not affect a member's returns. Any increase in the initial per-pound value for Grade A would be exactly offset by a reduction in its refund.

It is possible to go one step further and create a separate refund "pool" for each lot or each member. This, however,

TABLE 1

FREQUENCY OF DIFFERENT METHODS OF INITIAL VALUATION, 1954

Number of associations polled	Commodity group	Percentage using:			
		Pooling	Individual results	Immediate fixation	Nonpooling combination
165	Citrus	99	1	..	..
32	Berries	44	44	12	..
27	Grapes	85	11	..	4
24	Apples	67	25	4	4
22	Soft deciduous	54	41	..	5
30	Apples and soft deciduous	70	27	3	..
14	Mixed deciduous	72	14	14	..
14	Other fruits	79	21	..	..
24	Potatoes	58	25	13	4
57	Mixed vegetables	56	33	12	..
24	Mixed fruits and vegetables	63	21	12	4
18	Tree nuts	89	11	..	..
4	Mixed fruits, vegetables, and/or tree nuts	75	..	25	..
10	California field crops	30	..	..	..
9	California wine	100	..	..	..
5	California dairy products	80	..	..	..
4	California poultry products	100	..	..	..

SOURCES: (1) Markeson, 1959, p. 7. (Markeson's figures were slightly altered by transferring three so-called single-pool associations, mentioned on his page 26, to the immediate fixation column.) (2) Mueller and Tinley, 1958, p. 36.

would determine refunds not by pooling but by individual results. Indeed, this method would nullify initial valuation by either immediate fixation or pooling and would base valuation entirely on individual results. Hence, the common assertion that a cooperative must use pooling is not correct.

Frequency and Advantages of Pooling

While, as we have seen, cooperatives could avoid pooling if they wished, in practice it is apparently universal for refunds and common for initial valuation. Recent data showing the relative frequency of the several methods of initial valuation are summarized in table 1.[2]

Of the three methods of initial valuation, pooling appears to be the one most used by American cooperatives. On the other hand, there seem to be few commodities for which 100 per cent of the marketing cooperatives use pooling in initial valuation.

Whether an association uses pooling may be influenced by historical accident, by personal considerations, by the ability of members to reach mutually acceptable compromises, and by competitors' practices. It may also be influenced by the objective advantages and disadvantages of the several valuation methods, including their influence on the problem of reselling members' deliveries. This study will not discuss the situations where the advantages of each method might become dominant, but rather concentrate on pooling and, specifically, its use in initial valuation. Important characteristics of the three methods of initial valuation, however, are summarized in table 2.

[2] Concerning livestock, it is reported that pooling was practiced during 1959 by 534 cooperative and noncooperative marketing agencies located in 33 states. For the seven-state area consisting of Georgia, Kentucky, Missouri, Ohio, Tennessee, Virginia, and West Virginia, agencies using pooling handled 16 per cent of the cattle and calves marketed, 18 per cent of the hogs and pigs, and 50 per cent of the sheep and lambs. (Stevens and Haas, 1961, p. 6, 15.)

Pooling Problems

At least four choices must be made in pooling:

(1) What is to be the number and kind of pools? That is, what lots will receive the same per-unit initial values?

(2) Will the revenues assigned to each pool be actual invoice amounts or will they be management determined? (Determination by management may seem preferable if accumulating invoice amounts is expensive; or if there are differences, such as unequal storability, that selling prices do not reflect; or if premium prices are related, not to intrinsic differences among pools, but to differences in advertising, destination, processing, storage, or diversion of "surplus.") Management may adopt the invoice-determined figure for one pool as a base, and assign per-unit revenues equal to specified percentages of the base to all other pools. Selecting and revising the percentages then become critical problems.

(3) How will the association calculate and allocate, either to pools or directly to members: (a) separable costs, such as harvesting, infreight, tallying, outfreight, loss in transit, bad debts, price guarantees, cash and volume discounts, spoilage, and "surplus"; (b) common costs, such as shrink, payroll, supplies, utilities, interest, and depreciation (for example, should unsized lots bear any of the costs of sizing equipment?); and (c) profits or losses from other sources, such as nonmember patronage, byproducts, companion lines, investment income, and capital gains?

(4) Concerning the operating retain that is designed to cover unseparated costs, several questions must be answered: Should it be set safely high? How should it be revised as the season progresses? Is its yield more predictable and is it more equitable if levied as a percentage of dollar volume, on a per-unit basis, or on some combination basis, and perhaps incorporating quantity discounts? Is it consistent to charge a per-unit operating retain and pay a percentage refund?

In some respects the four issues, together with decisions about marketing policies, are interrelated. For example, if differences among members in per-unit handling costs are billed directly to the members, it will be unnecessary to create separate pools for deliveries that are otherwise equivalent. Similarly, if pool revenues are established by management instead of being read off invoices, the bookkeeping costs associated with every pooling alternative may be, say, 10 per cent less. Then the absolute savings in bookkeeping costs that would result from decreasing the number of pools would be smaller, and the appropriate number of pools might be larger. For present purposes, however, let us

TABLE 2

CHARACTERISTICS OF DIFFERENT METHODS OF INITIAL VALUATION

Characteristic	Pooling	Individual results	Immediate fixation
1. Common costs must be allocated among commodities, grades, and so forth	yes	yes	no
2. Revenues received for individual deliveries must be determined	no	yes	no
3. Compatible with commingling	yes	no	yes
4. Control of selling vested in the management of the association	yes	no	yes
5. Little managerial discretion required to make initial valuations	yes	yes	no
6. "Excessive" initial values unlikely	yes	yes	no
7. Risks of unpredictable losses spread over a number of members	yes	no	yes
8. Initial values related to actual net revenues	yes	yes	no
9. Initial values related to competitors' prices	no	no	yes
10. Prompt determination of initial values	no	no	yes
11. Investments serving some commodities will increase returns for others	no	no	yes

suppose that at least tentative conclusions have been reached on all questions but one—the number and kind of pools.

OPTIMAL NUMBER AND KIND OF POOLS

The method used here to determine an optimal set of pools can be divided into ten steps: (1) determining feasible alternatives, (2) determining the effects of a choice, (3) choosing ways to measure effects, (4) adopting a criterion of optimality, (5) sampling among alternatives, (6) estimating savings, (7) sampling among members and seasons, (8) calculating sample inequity, (9) estimating all-member inequity, and (10) identifying the overall optimum among the sampled alternatives.

For concreteness, further remarks will relate to a specific case—the marketing of fresh avocados by Calavo Growers of California, a cooperative that handles about half of the California tonnage.

STEP ONE
DETERMINING FEASIBLE ALTERNATIVES

Feasible pooling alternatives range from a lower limit to an upper limit.

The Limiting Alternatives

The lower limit consists of a single pool per time period—for example, per crop year. With this alternative, all avocados delivered during the same season would be valued at the same price, even though sold at different prices.

The upper limit consists of as many pools as there are separate sales and therefore selling prices. (A sale might be divided into two or more pools if there were differences in per-unit handling costs among the avocados that had not been billed directly to the members. Without such differences, however, subdivision would be pointless. Each division would be assigned the same per-unit revenues and costs and therefore produce the same per-unit initial values.)

The upper limit is not equivalent to valuation according to individual results. Individual sales ordinarily include avocados delivered by more than one member since deliveries are sorted and commingled before being shipped.

In selling, Calavo quotes "asking prices" f.o.b. Los Angeles. Prices are quoted for groups of one or more commingling categories. The price list is revised approximately once per week, in accordance with trends in inventories and in off-list sales. Negotiated discounts vary from sale to sale, especially within groups that include a number of commingling categories.

Calavo has tried to create commingling categories that are so nearly homogeneous that the extra cost of a more detailed classification would outweigh any of its advantages. Furthermore, Calavo attempts to grade and size all deliveries uniformly. The early history of most marketing cooperatives shows the importance of giving careful attention to both the categories formed and the sorting techniques used. Whether or not Calavo has solved these problems, however, the commingling categories actually being used represent the classification associated with actual sales and therefore are the most detailed classification available for pooling purposes.

Calavo's Commingling Categories

Calavo commingles avocados according to variety, grade, and size. These characteristics, plus the date delivered, give avocados different resale potential after they are inside one of Calavo's three packing houses. The differing locations of the packing houses do not significantly affect resale value.

Members deliver more than 150 varieties of avocados to Calavo. Each variety has a different frequency distribution for time of maturity; color, texture, and thickness of skin; size and shape; seed size; percentage oil content (a principal determinant of palatability); and other fruit characteristics. These differences remain significant even after grading and sizing, and Calavo maintains varietal identity in its packaging, price quotations, and record keeping.

Calavo distinguishes 10 grades. Fruits of the leading variety, Fuerte, are eligible for all 10 grades. Fruits of 11 other varieties are eligible for 7 grades. Fruits of the remaining varieties are eligible for 5 grades.

In each case, 3 of the grades are for abnormal avocados. Those affected by unusual weather are graded "Special." Avocados that are unusually small, but of good quality, are designated "Small." Unusually small avocados that are seedless are classified as "Cukes"; they are sold without distinction as to the variety involved.

In addition, 3 grades are used for abnormal Fuertes. "Rusty" is applied to stained fruits. "Offbloom" is applied to high-quality offseason fruits. "Coast" is applied to high-quality fruits from particular regions.

There remain 4 "regular" grades. The grade name "Calavo" is applied to the highest quality avocados of the 12 most palatable varieties. Avocados of these varieties that contain more than 8 per cent oil (the legal minimum in California for marketability) but less than 12 per cent (the minimum required by the association for Calavo grade), and that are otherwise of high quality, are graded "Number One." Medium quality fruits of these varieties are called "Circle C." The low-quality fruits are designated "Standard."

"Number One" and "Standard" are names applied not only to avocados of the 12 varieties that are eligible for Calavo grade, but also to avocados of the 150-odd remaining varieties. It has been decided that fruits of these varieties are eligible for only these 2 of the 4 regular grades.

Selling price is related also to fruit size. Fruits that grade Calavo, Number One, Circle C, Rusty, Offbloom, and Coast (but not Cuke, Special, Small, and Standard) are further sorted according to weight and then identified by count. The count is the number of avocados that are packed together in a standard box designed to have a net weight of approximately 13 pounds. Ten packs are used for sized fruits, with counts per box of 42, 35, 30, 24, 20, 16, 14, 12, 10, and 8.

Relative Tonnages of Categories

An idea of the proportion of Calavo's deliveries in each variety-grade-size category can be obtained from table 3.

All 10 grades appear in the table. Because data is unavailable, the 10 sizes have been reduced to 5 groups of adjacent pairs, which appear along with "Undistinguished," applicable to the unsized grades, Small, Special, Standard, and Cuke.

The figures shown apply to the 1955–56 season. For reasons that will be explained under "Sampling Members and Seasons," page 74, our attention will center on data for this season. If table 3 had been compiled for another season, the proportion shown for each size pair and each regular grade would not differ by more than about one-fourth. The figures for Small, Special, and Cuke, however, might vary by as much as a factor of 4.

In table 3, the 187 varieties received in 1955–56 are classified into 5 groups plus "Undistinguished," which applies to Cukes. The first group consists of 3 varieties that Calavo pooled together until 1956—Fuerte, Edranol, and Murietta Green. Fuerte accounts for almost all the tonnage in this group. In 1955–56 Fuerte represented 63.1 per cent of Calavo's deliveries, a normal proportion; Edranol represented 1.3 per cent, a figure that was about 1.5 times normal; and Murietta Green represented less than 1/50 of one per cent, an amount that was negligible, as usual.

The second group consists of all other green-skinned varieties except green Thinskins. In 1955–56 these varieties were classified into 5 groups for pooling

Table 3

VARIETY-GRADE-SIZE COMPOSITION OF CALAVO'S DELIVERIES, 1955–56

Variety group	Grade group	Size group						
		Undistinguished	42 plus 35	30 plus 24	20 plus 16	14 plus 12	10 plus 8	All sizes*
		per cent	per cent	per cent	per cent	per cent	per cent	per cent
	Small	0.53	....	....	....	....	....	0.53
	Calavo	....	8.39	29.22	8.19	0.01	0.00	45.81
Group 1 includes:	Number One	....	0.34	2.31	1.16	0.00	0.00	3.81
Fuerte	Circle C	....	1.26	4.90	1.78	0.00	0.00	7.94
Edranol	Coast	....	0.33	0.46	0.05	0.00	0.00	0.84
Murietta Green	Rusty	....	0.58	0.79	0.12	0.00	0.00	1.49
	Offbloom	....	0.01	0.38	0.06	0.00	0.00	0.45
	Special	0.08	....	....	....	....	....	0.08
	Standard	3.21	....	....	....	....	....	3.21
Group 2 includes:	Small	0.06	....	....	....	....	....	0.06
Calavo-Eligible Green Three-Star	Calavo	....	0.42	2.54	5.22	4.39	1.09	13.66
Calavo-Eligible Green Two-Star	Number One	....	0.54	1.21	1.54	1.60	0.31	5.20
El Dorado Green Three-Star	Circle C	....	0.13	0.52	1.20	1.47	0.71	4.03
El Dorado Green Two-Star	Special	0.03	....	....	....	....	....	0.03
Fino Green	Standard	1.59	....	....	....	....	....	1.59
	Small	0.24	....	....	....	....	....	0.24
Group 3 includes:	Calavo	....	1.19	3.13	1.23	0.00	0.00	5.55
Hass	Number One	....	0.16	0.06	0.16	0.00	0.00	0.38
Puebla	Circle C	....	0.10	0.40	0.24	0.00	0.00	0.75
Henry's Select	Special	0.01	....	....	....	....	....	0.01
	Standard	0.55	....	....	....	....	....	0.55
Group 4 includes:	Small	0.00	....	....	....	....	....	0.00
Calavo-Eligible Black Three-Star	Calavo	....	0.01	0.07	0.13	0.08	0.04	0.33
Calavo-Eligible Black Two-Star	Number One	....	0.03	0.51	1.54	0.42	0.02	2.52
El Dorado Black Three-Star	Circle C	....	0.00	0.01	0.02	0.01	0.01	0.05
El Dorado Black Two-Star	Special	0.01	....	....	....	....	....	0.01
Fino Black	Standard	0.21	....	....	....	....	....	0.21
	Small	0.09	....	....	....	....	....	0.09
Group 5	Number One	....	0.13	0.07	0.01	0.00	0.00	0.21
Thinskins	Special	0.00	....	....	....	....	....	0.00
	Standard	0.08	....	....	....	....	....	0.08
Group 6								
Undistinguished	Cuke	0.28	....	....	....	....	....	0.28
All varieties and grades*		6.97	13.63	46.59	22.64	7.98	2.18	100.0

* Because of rounding, some sums of subtotals differ from the totals shown.

purposes, Calavo-Eligible Green Three-Star, Calavo-Eligible Green Two-Star, El Dorado Green Three-Star, El Dorado Green Two-Star, and Fino Green. The first 2 groups contained varieties that were eligible for Calavo grade, as were Fuerte, Edranol, and Murietta Green. Within any one of the 5 groups, price differences usually were small compared to price differences among varieties in different groups. Together, these varieties accounted for 24.6 per cent of Calavo's deliveries in 1955–56, a proportion that has since declined—sometimes to less than 18 per cent.

The third group consists of three varieties that Calavo pooled together until 1958—Hass, Puebla, and Henry's Select. Hass accounts for almost all of the tonnage in the group. In 1955–56 Hass represented 7.3 per cent of Calavo's deliveries, a proportion about half that attained recently, and Puebla and Henry's Select each represented less than 0.1 per cent, figures consistent with their dwindling importance.

The fourth group consists of all other dark-skinned varieties except dark Thinskins. This group accounted for 3.1 per cent of Calavo's deliveries in 1955–56. The proportion has since fallen to less than 2 per cent.

The fifth group consists of all Thinskin varieties. In 1955–1956 Thinskins accounted for 0.4 per cent of Calavo's deliveries, a proportion that has since increased to as much as 1.4 per cent.

Relative Prices of Categories

Calavo has received and paid markedly different prices for lots in different variety-grade-size categories. The differences explain why the pools that are formed have been a matter of great concern to members. Some generalizations can be made about relative prices.

As to varieties, Fuerte has, from the time that Calavo began selling in 1924, been unequaled in marketability. Among the important varieties, Edranol is second, followed by Hass and Thinskins. Certain of the other Calavo-eligible green varieties (notably Rincon) rival Hass in selling price, but most of them sell for distinctly less, as do the other dark varieties. For the latter collectively, Calavo has typically received a price about half that received at the same time for Fuertes of the same grade and size.

Among the grades, selling prices generally rank in the order listed in table 3, although Offbloom is highly variable. Typically, Standard avocados have sold for about one-third the price prevailing at the same time for Small or Calavo avocados of the same variety and size.

Price has been consistently related to fruit size. As size increases, price per pound goes down—at least with the relative supplies that have existed. Calavo has typically received for size 10 (that is, 10 fruits to a 13-pound box) about 60 per cent of the price received at the same time for size 42 of the same variety and grade.

Table 4 shows the season-average prices paid by Calavo to its members in 1955–56 for the various variety-grade-size categories of table 3. The prices are weighted averages and have been expressed as percentages of the overall weighted average price for the season, 19.1 cents per pound. This is the figure obtained when total basic pool payments for the season ($4,518,332) are divided by total pounds delivered (23,696,511). The range is substantial, from as low as 11.5 per cent of the overall average to as high as 151.3 per cent. The entries do not indicate what relative prices were paid during any subperiod, however, since (as we shall see) the price level varied considerably over the season and the categories represented different proportions of total tonnage at different times. To find concurrent relative prices, consequently, table 4 should be examined in conjunction with table 6 below.

Time Pattern of Deliveries

Price variation over a season is primarily related to fruit maturity and harvesting, based on the varietal and

Table 4

SEASON-AVERAGE POOL PRICES, 1955–56, AS PER CENT OF OVERALL AVERAGE

Variety group	Grade group	Size group: Undistinguished	42 plus 35	30 plus 24	20 plus 16	14 plus 12	10 plus 8	All sizes
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
	Small	113.6	....	....	....	....	....	113.6
	Calavo	....	114.7	113.6	112.0	117.8	73.3	113.6
Group 1 includes:	Number One	....	124.6	109.9	102.6	....	....	108.9
Fuerte	Circle C	....	97.4	94.2	90.0	76.4	52.4	93.7
Edranol	Coast	....	79.6	80.1	80.6	....	....	80.1
Murietta Green	Rusty	....	81.1	77.5	76.4	....	....	79.1
	Offbloom	....	151.3	66.5	78.0	....	....	69.6
	Special	60.3	....	....	....	....	....	60.3
	Standard	45.0	....	....	....	....	....	45.0
Group 2 includes:	Small	67.0	....	....	....	....	....	67.0
Calavo-Eligible Green Three-Star	Calavo	....	110.5	125.1	116.7	87.4	65.4	104.7
Calavo-Eligible Green Two-Star	Number One	....	91.6	100.0	93.2	70.7	61.8	85.9
El Dorado Green Three-Star	Circle C	....	99.5	104.2	84.8	73.8	28.3	67.0
El Dorado Green Two-Star	Special	63.3	....	....	....	....	....	63.3
Fino Green	Standard	36.6	....	....	....	....	....	36.6
	Small	77.5	....	....	....	....	....	77.5
Group 3 includes:	Calavo	....	126.2	127.2	97.9	....	....	120.4
Hass	Number One	....	69.1	89.5	24.1	....	....	52.9
Puebla	Circle C	....	109.4	83.8	58.1	....	....	79.1
Henry's Select	Special	45.0	....	....	....	....	....	45.0
	Standard	25.1	....	....	....	....	....	25.1
Group 4 includes:	Small	25.6	....	....	....	....	....	25.6
Calavo-Eligible Black Three-Star	Calavo	....	71.2	89.5	89.0	70.7	64.4	81.1
Calavo-Eligible Black Two-Star	Number One	....	67.0	52.9	45.5	30.4	43.5	44.5
El Dorado Black Three-Star	Circle C	....	80.1	78.0	68.6	51.8	43.5	62.3
El Dorado Black Two-Star	Special	37.2	....	....	....	....	....	37.2
Fino Black	Standard	11.5	....	....	....	....	....	11.5
	Number One	....	84.8	75.9	84.3	63.3	....	81.7
Group 5	Small	81.1	....	....	....	....	....	81.1
Thinskins	Special	43.4	....	....	....	....	....	43.4
	Standard	31.4	....	....	....	....	....	31.4
Group 6 Undistinguished	Cuke	104.7	....	....	....	....	....	104.7
All varieties and grades		47.6	109.9	110.5	101.0	74.9	52.4	100.0

TABLE 5

TIME PATTERN OF CALAVO'S DELIVERIES, 1955–56

Time period	Ending date	Fuerte group	Other green	Hass group	Other black	Thinskins	All varieties*
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1A	10/6	0.21	1.15	0.53	0.25	0.04	2.18
1B	10/13	0.27	1.41	0.37	0.28	0.06	2.39
1C	10/20	0.38	1.13	0.98	0.13	0.04	2.66
1D	10/30	0.41	0.79	1.07	0.44	0.05	2.76
2A	11/10	0.32	0.61	0.43	0.48	0.05	1.89
2B	11/17	0.50	0.15	0.13	0.05	0.01	0.84
2C	11/23	0.96	0.20	0.13	0.00	0.02	1.31
2D	11/30	1.77	0.31	0.10	0.00	0.03	2.21
3	12/31	5.85	0.48	0.20	0.01	0.03	6.57
4	1/31	8.77	0.39	0.16	0.01	0.01	9.34
5	2/29	11.80	0.56	0.05	0.02	0.00	12.43
6	3/31	11.95	0.38	0.04	0.02	0.00	12.39
7	4/30	12.52	0.36	0.09	0.03	0.01	13.01
8A	5/10	4.12	0.24	0.08	0.03	0.00	4.47
8B	5/17	1.60	0.19	0.08	0.03	0.00	1.90
8C	5/24	1.16	0.23	0.16	0.06	0.00	1.61
8D	5/31	0.66	0.33	0.26	0.04	0.00	1.29
9	6/30	1.05	1.82	1.27	0.17	0.00	4.31
10	7/31	0.06	4.67	0.48	0.39	0.00	5.60
11	8/31	0.01	4.31	0.41	0.37	0.00	5.10
12	9/30	0.05	4.88	0.46	0.31	0.02	5.72
All periods		64.42	24.59	7.48	3.12	0.37	100.0

* Because of rounding, some sums of subtotals differ from the totals shown.

geographic distribution of members' trees. While Calavo receives avocados throughout the year, monthly deliveries invariably rise to a single peak in March or April, the heart of Fuerte harvesting, and then gradually diminish. Shipment occurs within 2 weeks after delivery, since avocados should be eaten from one to 4 weeks after picking (depending on oil content and storage temperatures).

Table 5 indicates what proportion of total tonnage was received during various subperiods of 1955–56. Proportions are indicated for each of the 5 variety groups mentioned earlier, as well as for all deliveries combined.

The 1955–56 time pattern reflected somewhat unusual varietal composition and maturation. Ordinarily, the percentages for October (periods 1A–1D in table 5) and November (periods 2A–2D) would be, not 10 and 6, but 3 to 4, and for September (period 12) not 6, but 4 to 5. Conversely, average percentages for March, April, May (periods 8A–8D), and June would be, not 12, 13, 9, and 4, but 14, 14, 13, and 8, respectively.

The subdivisions of the season shown in table 5 represent the time periods actually used by Calavo for pooling in 1955–56. Calavo has a standard pooling period of one month. The board of directors, however, is empowered to subdivide months if it sees fit. The power is usually exercised, on the recommendation of the general manager and after notice to members, when prices are rising or falling more than about one cent per pound per week. As a result, October, November, and May are usually subdivided into periods lasting from 1 to 3 weeks. In 1955–56 each of these months was split into 4 periods, making a total of 21 pooling periods for the season. Usually the number would be several fewer.

Intraseasonal Price Variation

Calavo receives and pays markedly different prices at different times of the year. Price levels vary within a season not only because fruit maturities vary, but also because of competition from Florida avocados from July through

TABLE 6
POOL PRICES BY TIME PERIODS, 1955–56, AS PER CENT OF OVERALL AVERAGE

Time period	Ending date	Variety, grade and size group					
		Fuerte-group, Calavo, 30 plus 24	Other-green, Calavo, 30 plus 24	Hass-group, Calavo, 30 plus 24	Other black, Calavo, 30 plus 24	Thinskin, Number One, 30 plus 24	All varieties, grades, and sizes
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1A	10/6	129.3	92.7	89.0	28.8	65.4	57.1
1B	10/13	115.2	94.2	89.0	50.8	68.1	56.0
1C	10/20	115.2	90.6	83.8	52.4	68.1	59.7
1D	10/30	115.2	94.2	81.1	52.4	68.1	60.7
2A	11/10	120.4	89.5	81.1	47.1	78.5	58.1
2B	11/17	120.4*	88.0	83.8	41.9	78.5	90.6
2C	11/23	104.7*	83.8	91.6	41.9	78.5	86.9
2D	11/30	101.0*	78.5	89.0	41.9	78.5	78.0
3	12/31	107.3	79.6	78.5	70.7	70.7	88.5
4	1/31	105.8	80.6	81.1	73.3	73.3	96.3
5	2/29	109.4	80.6	83.8	75.9	75.9	102.6
6	3/31	116.2	85.3	89.0	78.5	78.5	108.9
7	4/30	115.2	81.1	94.2	52.9	83.8	106.8
8A	5/10	115.2	100.0	94.2	80.1	89.0	106.8
8B	5/17	125.6	113.6	109.9	90.0	94.2	113.6
8C	5/24	138.7	125.1	125.6	105.2	104.7	123.0
8D	5/31	150.8	130.4	138.7	107.3	117.8	128.3
9	6/30	161.8	153.9	161.3	120.9	117.8	139.3
10	7/31	162.3	162.3	167.5	94.2	83.8*	102.1
11	8/31	157.1	157.1	170.2	94.2	83.8	101.0
12	9/30	162.3	162.3	172.8	115.2	172.8	116.2
All periods		113.6	125.1	127.2	89.5	75.9	100.0

* Because no avocados of the kind indicated were delivered during this period, the price used was that of another grade-size of the same variety group whose price was the same for the last period in which both were available.

March. Until 1960, competition from Cuban avocados from June through October also contributed to intraseasonal variation. In addition, demand appears to shift in a systematic way over the course of a season. The curve showing what price can be obtained for each quantity progressively flattens from October through March, then steepens from March through September. This shifting presumably results from changes in the availability of numerous competitive and complementary fresh fruits and vegetables (Sosnick, 1962, p. 743).

Table 6 presents a sample of the pool prices that Calavo paid during each subperiod of 1955–56. Prices are shown for 5 variety-grade-size categories, along with the weighted average for all deliveries combined. The latter changes not only because of price movements, but also because of changes in the composition of deliveries, shown in table 5. Each entry represents a relative price: the overall average for the season of 19.1 cents per pound is taken as 100 per cent; the actual prices paid for each category are shown as percentages of this overall average.

Despite the somewhat unusual time pattern of deliveries mentioned above, the overall price pattern for the Fuerte, other green, Hass, and other black groups contains a typical initial decline and later increase. The trough, however, would usually occur, not at the end of November, as appears in table 6, but rather about February, and prices in October and November would usually exceed those in September.

Dating Criteria for Pools

If a number of sales are to be pooled, intervals such as a day or a month can be used for pooling periods. The association can decide to pool sales only if they occur in the same day or month, or only if shipment, delivery, or maturity of their fruits occurred in the same period.

Both sale and shipment bases for pooling cause more difficulty than a delivery basis when deliveries are commingled. Additional expenses are required to retain the identity of the grower of particular fruits after they have been sorted. Furthermore, growers may receive different prices for lots that mature or are delivered at the same time but happen to be shipped or sold in different pooling periods.

A maturity basis also can be troublesome. It is necessary to specify the applicable criterion (for avocados, oil percentage is the criterion in California, and Calavo specifies different percentages for different varieties and grades), to consider parts of orchards, and to match the initial determination of maturity date with the later determination of grades and sizes. In addition, greater delay in payment may result, since settlement cannot be made for a delivery until all the fruits that mature during the same period have been sold. Finally, a maturity basis may deprive some members of the benefits associated with holding their production on the trees longer than other members. For certain varieties in certain locations, on-tree storage may continue until 20 weeks beyond maturity before physical changes cause significant loss.

In fact, Calavo uses a delivery basis. The principal problem is that different prices may be paid to members whose fruits, although they mature simultaneously, happen to be harvested at different times *at the request of the association.* The problem can be alleviated by using time periods during certain parts of the season that are long enough to put such fruits in the same pool. Because of inadequate information concerning maturities, no further reference will be made to this problem.

The Pooling Alternatives

The upper limit for avocado pooling includes all the distinctions that we have reviewed. It includes approximately 150 distinctions for variety, 10 for grade, and 11 for size (including Undistinguished). The upper limit also includes time periods that are not longer than one day, and could be so short as to consist of single sales. With daily periods, the number of possible pools per season would equal the product of approximately 300 (for days) times 150 (for varieties) times 10 (for grades) times 11 (for size), or nearly 5 million. However, no variety is represented every day in every grade and size, so the number of non-empty pools would be less. In a typical day, there are approximately 400 variety-grade-size categories of fruit available. This implies an upper limit, with daily periods, of about 120,000 non-empty pools per season.

Other pooling possibilities arise from consolidating two or more of these 120,000 categories for purposes of valuing members' deliveries, even though they continue to be used for selling purposes. Since any number of consolidations is possible, down to the lower limit of a single pool per season, each integer from one to about 120,000 represents a feasible number of non-empty pools.

There are, however, many more than 120,000 pooling alternatives. If there is to be either one pool or 120,000 pools, the pools are uniquely determined. But for each intermediate number, there are many different ways in which the 120,000 non-empty categories could be consolidated in order to obtain the specified number of pools. It would be possible, for example, to achieve two pools by keeping any one of the 120,000 categories as one pool while consolidating all the others to make the second; similarly, any 60,000 categories could be consolidated into one pool and the remaining 60,000 into the second; and so forth. The possibilities would be reduced if we permitted consolidation only of adjacent categories (ones that differ in the fewest respects), but the number would remain large. These are, nevertheless, the feasible alternatives from which a choice must be made.

STEP TWO

DETERMINING THE EFFECTS OF A POOLING CHOICE

The second step is to decide what differences a choice could make. The effects that appear to be relevant will be divided into four classes—savings, risk-spreading, inequity, and disincentives. Other classifications are possible; see, for example, the one in Wellman (1926, p. 5–6).

Savings

Different pooling alternatives will require different amounts of labor, equipment, and supplies for recording, calculation, and reporting. One might expect that savings would increase as the number of consolidations of commingling categories increases—that is, as the number of distinctions for variety, grade, size, or date that are used in pooling decreases.

It is generally agreed that, other things being equal, greater savings are desirable. They increase members' combined valuation, and they help the association to compete with other handlers.

Risk-Spreading

Different pooling alternatives will imply different tonnages per pool. As the tonnage in a pool increases, so does the share of unpredictable losses (for example, spoilage, breach of contract, and isolated low prices) that is borne by other lots and therefore other members. For any one member, consequently, the probability of his bearing a proportionately large loss is reduced. (But conversely, the probability of his receiving a proportionately large unpredictable gain is also reduced.) One would expect that tonnage per pool would increase as the number of distinctions for variety, grade, size, and date decreased.

There appears to be general agreement that, other things being equal, greater risk-spreading in the form of larger pools is desirable. It diminishes managerial concern about revenues for individual lots compared to revenues for all lots combined. It lessens the need for costly protective measures. It reduces the influence of chance on commercial success. It facilitates borrowing. It appeals to a sense of fairness. (Why should members receive different returns for fruit of equal quality delivered at the same time?)

Inequity

If two or more commingling categories, such as Fuerte-Offbloom-30's delivered August 10 and Edranol-Calavo-24's delivered August 17, are made into a single pool, a member will receive the same price for both kinds of avocados. The price (say, 26 cents) will equal a weighted average of the prices without consolidation (perhaps 30 and 20 cents). The weights are the tonnages (perhaps 600 and 400 pounds) that were delivered in each category by all members. This average will differ from an average that uses the member's individual tonnages in the two categories (perhaps 100 and 0 pounds) as weights (unless the prices being averaged are equal or unless the weights are proportional; proportionality is possible for every member only if the percentage of deliveries falling in any one category is the same for all members). In the extreme case of a single pool, there will be one such averaging process, and all members whose individual averages over all commingling categories are less than the association average would gain, while all whose individual averages are greater would lose.

More generally, there will be a number of pools and averaging processes. Then the impact on a member's overall returns will depend on whether his gains from the price averagings that work out to his advantage outweigh his losses from the others. In turn, this impact will vary with the consolidations that are used. Hence, variation will also occur in the degree of "inequity"—defined as disparity among members in the relation between the valuation assigned to them by the association and the potential net resale value of their deliveries. (The latter may be viewed as the valuation that would result if the pools used were the most complex ones consistent with spreading risks of unpredictable losses.) One might expect inequity to increase as the number of distinctions for variety, grade, size, or date decreases.

There appears to be general agreement that, other things being equal, greater inequity is undesirable. It is objectionable in itself. It also endangers the viability of the association, both by fostering discontent and by impairing ability to compete for all kinds of growers. (A qualification should be mentioned pertaining to the competitive implications of seasonal pools. Cash buyers typically alter their offers at Calavo's pool closings and attempt to make their grower prices—usually quoted as a single figure for a whole pick—appear more favorable than Calavo's. With a seasonal time period, it would be more difficult to adopt Calavo's prices as a base. On the other hand, seasonal pools involve considerable delay in financial settlement.)

Disincentives

If two commingling categories are consolidated for pooling purposes, a price premium may be eliminated. In the example above, a premium of 10 cents was eliminated. A member who delivers the higher valued lots instead of the lower valued ones then does not receive 100 per cent of the additional net revenue to the association. Instead, he receives a percentage equal to his share of the tonnage in the pool. It may then no longer pay him, for example, to convert to the higher valued variety, or to take the pains for the higher grade, or to harvest early although weight is increasing. "Disincentives" result, defined as disparity among lots in the relation between the value assigned them by the association and their potential net resale value.

On the other hand, the price paid for the lower valued lots in the pool will increase. In the example, one of the prices rose from 20 to 26 cents. It is possible that the increase will restore a premium for these lots over lots whose price, determined in a different pool, also was averaged upward. Only with the lower limit of a single pool can it be stated unequivocally how the various premiums will be revised; all will be eliminated. Nevertheless, one might expect that disincentives as a whole would increase as the number of distinctions for variety, grade, size, or date decreased.

There appears to be general agreement that, other things being equal, greater disincentives are undesirable. They contribute to uneconomical production and marketing choices by members, to an inferior product mix for the association, and to lower overall returns.

A Problem of Balance

As the number of pooling distinctions decreases from the upper limit, savings and risk-spreading apparently tend to increase, but so do inequity and disincentives. The target is to learn the point beyond which fewer distinctions would produce increases in inequity and disincentives that would outweigh the increases in savings and risk-spreading.[8]

[8] Even in highly valuable studies, little attention has been paid to conflicts among objectives. Conclusions then become impressionistic. Thus: "If the market is characterized by *relatively* sharp and sudden changes in price, or by *distinct* early-, mid-, and late-season prices, the pool periods *must* be adjusted accordingly. If a grower takes special pains to obtain the advantages of early-season prices, . . . a daily pool or a single-shipment pool would be most equitable, and

STEP THREE
CHOOSING MEASURES OF EFFECTS

The next step is to decide how to measure savings, inequity, disincentives, and risk-spreading.

Savings

In measuring savings, it is well to try to minimize the problems associated with allocation of common costs. A way to do so is by adopting one alternative as a base and comparing others to it, so that savings are measured in terms, not of cost levels, but of cost differences. Accordingly, let us define "total savings" for an alternative as the reduction in total cost per season that is attainable by adopting it instead of the base alternative, other things being equal.

The base alternative can be specified to be the one under consideration which comes closest to fulfilling a certain condition—namely, that every other alternative involves pools that are merely consolidations of its pools. If the alternatives under consideration include the upper limit, where every sale becomes a separate pool, complete fulfillment of the condition is assured. But complete fulfillment is possible even if no alternative under consideration makes every sale a separate pool, and we will see shortly (under "A Veto for Disincentives and Risk-Spreading," page 63) why it may actually be preferable to have a less complex possibility serve as the base alternative. In any event, the base alternative is likely to be the most costly one under consideration, so that we will have the convenience of non-negative numbers for total savings.

Total savings accrue to members collectively. Calavo prorates pooling expenses, together with other common costs, among members by use of a uniform per-pound operating retain. The savings that would accrue to an individual member, consequently, equal total savings times the member's proportion of total tonnage. This is his "individual savings."

Inequity

Each pooling alternative would produce different discrepancies between the valuation assigned to individual members and the potential net resale value of their deliveries. For an approximation to resale values, we can again refer to the base alternative, since it is the most complex alternative under consideration. To quantify inequity, members' valuations with the base alternative can be compared with the valuations they would receive with other possibilities.

Each alternative can be rated in four steps. First, learn what returns for his deliveries a member would receive under the alternative before adding his share in the savings. Second, identify the members who would be disadvantaged by the alternative; that is, mem-

possibly even necessary to attract his membership." (Bakken and Schaars, 1937, p. 455; italics added.)

Similarly: "The differences in returns to the 56 growers, over the ten-year period, with monthly shipping pools as compared with two six-month shipping pools are *relatively small,* as shown in table 28. Almost 90 per cent of the growers would have received within 5 cents a packed box of the same price under either system." (Wellman and Street, 1938, p. 51; italics added.)

It should be mentioned that these two studies are among the very few that have undertaken to evaluate alternative procedures either for pooling or for patronage refunds. The index of a prominent book of selected readings (Abrahamsen and Scroggs, 1957) contains one entry for pooling. A search of the American literature on cooperation indicates only 25 other publications with even brief evaluative commentary (Black and Price, 1924), (Black, Robotka, and Miller, 1921), (Camp, 1922), (Camp, 1926), (Christensen, 1920), (Erdman and Wellman, 1927), (Federal Trade Commission, 1928), (Fessenden, 1917), (Filley, 1929), (Hulbert and Mischler, 1958), (Jesness, 1923), (Markeson, 1959), (Mauser, 1960), (Mayhew, 1948), (McKay and Kuhrt, 1926), (McKay and Lane, 1928), (Mears and Tobriner, 1926), (Nourse, 1927), (Paulson and Baggett, 1937), (Powell, 1913), (Robotka, 1922), (Stevens and Haas, 1961), (Tinley, 1951), (Tudsbury, 1924), (Wellman, 1926).

bers who would receive less (before adding savings) than if the base alternative were used. Third, determine how much these members' valuations would be reduced, before adding savings, if the chosen pooling alternative were used rather than the base alternative. Fourth, consider these reductions individually, or else add them together and obtain a number which will be called the "aggregate inequity" of the alternative. Aggregate inequity represents the total dollar value that the alternative would transfer from the disadvantaged members to their fellows. Both the individual reductions and the aggregate inequity for an alternative are commensurable with the corresponding measure of savings. The unit is dollars for inequity as well as savings, and each equals zero for the base alternative.

Inequity could be measured for different periods. The reductions in valuation that enter the measure could be reductions that would occur during an interval ranging from one day up to the average duration of memberships. Any one day or season could give quite atypical results, since the proportion of tonnage in different categories varies from day to day and from season to season. The longer the period considered, the smaller will be the chance that some of the inequity found during one period would average out during the following period, thereby making the sum of reductions to members who were disadvantaged for the entire interval a smaller proportion of the total valuation. However, people may appraise the association and its management on the basis of recent returns, so even misvaluations that will soon be averaged out can be significant. For Calavo, a period of one season may be a reasonable compromise, since there is a year-end refund and since $11\frac{1}{2}$ months elapse between the periods when members may resign.

Similarly, it is possible to calculate individual and aggregate inequity for less than all members. For instance, an association whose survival is threatened might consider inequity only to members whose resignation would be both likely and crippling. The smaller the number considered, the fewer would be the pools and the larger the savings that appeared optimal. To disregard inequities to part of the membership would generally be regarded as an undesirable abandonment of impartiality. Nevertheless, competitive conditions are important and variable, so it cannot be said that a particular group, such as all members, should always be included. In Calavo's case, the question can be bypassed. Using any of the plausible groups leads to ranking the same alternative highest among those considered.

A Veto for Disincentives and Risk-Spreading

While savings and inequity appear to be quantifiable, commensurable, and predictable, disincentives and risk-spreading are not as easily measured. As a result, alternatives apparently must be compared in terms of disincentives and risk-spreading in a different and impressionistic way.

The desirability of spreading risks can be recognized at the outset in the choice of a base alternative. In measuring inequity, the base alternative serves as an approximation to a situation free of inequity. If the base alternative were made the upper limit where every sale is a pool, it would reproduce every unpredictable loss. Instead, an alternative can be chosen as the base that would provide an acceptable minimum of risk-spreading. Then inequity would be measured relative to a situation in which unpredictable losses were already averaged over a number of sales.

Similarly, we may simply disregard any alternative that is so simplified that its disincentives would obviously outweigh its savings and risk-spreading. This means, to use extreme examples, that we need not bother with any alternative that automatically places the same value on a pound of different commodities or on different tonnages of the same commodity. The former would encourage delivery of only the least-cost commodity. The latter would encourage delivery of only one pound.

Additional reference to risk-spreading and disincentives can be made after it is apparent how various alternatives compare on the rather objective grounds of savings and inequity. At that stage a substantial superiority for one alternative in disincentives and risk-spreading can be allowed to outweigh a superiority for another alternative in savings and inequity that turns out to be slight. Such a comparison remains subjective, but at least it is made in terms of specific advantages and disadvantages and without a need to generalize about how to make the compromise.

STEP FOUR

CHOOSING A CRITERION OF OPTIMALITY

The next step is to decide how savings and inequity will be compared in order to select an alternative that provides an optimal balance in these respects. Three criteria will be considered.

The Base-Oriented Optimum

One criterion stems from the attitude that total savings, and therefore the combined valuation of all members, should be as large as possible without reducing the valuation of any member below what he would receive with the base alternative. In other words, commingling categories should be consolidated only if the resulting savings are sufficient to increase valuation even for members who deliver the highest valued lots and therefore stand to gain from having numerous pools.

To compare savings and inequity from this viewpoint, we refer initially to the net effect of an alternative on members individually. For each member, we compare his individual inequity during a "representative" season with his individual savings. If his inequity does not exceed his savings, then his valuation with the alternative after savings are added would be no less than with the base alternative.

Now we identify the alternatives for which no member has greater inequity than savings. Since both savings and inequity equal zero for the base alternative, there will be at least one such alternative under consideration. All these alternatives meet the requirement of giving each member as much valuation as does the base alternative, so what remains is to find the one whose total savings are largest. This alternative will be called the "base-oriented optimum."

To illustrate, consider the hypothetical data in table 7. Alternatives 1 and 3 are eligible to be the base-oriented optimum; with both of them no member's inequity exceeds his savings. Of the two, alternative 3 has the larger total savings and therefore is the base-oriented optimum.

The base-oriented optimum maximizes the valuation of all members collectively, subject to the condition that no member can receive less than his base-alternative valuation. Every member, consequently, has reason to prefer it to the base alternative. The base-oriented optimum also has the property that no change from it could be made that would increase valuations for some members without reducing valuations for others. An alternative with smaller total savings would have smaller combined valuations, and one with larger savings would cause at least one member to receive less than his base-alternative valuation.

An important objection to adopting the base-oriented optimum is that it may be unreasonably costly. All alternatives except the base alternative might be rejected, including some with total savings far greater than their aggregate inequity. The foregone savings might even exceed the actual base-alternative valuation of the (perhaps two) members who would be disadvantaged by

Table 7
ILLUSTRATION OF ALTERNATIVE VALUATIONS

Member		Alternative																				
Name	Per cent of tonnage	1 (base)			2			3			4a			4b			5			6 (one pool)		
		S	I	V	S	I	V	S	I	V	S	I	V	S	I	V	S	I	V	S	I	V
A	40	0	0	600	8	2	606	12	12	600	16	20	596	16	22	594	20	28	592	24	200	424
B	10	0	0	150	2	3	149	3	3	150	4	6	148	4	6	148	5	9	146	6	50	106
C	30	0	0	150	6	−3	159	9	4	155	12	−15	177	12	−15	177	15	−27	192	18	−150	318
D	20	0	0	100	4	−2	106	6	−19	125	8	−11	119	8	−13	121	10	−10	120	12	−100	212
Σ	100	0	0	1,000	20	5	1,020	30	19	1,030	40	26	1,040	40	28	1,040	50	37	1,050	60	250	1,060
ΣS − ΣI		0			15			11			14			12			13			−190		

Key: S = individual savings
I = individual inequity (undervaluation before adding savings)
V = valuation with the alternative
Σ = sum of positive entries in column

consolidating categories. In this event, it would cost the other members more to settle for the base-oriented optimum than to pay the disadvantaged members, at base-alternative prices, to abandon their production. This result would be understandably objectionable to an association whose viability is threatened by competition and whose competitors appear to take little account of differences in attributes such as variety and size when naming grower prices.

On the other hand, an association whose prices already compare favorably with the prices of competing handlers might adopt the base-oriented optimum even though it implies a somewhat smaller combined valuation. To do so would be especially understandable if (to mention a "political" consideration) lower cost alternatives would generate inequities to members who serve on the board of directors.

The Interpersonal Optimum

Another criterion derives from the attitude that it is acceptable to reduce valuations to some members below base-alternative (or other) levels provided the valuations of other members increase at least as much because savings are realized. That is, a dollar of savings accruing to nondisadvantaged members should count the same as a dollar of reduced valuation suffered by disadvantaged members, and the difference between the savings and the reduced valuations should be maximized. If we add to both components of this difference the part of total savings that accrues to disadvantaged members, we obtain a clearer statement. The variable to be maximized is equal to the difference between total savings and aggregate inequity.

To compare savings and inequity from this viewpoint, we refer to the net effect of an alternative on members collectively. We calculate for each alternative the excess of its total savings over its aggregate inequity during a "representative" season. We then identify the alternative for which the excess is largest, which will be called the "interpersonal optimum." (In case of ties, we prefer the alternative with greater savings; it would produce greater valuation for all members collectively.) Thus in table 7 the interpersonal optimum is alternative 2. Its excess of total savings over aggregate inequity—equal to 15—is the largest among all the possibilities.

Like the base-oriented optimum, the interpersonal optimum has the property that no change from it could be made that would increase valuations for some members without reducing valuations for others. An alternative with smaller total savings would have smaller combined valuation, and one with added savings would have even more added inequity.

The largest excess of total savings over aggregate inequity will be non-negative, since the excess for the base alternative equals zero minus zero. Having a non-negative excess, consequently, is a necessary but not sufficient qualification for being the interpersonal optimum as well as for being the base-oriented optimum (or both).

An important objection to adopting the interpersonal optimum is that the base-oriented optimum may be less costly. The latter may have greater total savings even though its extra savings are less than its extra inequity. For example, the base-oriented optimum in table 7 (alternative 3) has total savings of 30 and aggregate inequity of 19, while the interpersonal optimum (alternative 2) has total savings of only 20 and aggregate inequity of 5.

In such cases the base-oriented optimum would produce greater combined valuation for all members. Furthermore, aggregate inequity with the interpersonal optimum, although smaller, might be concentrated on particular members. Then the interpersonal optimum, unlike the base-oriented optimum, could also reduce some members' valuations below what they would receive with the base alternative. Thus member

B in table 7 receives 149 with the interpersonal optimum, compared to 150 with both the base alternative and the base-oriented optimum.

The Overall Optimum

The base-oriented optimum may be acceptable if it implies larger savings than the interpersonal optimum, and the interpersonal optimum may be acceptable if it implies larger savings than the base-oriented optimum. For the alternative that best balances savings and inequity, therefore, a cooperative might choose whichever of the two optima has larger savings—in other words, the "overall optimum."

Thus in table 7 the overall optimum is alternative 3. Total savings with the base-oriented optimum (number 3) are 30, whereas they are only 20 with the interpersonal optimum (number 2).

The overall optimum has the property that it increases the combined valuation of all members as much as is possible if the attractive restraints underlying the base-oriented and the interpersonal optima are not both to be violated. One is that no member shall receive less than his base-alternative valuation. The other is that combined valuation should not be increased at the cost of an even greater increase in aggregate inequity. As a result, the overall optimum represents a compromise between alternatives with greater savings and those with smaller inequity, and perhaps many people will find this particular compromise intuitively appealing.

The optimality criterion seems intuitively appealing for another reason. It fulfills ten abstract standards for decisions which attempt to combine the preferences of members of a group. (On these standards see, for example, Luce and Raiffa, 1957, Chapter 14.)

One standard is decisiveness. The criterion identifies exactly one alternative as the overall optimum.

A second standard is transitivity. The same answer is obtained regardless of the sequence in which alternatives are compared in order to identify the base-oriented optimum and the interpersonal optimum and regardless of which of these optima is located first.

A third standard is universal domain. The criterion selects an overall optimum for any conceivable number of members, number of alternatives, and profile of member valuations with different alternatives.

A fourth is neutrality. The answer is not affected by changing the names of the alternatives.

A fifth is anonymity. The answer is not affected by coding the names of the members.

A sixth is nonimposition. The answer depends only on members' valuations—not, for example, on customers' wishes.

A seventh is nondictatorship. The solution procedure takes account of all members' valuations; no valuations are excluded from consideration, or merely allowed to break ties, even by a randomizing device (unless management deliberately omits some members in calculating inequity).

An eighth is Pareto optimality, or the unavailability of revisions that would benefit some people and harm none. As we have seen, an alternative cannot be either the base-oriented optimum or the interpersonal optimum, and therefore the overall optimum, if there is another under consideration with which valuation (and therefore, by assumption, desirability) would be greater for some members and smaller for none. As a corollary, if the set of pools that happens to be in use at the time is among the alternatives under consideration, a change from it to the overall optimum should have some supporters. The change must increase valuations for at least some members or else reduce valuations for none. (However, the procedure, as distinct from the solution, may not be Pareto optimal; all members might prefer a more intelligible decision rule.)

A ninth satisfied condition is positive association. A mistake in the figures for an alternative may be discovered, and correcting it may increase some members' valuations while reducing none. If the alternative was already the overall optimum, it will remain so, since its savings can only have increased.

A tenth condition—invariance—is partially satisfied. Some basic figures, such as the total cost of pooling with each alternative, will be changeable in the sense that, for a different season or a different arbitrary allocation of common costs, each figure would be altered by the same amount or proportion. It seems desirable that the solution remain the same despite such adjustments. The overall optimum does remain the same after certain adjustments—any that result in altering all or even some members' valuations with every alternative by a constant. The solution remains the same since no change then occurs in the figures for savings and inequity or in what alternatives are eligible to be the base-oriented optimum. Thus, adding a constant to all pooling costs, or increasing some members' base-alternative valuations, produces the same answer. However, a *proportionate* increase in all pooling costs might change the answer, since total savings would increase by zero for the base alternative and by varying amounts for all other alternatives.

Disadvantages of the Optimality Criterion

One disadvantage of the optimality criterion is that it violates four other intuitively appealing axioms.

One is compensation; a change from the status quo that affects combined incomes should not be recommended unless all whose position would be worsened will be compensated, or at least unless two conditions are met: (1) the monetary value of the change to the gainers exceeds its monetary cost to the losers, and (2) the new distribution of income is not regarded as inferior by the decision-makers.

In contrast, the optimality criterion treats the possibility that one alternative is already the status quo as an irrelevant accident. The criterion may, as a result, recommend a change although the status quo alternative has greater total savings, in which event shifting to the overall optimum would increase the gainers' valuations too little even to enable them to compensate the losers. Also, the criterion disregards the possibility that, once the overall optimum became the status quo, a change from it to an alternative with greater total savings could be made with compensation. The criterion may, as a result, fail to recommend the alternative with greatest total savings even when the redistribution involved in shifting to that alternative from the overall optimum would, on investigation, prove either acceptable to all concerned or compensable.

A second violated desideratum is complete ordering. The criterion does not rank all possibilities. If the overall optimum, and perhaps other alternatives, prove infeasible, or unacceptable on grounds of risk-spreading or disincentives, a new answer can be obtained only with the inconvenience of reviewing the data on savings and inequity for the remaining possibilities.

A third violated condition is independence of irrelevant alternatives. An alternative that is not the overall optimum might become the solution if the sample of alternatives under consideration were enlarged. This result could occur even if the same alternative served as the base after additional possibilities were included, as can be seen by referring back to table 7. We saw earlier that the overall optimum among all the alternatives in table 7 is alternative 3. However, if alternative 2 had been omitted from the sample, alternative 4a, not 3, would have been the overall optimum. Number 4a would have won because it would have been the interpersonal optimum, and when it came to be asked whether the base-oriented optimum (still number 3) or the interpersonal optimum (now number 4a) had larger savings, the answer now would have been the latter.

A final violated condition is responsiveness. Suppose a mistake in the figures for an alternative is corrected, with the effect that some members now receive greater valuation with the alternative than with some alternatives that previously they had ranked higher, while no members now rank the alternative any lower than before. The alternative may not now be the overall optimum even though it was previously. Put differently, if an alternative that would have been the overall optimum happens to be omitted from the sample of alternatives under consideration, another alternative that every member ranks at least as high may fail to become the overall optimum instead.

Thus suppose that the alternatives under consideration are numbers 1, 3, 4a, 5, and 6 in table 7. Then the base-oriented optimum is number 3, and the interpersonal and overall optimum is number 4a. (The same answer results if number 4b is included.) Suppose, however, that 4a is not in the sample but 4b is, either because 4a is overlooked or because inequity was miscalculated for 4a and the correct figures are those shown for 4b. Then the base-oriented optimum remains number 3, but the interpersonal and overall optimum now is number 5 instead of 4a. Yet members A and B receive greater valuation, and member C receives smaller valuation, with both 4a and 4b than with 5, and member D receives less with 4a and more with 4b than with 5. In other words, members A, B, and C do not alter their rankings in favor of number 5, and member D alters his rankings against it, yet 5 now becomes the overall optimum, not 4b.

While in principle the overall optimum is not responsive and independent of other alternatives, how frequently it will be so in fact is not known. The answer depends on what profiles of member valuations are encountered. The profiles in table 7 should not be regarded as typical. They were difficult to construct even with the desired result in mind.

In any event, no criterion can satisfy both independence and responsiveness so long as decisiveness, transitivity, universal domain, nonimposition, and nondictatorship are also to be satisfied. Arrow has shown that these seven conditions are incompatible (Luce and Raiffa, 1957, p. 339).

Furthermore, if even decisiveness, universal domain, neutrality, and anonymity are to be retained, either responsiveness must be sacrificed or the criterion must be changed to simple majority rule. May has shown that only decision by majority ranking satisfies these four conditions plus responsiveness (Luce and Raiffa, 1957, p. 357).

Majority rule itself is a possible decision rule, but it seems to be a less satisfactory solution. It does not take account of the size of different members' gains and losses. Also, it can violate transitivity unless members' valuations vary quite similarly among the alternatives; it must be possible to arrange the alternatives so that, as we consider them in turn, every member's valuation progressively increases and then (beyond some point that may vary with the member) progressively decreases, with not more than one change in direction for each member.

A second disadvantage of the criterion of optimality proposed here is that the overall optimum depends on what aternatives are considered. Only alternatives in the sample, the most complex of which is the base alternative, will be eligible to be the overall optimum.

This limitation can be overcome by further sampling in the neighborhood of the apparent optimum. In fact, if the savings and inequity calculated for alternatives in the sample show a pattern of regular increase as categories are consolidated, further sampling could be replaced by interpolation to other alternatives in the neighborhood, or even by extrapolation to alternatives involving greater complexity than the base alternative. (This extrapolation would require shifting the scale used to measure aggregate inequity, since the zero point would previously have been assigned to inequity with the base alternative.)

A third and more serious problem is that the calculation of inequity presumes that the base alternative represents "correct" valuation. It is possible that the calculated differences in inequity among alternatives, and even the ranking of alternatives according to inequity, would change if a more complex possibility were chosen to serve as the base alternative. For this reason, it is well to select for the base alternative the closest approximation to the upper limit that is permitted by available data and adequate risk-spreading.

When the base alternative is so located, the overall optimum will be a reasonable choice. Like any other criterion, however, it cannot satisfy all objectives in all situations, and therefore cannot be claimed to be universally appropriate.

A Problem Avoided

Some circumlocution was necessary in this section because of an important consideration; the members who would be disadvantaged by one alternative may not be the same members who would be disadvantaged by another. Failure to recognize this possibility can lead to an absurd answer for the interpersonal optimum and to overstating the properties of the base-oriented optimum. Consider, for example, the situation that proved to be true for Calavo in 1955–56.

Certain members would have been disadvantaged by a single pool. These were members who delivered relatively large proportions of the higher priced varieties and the higher priced grades, and disproportionately during the higher priced months. But it turned out that these members also delivered disproportionately large amounts of the lower priced sizes, and disproportionately during the lower priced weeks of the 3 months that Calavo subdivided for pooling.

Consider how these members would have fared with an alternative involving numerous variety groups and grade groups, but monthly time periods and few size groups. With this alternative, these members would have received their varietal, grade, and monthly price premiums, but not their size and weekly discounts. As a result, if the combined valuation of these members, even without adding for savings, were calculated for this alternative, the sum would actually exceed their base-alternative valuation. The members whom this alternative would disadvantage are clearly not the same as those whom a single pool would disadvantage.

If the changing identity of disadvantaged members were neglected in measuring inequity, the attractiveness of the interpersonal optimum would be undermined. Suppose that Calavo calculated aggregate inequity for each alternative as the difference between valuation with the base alternative and with it for members who would be disadvantaged *with a single pool.* Then aggregate inequity would be a negative number for alternatives that overvalue these members' deliveries. The alternative that maximizes the difference between total savings and aggregate inequity would be an alternative like the one just mentioned, containing numerous variety and grade groups, but monthly time periods and few size groups. Such an alternative would be the interpersonal optimum regardless of the resulting undervaluations to other members and regardless of how small the cost of ameliorating them would be. This result is avoided by measuring the inequity of an alternative by its reduction in valuation for members whose valuations would be reduced *with that alternative.*

Because the identity of disadvantaged members varies among alternatives, the base-oriented optimum is not necessarily an improvement for all members compared with every more costly alternative under consideration. It is assuredly an improvement for all members only compared with the base alternative. Furthermore, if some alternatives with smaller savings have a different set of disadvantaged members, the base-oriented optimum and the interpersonal optimum are not the only alternatives from which any change must reduce some members' valuations. The claims for them have been scaled accordingly.

STEP FIVE
SAMPLING AMONG ALTERNATIVES

Step five, sampling alternatives, is necessary in Calavo's case because the alternatives are very numerous. From a well-chosen sample, we can hope to learn what large steps are worthwhile and what smaller ones merit further attention.

Interdependence of Effects

In choosing a sample, we should keep in mind that the inequity of a particular grouping of, for example, varieties will change with the groupings of grades, sizes, and dates. To illustrate, the average count of Fuerte fruits is relatively high, so grouping Fuerte with other varieties may create more inequity when high and low counts are grouped together than when they are separated.

When such correlations exist, it is not possible to learn what grouping is optimal in one direction without specifying the groupings that will be used in the others. Ideally, we should specify whatever other groupings will prove to be optimal in the other directions and solve for each simultaneously. This procedure requires studying grouping possibilities in any one direction while each of a number of possible combinations is assumed for other groupings.

Unfortunately, sample size then expands exponentially. For example, if only three groupings are considered in each of four dimensions, the alternatives number 3^4, or 81.

To curtail sample size, or to adapt to constraints or data limitations, we could decide to consider only one grouping of, say, varieties and solve for the groupings in other directions that then would be optimal. No problems result if the specified grouping of varieties is actually to be used. If another grouping is to be used, however, we could merely hope that the answers would be close.

The Groupings Selected

The groupings for which at least partial information has been obtained are indicated in table 8. Brackets show what categories were consolidated, while the figure at the bottom of each column shows the number of groups that resulted. For convenience, let us hereafter designate the number of groups for variety, grade, size, and time as v, g, s, and t, respectively.

The selections were based on plausibility and on availability of information. In addition, they were designed to represent a wide range of possibilities. As a result, the selections include most of the groupings that Calavo has ever used or seriously considered. For grade, the groupings range from all selling grades, through two intermediate possibilities, to a single group containing all grades. For size, the groupings consist of the adjacent pairs that Calavo used for pooling in 1955–1956, two intermediate possibilities, and a single group. For time, the groupings consist of the combination of 9 months and 12 weeks that Calavo used during 1955–56, plus 12 months and a whole season.[4] For

[4] An intriguing possibility was not included. This is the use of overlapping time periods. Each period might, for example, consist of 3 months (or perhaps 3 weeks) centered on the month (or week) of delivery. The price paid for any variety-grade-size category then would be a 3-month moving weighted average of the prices that would have been paid with monthly periods. (*Cont.*)

TABLE 8
POOLING GROUPS TO BE STUDIED

Variety groupings

Varieties	Groups		
Fuerte			
Edranol	1	1	
Murietta Green			
Calavo-Eligible Green Three-Star	1		
Calavo-Eligible Green Two-Star	1	1	
El Dorado Green Three-Star	1		
El Dorado Green Two-Star	1		
Fino Green	1		
Hass			1
Puebla	1	1	
Henry's Select			
Calavo-Eligible Black Three-Star	1		
Calavo-Eligible Black Two-Star	1		
El Dorado Black Three-Star	1	1	
El Dorado Black Two-Star	1		
Fino Black	1		
Thinskins	1	1	
Undistinguished	1	1	
Number of groups	14	6	1

Grade groupings

Grades	Groups			
Calavo	1	1		
Number 1	1			
Circle C	1		1	
Coast	1	1		
Rusty	1			
Offbloom	1			1
Special	1	1	1	
Standard	1			
Small	1	1	1	
Cuke	1	1	1	
Number of groups	10	5	4	1

Size groupings

Counts	Groups			
8	1			
10				
12	1	1		
14				
16	1		1	1
20				
24	1	1		
30				
35	1	1		
42				
Undistinguished	1	1	1	
Number of groups	6	4	2	1

Time groupings

Periods	Groups		
1A	1		
1B	1	1	
1C	1		
1D	1		
2A	1		
2B	1	1	
2C	1		
2D	1		
3	1	1	
4	1	1	
5	1	1	1
6	1	1	
7	1	1	
8A	1		
8B	1	1	
8C	1		
8D	1		
9	1	1	
10	1	1	
11	1	1	
12	1	1	
Number of groups	21	12	1

variety, the groupings consist of 14 groups that Calavo used in 1955–56 (including Undistinguished for avocados graded Cuke and therefore not classified by variety), five groups that approximate those that Calavo has used since 1956–57, and a single group.

The groupings presently used by Calavo were adopted in 1956–57 as part of a comprehensive effort to reduce costs. The groupings are approximately those for ($v = 6$, $g = 10$, $s = 4$, $t = 21$). One difference is that months are not always subdivided as shown. In addition, Calavo presently groups size 20 with sizes 24 and 30, not with the lower counts, and groups grade Small with sizes 35 and 42. For variety, Calavo has restricted the Fuerte and Hass groups to those varieties only and expanded the Thinskin group to include Henry's Select. The association has placed all the remaining green-skinned varieties (including Edranol and Murietta Green) in a group called "Other Green Varieties," and placed all remaining dark-skinned varieties (including Puebla) in a group called "Other Black Varieties" (and continues to make no varietal distinctions for Cukes).

[4] (*Cont.*) The advantage of such overlapping periods would be a tendency to lessen the difference between returns on the last day of one period and on the first day of the next period. This difference has created some dissatisfaction among members, has caused some difficulty in assigning harvest schedules to particular orchards, and has led to especially heavy or light picking by members who anticipate price changes.

On the other hand, overlapping periods would require calculating pool prices each month (or week) even though each period lasted, say, 3 months (or weeks). Overlapping periods would also entail a difference between the association's net marketing income and its payments to members during any one fiscal year.

STEP SIX
ESTIMATING SAVINGS

The next step is to estimate total savings for alternatives in the sample—that is, to estimate how much the simplification of recording, calculation, and reporting with each alternative reduces minimum seasonal costs below minimum costs for the base alternative.

Estimates of savings, based on information obtained by Calavo, are shown in table 9. Each figure represents total savings compared with the alternative actually used in 1955–56—namely, ($v = 14$, $g = 10$, $s = 6$, $t = 21$). This is the base alternative, every other under consideration representing merely a consolidation of its pools. (The actual cost of pooling *per se* with the base alternative is estimated at $30,000 per season, assuming continued use of invoice amounts to determine pool revenues.) Estimated total savings range up to $20,000 per season. Several points about table 9 need explanation.

No reference is made to total tonnage or to number of members. The figures shown apply to the situation recently experienced—roughly 60 million pounds and 3,000 members. If either were to increase, levels of savings (along with levels of costs) also would increase.

Table 9 shows no greater savings for ($t = 1$) than for ($t = 12$). One might infer that about $400 should be saved by reducing 12 monthly periods to one seasonal period, since reducing 12 weekly periods to three monthly periods is shown to save $300 (regardless of g and s). However, Calavo's management feels that advance payments would become common or even automatic if pools lasted more than 30 days. (Although 60 per cent advances are available at present, they are requested for less than one per cent of deliveries.) The expense of making frequent advances and accumulating information about them is estimated to offset the savings from a seasonal pool.

In addition, table 9 shows no greater savings for ($v = 2$) than for ($v = 6$), nor for ($g = 1$) than for ($g = 3$), nor in some instances, for ($g = 1$) than for ($g = 4$). The reason is that Calavo expects that the contractual charge of its data processor will be approximately proportional to the number of data cards that must be punched, sorted, and ac-

TABLE 9
ESTIMATED SAVINGS FOR SELECTED ALTERNATIVES

Number of variety groups	Number of grade groups	Number of time groups: 1				12				21			
		Number of size groups: 1	2	4	6	1	2	4	6	1	2	4	6
		thousands of dollars per season											
1	1	20.0											
2–6	1–3	19.3	19.0	13.8	10.8	19.3	19.0	13.8	10.8	19.0	18.7	13.5	10.5
	4		19.0	13.0	10.0		19.0	13.0	10.0		18.7	12.7	9.7
	5		18.9	12.9	9.9		18.9	12.9	9.9		18.6	12.6	9.6
	10		18.8	12.8	9.8		18.8	12.8	9.8		18.5	12.5*	9.5
14	10												0

* Savings for pools presently used compared to 1955–56 pools.

cumulated, and the changes mentioned will not reduce the number of cards as long as more than one size group is used.

STEP SEVEN

SAMPLING MEMBERS AND SEASONS

Step seven in determining the optimal pools is to sample from past seasons and memberships in order to estimate what inequities various alternatives would produce during a "representative" future season.

The most recent season for which inequity could be estimated for a wide range of alternatives at reasonable cost was 1955–56. Subsequently, Calavo used fewer distinctions for variety and size in its pooling, and information was not available to undo the resulting consolidations.

Data cards were available showing every lot delivered during 1955–56 by 201 out of the total of 4,919 members (membership has since fallen below 2,800). Approximately 20,000 lots were involved, each lot being identified by variety, grade, size, date received, pounds, price paid, and member. These deliveries represented 34.2 per cent of Calavo's tonnage received and 33.4 per cent of Calavo's pool payments. The 201 members were selected by identifying for each of Calavo's 12 "production districts" the members whose tonnages were among the ten largest in the district in one or more of three seasons (1954–55, 1955–56, and 1956–57).

The 201 members in the sample are not necessarily representative of all members. They do, however, represent the potentially most permanent members, since small groves change hands relatively frequently. In addition, larger members tend to be more price conscious, since they have larger investments and since a smaller price improvement would suffice to recoup the costs of search and shift. In the Great Withdrawal of October 1958, resignations were received from 10.5 per cent of Calavo's total membership, but from 23.7 per cent of the 1,100 members whose deliveries had averaged more than 5,000 pounds during 1956–57 and 1957–58. Calavo's management is especially concerned to provide equitable treatment for such large members.

STEP EIGHT

CALCULATING SAMPLE INEQUITY

Step eight is to calculate the inequity that each alternative in the sample would have produced for the selected members and seasons.

Hypothetical Pool Prices

Initially, it was necessary to determine what 1955–56 pool prices each alternative would have produced. The price for each hypothetical pool was obtained by identifying the actual 1955–56 pools that it contained, summing Calavo's dollar payments and pounds in these pools, and dividing the dollar total by the pound total. The figures for ($v = 6$, $g = 10$, $s = 6$, $t = 1$) were shown in percentage form in tables 3 and 4 above, while those for ($v = 1$, $g = 1$, $s = 1$, $t = 21$) appeared in the "All varieties" column of tables 5 and 6. (For the benefit of persons who might want to undertake similar studies, it should be mentioned that the calculations required approximately one man-month.)

The alternatives to consider were selected with this calculation in mind. The calculation was not feasible for an alternative that would subdivide any actual pools, since the dollars and pounds to apportion to each part were not known. It was not possible, for example, to separate the figures for Fuerte from those for Edranol and Murietta Green, or to combine grade Small with sizes 42 and 35 when the combination was, in contrast with the actual treatment of Small fruits, to be subdivided according to quality.

The Base Alternative

The limitation just mentioned made it impossible to determine from the information at hand what prices would have been paid with an alternative more complex than the one actually used. Hence the base alternative was made the actual 1955–56 groupings—($v = 14$, $g = 10$, $s = 6$, $t = 21$)—even though a more complex alternative apparently could have provided adequate risk-spreading.

It should be emphasized that adopting the actual groupings for the base alternative was a matter of convenience, not necessity. A more complex alternative can be used provided the investigator has enough resources to repeat the calculations that the association made in order to fix its pool prices initially.

The groupings that serve here as the base alternative are in all respects at least as numerous as those presently being used or seriously considered; the present groupings are approximately those for ($v = 6$, $g = 10$, $s = 4$, $t = 21$). Consequently, interesting comparisons remain possible in each dimension, something which would not be true if a more recent year had been chosen for analysis and its actual groupings used as the base alternative.

Calculated Inequity

For each alternative the hypothetical pool prices were multiplied by the corresponding tonnage that each of the 201 members had delivered. The sum of these products for each member represented the dollar valuation that he would have received with that alternative before adding for savings. These valuations were subtracted from the base-alternative valuations of the members. To obtain aggregate inequity, all positive remainders were summed. (It will interest persons who contemplate similar studies to know that, using an IBM 1620, the processing of punched data cards involved approximately 20 man-hours for programming and 60 machine-hours for computations, the equivalent of about $2,000.) The results, which range up to $79,100 per season, appear in table 10.

TABLE 10
1955–56 AGGREGATE INEQUITY OF SELECTED ALTERNATIVES TO 201 LARGE MEMBERS

Number of variety groups	Number of grade groups	Number of time groups: 1				12				21			
		Number of size groups: 1	2	4	6	1	2	4	6	1	2	4	6
		thousands of dollars											
1	1	79.1											
6	1	74.5				46.8				49.7			
	4		69.2	67.8	65.0		35.3	30.4	25.9		51.4	36.7	32.2
	5		55.2	55.6	55.4		28.8	36.8	19.1		31.0	40.3	19.7
	10		55.1	52.7			31.8	22.7	23.9		30.2	23.1	24.5
14	10												0

TABLE 11

VALUATION OF SAMPLE MEMBERS WITH SELECTED ALTERNATIVES

Number of variety groups	Number of grade groups	Number of time groups											
		1				12				21			
		Number of size groups											
		1	2	4	6	1	2	4	6	1	2	4	6
		per cent of actual 1955–56 valuation											
1	1	103.6											
6	1	100.8				93.7				98.9			
	4		100.9	100.5	100.0		94.6	94.3	94.4		99.9	99.2	99.2
	6		101.7	101.2	100.6		93.7	103.4	99.9		102.3	98.4	102.2
	10		101.6	101.2			101.9	100.2	104.8		101.2	99.8	98.9
14	10												100.0

STEP NINE
ESTIMATING ALL-MEMBER INEQUITY

Step nine is to estimate the aggregate inequity that alternatives in the sample would have produced for all members.

In Calavo's case, this step is not needed to identify an optimal alternative. With no alternative do estimated savings exceed the aggregate inequity even to the 201 members in the sample. But the step is needed in order to rank the alternatives, to see whether the results are sufficiently regular to make extrapolation plausible, and to illustrate a technique which may be useful in other studies.

Inflating the Sample Results

The figures in table 10 represent aggregate inequity to a sample of members who accounted for almost exactly one-third of the total 1955–56 valuation. As a result, even though the sample was not drawn randomly, aggregate inequity for all members might be estimated as three times as great.

Additional information is available, however. Table 11 shows what the total valuation of the sample members would have been with each alternative, expressed as a percentage of their actual 1955–56 valuation ($1,509,651). The figures vary considerably—from 93.7 to 104.8 per cent.

The significance of these percentages derives from the fact that Calavo's total valuation was held constant in calculating hypothetical pool prices. Consequently, for an alternative with which the total valuation of all sample members is, say, less than their actual valuation, the total valuation of all members not in the sample would exceed their actual valuation. That is, the reduced valuations of some members in the sample are not fully offset by increased valuations for other sample members, and the difference must accrue to members not in the sample. Such an alternative is a relatively favorable one for members not in the sample. As a result, aggregate inequity to them with the alternative seems likely to be less than twice the sample inequity. In other words, for such an alternative the average inequity over all samples of one-third of total valuation seems likely to be less than table 10 indicates.

How much less the average inequity would be is problematical, but we may, rather arbitrarily, estimate that for an alternative with which the total valuation of our sample members was, say, 96 per cent of their actual valuation, the average inequity would be 96 per cent as much as table 10 indicates. Conversely, if the figure in table 11 is, say, 104 per cent, we may estimate that the average inequity would be 104 per cent of the corresponding figure in table 10.

Accordingly, to estimate the aggregate inequity of an alternative to all members, the figure shown in table 10 was multiplied, not by 3, but by 3 times the corresponding ratio of hypothetical to actual valuation of sample members shown in table 11. The results, ranging up to $246,000 per season, appear in table 12.

Relation to Groupings

Table 12 allows us to compare the aggregate inequity associated with different size grouping in nine cases, each involving the same 6 variety groups but different groupings of grades and dates. The pattern of results varies systematically with g. In all 3 cases where $(g = 4)$, inequity increases as s decreases from 6 to 4 and from 4 to 2. With $(g = 5)$, inequity increases each time that s drops from 6 to 4, but then partly recovers when s drops from 4 to 2. With $(g = 10)$, inequity increases when s drops from 4 to 2, but decreases when s drops from 6 to 4. In no case, it should be noted, is the inequity associated with $(s \leq 2)$ the smallest in a row—that is, in no case is elimination of size distinctions most equitable.

Table 12 also allows us to compare the inequity associated with varying grade groupings while holding groupings in other respects constant. It should be noted that, while inequity with $(g \leq 4)$ is twice less than inequity with $(g = 5)$ and once less than inequity with $(g = 10)$, it is in no case the smallest inequity in a column. That is, in no case is near or complete elimination of grade distinctions most equitable.

Concerning time groupings, it should be noted that inequity invariably is much greater for seasonal than for either monthly or split-monthly pools. However, monthly pools were associated

TABLE 12

ESTIMATED 1955–56 AGGREGATE INEQUITY OF SELECTED ALTERNATIVES TO ALL MEMBERS

Number of variety groups	Number of grade groups	Number of time groups											
		1				12				21			
		Number of size groups											
		1	2	4	6	1	2	4	6	1	2	4	6
		thousands of dollars											
1	1	246											
6	1	225				132				147			
6	4		209	204	195		100	86	73		154	109	96
6	5		168	169	167		81	114	57		95	119	60
6	10		168	160			97	68	75		92	69*	73
14	10												0

* Inequity for pools presently used compared to 1955–56 pools.

with less inequity than were split-monthly pools in 8 out of 10 cases.

Aside from these observations, the most important point about table 12 is that it contains many irregularities. They make it impossible to obtain a simple functional relation that could be used to predict aggregate inequity for other values of v, g, s, t (and perhaps other variables, such as pounds delivered and average price). That is, no simple relation can systematize a substantial proportion of the variance in inequity in table 12, or even be defended as a result of more than chance. Hence, not only extrapolation, but also interpolation has proved to be infeasible.

Explaining the Results

The irregularities in table 12 might be attributed to correlations among fruit characteristics and/or to reversals in premiums for certain fruits. Consider, for example, the result that, when $(g=5)$, inequity first increases and then decreases when s drops from 6 to 4 to 2.

A possible explanation is that the members who are disadvantaged when $(g=5)$ are those who suffer when Number One grade is pooled with lower-priced grades and that these members deliver disproportionately large amounts of 20-count avocados. This combination could explain the result since the prices assigned to 20's fall when s drops from 6 to 4 (because then 20's are pooled with lower counts), but the prices rise when s drops from 4 to 2 (because then 20's are pooled also with higher counts). Consequently, the members who are disadvantaged when $(g=5)$ would increase their losses when s drops from 6 to 4 but reduce their losses when s drops from 4 to 2. The drop from 4 to 2 would counteract some of the inequity resulting from the drop from 6 to 4.

Such rationalizations of the results in table 12 are very difficult—perhaps impossible—to keep consistent. A consistent explanation is not apparent, for instance, as to why inequity is less for $(v=6, g=5, s=2, t=12)$ than for $(v=6, g=10, s=2, t=12)$, for $(v=6, g=5, s=4, t=12)$, and for $(v=6, g=5, s=2, t=21)$, yet more than for $(v=6, g=10, s=4, t=21)$.

Even if consistent, however, such explanations apparently would be misleading. They presuppose that the identity of the disadvantaged members is approximately constant, so that the results can be explained by correlations

TABLE 13

SAMPLE MEMBERS DISADVANTAGED BY SELECTED ALTERNATIVES

Number of variety groups	Number of grade groups	Number of time groups: 1				12				21			
		Number of size groups: 1	2	4	6	1	2	4	6	1	2	4	6
		per cent of 201 sample members											
1	1	50											
6	1	44				51				46			
	4		43	43	43		43	50	52		51	51	57
	5		45	48	49		30	55	58		35	65	71
	10		44	44			33	49	59		35	62	75
14	10												0

among attributes of their deliveries. In contrast, table 13 shows that the proportion of the 201 members who were disadvantaged by the various alternatives varies widely.

The proportion disadvantaged by nonbase alternatives ranges from a high of 75 per cent to a low of 30 per cent, and it differs by as much as 30 percentage points between adjacent alternatives. This variation apparently is the principal reason for the irregularities in table 12.

STEP TEN

IDENTIFYING THE SAMPLE OVERALL OPTIMUM

The next step is to decide which is the overall optimum among the alternatives sampled.

The Base-Oriented Optimum

If an alternative is to be the base-oriented optimum, it must not produce greater individual inequity than individual savings for any member. This condition cannot be met if total savings for the alternative are less than its aggregate inequity. For, even if the total savings were allocated only to disadvantaged members and in the most appropriate way, total savings would still be too small to allow the shares accruing to disadvantaged members to offset their shares of the aggregate inequity. Table 14 shows the difference between total savings and aggregate inequity for the alternatives for which inequity was estimated.

According to table 14, total savings do fall short of aggregate inequity for every alternative other than ($v = 14$, $g = 10$, $s = 6$, $t = 21$), which is the base alternative. The latter, with zero savings and zero inequity, then is the alternative in the sample whose savings are largest among those that meet the condition that no member shall receive less than his base-alternative valuation.

The Interpersonal Optimum

The alternative with the largest excess of total savings over aggregate inequity is also ($v = 14$, $g = 10$, $s = 6$, $t = 21$). For all others studied, total savings are substantially less than aggregate inequity. In fact, their total savings are never as

TABLE 14

ESTIMATED EXCESS OF TOTAL SAVINGS OVER 1955–56 AGGREGATE INEQUITY FOR SELECTED ALTERNATIVES

Number of variety groups	Number of grade groups	Number of time groups: 1				12				21			
		Number of size groups: 1	2	4	6	1	2	4	6	1	2	4	6
		thousands of dollars											
1	1	−226											
6	1	−206				−113				−128			
	4		−190	−191	−185		−81	−73	−63		−135	−96	−86
	5		−149	−156	−157		−62	−101	−47		−76	−106	−50
	10		−149	−147			−78	−55	−65		−73	−56*	−63
14	10												0

* Excess for pools presently used compared to 1955–56 pools.

much as two-thirds of even the inequity to the 201 members in the sample. As a result, the conclusion would stand even if substantial changes were made in estimates of savings, in the method of inflating the inequity of the 201 members, or in the total dollar value of a season's deliveries.

If we rank the other alternatives according to the criterion underlying the interpersonal optimum, we find ($v = 6$, $g = 5$, $s = 6$, $t = 12$) in second place. Compared with the base alternative, it would have produced estimated savings of \$10,000 and estimated 1955–56 inequity of \$57,000, a difference of minus \$47,000.

The pools presently used are approximately those associated with ($v = 6$, $g = 10$, $s = 4$, $t = 21$). This alternative ranks fifth, following also ($v = 6$, $g = 5$, $s = 6$, $t = 21$) and ($v = 6$, $g = 10$, $s = 4$, $t = 12$). It was associated with savings of \$13,000 and inequity of \$69,000, a difference of minus \$56,000.

The Overall Optimum

Since ($v = 14$, $g = 10$, $s = 6$, $t = 21$) is both the base-oriented optimum and the interpersonal optimum, it is also the one among these two that has the larger savings. Among the 31 alternatives studied, it stands out as the most appealing on grounds of savings and 1955–56 inequity.

The desirability of ($v = 14$, $g = 10$, $s = 6$, $t = 21$) could be affected by disadvantages with respect to the other two relevant considerations—disincentives and risk-spreading. No such disadvantages are apparent. Since ($v = 14$, $g = 10$, $s = 6$, $t = 21$) was abandoned in favor of the present, less complex procedure apparently only in order to obtain savings, not to increase risk-spreading, differences in risk-spreading may not be important in the range at issue, or may be offset by differences in disincentives. That is, changes in tonnage per pool or in production and marketing decisions may not be predictable in the range considered, or may offset each other. If so, it can still be said that, on the limited evidence available and according to the criterion adopted, ($v = 6$, $g = 10$, $s = 6$, $t = 21$) ranks highest among the 31 alternatives considered.

Possible Bias

The fact that ($v = 14$, $g = 10$, $s = 6$, $t = 21$) was also the base alternative may lead one to wonder whether the solution was biased in that direction.

There is a reason why this bias may exist. If an alternative closer to the upper limit could be introduced as a new base alternative and aggregate inequity recalculated, a positive figure presumably would appear for ($v = 14$, $g = 10$, $s = 6$, $t = 21$). Aggregate inequity for other alternatives, however, might increase by less than this figure. Indeed, for alternatives that, because of correlations among avocado characteristics, counteract some of the newly found inequity in ($v = 14$, $g = 10$, $s = 6$, $t = 21$), aggregate inequity could even decrease. (See "Explaining the Results," p. 78, for an example of how such counteraction can arise.)

On the other hand, for ($v = 14$, $g = 10$, $s = 6$, $t = 21$), inequity had to come out zero in our calculations, whereas for any other alternatives, aggregate inequity may have been underestimated. It could have been artificially reduced because the members or the season in the sample were unrepresentative or because mistakes occurred in the calculations.

In the net, no adjustments in the solution procedure appear to be warranted. It is hoped, however, that additional studies will shed more light on this question.

CONCLUSIONS CONCERNING CALIFORNIA AVOCADO POOLS

Variety Groups

We have considered a number of pooling alternatives involving 6 variety groups (Fuerte group, other green, Hass group, other dark, Thinskins, and Undistinguished for Cukes). We found that these alternatives would have produced both savings and inequity for the 1955–56 season compared with the 14-group alternative actually used in 1955–56, but that for each of 29 such alternatives the aggregate inequity substantially exceeds the total savings. "Total savings" here refers to the potential reduction in annual pooling costs, while "aggregate inequity" refers to the sum of undervaluations for members whose valuations would have been reduced. In turn, a particular alternative (a single pool per season) that involves one variety group would have produced a still larger excess of aggregate inequity over total savings.

One can infer from these results that no pooling alternative with as few as 6 variety groups would have produced as much total savings as aggregate inequity during 1955–56, and perhaps that the same is true (despite changes in accounting costs, commingling categories, price premiums, relative tonnages, incentives, and so forth) for future seasons. In order to bring aggregate inequity as low as total savings—which may be regarded as an objective— it will then be necessary to use more than 6 variety groups. In particular, it will be necessary to subdivide one or both of the "other green" and "other black" groups that Calavo has used since 1956–57. In these terms, adopting the latter groups appears to have been a mistake.

To decide how the particular subdivision of the "other green" and "other black" groups used in 1955–56 compares with other possible subdivisions will require further study, since the sample considered here contains only the former. Further study should refer not only to savings and inequity, but also to the two additional but noncommensurable objectives—spreading risks and maintaining members' incentives.

Grade, Size, and Time Groups

We obtained estimates of savings and inequity for 29 alternatives involving 6 variety groups, each of the 29 representing a different combination of grade, size, and time groups. Since the 6 variety groups closely approximate the 6 that Calavo presently uses (see "The Groupings Selected," p. 71), the results will be directly relevant if Calavo chooses to continue to use 6 variety groups despite the indications that a larger number would be preferable.

The combination of groupings for grades, sizes, and dates that had the smallest excess of 1955–56 aggregate inequity over total savings with 6 variety groups was ($v = 6$, $g = 5$, $s = 6$, $t = 12$)—that is, grouping together the 5 intermediate grades, pooling only adjacent pairs of sizes, and using monthly (not split-monthly) time periods.

The combination that approximates the procedure presently used by Calavo —namely ($v = 6$, $g = 10$, $s = 4$, $t = 21$)— involves a larger number of grade and time groups and a smaller number of size groups. This combination was associated with both smaller total savings and larger 1955–56 aggregate inequity, although the result was not a smaller valuation for every member in the sample. The status quo alternative, furthermore, appears to have no superiority in terms of spreading risks and maintaining incentives. While it is unknown how inequity would compare if calculated for additional seasons, the evidence available indicates that ($v = 6$, $g = 5$, $s = 6$, $t = 12$) would be a reasonable replacement for the present set of pools.

The sample of alternatives considered does not provide information about the effects of different groupings of grades, sizes, and dates if other than 6 variety groups are used. The effects with 6 variety groups, however, indicate what may be true if Calavo decides, as suggested above, to use more than 6. At least with the 1955–56 composition of deliveries, grouping Calavo with lower grades, grouping all sizes together, or using a seasonal pool increases aggregate inequity by more than total savings.

More exact indications could be obtained if Calavo were to arrange for the study of additional samples of alternatives and seasons. It is likely that some possibilities will outrank ($v=6$, $g=5$, $s=6$, $t=12$), which had the smallest excess of aggregate inequity over total savings among the 29 alternatives that retained the present 6 variety groups. Some alternatives may even outrank the 1955–56 set of pools, which ranked highest among all 31 possibilities considered here. Additional sampling, in other words, could locate alternatives that are closer approximations to the overall optimum, which is the set of pools that has here been proposed as a reasonable compromise among the conflicting objectives at stake.

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