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Pricing Raw Product in Complex Milk Markets

By R. G. Bressler

The dairy industry is based on the production of a raw product that is nearly homogeneous—whole milk—on farms geographically scattered, and the disposal of this raw product in alternative forms—fluid milk, cream, manufactured products—and to alternative metropolitan markets. Alternative markets represent concentrations of population. These also are geographically dispersed, but with patterns imperfectly correlated with milk and product production. The problem faced in the study that formed the basis for this paper was to examine the interactions of supply and demand conditions and the interdependent determination of prices and of raw product utilization. As his paper shows, the author approaches the problem by first considering a greatly simplified model based on static conditions and perfect competition. This is modified to admit dynamic forces, especially in the form of seasonal changes in supply and demand. Noncompetitive elements are then introduced in the form of segmented markets and discriminatory pricing, based on ultimate utilization of the raw product. Finally, these models are used to suggest principles of efficient pricing and utilization, within the constraint of a classified system of discriminatory prices.

This paper was originally prepared in connection with the study of class III pricing in the New York milkshed currently being conducted by the Market Organization and Cost Branch of the Agricultural Marketing Service. The object was to develop theoretical models that would provide a framework within which the empirical research work could be organized and carried out. The paper is published here because of its evident value as an analytical tool to research workers engaged in analyzing the efficiency of alternative pricing and utilization systems for milk and other agricultural products. It should perhaps be emphasized that the theoretical models presented involve a considerable degree of simplification, and that various amendments may be necessary in the empirical analysis of any particular milk marketing situation. It should also be understood that not all analysts will necessarily concur fully with some of the stated implications of Professor Bressler's model, particularly with respect to the explanation of classified pricing wholly in terms of differing demand elasticities and the extent to which classified pricing may act as a barrier to freedom of entry. Readers with a particular interest in the economics of the milk market structure may wish to examine the AMS study, "Regulations Affecting the Movement and Merchandising of Milk," published in 1955, which also contains analyses bearing on some of the problems considered in this article.

OUR THEORETICAL MODELS are based on a number of simplifying assumptions, the most important of which are:

1. A homogeneous raw product, regardless of final use. This is later relaxed by considering the effects of qualitative differences in raw product for alternative uses.

2. Given fixed geographic patterns of production of milk and of consumption of fluid milk in local markets. This will then be relaxed (a) to permit changes associated with the elasticity of demand and supply; and (b) seasonal variations in supply and demand.

3. Transport costs that increase with distance and that, on a milk equivalent basis, are inversely related to the degree of product concentration; that is, cream rates lower than milk rates, butter rates lower than cream rates (and so on) per hundredweight of milk equivalent. Graphically, we treat these as relationships linear with distance. This does not distort our consideration of the nature of decisions, but actual determination of a margin between alternative products can only be specified in terms of actual rates in effect.

4. Total processing costs for a plant include a fixed component per year (reflecting the type of equipment available, and so on) plus constant variable costs per unit of product or per hundredweight of milk equivalent for each product handled. The effects of scale of operation are not considered originally, but these could be introduced in the analysis without difficulty.

Competitive Markets—Static Conditions

The General Model

Consider the case of a central market with given quantities of several dairy products demanded. To be specific, assume that whole milk, cream, and butter are involved. For each product we know: (1) The conversion factor between raw product and finished product; (2) the processing costs for plant operation; (3) the transportation cost to market. Neglect for the moment any byproduct costs and values. The market is surrounded by a producing area, and production, while not necessarily uniform throughout the area, is assumed to be fixed in quantity for any sub-area. Under these conditions and with perfect competition, how will the producing area be allocated among alternative products, and what will be the associated patterns of market and at-country-plant prices for products and raw material? We limit our detailed discussion to the interrelations between two products, as the same principles will apply at each two-product margin.[1]

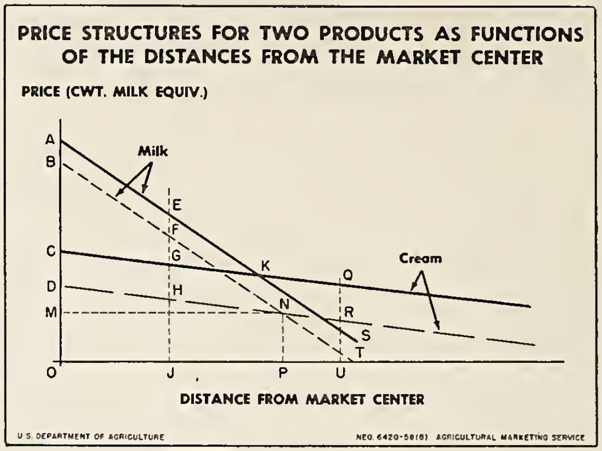

Figure 1.

Geographic Price Structures and Product Zones

Assume that a particular set of at-market prices for products has been established. These market prices and the transportation costs, then, establish geographic structures of product prices throughout the region, so that the price at any point is represented by the market price less transportation costs. This is suggested by figure 1, where all prices and costs are given in terms of milk equivalent values. If there were no processing costs, it is clear that at-plant values for milk in whole form would equal at-plant values for milk in cream form at some distance from market, such as at point K in the diagram. But differences in processing costs do exist, and these, as well as differences in transportation costs, must be considered.

Suppose country-plant costs equal AB for milk and CD for cream. Then *net values* of the raw product at various distances from market would be represented by line BT for milk as whole milk, and by line DR for milk as cream. At any distance from market such as OJ, a plant operator would find that net value of raw product would be JF

[1] Technically speaking, we compare sets of joint products (byproducts). This modification will be covered later.

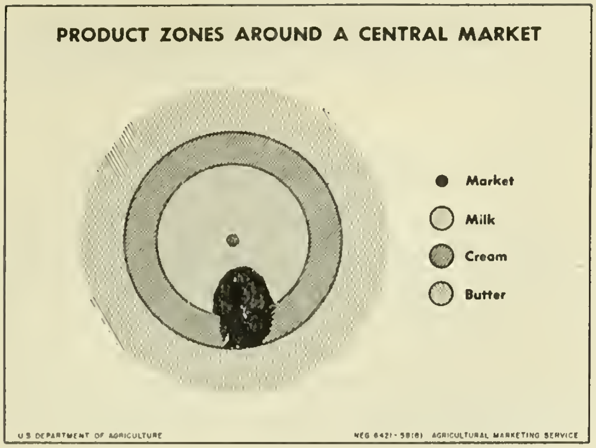

Figure 2.

for whole milk and JH for cream. Moreover, competition would *force* him to pay producers the highest value to obtain the raw product—and this would be JF. Thus, competition would lead him to select the highest value use, for in any other use he would operate at a substantial loss.

At some distance OP the net values for raw product would be exactly equal in the alternative uses. At this location, a manager would be indifferent as to the shipment pattern, and this distance would represent the competitive boundary or margin between the area shipping whole milk and the area shipping cream under the given market price. A plant operator still farther away from market would find that shipping cream would be his best alternative, in fact, the only one through which he could survive under the pressure of competition.

Disregarding the peculiar characteristics of terrain, road and rail networks, and transportation charges, this and other two-product boundaries would take the form of concentric circles centered on the market (fig. 2). The product zone for whole milk—the most bulky product with highest transport costs per unit of milk equivalent—would be a circle located relatively close to the market; zones for less bulky products would form rings around the milk zone. These rings would extend away from market until the margin of farm dairy production was reached, or until this market was forced to compete with other markets for available supplies.

In all of this, we assumed a particular set of market prices. If these had been arbitrarily chosen, the quantities of milk and products delivered to the market from the several zones would only by chance equal market demand. Suppose, for example, that the allocations illustrated resulted in a large excess of milk receipts and a deficiency in cream receipts at the market. This would represent a disequilibrium situation, and the price of milk would fall relative to the price of cream. The decrease in the price of milk would bring a contraction of the milk-cream boundary, and the process would continue until the market structure of prices was brought into equilibrium—where the quantities of all products would exactly equal the market demand.

More generally, both consumption and production would respond to price changes—demands and supplies would have some elasticity—and the final equilibrium would involve balancing these and the corresponding supply area allocations to arrive at perfect adjustment between supply and demand for all products. Notice that the product equilibria positions will be interdependent—an increase in the demand for any one product, for example, would influence *all* prices and supply area allocations. But in the final equilibrium adjustments, the situation at any product boundary would be similar to that shown in figure 1.

Minimum Transfer Costs and Maximum Producer Returns

We have demonstrated that, under competitive conditions, plant operators would select the dairy products to produce and ship by considering market prices, transportation costs, and processing costs, and that by following their own self interest they would bring about the allocation of the producing territory into an interdependent set of product zones. In algebraic terms, the at-plant net value (N) of raw product resulting from any alternative process (Products 1, 2, . . .), is represented by:

$$N=P-t-c$$

in which P represents the market price, t the transfer cost (a function of distance), and c the plant processing cost—all expressed per unit of raw product. The boundary between two alternative products 1 and 2, then, is:

$$N_1=N_2$$
$$\text{or, } P_1-t_1-c_1=P_2-t_2-c_2$$

It should be recognized that final equilibrium must involve higher market prices (in milk equivalent terms) for the bulky, high-transport-cost products, with lower and lower prices for more-and-more concentrated products. If this were not true, there would be no location within the producing area from which it would be profitable to ship the bulky product, and the market would be left with zero supply. Prices for these bulky products therefore "push up" through the price surfaces of competing products until market demands are satisfied.

It is easy to demonstrate that these free-choice boundaries minimize total transportation costs for the aggregate of all products, so long as market requirements are met. Suppose we consider shifting a unit of production at some point 1 in the milk zone from milk to cream, and compensate by shifting a unit of production at any point 2 in the cream zone (and therefore farther from market than point 1) from cream to milk.

The indicated shifts will represent a net increase in the distance that milk is shipped, and an exactly equal decrease in the distance that cream is shipped. But as it costs more to ship milk than cream any distance (per hundred-weight of milk equivalent), it follows that the shift must increase total transportation costs. This would be true for any pairs of points considered—the points selected were not specifically located and so represent any points within the two product zones. Moreover, a similar analysis is appropriate between any two products—the milk-cream boundary, the cream-butter boundary, and so on.

Not only do these boundaries represent the most efficient organization of transportation; they also permit the maximum return to producers consistent with perfect competition. Point 1 is located in the milk zone, and so is closer to market than point 2 in the cream zone. We know that at point 1 the net value of the product is higher for milk than for cream, while the reverse is true for point 2. Shifting to cream at point 1 would thus *reduce* the net value, and shifting to milk at point 2 would also reduce net value. On both scores, then, net values would be reduced. As net values represent producer payments (at the plant), it is clear that the competitive or free-choice boundaries are consistent with the largest possible returns to producers. From a comparable argument, it follows also that these competitive zones permit consumers at the market to obtain the demanded quantities of the several products at the *lowest* aggregate expense.

Qualitative Differences in Raw Product

We have assumed that the several alternative products are derived from a completely homogeneous raw product. Actually, the raw product will differ in quality and in farm production costs. One such difference relates to butterfat content—individual herds may vary by producing milk with fat tests ranging from nearly 3 percent to well over 5 percent.

We shall not comment on differences in the fat test other than to point out that, under competitive conditions, the determination of equilibrium prices for products varying in butterfat content simultaneously fixes a consistent schedule of prices or butterfat differentials for milk of different tests. This is true also in fluid milk markets where standardization is permitted.[2]

In many markets, milk for fluid consumption must meet somewhat more rigid sanitary regulations than milk for cream, and this involves some difference in production costs. These differences will modify our previous equilibrium analysis. Assume that farm production costs for milk for fluid purposes are higher than costs for milk for cream by some constant amount per hundredweight. The equilibrium adjustment at the milk-cream margin, then, will not involve equal net values for the raw product, for under these conditions a farmer near the margin would find it to his advantage to produce the lower cost product. The net value for milk for fluid purposes must exceed the value for cream by an amount equal to the higher unit production costs. In equation form:

$$N'_1 = N_2$$

$$P_1 - t_1 - c_1 - s_1 = P_2 - t_2 - c_2$$

in which s represents the higher farm production costs, and in which the setting of these equations equal to each other defines the new boundary.

This presentation is greatly oversimplified, though it may be adequate for present purposes.

[2] For details, see Clarke, D. A., Jr. and Hassler, J. B. PRICING FAT AND SKIM COMPONENTS OF MILK. California Agr. Expt. Sta. Bul. 737. 1953.

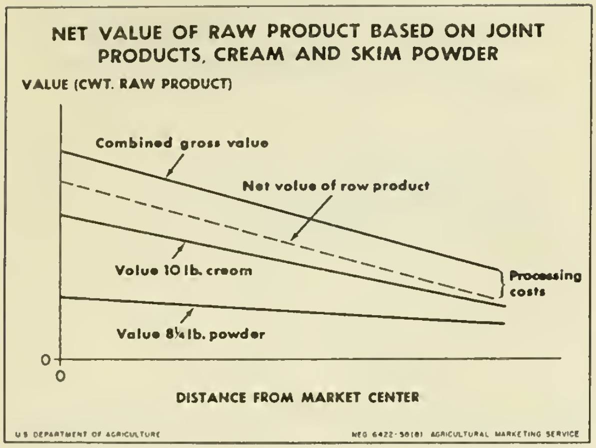

Figure 3.

Actually, differences in production costs would not enter in this simple way—for every farm would have somewhat different costs. Differences in sanitary requirements will influence farm production decisions and so modify supply. In equilibrium, the interaction of supply and demand will determine not only the structure of market prices and product zones, but also the supply-price to cover the changed production conditions. In short, this price differential will be set by the market mechanism itself, and at a level just adequate to induce a sufficient number of farmers to meet the added requirements. The cost difference that we assumed above, therefore, is really an equilibrium supply-price for the added services. Moreover, it may vary throughout a region, reflecting differences in conditions of production and size of farm.

Byproduct Costs and Values

We have assumed also that the alternatives facing a plant operator were in the form of single products. Yet it is clear that most manufactured products do not utilize all of the components of whole milk, nor use them in the proportions in which they occur in whole milk. Cream and butter operations have byproducts in the form of skim milk, and this in turn can be processed into such alternative forms as powdered nonfat solids or condensed skim. Cheese yields whey or whey solids as byproducts, plus a small quantity of whey butter. Evaporated milk will result in byproducts based on skim milk if the raw product has a test less than approximately 3.8 percent butterfat, and cream if the test exceeds 3.8 percent.

For any given raw product test, the alternatives open to a plant manager form a set of joint products, with each bundle of joint products produced in fixed proportions. With 100 pounds of 4 percent milk, for example, the joint products might be approximately 10 pounds of 40-percent cream plus 90 pounds of skim milk, or 5 pounds of butter and 8.75 pounds of skim milk powder. Net value of raw product at any location, then, will represent the quantity of each product in the bundle multiplied by market price minus transportation costs with the gross at-plant value reduced by subtracting aggregate processing costs. This is suggested in figure 3 for the joint products cream and skim powder. With this modification, our previous analysis is essentially correct. But note that the product zones now refer to joint products rather than to single products—and so to real alternatives in plant operation.

Plant Costs and Efficient Organization

Before completing our consideration of static competitive models, we should be more specific with reference to plant or processing costs. In the foregoing, these have been treated as constant allowances for particular products. As in the case of differences in production costs, processing costs are not adequately represented by a given and fixed cost allowance but rather are determined in the marketplace. In short, these too represent equilibrium supply-prices, adequate, but only adequate, to bring forth the required plant services.

In the present discussion, we have considered these in relation to the raw product and indicated a flat deduction to cover plant costs. In sections to follow we shall find it essential to distinguish between fixed and variable costs, but we shall view the process correctly as involving decisions that can be expressed ultimately in terms of costs and return per unit of raw product.

If we represent plant costs as a constant "price" resulting from the competitive market equilibrium, we disregard the effects of scale of plant. More exactly, we assume that equilibrium involves an organization of plants that is optimum with respect to location, size, and type. With these assumptions, the long-run costs for any particular type of operation are taken to be uniform and at optimum levels.

We shall proceed on this basis, but we emphasize that this will not be strictly correct, even under ideal conditions. The optimum size for a plant of any type will depend on the economies of scale that characterize plant costs and on the diseconomies of assembling larger volumes at a particular point. These are balanced off to indicate that size of plant which results in the lowest combined average costs of plant operation and assembly.

But assembly costs are affected by such factors as size of farm and density of production: Costs increase with total volume assembled under any situation, but they increase at more rapid rates in areas with small farms and sparse production density. Consequently, the ideal plant will be of somewhat smaller scale in such areas, and plant costs (as well as combined costs) somewhat higher. Moreover, these factors will have a differential effect on costs and optimum organization for plants of different types because each type will have characteristically different economy-of-scale curves. This may mean some modifications to the perfectly circular product zones—and so provide a rational explanation of the persistence of a particular form of plant operation in what would otherwise appear to be an inefficient location.

We have suggested that competitive market conditions would balance off plant and assembly costs, and eventually result in a perfect organization of plant facilities with respect to location, size, and type. A further digression on this subject seems necessary, for these situations are unavoidably involved in elements of spatial or location monopoly. Under perfect market assumptions, the plant manager obtains raw product (and other inputs) by offering a given and constant market price, obtaining all that he requires at this price. But apparently in this country plant situation, increases in raw product can be obtained only by offering higher and higher at-plant prices—prices increasing to offset the higher assembly costs. In short, the manager is faced with a positively inclined factor supply relationship—and so finds himself in a monopsonistic situation. He cannot be unaware of this, and so he can be expected to take it into account in making his decisions.

With a given price for the finished product at the country plant location—representing the equilibrium market price minus transfer costs—and raw product cost that increases with increases in plant volume, the manager faces a price spread or margin that decreases with increases in volume.

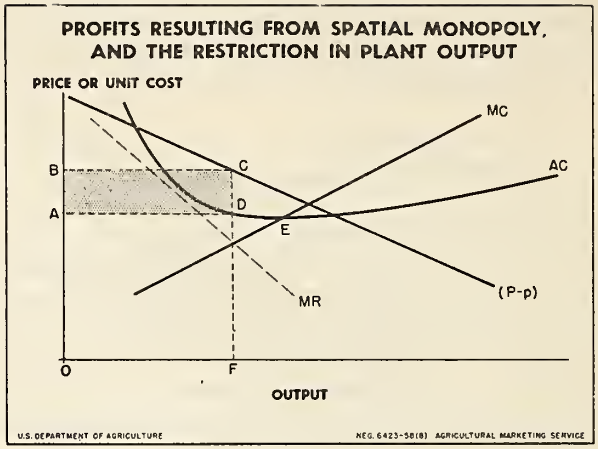

Figure 4.

This is illustrated in figure 4 by the line $(P-p)$—the at-plant finished product price (milk equivalent) minus the increasing price paid to obtain raw product. Marginal revenue from plant operation is then represented by the line MR and the manager would maximize profits by operating at output OF where marginal revenue and plant marginal costs are equal. Average plant costs would then be FD and average revenue FC, yielding monopsonistic profits equal to CD per unit or ABCD in total. Notice that optimum long-run organization would have been at point E if the prices paid for raw product had been constant rather than increasing with volume, and that this is the minimum point on the average cost curve. Because of spatial monopoly elements, however, plant volume will be lower than the cost-minimizing output, costs will be higher, payments to producers lower, and profits greater than normal.

This analysis indicates that the country organization will consist of plants with average volumes approximating OF. A plant in an isolated location would have a circular supply area, but with competition from other plants the resulting pattern of plant supply areas would resemble the large network of hexagonal areas shown in figure 5. But with excess profits, the industry would attract new firms, and they would seek intermediate locations such as points D, E, and F. A new plant at point E will compete for supplies with the established plants and eventually carve out a triangular area (HJM) with half the volume of the original plant areas. Such entry will continue until the entire

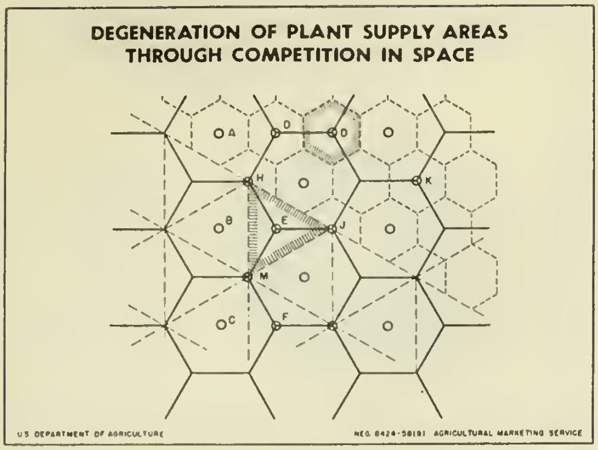

Figure 5.

district has been reallocated—with twice as many plants, each handling half the original average volume.

But this is not the end, for still more plants can force their way into the area, occupying such corner positions as H, M, J, G, and K on the triangular plant areas. Again the district will be reallocated among plants, eventually forming a new hexagonal network as shown around point G—now with three times as many plants as in the original solution. This entry of new firms might be expected to continue until excess profits disappear, or until line $P-p$ in figure 4 is shifted to the left so far that it is tangent to the average cost curve.

But even this is not the limit. The regular encroachment of new firms will result in increased costs and so make it impossible for any firms to be efficient. With a regular increase in costs for all plants, the market price (P) for the product will be forced up and the producer prices for raw product (p) forced down—in short, competition is not and cannot be effective in bringing about low costs and the optimum organization of plants and facilities.

Within this framework of industry inefficiency, there are still opportunities for firms to operate profitably and efficiently through plant integration and consolidation. When the situation becomes bad enough, a single firm (private or cooperative) may buy and consolidate several plants in a district, thus returning the overall organization toward the efficient level. But now the whole process could start over again, unless single firms were able to obtain real control of local supplies, and thus prevent the entry of new firms.

In any event, it is clear that spatial monopoly creates an unstable situation and can be expected to result in an excessive number of plants and correspondingly higher-than-optimum costs. This tendency is sometimes called "the law of mediocrity," and its operation is not limited to country phases of the dairy industry. In retail milk distribution, for example, the overlapping of delivery routes reduces the efficiency of all distributors, and so limits the effectiveness of competition in bringing about an efficient system. The mushrooming of gasoline stations is a familiar example where spatial monopoly and product differentiation result in a type of competition that is unstable and inadequate to insure efficiency in the aggregate system.

Competitive Markets—Seasonal Variation

Seasonal Changes in Production, Consumption, and Prices

We now complicate our model by recognizing that production and consumption are not static, but change through time. Specifically, we consider seasonal changes, and inquire into the effects of these on prices and product zones. Even a casual consideration of this problem will suggest that such supply and demand changes must give rise to seasonal patterns in product prices. These in turn affect the boundaries between product zones through seasonal contractions and expansions. As a consequence, the boundary between any two products is not fixed but varies from month to month, and between zones that are always specialized in the shipment of particular products there will be transitional zones that sometimes ship one product and sometimes another.

We shall now examine this situation in detail to learn how such seasonal variations influence firm decisions, and so understand how prices and product zones are interrelated. We maintain the assumption of perfect markets and the other postulates of our first model, except the assumption of constant production of milk and consumption of fluid milk. As we are interested primarily in how seasonal changes influence the system, we only specify a more or less regular seasonal cycle without attempting to delineate any particular pattern. We assume that managers act intelligently in their own self interest and are not misled by some common accounting folklore with respect to fixed costs—although this is more a warning to our readers than a separate assumption, as it is implicit in the assumption of a perfect market.

A Firm in the Transition Zone

The general outlines of product zones with seasonal variation is suggested by figure 6. Here we show a specialized milk zone near the market, which ships whole milk to market throughout the year. Farther out we find a specialized cream zone, shipping cream year-round, while still farther from market is a specialized butter area. Between these specialized zones—and overlapping them if seasonal variation in production is quite large—are diversified or transition zones: a zone shipping both milk and cream; and a zone shipping both cream and butter.

Suppose we select a location in one of the transition zones, and explore in detail the situation that confronts the plant manager. To be specific, we shall select a plant in the milk-cream zone, but the general findings for this zone are appropriate for other diversified zones.

We assume that this plant serves a given number of producers located in the nearby territory and that this number is constant throughout the year. Production per farm varies seasonally, however, so that even under ideal conditions the plant will have volumes less than capacity during the fall and winter. We assume that the plant is equipped with appropriate separating facilities so that it can operate either as a cream shipping plant or, by not using the separating equipment, as a whole milk shipper. We further assume that market prices for milk and cream vary seasonally and that in order to meet market demands in the low-production period, milk prices change more than cream prices. With the given plant location and transportation costs to market, this means that the manager is faced with changing milk and cream prices f. o. b. his plant. Our problem is to indicate the effects of these changes on plant operations.

Consider first the cost function for this plant. Under our general assumptions, variable costs are easy to handle—each product is characterized by a given and constant variable cost per unit of output, and the manager can expand output along any line at the specified variable cost per unit up to the limits imposed by the available raw prod-

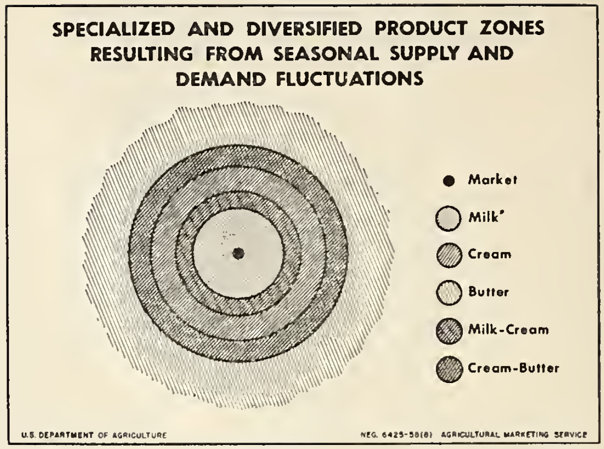

Figure 6.

uct and by plant equipment and capacity. At the same time, the plant is faced by certain fixed or overhead costs. These fixed costs are independent of the volumes of the several products, but reflect the particular pattern of plant facilities and equipment provided. So far as fixed costs are concerned, the several outputs must be recognized as joint products. There are any number of ways in which fixed costs might be allocated among these joint products but all are arbitrary.

Fortunately, such allocations are not necessary to the determination of firm policy and the selection of the optimum production patterns—in fact, fixed cost allocations serve no purpose except perhaps to confuse the issue. We take the fixed costs as given *in total* for the year—although even this is arbitrary for the outputs of any 2 years are also joint products and the assumption of equal fixed costs per year is thus unjustified.

The important issue is that the firm should recover its investment over appropriate life periods—if it does not, it will not continue to operate over the long run; if it more than recovers investments (plus interests, etc.,) then the abnormal level of returns will attract new firms and reduce profits to the normal level. Many of the fixed costs associated with investments and plant operations are institutionally connected to the fiscal year, however, and for this reason the assumption of given total fixed costs per year appears to be appropriate. Examples include annual interest charges, annual taxes, and annual salaries for management and key personnel.

In terms of total costs (fixed plus variable) per year, we visualize a surface corresponding to an equation of the type:

$$TC=a+bV_1+cV_2$$

in which a represents annual fixed costs, V_1 and V_2 the annual output of the two products, b the variable cost per unit of product 1, c the variable cost per unit of product 2, and so on—this may readily be expanded to accommodate more than two products. Note that this cost surface does not extend indefinitely, as V_1 and V_2 are limited by available raw product and plant capacity. Gross revenue for the plant is represented by product outputs multiplied by appropriate f. o. b. plant prices, or:

$$TR=P'_1V_1+P'_2V_2$$

Net returns—or net value of raw product in our earlier expressions—is represented by total revenue minus total costs, or:

$$NR=TR-TC=P'_1V_1+P'_2V_2-a-bV_1-cV_2.$$

If the manager wishes to maximize his net returns—and under perfect competition he has no alternative if he is to remain in business—he can do this by computing the additions to net revenue that will accompany the expansion of either product and selecting the product that yields the greater increase. Marginal net revenue functions are:

$$\frac{\partial NR}{\partial V_1}=P'_1-b$$

$$\frac{\partial NR}{\partial V_2}=P'_2-c$$

These marginal functions may be made directly comparable by expressing them in milk equivalent terms, in which y_1 and y_2 represent the respective yields per hundredweight of raw product:

$$\frac{\partial NR}{\partial y_1V_1}=(P'_1-b)y_1$$

$$\frac{\partial NR}{\partial y_2V_2}=(P'_2-c)y_2$$

By observing marginal net values per unit of raw product, the manager can determine which product to ship. Remember that total output is limited by the available supply of raw product, and that we have assumed capacities adequate to handle this supply in either product. With given at-plant prices and constant marginal costs, the marginal net value comparisons will indicate an advantage in one or the other product, and net revenue will be maximized by diverting the entire milk supply to the advantageous product.

In algebraic terms, we state the following rules for the manager:

if $(P'_1-b)y_1>(P'_2-c)y_2$, ship only product 1;
if $(P'_1-b)y_1<(P'_2-c)y_2$, ship only product 2;
if $(P'_1-b)y_1=(P'_2-c)y_2$, ship either 1 or 2.

These assume, of course, that prices exceed marginal costs; if marginal net revenues should be negative for all products, the optimum short-run program would be to discontinue operations entirely, but normally long-run considerations would dictate a program based on the product with least disadvantage. The third rule simply covers the chance case in which marginal net revenues per unit of raw product are exactly equal in the two lines of production, and so the choice of product is a matter of indifference.[3] Note that these optimum decisions in no way depend on fixed costs or on any arbitrary allocation of fixed costs.

We have stated that prices f. o. b. the plant will vary seasonally, with milk prices fluctuating over a wider range than cream prices. As these prices change, marginal net revenues will change—marginal net revenues from milk shipment will increase relative to marginal net revenues from cream shipments during low-production months and will decrease during months of high production. The manager will watch these changes in marginal net revenue. If $(P'_1-b)y_1$ always exceeds $(P'_2-c)y_2$, then the plant will always ship whole milk, and therefore must be in the specialized milk area. But if marginal net revenue from milk shipment is always lower than marginal net revenue from cream shipment, optimum plant operation will always call for cream shipment and the plant will be in the specialized cream zone.

[3] Under these conditions, the plant might ship both products simultaneously. Under other conditions, such simultaneous diversification would be optimum only if (a) capacity for a particular product is not adequate to permit complete diversion of the raw product, or (b) either marginal costs or marginal revenues change with changes in plant output. These appear to be unrealistic under the conditions stated, and so are disregarded.

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If this plant is in fact located in the diversified milk-cream zone, then during some of the fall and winter months the marginal net revenue from milk will exceed the marginal net revenue from cream and the plant will ship only milk. But during some of the spring and summer months, these marginal net revenues will be reversed, and the plant will ship only cream. Day-by-day and week-by-week the manager will make these decisions, and the result will be a particular pattern of milk and cream shipments. If the plant is located near the inner boundary of the transition zone, it will ship milk during most of the year and cream during only a few weeks or even days at the peak production period. Conversely, a plant near the outer boundary of this zone will ship cream during most of the year and milk only for a few days at the very-low-production period.

Specialized Milk Versus Milk-Cream Plants

It may be protested that the foregoing analysis is incorrect because a plant that utilizes its separating equipment for only a few days must have very high cream costs. This is a common misunderstanding; it arises from the practice of allocating fixed costs to particular products. Nevertheless, a grain of truth is involved, and it can be correctly interpreted by considering the alternatives of specialized milk plant or milk-cream diversification near the milk and milk-cream boundary.

We have seen that the net value of raw product for the diversified plant can be represented by:

$$NR_{12}=P'_1V_1+P'_2V_2-a-bV_1-cV_2$$

In a similar way, we represent net values for the specialized milk plant as:

$$NR_1=P'_1V-d-bV$$

in which d represents the fixed costs for a specialized milk plant and b the variable costs—we assume variable costs of shipping milk as the same in the two types of plant, although this may not be true and is not essential to our argument.

In our equations prices are given in terms of the milk equivalent of the whole milk or cream, and expressed at country-plant location. Remembering that the at-plant price is market price less transportation cost to market and that transportation costs are functions of distance, these costs can be used to define the economic boundary between the specialized milk plant zone and the transition milk-cream zone. For simplicity, we represent the transportation costs by t_1D and t_2D, and give the expression for the distance to the boundary of indifference below:

$$D=\frac{(P_1-b)-(P_2-c)+\frac{a-d}{V_2}}{t_1-t_2}$$

Note that this boundary is long-run in nature—it defines the distance within which it will not be economical to provide separating facilities but beyond which plants will be built with such facilities.[4] The short-run situation would be represented by the margin between specialized milk shipment and diversified milk-cream shipments *where all plants are already equipped to handle both products.* From the material given earlier, it is clear that the equation for the short-run boundary will be exactly the same as the long-run equation, *except* that the fixed costs term $\frac{a-d}{V_2}$ will be eliminated. From this it follows that the long-run boundary will be farther from market than the short-run boundary. If a market has reached stable equilibrium, separating facilities will not be provided until a substantial volume of milk can be separated.

The actual determination of these boundaries will depend on the specific magnitudes of the several fixed and variable cost coefficients, the patterns of seasonal production, the relative transfer costs, and the patterns of seasonal price changes. Ideally, these all interact to give a total equilibrium for the market. We may illustrate the solution, however, by assuming some values for the various parameters and seasonal patterns. This has been done, with the results shown in figure 7. Here we have assumed that fluid milk prices change seasonally—the prices minus unit variable costs at country points are represented by line AB

[4] We assume that equipment will have adequate capacity to handle total plant volume. There remains the possibility that a plant would provide some equipment for a particular product, but less than enough to permit complete diversion. As equipment investments and operating costs normally increase less rapidly than capacity, it usually will pay to provide equipment to permit complete diversion of plant volume if it pays to diversify at all.

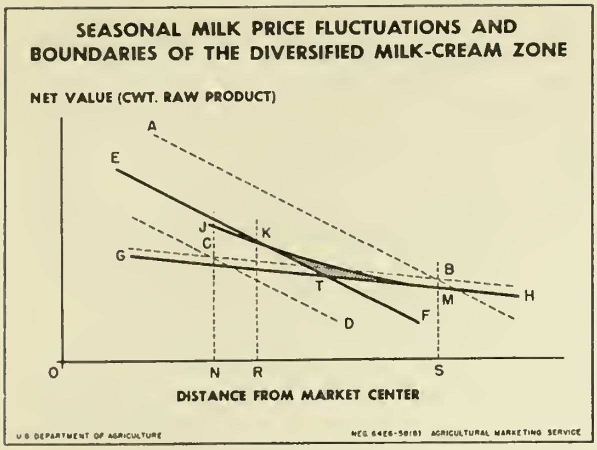


Figure 7.

for the high-price season and line CD for the low-price season. We have assumed that cream prices are constant. Although this is not strictly correct, it will permit us to indicate the final solution in somewhat less complicated form than otherwise would be necessary. The geographic structure of cream prices less direct variable costs is represented by line CB. Apparently, the short-run boundary between the specialized milk zone and the milk-cream zone would be at distance ON, for at point C net raw product values would be equal in either alternative. Similarly, the outer short-run margin between the milk-cream zone and the specialized cream zone would be at distance OS.

Consider the long-run situation where decisions as to plant and equipment are involved. For convenience, express all net values in terms of the averages for the entire year. The net value of raw product from specialized milk plants is represented by line EF. This line is a weighted average of such lines as AB and CD—each weighted by the quantity of milk handled at that particular price—the line represents the seasonal weighted average price minus direct variable cost *and minus* annual average fixed costs d/v per unit of raw product. In other words, this net value line is long-run in that it shows the effects of fixed costs as well as variable costs and seasonal price and production changes. Similarly line GH represents long-run net value of raw product in specialized cream plants differing from CB by the subtraction of average fixed costs a/v. Apparently, the economic boundary between specialized milk and specialized cream plants would be at point T *if we prohibited diversified operations.* But we know that plants equipped with separators would find it economical to diversify seasonally in zone NS.

The increase in net value realized by cream plants through seasonal milk shipments is represented by the curved line JKM in the diagram. As we start at point M on the outer boundary of the diversified zone and move to plants located closer to market, an increasing proportion of the raw product during any given year will be shipped to market as whole milk. These milk shipments occur during the low-production season, as milk prices are then at their highest levels. Observe that these plants are covering total costs—including the costs for fixed separating equipment, even though a smaller and smaller volume of milk is separated. That is, the dominant consideration in this situation is the opportunity for higher net values through milk shipments—and not higher costs based on an arbitrary allocation of certain fixed costs to a diminishing volume of cream. Notice also that, under competitive conditions, plants must make this shift to milk shipment. Otherwise, they could not compete for raw product and so would be forced out of business.

Although plants equipped with separating equipment would find it economical to ship small volumes of cream in the low-price period even from the zone NR, the gains would not be adequate to cover the long-run costs of supplying separating equipment. This means that specialized milk plants—without separating equipment and so with lower fixed costs—are more economical in this zone. This is indicated by the fact that line JKM falls below the net value line EF for specialized milk plants in the JK segment. The boundary specified by our long-run equation is found at distance OR, where net long-run values are equal for specialized milk plants and for diversified plants—RK. Plants at this boundary would find it economical to ship cream for a month or two each year if they shipped cream at all. This abrupt change from specialized milk plants to plants shipping a fairly substantial volume of cream is a reflection of the added fixed costs, and this represents the previously mentioned grain of truth in the usual statements about the high plant costs involved in shipping low volumes of cream or similar products.

Price Discrimination and the Classified Price System

No matter how revealing the theory of competitive markets may be, it is clear that it cannot apply directly to modern milk markets. Milk, cream, and the several manufactured dairy products serve different uses, and are characterized by different (although to some extent interrelated) demands. Moreover, bulkiness of product and high transportation costs segregate fluid milk markets, and this segregation is at times enhanced by differences in sanitary regulations. In any market, as a consequence, there will be a relatively inelastic demand for fluid milk and a somewhat more elastic demand for cream. Most of the manufactured products produced in the local milkshed must be sold in direct competition with the output of the major dairy areas, and so the demands for these products in the local market normally appear to be quite elastic to local producers. It should be recognized, however, that some manufactured products are rather bulky and perishable, and so may have a local market somewhat differentiated and segregated from national markets.

Differing demand elasticities for alternative dairy products long ago gave rise to systems of price discrimination. Here we refer to differences in f. o. b. market prices that are greater than, and unrelated to, the differences resulting from differences in processing costs, transfer costs, and the costs of meeting any higher sanitary requirements. In addition, producers in most markets have developed collective bargaining arrangements in dealing with milk distributors. These have commonly resulted in some form of classified pricing, under which handlers pay producers according to a schedule with different prices based on the final use made of the raw product. Whatever else may be said about classified pricing plans, it is clear that they involve price discrimination in several segments of a market. Thus, a completely homogeneous raw product may be priced at different levels according to the use made of the product. Because of the nature of available substitutes and so of demand elasticities, these classified or use prices are normally highest for fluid milk, lower for milk used as fluid cream, and lower still (and approximating competitive market levels) for the major manufactured dairy products.

We need not explore the theory of price discrimination here—its general conclusion that products should be allocated among market segments so as to equate marginal revenues in all segments and equate these to marginal costs is familiar enough. We point out, however, that these principles refer to the maximizing of profits or returns through price discrimination. Although price discrimination is the rule in fluid milk markets, it is doubtful whether it ever is carried to the point representing maximum returns, at least in any short-run sense. But prices do move away from competitive levels in the directions indicated by the theory, and returns are increased even though they are not necessarily maximized.

To avoid misunderstanding, we emphasize that considerations of supply as well as demand are involved in milk pricing. We have already pointed out that the demands for the major manufactured products appear to be perfectly or nearly perfectly elastic to sellers in the local market. Supply diversions to and from the national market keep prices in line in the local market, and the impact of local supplies is relatively insignificant in the national market. These diversions and the impracticability of market exclusion prevent significant price discrimination.

Similar diversions are physically possible for fluid milk, although at relatively higher transportation costs, and in a perfect multiple-market system all prices would be interdependent through supply and demand interactions. But here market exclusion is both practical and practiced, through such devices as differences in sanitary regulations, refusal to inspect farms beyond the normal milkshed, refusal to certify farms as "Grade A" unless they have a fluid milk market, and provisions of a variety of pooling plans and base or quota arrangements.

The classified price system itself is an effective barrier to entry if it is enforced by an agency with power extending across State lines, for this plan effectively eliminates the incentives for milk dealers to reach out and buy milk from low-priced and unregulated sources. Even in the absence of complete jurisdiction, classified prices may make market entry difficult through general acceptance of the pricing plan by dealers in any given market.

These and other market exclusion devices may be far from perfect, however, especially over a period of time. Class I prices at discriminatory levels may encourage expanded production by present and new producers within the existing milkshed and so may dilute composite prices through a growing proportion of surplus milk. High prices may encourage consumers to seek substitutes and thus increase the elasticity of long-run demands. Fear of popular rejection of pricing schemes, plus concern of the regulating agency for the public interest, may place effective ceilings on class I prices, even though short-run demands are inelastic.

All of these and other considerations influence and limit the operation of classified pricing plans. But extreme differences between class I and surplus prices, between prices in alternative markets, and between prices paid to neighboring farmers provide evidence that barriers to market entry are important in fluid milk markets and that discriminatory prices for fluid milk exploit these effective barriers. This evidence is bolstered by reports of attempts to restrain increases in production and supply, and of shifts to milk pricing under Federal authority when State price regulation becomes ineffective.

From our present standpoint, the important aspect of classified pricing is that this system establishes a schedule of prices *to be paid to farmers* by handlers, and that these prices refer to specific alternative uses for the raw product. We add a second aspect that is appropriate for the New York market, although not for all fluid markets: the market is operated on the basis of a marketwide pool. This means that the classified prices paid by handlers do not go directly to their producers but in essence are paid into a pool. All producers are then paid from the pool on an uniform basis, after appropriate adjustments for butterfat test and for location.

Three important modifications are thus required in our foregoing theory: (1) At-market prices will no longer represent competitive equilibrium levels; (2) returns to producers in any locality are not directly influenced by the particular use made of their milk—prices paid producers by two plants will be uniform pool prices even though the plants process and ship quite different products; and (3) the analysis in terms of net values of raw product must now reflect firm decisions when raw product is priced by a central agency—where raw product costs are determined by classified prices rather than directly by competition.

Classified Prices and Managerial Decisions

We have seen that, under competitive conditions, plant managers would tend to utilize milk in optimum outlets in order to meet competition and so survive, and that these optimum use patterns would depend on market prices and on transport costs. With classified prices and market pooling, however, the raw product cost to a plant is determined by the particular use pattern, while payments to producers from a market pool are a reflection of the total market utilization. As a consequence, producer payments will be fixed for any location regardless of utilization; they cannot be effective in encouraging optimum use patterns. The plant manager is now faced with the problem of maximizing his returns when faced on one hand with a set of market prices for products and on the other by a set of classified prices for raw product.

Suppose we begin our examination of this problem by assuming that market prices and transportation costs are given and fixed—thus fixing the particular set of product prices f. o. b. the country plant at any specified location. Assume also that classified prices are established to reflect as closely as possible the net values of the raw product in any use. This means that the gross value of products of a hundredweight of milk will be reduced to net value basis by subtracting the efficient processing costs, and that these net values will be further reduced by subtracting appropriate transfer costs. In short, the net value curves in the previous diagrams will now represent classified prices for any particular use and at any specified location.

Although this might appear to be an ideal arrangement at first glance, further consideration will indicate that such a system would completely eliminate the economic incentives that could be expected to yield optimum use and geographic patterns. We have indicated that actual payments to producers are divorced from the particular plant utilization under marketwide pooling, and so there is no incentive for a producer to shift from one plant to another. By the same token, the threat of losing producers because of low producer payments is no longer a problem for the plant manager.

Moreover, if processing and transportation costs are reflected accurately in the structure of classified prices, the manager will find that he can earn only normal profits, but that he will earn these normal profits regardless of the use he makes of the raw product. Under these assumptions, then, utilization patterns through the milkshed will be more or less random and chance.

This can be made clear by considering the plant profit function. We have defined net values for the raw product in terms of product prices at the market, transfer costs, and plant operating costs. Now we subtract raw product costs as specified by classified prices, and for a diversified plant we define profits as follows:

$$\text{Profit} = (P_1 - t_1D)V_1 + (P_2 - t_2D)V_2 - a - bV_1 - cV_2 - C_1V_1 - C_2V_2$$

in which C_1 and C_2 are the established class prices at this plant location. These are defined perfectly to reflect net values, as noted above, or:

$$C_1 = P_1 - t_1D - b - d/V_1$$
$$C_2 = P_2 - t_2D - c - (a-d)/V_2$$

Notice that the last terms in these equations refer to fixed costs—d for specialized milk plants, and a for diversified plants. If these values for the classified prices are substituted in the profit equation, the result is zero excess profits (normal profits, of course, are included as a part of plant operating costs). In short, with these perfectly calibrated classified prices, there would be no abnormal profits, but normal profits could be earned with any product combination and at any location.

Significantly, marketwide pooling makes this a stable situation by removing any direct impact of a plant's utilization pattern on payments to the producers who deliver to this plant. Suppose we assume that the market pool is replaced by individual plant pools (these would differ from the familiar individual handler pools if handlers operate more than one plant). Maintain all of the above assumptions, so that the manager will still earn only normal profits regardless of location or product mix. The product mix or utilization pattern would now have a direct bearing on producer payments, however, and this would modify the situation.

Consider two neighboring plants in what would normally be the milk shipping zone. Assume that, as profits would be equivalent, one manager elects to ship milk and the other cream. As the classified price for milk will be higher than the classified price for cream use in this zone, the first plant will pay its producers a substantially higher price than the second. This creates producer dissatisfaction, and some transfer of producers and volume from the second plant to the first. The individual plant pool, therefore, would provide a real incentive through the level of producer payments to bring about the optimum utilization of the raw product.

Let us now make our models more realistic by admitting that market prices for the several products are determined by supply and demand rather than being given and fixed. Classified prices are fixed by the appropriate agency. In some instances, they are tied to market product prices through formulas. To fix ideas, assume that the price for fluid milk delivered to the market is free to vary in response to changes in supply and demand; that the class I price is fixed at some predetermined level and with location differentials accurately reflecting transfer costs; that other product prices (cream, butter, . . .) respond primarily to supply and demand conditions in a national or regional market and so may be considered as given in the market in question, but subject to variation through time; and that class II and other classified prices are tied to product prices as accurately as possible through net value formulas and transfer cost differentials.

Under these conditions, plant profits in nonfluid milk operations would be uniform regardless of specific use or location. Product prices would move with national market conditions, but class prices would change in perfect adjustment to product prices. Prices of fluid milk, however, would move up or down relative to the established class I price, sometimes making fluid milk shipment more profitable and at other times less profitable than the nonfluid outlets. Under the assumed conditions, moreover, all of the available raw product would be attracted into or moved out of class I—there would be no graduated supply curve with prices adjusting until the quantities demanded just equaled the quantities offered.

Without going further, it should be clear that efficient utilization of raw product under a system of classified prices can be expected only if the pricing provisions put premiums on optimum uses. These premiums may take the form of larger profits from plant operations, or competitive losses in plant volume, or both. The pricing system must make the manager "feel" the advantages (profits and available raw product) of efficient utilization, and the disadvantages (losses and diminishing raw product supply) of inefficient use, so that his responses and adjustments will lead toward the optimum organization for the entire market. In the following section, we explore several methods of providing such incentives.

Pricing for Efficient Utilization

At the start of this section, we should make clear what we mean by efficient utilization. Earlier, we pointed out that a competitive system of product zones and equilibrium market prices mean aggregate transportation costs as low as possible. This will be true of such zones even if product prices are determined monopolistically—the most efficient organization of product zones will be consistent with competitive prices. Stated in another way, if we disregard market prices and simply determine the organization of processing throughout a milkshed that will minimize the transfer costs of obtaining specified quantities of the several products, the resulting zones will be the same as would characterize a market with competitive prices.

In the language of the linear programer, we say that the solution of the system of competitive prices among products and markets involves a *dual* solution in terms of minimum transfer costs. In the same sense, the solution of the problem of minimizing transfer costs involves a dual solution in terms of competitive prices—but these are *shadow* prices and need not correspond to actual prices. In the latter instance, of course, the allocations of producing areas will be consistent with the set of competitive shadow prices; they will not represent the free choice areas consistent with the noncompetitive prices.

This dual efficiency solution extends far beyond the minimizing of transportation costs. Suppose we have given the geographic location of production, processing costs, transportation rates, and quantities of the several products required at the market. Given this information, it is possible (though often involved) to develop a program that will supply the market with these quantities, allocate products by zones in the milkshed, minimize the combined aggregate costs of transportation and processing, and *return the highest aggregate net value* to the raw product.

If in this model we have specified efficient levels of processing costs, the resulting allocation will represent the ideal "long-run"solution with plants perfectly organized with respect to type and location. But we can enter specific plant sizes, locations, and types in the model, and obtain the best possible solution within these restraints—the optimum short-run solution. In our present context, however, we take efficient utilization to mean the optimum long-run pattern as described above, and we emphasize that this will mean the largest possible aggregate return to the raw product within the restraints imposed.

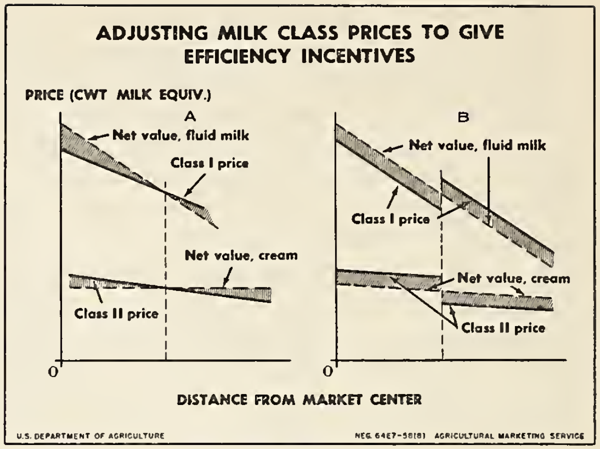
We have suggested a modification to the pricing system that might make plant managers feel the consequences of inefficient utilization—the elimination of marketwide pooling and the substitution of plant pools. This modification would be effective if the high-use plants had outlets for more and more fluid milk, but this is patently unrealistic on a total market basis. Under most circumstances, there would be little incentive under classified prices and plant pools for a plant to take on additional producers. Often, more producers would only add to the nonclass I volume of milk in the plant and so would lower the blend price to all producers. It is common observation that marked differences between the blend prices received by producers can exist and persist for long periods of time. Therefore, this is not a very dependable way to obtain improved efficiency in utilization, and it has serious deficiencies from the standpoint of equity of individual producers.

The real answer to this problem is to establish a pricing system that permits handlers to participate in the gains from efficient utilization. This means that class prices throughout the milkshed must depart somewhat from the perfect net values of raw product discussed earlier—some of the higher net values resulting from optimum utilization and location must go to handlers. Perhaps this should be called the principle of efficient pricing. We shall not attempt to guess at the magnitude of the required incentives, other than to express an opinion that reasonably small incentives should bring fairly substantial improvements in utilization.[5] Neither shall we attempt to spell out the detailed modifications to a classified pricing system that would provide such incentives. But in the paragraphs that follow we do note some types of adjustments that appear to be consistent with this principle.

1. If products are ranked according to at-market equivalent values, the at-market allowances to cover processing costs should exceed efficient levels for the high-value products but be less than cost for the low-value products. Furthermore, the geographic structure of class prices should decline with distance from market less rapidly than transportation costs for low-value product. Note that these work together to give an incentive structure favoring high-value (and bulky) products near the market and low-value (and concentrated) products at a distance from market.

Handlers shipping fluid milk from plants located in the nearby zone receive a "premium" in the form of the difference between the net value in fluid use and the class I price. If these same plants elect to ship cream, the class II price will exceed the net value of cream and so a "penalty" will result from this inefficient use of milk supplies. The converse would be the case for plants located in the more remote parts of the milkshed. Ideally, these incentives should be equal at a distance consistent with the efficient milk-cream boundary, and similar zone boundaries for other product combinations. This is suggested by the construction in figure 8–A.

2. As an alternative to the blending together of incentives as suggested above, a more effective device might be one that provides the desired incentives through a uniform combination of "premiums" and "penalties." These would favor efficient production in any specified zone, making the incentive effective by a reduction in the appropriate class price for the specified zone and an increase in class prices in alternative "nonefficient" zones. The reduction in class prices is essentially similar to the provisions that permit an "incentive" reduction in the class III price for butter or cheese uses, but these specify the incentive for particular time periods while the above relate to specified distance zones (figure 8–B).



Figures 8–A and 8–B.

3. When several products are included in a single class for pricing, a class price that reflects a low margin on the lowest value (at-market) product will discourage its production and encourage utilization for the higher value products within the class. At the same time, this procedure can be expected to establish "subzones" within the major zone. In this way, relatively bulky, high-value, high-margin products will tend to be produced near the inner boundary of the manufacturing zone, while the more concentrated, low-value, low-margin products are confined to the more distant edges of the milkshed.

4. Corollary to (3), limiting surplus classes to one or two, with a number of alternative product uses in each class, will tend to improve utilization efficiency and also simplify administrative problems. It must be recognized, however, that this will reduce returns to producers if wide and persistent differences in product values exist within a given class. In short, the gain in efficiency may be offset (from producer standpoint) by failure to fully exploit product values.

[5] It should be clear that the increased efficiency induced by these incentives would, among other things, increase the net value of the milk in the production area by selecting the optimum use and by minimizing aggregate transfer cost. It would be possible, of course, to provide incentives of such magnitude that the amount "given away" to handlers could exceed the net gain by cost reduction. Therefore, these incentives will need to be calibrated so as to accomplish the desired objective without at the same time dissipating the benefits to be derived.

5. Except for discrepancies resulting from errors and imperfections of knowledge, the efficient utilization pattern for a milkshed would be achieved if the total market supplies were under the management of a single agency, dedicated, within the restraints of the established class prices, to maximizing returns to the raw product. In most situations, it would be unrealistic to consider consolidating all country facilities under a single firm. Nevertheless this general idea may have some application in the operation of a market. For example, the market administrator might assign utilization quotas for the several products to each plant, making these consistent with the efficiency model.

Some Comments on the New York Study

The Use of Efficiency Models

This paper was written to summarize principles developed and used in the conduct of parts of the present study of the New York milk market. Specifically, the theoretical models provide a framework for the organization of empirical research work. By discussing the attributes of efficiency models, we point to various types of information essential to the empirical study of this market and its operation. Major focus is on decision making by individual firms, for this is the mechanism that activates the whole market. From the theory, it is clear that specific information is needed on such items as product prices at the metropolitan market, processing costs for the various products and joint products in the milkshed, transfer costs, and past and present patterns of actual utilization by product, location, and season.

With these data and the efficiency models, the market can be "programmed" to indicate the optimum situation and changes in this optimum through time. By contrasting these synthetic results with actual utilization patterns, it is possible to judge the operating efficiency of the whole market. These comparisons can be made specific in terms of savings in costs and increases in net values that could result from efficient operation. Moreover, specific subphases of the research can appraise the efficiency of such operations as the combination of ingredients in an optimum or low-cost ice cream mix—and so provide useful management guides to operating firms.

By adding the specific provisions of the classified pricing system to the efficiency model, and relating it to the actual distribution of plants and facilities, a modified short-run efficiency model results. This should more nearly resemble the actual situation, although discrepancies are still to be expected. The model would be especially useful in checking the effects of changes in product prices, cost rates and allowances, and classified prices on the market, and on its aggregate efficiency. Note also that this model can be applied to the operation of any actual firm—taking as given its total utilization pattern and its endownment of plants and facilities, and checking optimum utilization. Again, results may indicate inefficiencies but it is expected that its application will be of more value in indicating the impact of classified prices and other factors on the firm decision making.

Finally, these research results can be combined with the results of management interviews to determine as accurately as possible the way in which firms and the market adjust to changing prices, costs, and classified prices of raw product. This should permit a final appraisal of the market, and suggest specific modifications and changes that would improve efficiency.

Secondary and Competing Markets

As an epilogue, we point to the perhaps obvious simplifications of our theoretical models, and the need for elaboration in actual operation. Some of these have been suggested by the addition of a number of products and byproducts, the treating of plant alternatives rather than individual products, and the insertion of more realistic (and more complicated) cost relationships. These represent merely an elaboration of the model, but some aspects are in the nature of major additions. They include the consideration of competition between New York and other major markets, and the relationships between New York and various "upstate" secondary markets completely surrounded by the major milkshed (and now subject to the New York market order).

Our models relate to a single central market with product zones in the milkshed surrounding this market. Alternative utilization thus involves processing costs, prices for products at the major market, and transfer costs from country points to

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the major market center. With the addition of other markets—major or secondary—the analysis must be repeated for each market, and alternative market outlets as well as product outlets given specific consideration. The major principles involved remain as we have stated them in the previous pages, but the final complex model describes the efficient organization for an entire region, and the consistent structure of intermarket prices (or shadow prices) and market-product zones.

From the viewpoint of the present study, it seems probable that limitations of time will force major emphasis on the New York metropolitan market. This will be accomplished by accepting the actual geographic pattern of farm production, plants, and plant-to-market shipments, and inquiring as to efficient operation within these given patterns. This is done with the realization that the specific inclusion of such secondary markets as Albany, Syracuse, Buffalo and Rochester, and such major markets as Boston, Philadelphia, and Pittsburgh would no doubt reveal inefficiencies in the present among-market allocations, and yield valuable information about the problem of pricing in competing markets. But so long as this appears to be impracticable in the present study, it seems appropriate to eliminate all shipments to other markets, and to concentrate attention on the remaining volumes pertinent to the New York market. In this connection, it is recognized that many plants within the New York milkshed serve local markets and are not covered by the New York market operation—thus are not included in the market statistics. Thus the elimination of the pool milk that goes to nonmajor markets means that all supplies for these secondary markets are eliminated from consideration.

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The Effect of Price on Acreage and Yield of Potatoes

By Olman Hee

Farmers' response to price has usually been measured by acreage response. Changes in yield were regarded largely as a consequence of weather. Accordingly, the inclusion of such changes would tend to obscure the underlying production-price responses of farmers. Weather has played a much less important role as a determinant of yields during World War II and the postwar period, and the notion of a yield response to price has become a logical assumption in the statistical measurement of supply response. The effects of weather were not analyzed in this particular study.

In this paper, relationships between supply of potatoes (as measured by acreage and yield response) and expected "normal" price are studied. This price differs from previous year's price. Farmers are believed to gage the prospective price for the current crop from an evaluation of past prices to form some sort of "normal" price. The prospective or expected price is modified each year by the knowledge gained from actual price.

Two objects are sought: (1) To obtain total elasticity of supply measures from elasticity of acreage and elasticity of yield, and (2) to evaluate farmers' response to expected "normal" price as contrasted with previous year's price. The study provides for a single yearly adjustment to price and therefore does not consider projected adjustments that might occur over long periods.

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THIS STUDY shows that high prices of potatoes tend to encourage both the expansion of acreage and higher yields. It shows also that low potato prices discourage the expansion of acreage and tend to hold down the level of yields.

Previous studies include those of Bean (*2*)[1] Walsh (*9*), Pubols and Klaman (*8*), Kohls and Paarlberg (*6*), Bowlen (*3*), and Gray, Sorenson, and Cochrane (*5*). The supply elasticity coefficient obtained in these studies measured acreage response to price. They did not attempt to include other facets of the supply function, such as level of technology (sometimes represented by yield), prices of input factors, farm income, and labor-leisure relationship.

These studies consistently found low supply elasticities of acreage response to price. Some of these elasticities are as follows: Walsh for cotton, 0.20; Kohls and Paarlberg for corn, 0.07, for wheat 0.40, and for potatoes, 0.08; Pubols and Klaman for potatoes, 0.23; and Bowlen for the total United States crop of wheat, a regression coefficient that did not differ enough from zero to justify an elasticity estimate.

Despite these low elasticities, some of the studies indicated that it would be incorrect to say that price was not an important consideration in the decision-making processes of farmers. Rather the conclusions were that the direction and extent of farmers' supply response is influenced by a very diverse set of factors that differ among areas, among farms, and over time.

Response to Expected Price

Prices of potatoes vary considerably from year to year. It has been argued that farmers would receive lower incomes if they revised production plans in relation to these wide swings in prices (*6*). In making decisions with respect to production levels, potato producers are concerned mainly with what the current year's price will be. In other words, potato producers respond, it is argued, not directly to the previous year's price, but to an expected price, though this expected price may be based in part upon the previous year's price.

[1] Italic numbers in parentheses refer to Literature cited, page 140.

Price expectations are shaped by a host of conditions and events. Input-output ratios, cost expectations, past prices, and other influences enter into the formulation of such expectations. Of these, past prices are the most important because each past price is a reflection of the factors that affect a short-run market supply-demand situation.

If we agree that producers do not rely solely on last year's price, we must develop an hypothesis that explains the way price expectations are formed. One such hypothesis has been advanced by Nerlove (7) in a study of elasticities of acreages of corn, wheat, and cotton with respect to expected price. He assumes that farmers adjust their expectations of price by the margin of error that they made in predicting the previous year's price. Using this hypothesis, he obtains higher elasticities than those obtained from analyses based on previous year's price. Nerlove's formulation is incorporated in the explanation model discussed in the next section.

The Expectation Model

Total production (supply) of potatoes in any crop year equals the number of acres in potatoes times yield per acre. One could make a study of supply response that ignored these individual components and analyze directly the factors that affect total supply. However, acreage response and yield response are two separate and distinct functions; a considerable quantity of information in regard to farmers' behavior may be lost when only a single supply function is considered.

The formulation presented here considers the elasticity of supply with respect to price to be an additive function of the elasticity of acreage and the elasticity of yield.[2]

Acreage Response Function

The formulation of the expectation model for acreage response follows that of Nerlove (7).

Assumption No. 1.—Acreage of potatoes planted depends upon expected price in the year of harvest. We express this as follows:

$$X_t = a_1 + b_1 P_t^* + U_t \qquad (1)$$

where

X_t=planted acreage
P_t^*=expected price
U_t=random residual term

[2] Proof that the relationships are additive are given in Allen (*1*, P. 252).

Assumption No. 2.—Potato producers adjust their expectations of price in the year of harvest by the margin of error (or proportion of it) that they made in predicting last year's price. This takes the following form:

$$[P_t^* - P_{t-1}^*] = \beta[P_{t-1} - P_{t-1}^*] \qquad (2)$$

where

P_t^*=expected price for current year
P_{t-1}^*=expected price for previous year
P_{t-1}=actual price for the previous year
β=coefficient of expectation (the proportion of the margin of error by which farmers adjust their expectation)

We assume that β will always lie between zero and one.[3] If β equals one, equation (2) becomes $P^*_t = P_{t-1}$. Thus P^*_t in equation (1) can be replaced by P_{t-1}. This is equivalent to saying that farmers rely solely on last year's price in making their decisions. However, we assume that farmers do not respond solely to last year's price but to expected price and that they revise their expectations continually; therefore, the value of β will be less than one.

We cannot observe P^*_t, so that an estimating equation containing P^*_t cannot be fitted from empirical data. However, given relationships (1) and (2), an equation may be derived whose coefficients can be estimated from observed variables. Estimates of these coefficients, in turn, can be used to estimate the parameters in equation (1). From equation (1), we know that expected price, P^*_t, is a linear function of acreage, X_t. Last year's expected price must also be a linear function of last year's acreage; thus,

$$P_{t-1}^* = -\frac{a_1}{b_1} + \frac{1}{b_1} X_{t-1} - \frac{1}{b_1} U_{t-1} \qquad (3)$$

Substituting (3) for P_{t-1}^* in (2), we get

$$P_t^* + \frac{a_1}{b_1} - \frac{1}{b_1} X_{t-1} + \frac{1}{b_1} U_{t-1}$$
$$= \beta\left[P_{t-1} + \frac{a_1}{b_1} - \frac{1}{b_1} X_{t-1} + \frac{1}{b_1} U_{t-1}\right] \qquad (4)$$

[3] Although it is not a necessary assumption, this mathematical property conveniently places a restriction on the limits of values of β. All known empirical studies indicate that the assumption is a correct one.

Combining like terms and expressing in terms of P_t^* equation (4) becomes

$$P_t^* = \frac{a_1\beta - a_1}{b_1} + \beta P_{t-1} + \left(\frac{1-\beta}{b_1}\right) X_{t-1} - \left(\frac{1-\beta}{b_1}\right) U_{t-1} \tag{5}$$

Substituting equation (5) for P_t^* in (1) results in

$$X_t = a_1 + b_1 \left[\frac{a_1\beta - a_1}{b_1} + \beta P_{t-1} + \left(\frac{1-\beta}{b_1}\right) X_{t-1} - \left(\frac{1-\beta}{b_1}\right) U_{t-1} \right] + U_t \tag{6}$$

which simplifies to

$$X_t = a_1\beta + b_1\beta P_{t-1} + (1-\beta) X_{t-1} + U_t - (1-\beta) U_{t-1} \tag{7}$$

and can be rewritten as

$$X_t = \pi 0 + \pi 1 P_{t-1} + \pi 2 X_{t-1} + V_t \tag{8}$$

Estimates of the parameters obtained from equation (8) may be used to compute algebraically the coefficient of expectation, β, in equation (2) and to estimate the parameters in the acreage response relation (equation 1). The pertinent algebraic relationships between the relevant parameters are as follows:

$$\beta = 1 - \pi_2$$
$$a_1 = \frac{\pi 0}{\beta} \tag{9}$$
$$b_1 = \frac{\pi 1}{\beta}$$

The mathematical formulation may now be stated in more general terms. We assumed that farmers made adjustments in potato acreage on the basis of expected price and that their price expectations were influenced to a considerable degree by the prices they received in previous years. Basic source information on expected price was not available to measure statistically its influence on acreage directly. However, by assuming that acreage in the previous year reflects past price expectations and by including both the price and acreage in the previous year as variables in the regression equation (8), we delineate statistically that part of acreage resulting from last year's price and that portion from previous expectations. Thus, the coefficient of expectation (adjustment) derived from this regression essentially tells us the relative contributions of the price in the previous year and past prices in the other years toward formation of expected price.

Because of this, the coefficient (π_1 in equation (8)) showing the effect of the previous year's price on acreage bears a similar relationship with the coefficient (b_1 in equation (1)) showing the effect of expected price on acreage. Thus, the coefficient associated with last year's price refers to that portion of the total response (b_1) to expected price which is attributable to price in the previous year. Specifically, the coefficient equals the total response, b_1, times some adjustment factor which in this case is the coefficient of expectation, β (see relation 7). Hence, if we know the response of acreage to previous year's price and we know the coefficient of expectation, we can compute the acreage response to expected price, even though we have no data on expected price (see relation 9).

Yield Response Function

The yield response function is similar to the acreage response function. We assume that farmers adjust their production plans to a desired yield level in relation to expected price, complementary to the relation found in equation (1). In addition, it takes into account a cost factor. Thus, the yield function becomes:

$$Y_t = a_1 + b_1 P_t^* + b_2 C_t + U_t \tag{10}$$

where C_t, cost of fertilizer, is the only variable not previously identified.

As in the case of the acreage response function, potato producers revise their expectations of price in the manner indicated by relation (2). Thus, coefficients in equation (10), making use of relation (2), may be computed from coefficients in the following estimating equation:

$$Y_t' = \pi 0 + \pi_1 P_{t-1} + \pi 2 Y_{t-1} + \pi 3 C_t + \pi 4 C_{t-1} + V_t \tag{11}$$

Coefficients in equation (11) bear a similar relation to equations (10) and (2), as did equation (8) to (1) and (2).

Statistical Analyses

The estimates of supply response for potatoes are based upon two fitted relationships: (1) A regression of acreage on price and other factors, and (2) a regression of yield on price and other factors.

The two periods used in the analyses [1930–41] and [1930–31 and 1951–56] are considered to be as close to free market supply and demand conditions as can be found in the potato industry in the last three decades. The data used (crop-year basis) are those provided by the Crop Reporting Board, Agricultural Marketing Service.

Acreage Response

The acreage estimating equation was fitted by least squares method for two periods—[1930–41] and [1930–41 and 1951–56]. The variables used are as follows:

X_t=Planted acreage of late summer and fall crop potatoes, in millions.

P_{t-1}=Season average price received by farmers for late summer and fall crop potatoes deflated by index of prices received by farmers for all farm products, dollars per hundredweight, lagged one year.

$X_{t-1}=X_t$ lagged one year.

T=Time, 1930=1. Linear trend assumed.

Planted rather than harvested acreage is used as the dependent variable as planted acreage reflects more closely the production plans of farmers. But data for planted acreage of potatoes date only from 1929. This places some limitation on the number of observations available for a free market span of years in the time series.

The use of harvested acreage for which data are available for earlier years as an alternate choice for analysis may not be consistent with assumptions implicit in this study. In years when some of the planted acreage is not harvested because of unfavorable prices, the supply relation with harvested acreage as the dependent variable is affected by current price. But current price is also affected by the demand for potatoes. A complete formulation using harvested acreage would of necessity have included a demand relation.

The following results were obtained from the regression analyses for planted acreage of late summer and fall crop potatoes. As for all analyses in this paper, the numbers in parentheses are the standard errors of the respective coefficients.

1930–41

$$X'_t=0.624+\underset{(.174)}{0.188}P_{t-1}+\underset{(.209)}{0.740}X_{t-1}-\underset{(.019)}{0.031}T \qquad (12)$$

1930–41 and 1951–56

$$X'_t=0.466+\underset{(.126)}{0.256}P_{t-1}+\underset{(.157)}{0.740}X_{t-1}-\underset{(.061)}{0.017}T \qquad (13)$$

The regression coefficient for acreage on price lagged one year differed significantly from zero at the 5 percent probability level in the analysis for the longer period but not for the 1930–41 period. However, both coefficients were of correct sign and approximately the same magnitude. When these coefficients are expressed as elasticities of acreage with respect to price, they are found to be around 0.1 (see table 1). These values are somewhat lower than the 0.2 obtained by Pubols and Klaman (*6*).

Apparently, the normally wide swings in prices of potatoes from one year to the next make farmers discount some of the most recent price change. This is confirmed by the low coefficients of expectation, B, of 0.260 that were obtained from the regression analyses in both periods. The relatively low values obtained indicate that potato producers, in making acreage adjustments, are influenced more by their ideas of expected "normal" price than by previous year's price. But the low coefficients of expectation also indicate that they make only moderate year-to-year (short-run) adjustments in their price expectations.

Other statistical measures pertaining to the regression analyses such as the coefficients of multiple determination are shown in table 1.

Estimates of coefficients for acreage response to expected price were computed by dividing the regression coefficient of acreage on price lagged one year by the coefficient of expectation (see algebraic relation 9, p. 133). Using the estimates of these coefficients an elasticity of acreage with respect to expected price of 0.3 was obtained from the analysis based on the [1930–41] period and 0.5 for the [1930–41 and 1951–56] period. As expected from the coefficients of expectation of 0.260, elasticities of acreage with respect to expected price are four times as large as the elasticities obtained pertaining to price lagged one year.

Yield Response

The following estimates of the coefficients in the yield-estimating equation for late summer and fall crop potatoes were obtained from regression analyses based on data for two periods, [1930–41] and [1930–41 and 1951–56]:

1930–41

$$Y_t = 1.889 + \underset{-(1.724)}{10.579} P_{t-1} + \underset{(.135)}{0.723} Y_{t-1} \underset{(.045)}{-0.004} C_t + \underset{(.046)}{0.007} C_{t-1} + \underset{(.289)}{1.188} T \quad (14)$$

1930–41 and 1951–56

$$Y_t = -24.392 + \underset{(5.154)}{10.883} P_{t-1} + \underset{(.118)}{0.734} Y_{t-1} + \underset{(.165)}{0.066} C_t + \underset{(.168)}{0.073} C_{t-1} + \underset{(.802)}{2.018} T \quad (15)$$

The variables used in the regression analyses, which have not been previously identified are as follows:

Y_t = Yield per acre of late summer and fall crop potatoes, in hundredweight.

Y_{t-1} = Y_t lagged 1 year.

C_t = Cost of fertilizer, April 1st, of each year deflated by wholesale price index 1947–49=100.

C_{t-1} = C_t lagged 1 year.

Regression coefficients in both analyses differ significantly from zero at the .05 probability level for all variables except the coefficients associated with fertilizer cost. The negligible effect of cost of fertilizer on yield may be explained in part by the notion that fertilizer applications once initiated are at least maintained at the most recent level even in the face of increased costs.

As expected, the coefficient associated with trend in yield per acre was substantially greater in the analysis including the postwar years. Yield per acre averaged 174 hundredweight during 1954–56 compared with 82 in 1939–41 and 67 in 1930–32. Much of the rise in yield occurred between 1945 and 1950; the increase was from 100 to 167 hundredweight during the period.

The regression coefficients for yield on price lagged one year are almost identical for both periods of analysis. When these coefficients are expressed as elasticities of yield with respect to previous year's price, they were found to be around 0.1, the same as the response of acreage to previous year's price (see table 1).

As in the case of the acreage-estimating equation, relatively low values were obtained for the coefficient of expectation, β, from the yield-estimating equations. The β values of 0.277 and 0.266 for the [1930–41] and [1930–41 and 1951–56] periods, respectively, were approximately of the same magnitude as those obtained from the acreage equations. Again, this would indicate that farmers change their expectations little in the short run and consequently they make moderate adjustments in production plans that affect yield. Potato producers apparently do not make sudden moves in adjusting to new levels of yield.

Other statistical measures pertaining to the regression analyses are shown in table 1.

Based on the above estimates of the price coefficient and the coefficient of expectation, an elasticity of yield with respect to expected price of 0.6 was obtained from the analysis based on the [1930–41] period and 0.4 for the [1930–41 and 1951–56] period. Because of relatively low coefficients of expectations, response of yield to expected price is about four times greater than the response to the most recent price.

Estimates of Planted Acreage and Yield Per Acre

Estimates of planted acreage—based upon acreage estimating relations derived from the model—were made for years included in the analysis and also for other years. Similar estimates were made for yield per acre.

Table 2 compares the estimates for planted acreage obtained from the acreage estimating equation with actual planted acreage published by the Crop Reporting Board, AMS, for the years 1930 to 1956.

Table 3 represents estimates for yield per acre obtained from the yield-estimating equation compared with actual yield per acre as published by the Crop Reporting Board, AMS, for the years 1930 to 1956.

Similar comparisons are shown graphically in figure 1. In addition, the estimates of acreage and yield are combined for comparison with actual production of fall crop potatoes.

For the years in the early 1930's, estimates of acreage obtained from the regression analysis tended to fall below actual acreage. Apparently, farmers were slow to adjust acreage downward during a prolonged period of depression. This behavior would appear to be consistent with the hypothesis suggested by Clodius (*4*, p. 429) that farmers tend to reduce acreage little in bad times

TABLE 1.—*Supply response for late summer and fall crop potatoes; as measured by elasticities of acreage and yield per acre with respect to price lagged 1 year and expected price, and related statistical data* [1]

Item	Acreage response		Yield response	
	1930–41	1930–41 and 1951–56	1930–41	1930–41 and 1951–56
Estimating equation:				
Coefficient of multiple determination	.84	.85	.98	.99
Standard error of estimate	.15	.13	1.29	5.34
Elasticity of dependent variable with respect to price lagged 1 year:				
Actual value	[2] .08	[3] .12	.15	[3] .10
Standard error	.07	.06	.02	.05
Durbin-Watson statistic	[4] 1.34	[4] 1.35	[4] 2.30	[4] 1.42
Coefficient of expectation	.260	.260	.277	.266
Elasticity of dependent variable with respect to expected price:				
Actual value	[2] .31	[2] .48	[2] .56	[2] .38
Standard error	.45	.45	.33	.25

[1] Prices are season average prices received by farmers for late summer and fall crop potatoes deflated by index of prices received by farmers for all farm products, 1910–14=100.

Data used for the dependent variable in the acreage response formulation were planted acreage and for the yield response formulation yield per harvested acre.

[2] Does not differ significantly from zero when tested at the .10 probability level.

[3] Differs significantly from zero when tested at the .10 probability level but not at the 0.05 level.

[4] Durbin-Watson statistic inconclusive at the .05 level.

because of (1) their desire to maintain total income and (2) the costs of shifting to other limited production alternatives.

As expected, the equation overestimated acreage during price-support years (1943–50). From 1943 to 1946, such wartime (and reconversion) influences on potato acreage as hired labor and equipment shortages and shifts to alternative enterprises combined to decrease acreage appreciably. For 1947–50, potato acreage allotments were in effect and the majority of potato farmers complied with the allotment program. With these limitations but with relatively favorable price relationships and assured markets, farmers increased the yield per acre of potatoes significantly during the years under price support. Yield per acre increased from 92 hundredweight in 1943–44 to 167 hundredweight in 1950, an increase of 82 percent in 6 years; whereas, yield per acre in 1943–44 was only 35 percent greater than in 1930–31. When estimates of acreage and yield are combined for the price-support years, the departures from actual production are relatively less since the overestimation of acreage is offset in part by underestimation of yield.

Estimates of planted acreage for the entire period (1930–56) deviated on the average from the actual acreage by 4.5 percent per year. Estimates of yield per acre for the same period deviated on the average from actual by 3.8 percent per year.

An "error tolerance" equal to twice the standard error of estimate was computed for each estimating equation. The "error tolerance" has the following approximate significance: If the economic structure represented by these regression analyses and the probability distribution of disturbances or residual errors still apply, we might expect actual acreage and yield to be within the range of 2 standard errors of forecast from estimates of acreage and yield, respectively, obtained from the regression equations in 19 out of 20 times, provided the values of the new observations fall within the range of observation included in the analyses. As the standard error of estimate is always smaller than the standard error of forecast, the "error tolerance" cited above is somewhat too small. The standard error of estimate is used in this paper as a measure of the confidence limit as it would be necessary to compute standard errors of forecast for each year.

When an "error tolerance" of twice the standard error of estimate (.26) is applied to estimates of acreage outside the period of fit (1942–50, including World War II and price-support period) one observation falls outside the limits of tolerance.

TABLE 2.—*Potatoes, late summer and fall crops: Estimated and actual planted acreage and related variables, 1930–56*

Crop year	Planted acreage		Price lagged 1 year [2]	Acreage lagged 1 year
	Estimated [1]	Actual		
	Million acres	*Million acres*	*Dollars per cwt.*	*Million acres*
1930	2. 617	2. 457	1. 52	2. 404
1931	2. 585	2. 730	1. 31	2. 457
1932	2. 666	2. 897	. 90	2. 730
1933	2. 765	2. 763	. 87	2. 897
1934	2. 833	2. 997	1. 59	2. 763
1935	2. 754	2. 798	. 67	2. 997
1936	2. 653	2. 421	. 92	2. 798
1937	2. 490	2. 337	1. 44	2. 421
1938	2. 225	2. 212	. 71	2. 337
1939	2. 171	2. 138	. 93	2. 212
1940	2. 156	2. 157	1. 15	2. 138
1941	2. 046	1. 998	. 73	2. 157
1942	1. 962	1. 988	. 93	1. 998
1943	[3] 1. 971	2. 424	1. 06	1. 988
1944	2. 267	2. 061	1. 02	2. 424
1945	2. 022	2. 012	1. 18	2. 061
1946	1. 925	1. 845	1. 01	2. 012
1947	1. 719	1. 461	. 75	1. 845
1948	1. 462	1. 459	. 93	1. 461
1949	1. 441	1. 348	. 92	1. 459
1950	1. 322	1. 278	. 84	1. 348
1951	1. 164	1. 021	. 49	1. 278
1952	1. 077	1. 075	. 96	1. 021
1953	1. 144	1. 160	1. 13	1. 075
1954	1. 021	1. 102	. 47	1. 160
1955	1. 058	1. 106	. 85	1. 102
1956	1. 009	1. 079	. 71	1. 106

[1] Estimated acreage based on following regression:

$$X_t = 0.466 + .256P_{t-1} + .740X_{t-1} - .017\ T$$

Coefficients relating to the analysis in this estimating equation are based on data for the period [1930–41 and 1951–56].

[2] Season average price received by farmers for late summer and fall crop potatoes deflated by index of prices received by farmers for all farm products, 1910–14=100.

[3] Estimate differs from actual by more than twice the standard error of estimate (.26). If the real economic relationships and the factors making for residual errors or disturbances are the same as in the [1930–41 and 1951–56] period in about 1 out of 20 times, actual acreage would be expected to deviate from estimates of acreage by more than 2 standard errors of forecast, provided the values of the independent variables for the new observations fall within the range established by the values for the years included in the analysis. The error tolerance as computed is slightly to considerably smaller than this, and therefore deviations of larger size would be expected somewhat more frequently.

When an "error tolerance" of 10.7 is applied to estimates of yield, 3 observations fall outside the tolerance limit. During the years of price support, some year-to-year changes in yield occurred that were far in excess of yield changes for preceding or later years. Apparently, this was due to such yield-stimulating factors as exodus of low-yielding farms, allotment programs, and greater price certainty present during the period.

Values of twice the standard deviation of year-to-year changes in actual acreage and yield were computed also. They were found to be 0.34 million acres and 13.2 hundredweight per acre, respectively. The "error tolerances" of the estimates of acreage and yield computed from the regression analysis are smaller than the standard deviations obtained for actual changes in acreage and yield.

Durbin-Watson Test

The Durbin-Watson test for serial correlation in the residuals was made for each regression analysis. The statistic for each analysis is given in table 1. The Durbin-Watson statistic in all the analyses was inconclusive at the .05 probability level. The most that can be said of the unex-

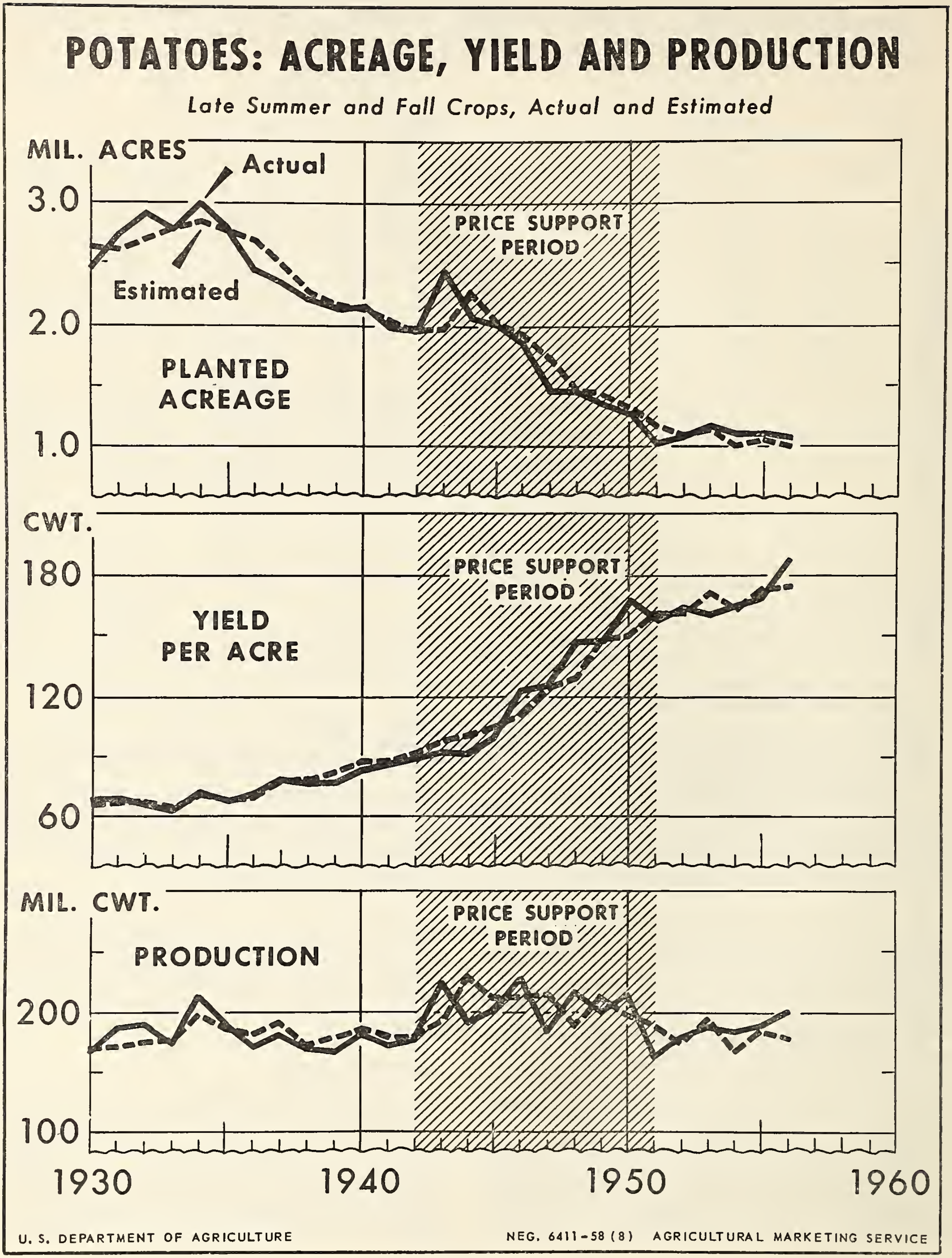
POTATOES: ACREAGE, YIELD AND PRODUCTION
Late Summer and Fall Crops, Actual and Estimated
MIL. ACRES
Actual
Estimated
3.0
2.0
1.0
PLANTED ACREAGE
PRICE SUPPORT PERIOD
CWT.
180
120
60
YIELD PER ACRE
PRICE SUPPORT PERIOD
MIL. CWT.
PRODUCTION
PRICE SUPPORT PERIOD
200
100
1930
1940
1950
1960
U. S. DEPARTMENT OF AGRICULTURE
NEG. 6411-58 (8)
AGRICULTURAL MARKETING SERVICE

Figure 1.

TABLE 3.—*Potatoes, late summer and fall crops: Estimated and actual yield per acre and related variables, 1930–56*

Crop year	Yield per acre		Price lagged 1 year [2]	Yield lagged 1 year	Cost of fertilizer lagged 1 year [3]
	Estimated [1]	Actual			
	Cwt.	*Cwt.*	*Dollars per cwt.*	*Cwt.*	*Index of dollars per ton*
1930	65.0	67.7	1.52	67.6	149
1931	66.1	68.2	1.31	67.7	157
1932	65.7	65.5	.90	68.2	175
1933	63.4	63.2	.87	65.5	173
1934	70.0	71.1	1.59	63.2	145
1935	67.5	67.5	.67	71.1	152
1936	68.2	70.2	.92	67.5	140
1937	77.0	77.5	1.44	70.2	131
1938	77.0	76.4	.71	77.5	128
1939	81.7	77.0	.93	76.4	141
1940	86.0	83.8	1.15	77.0	142
1941	86.8	86.0	.73	83.8	133
1942	91.5	89.3	.93	86.0	118
1943	97.6	92.3	1.06	89.3	118
1944	101.6	91.7	1.02	92.3	122
1945	104.9	99.8	1.18	91.7	121
1946	[4] 110.1	122.8	1.01	99.8	122
1947	124.4	124.6	.75	122.8	107
1948	[4] 128.9	147.4	.93	124.6	96
1949	148.3	147.6	.92	147.4	97
1950	[4] 149.7	167.3	.84	147.6	107
1951	161.4	156.9	.49	167.3	98
1952	160.9	163.9	.96	156.9	93
1953	170.4	161.4	1.13	163.9	98
1954	163.4	164.8	.47	161.4	100
1955	171.9	168.4	.85	164.8	98
1956	174.6	187.9	.71	168.4	98

[1] Estimated yield based on following regression:

$$Y_t' = -24.392 + 10.883\ P_{t-1} + .734\ Y_{t-1} + .066\ C_t + .073\ C_{t-1} + 2.018\ T$$

Coefficients relating to the analysis in this estimating equation are based upon the period [1930–41 and 1951–56].

[2] Season average price received by farmers for late summer and fall crop potatoes deflated by index of prices received by farmers for all farm products, 1910–14 = 100.

[3] Index of fertilizer prices paid by farmers deflated by the index of wholesale prices for all commodities, 1947–49 = 100.

[4] Estimate differs from actual by more than twice the standard error of estimate (10.68). If the real economic relationships and the factors making for residual errors or disturbances are the same as in the [1930-41 and 1951-56] period in about 1 out of 20 times actual yield would be expected to deviate from the estimates of acreage by more than 2 standard errors of forecast, provided the values of the independent variables for the new observations fall within the range established by the values for the years included in the analysis. The error tolerance as computed is slightly to considerably smaller than this, and therefore deviations of larger size would be expected somewhat more frequently.

plained residuals is that there does not appear to be strong evidence of positive or negative serial correlation.

Use of Supply Response Results

Results from the expectation model indicate that production of potatoes is influenced more by farmers' expectations of the long-run "normal" price than by the most recent change in the price of potatoes. Based on analyses for the 1930–41 period, potato farmers were found to increase acreage by about 0.3 percent for each upward revision of 1 percent in their price expectations. During the same period they tended also to increase yield per acre by 0.6 percent following the same 1 percent increase in expected "normal" price. Since, as shown earlier, acreage response and yield response are additive, a supply (production) response of 0.9 percent is indicated following a change of 1 percent in expected "normal" price. A supply elasticity (with respect to expected price) of 0.9 was found to hold also for the analyses based on the [1930–41 and 1951–56] period. However, during this period, the supply elasticity of 0.9 consisted of 0.5 from acreage response and 0.4 from yield response.

Although prices of potatoes vary considerably from one year to the next and although the estimated response to expected price is large (though still inelastic), potato farmers tend to make small adjustments in acreage and yield following changes in actual prices. This results because farmers tend to revise their long-run expectations of price little from year to year in relation to the wide swings in actual prices. This was indicated by the relatively low coefficients of expectations that were obtained from the analyses.

These values ranged between 0.26 and 0.28 and as expected, approximately the same values were obtained from both the acreage and yield analyses. That is, farmers tend to revise their previous estimates of expected "normal" price by about one-fourth of the amount by which the previous year's actual price differed from previous year's expected price (see relation 2). In relation to observed changes in price and production, a change in supply response of 0.2 percent may be expected following a 1-percent change in the actual price of potatoes.

Conclusions

Potato producers normally plan production under conditions of price uncertainty because of the wide year-to-year swings in prices of potatoes. Further, it is found that producers tend to change their production plans little from one year to the next in relation to the magnitude of changes in actual prices.

Because of price uncertainty, producers tend to make adjustments in acreage and yield based on some notions of expected "normal" price.

Apparently, potato growers not only look back at previous prices; they also look forward, in some sense, to long-run price expectations. But such long-run expectations are modified each year by some ratio of the relation between last year's price expectation and last year's actual price.

This study has found that farmers changed their expectations moderately. Specifically, they tend to change their notion of long-run expected price by about one-fourth of the difference between the price they expected the previous year and the price they actually received.

Given a change in expected price, production response under this formulation was found to be 0.9 percent for a 1-percent change in expected price. However, in relation to the year-to-year change in actual price, this study found the year-to-year production response to be 0.2.

If under conditions of free market and dynamic equilibrium, potato prices fell successively for 3 to 4 years and were expected to fall still further, producers probably would revise their price expectations downward to a greater extent than is suggested by the derived coefficient of expectation of .26–.28. As a result, larger year-to-year adjustments in acreage and yield would be expected to occur in a period of successive price changes (in the same direction) than in a period of fluctuating prices.

Estimates of acreage and yield obtained from the regression analyses indicate that fairly accurate predictions can be made from these estimating equations. When the regression analyses were used for the period outside of fit (1942–50, including World War II and price-support period), the estimate of acreage fell within the expected range of reported acreage. However, the estimates for yield differed from reported yields by more than the expected deviations. The substantial deviations in yield were a result of unusual changes in yield that occurred during the price-support period. These changes in yield were due largely to the sharp decline in number of low-yielding potato farms and to other important shifts that occurred in the potato industry.

Forthcoming studies that take into account (1) productivity change reflecting technological advances and (2) alternate dynamic expectation models, are both important and needed. It is fairly evident that all changes in production are not explainable by price, although many factors may be reflected in price. The supply-response function is so comprehensive that many theoretical and empirical studies are needed to give it full exploration.

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Book Reviews

Farm Prices: Myth and Reality. By Willard W. Cochrane. University of Minnesota Press. 1958. 189 pages. $4.00.

PROFESSOR COCHRANE'S current contribution to the mounting debate on agricultural price and income policy in brief, readable, stimulating, constructive, and controversial. The Cochranian drama unfolds in three parts. Part I recounts the "myth" of farm price-income behaviour, and unveils the "reality." Part II presents a statistical and theoretical analysis to support the theses concerning farm prices and income. Part III contains the policy implications and Cochrane's own prescription.

What is the myth? It is the belief that agriculture tends automatically to adjust to some desirable level of production, prices, and income. The myth has two variants. The first is that the adjustment would soon come about if agriculture "were left alone for a little while," and competitive prices permitted to work their wiles. The second is that agriculture needs a hand from the Government to overcome existing maladjustments, after which the invisible hand that dwells in the marketplace will take over and lead agriculture into the promised land of equilibrium.

If this be myth, what is reality? According to Cochrane, it is chronic instability of farm prices and income. This is compounded of two elements. The first is "wide and irregular swings in the farm price level" that imply chronic income instability for agriculture as a whole. The second is comprised of "irregular year-to-year commodity price variations around the moving farm price level." These gyrations in the price of individual products mean that the farmer faces continuous uncertainty as to what the market really wants, which in turn results in inefficient allocation of farm resources. These instabilities are not transitory; they are the norm for agriculture under free competition.

Though part II accounts for more than a third of the volume, it will be passed over briefly, as it is based to a very considerable extent on Cochrane's own previously published studies that are familiar to agricultural economists. It is enough to say that these three chapters culminate in the theory of the "agricultural treadmill"—a modern version of the farm dilemma, of which Professor Boulding was an early expositor.

Briefly, farmers, like the rest of us, attach a high value to technological advance; in the "sea of competitive behaviour" each farmer has an added incentive to reduce his costs and up his net returns;

but this causes a large rise in aggregate farm output; as the demand for farm products is extremely inelastic, the additional output brings a drastic decline in farm prices and income; this calls for more cost-reducing technologies; and so on, *ad infinitum* and *ad nauseam.*

What does Cochrane's analysis mean for farm policy? Given his basic tenet that the aggregate supply of farm commodities, driven by pervasive technological advance, tends persistently to outrun demand, certain policies are automatically classed as blind alleys. These include the free market approach; its "first cousin," flexible price supports; increased farm efficiency; and fixed supports accompanied by limited production controls.

The present program of moderate price supports, buttressed by the Soil Bank and foreign surplus disposal, is regarded as tenable, provided that surplus disposal is geared to the needs of underdeveloped countries and society is willing to pay the cost. It is Cochrane's judgment that society will not choose to pay the cost of the present program, or of an alternative program of compensatory payments.

With virtually all extant farm policy proposals consigned to limbo, is anything left? According to Cochrane, one solid alternative remains. There is a system of production and marketing controls that would effectively "bridle the rate of aggregate output expansion." This may sound like the old Triple-A, or even the Soil Bank, but Cochrane's plan differs so much in degree as to be different in kind.

Agriculture as a whole would be granted the status of a public utility or cartel. The USDA would establish annual national sales quotas for the principal farm commodities at levels that would result in fair, or parity, prices as stipulated by the Congress. Each farmer would receive negotiable certificates permitting him to market his *pro rata* share of the national allotments. All sales not covered by certificates would be illegal. Other "side programs," such as some export subsidies and storage programs to handle weather surplus, could be linked to the central structure, but the sales quotas established by law are the heart of the matter.

The only real stumbling block that Cochrane foresees is unwillingness of farmers to accept the high degree of control over their individual management decisions that the plan entails. But he believes this barrier can be surmounted "once the fog of the 'automatic-adjustment' myth is lifted," and farmers perceive what the Great Agrarian Cartel can mean to them in the way of adequate and stable incomes.

In order to keep this review somwhere near the allotted space, I shall limit myself to just a few comments. In arguing that price-income instability is the norm for agriculture, I think that Cochrane has overstated his case. He seems to be saying that this instability would have been just as great even if agriculture had been spared the impact of two world wars, the Great Depression, and extended periods of high price supports. I think it is equally arguable that if these factors had not been present, price-income instability in agriculture since 1910–14 would have been considerably moderated and the farm problem as a whole would have been more manageable.

My second comment concerns Cochrane's failure to deal effectively with the problem of setting fair prices under his plan. He espouses a direct legislative determination of individual commodity prices, which I think is inconsistent with his aggregative approach. It seems to me that such an approach requires, first of all, the setting of a total income goal for agriculture. The next step would be calculation of output goals for the principal commodities on the basis of past averages and trends. Estimates would then be made of the prices at which these outputs would sell. Next, prices and quantities would be summed and compared with the overall income goal. If this were exceeded, output objectives would be revised upward; if not attained, they would be revised downward. At any rate, I think the price objectives in a scheme to control aggregate output would logically be derived from an overall income goal, not determined separately in advance.

Finally, I would like to recommend this book to both the advocates and the opponents of stringent controls on total farm output. Regardless of how one views Cochrane's own proposal to solve the farm problem (which occupies only a small fraction of the volume), he will, in my opinion, find the basic issues and the alternative policies clearly and correctly stated. This by itself is an important contribution, for which the author deserves praise.

J. P. Cavin

Sampling Opinions—An Analysis of Survey Procedures. By Frederick F. Stephan and Philip J. McCarthy. John Wiley & Sons, Inc., New York; Chapman & Hall, Limited, London. 451 pages. 1958. $12.

A COLLEAGUE once showed me a paper entitled, "Statistical Theory in One Easy Lesson," which had been prepared by a professor of public administration to assist his students by describing in laymen's terms the sometimes mystical language of the statistician. The book under review can hardly be described as one easy lesson, but it does present in a nonmathematical, easily understood, manner a thorough description of (1) a variety of sampling methods and the theory that applies to their use in surveying attitudes, opinions, and consumer wants; (2) empirical studies undertaken by various survey agencies and comparisons of results; and (3) practical problems that arise in actually designing sample surveys and putting them into operation.

This book is the result of a "Study of Sampling" which the authors began shortly after World War II for the joint Committee on Measurement of Opinions, Attitudes, and Consumer Wants of the National Research Council and the Social Science Research Council. They acknowledge that their work, which is presented in three parts corresponding to the three topics outlined above, represents more of a progress report and a description of problems than a final answer to any major question. They add that statisticians "may be impatient with the verbal discussion of problems that can be expressed more succinctly and precisely by use of mathematics"—yet it is in this different approach to the subject of sampling that their work represents a significant contribution to the literature.

In part I, which relates to the nature and role of sampling, the authors begin by leading their readers through a philosophical discussion of such topics as the importance of studying and measuring opinions and attitudes, the worth of accuracy, what sampling is, what it accomplishes, and how its dependability can be judged. Moving then to a familiar description of the various sampling procedures, this part is concluded with the presentation of some models for use in selection and measurement procedures, and conclusions to be deduced from their use.

Part II is devoted to the examination of results of a variety of actual surveys conducted by a number of survey agencies. Survey data and descriptions of sampling methods were obtained as a first step in the Sampling Study, for the purpose of evaluating sampling methods. A feature of this part is a series of comparisons between survey results from use of quota vs. area sampling methods. As might be expected, comparisons range from reasonably close agreement to wide disagreement. Some instances of serious biases in the quota method were found, and the authors are led to conclude that "it seems impossible to place quota sampling on a sound theoretical basis" * * * (a conclusion which, incidentally, has gained rather universal acceptance in the planning of sample surveys by Government agencies.)

One chapter of part II is devoted to estimation of variances for selected probability model sampling procedures, and it is followed by a similar chapter which described sampling variability of quota sampling procedures. The authors assume that repeated application of a specific quota method will produce a sampling distribution; they proceed to compute rough variance estimates, although admitting at the outset that such procedures "are not to be interpreted as an attempt to put the estimates * * * on the same sound theoretical footing as now exists for well designed and executed probability samples." Further, no attempt is made to measure the systematic errors or biases associated with quota methods, such as result from errors in the original quotas or from the freedom permitted interviewers in selecting respondents to fill their quotas.

Part III deals with problems of sample survey design, beginning with the necessary formulation of objectives, assembly of population data and related information, review of possible sampling procedures, deciding on techniques of selection and estimation, and so on. This summary covers, in a general way—but in a way that is carefully thought through—all the things that need to be considered in designing a survey and putting it into operation.

Social scientists, administrators, survey sponsors, and a wide variety of poll-conscious readers will find in this book a better basis for understanding the principles and practices of sample-survey planning that lead to dependable, or undependable, results. They will find solace in the fact that it is written primarily for them, rather than for mathematicians.

J. Richard Grant

American Agriculture: Geography, Resources, Conservation. By Edward Higbee. John Wiley and Sons, Inc., New York. 399 pages. 1958. $7.95.

WRITTEN mainly for students of the agricultural sciences, vocational agriculture, conservation, and geography, *American Agriculture* purports to be a comprehensive survey of the agriculture of the United States. Though the book offers a stimulating and graphic presentation of many facets of American agriculture for the beginning student, it lacks the penetrating and probing analysis that would be of interest to more advanced students and researchers.

For the agricultural economist, the book provides an example of a somewhat different approach to the study of American agriculture than that typically employed by economists. Its worth to the research worker rests mainly in its presentation of the organization and use of land resources on farms selected to illustrate regional contrasts in agricultural production.

The author, a professor of geography and agricultural economics in the University of Delaware, has organized his materials into three parts. The first part deals with land resources and their use, climate and agriculture, and soils and land capability. If these deserve separate treatment, more attention should be given to such influences on American agriculture as technology, land ownership, and tenure, historical development of resources, and distribution and characteristics of population.

Part II gives a panoramic view of the dry West, and part III a similar treatment of the humid East. Here the author relates many firsthand observations that he has made on selected farms while traveling about the country. They stress repeatedly the importance of wise use and conservation of land resources, which is the underlying theme of the whole book.

The author has done a good job in focusing attention upon the importance of water in the West. Using this as a dominant theme for the discussion of western regions provides an underlying unity that would be lacking otherwise.

After reading in the preface about the inexactness of such terms as the Wheat Belt and Cotton Belt and after being told that "the pages which follow will be concerned with the reasons lying behind regional distinctions," students of geography in particular will be disappointed to find that the author does not have a more exact and complete regionalization to present. He discusses the Palouse and Willamette Valley separately as regions, but one finds no regional analysis of the Shenandoah and Imperial Valleys, for example. These are major shortcomings for a volume that is intended to be a study of agricultural regions.

Numerous maps, charts, and diagrams are used effectively throughout the book, but there are no photographs.

James R. Anderson

The World's Sugar: Progress and Policy. By Vladimir P. Timoshenko and Boric C. Swerling. Stanford University Press, Stanford, California. 364 pages. 1957. $6.50.

THE HISTORICAL and technological development of the world's sugar industry, which is covered in parts I and II of this book, provides the background for a detailed discussion of the economic and political problems that have accompanied the industry's growth. In their attempt "to contribute something significant by way of economic interpreation, objective analysis, and broad perspective" of the world's sugar industry, the authors do exceedingly well.

The relationship of sugar crops to other crops in producing countries, the position of sugar in the food supply, and the pattern of international trade and control are discussed in the first part of the book. The second part is devoted to an extensive review of the technological development and the internal structure and organization of sugar production. The last and largest part is given over to policy in regard to sugar.

In the chapter on the United States sugar supply, the Sugar Act, which bulks large in any such discussion, comes in for some harsh criticism. The most serious defect, according to the authors, is that quotas and restrictions, with their "shifts in the rules of the game and their windfall gains and losses, place a premium on winning political favors rather than on performing economic services." There is always the danger that the welfare of the industry may be confused with the welfare of the public, and that the administrative agency, whose functions parallel those of a public utility commission, may find itself in the position of industry advocate. Despite this danger, the impression is left that the Sugar Act has been administered fairly well. In this connection, it may be noted that the interests of the large industrial users provide some counterpoise to the producer interests emphasized by the authors.

The economic policies relating to sugar in major producing and consuming countries are so thoroughly entwined with their domestic politics that it is difficult to account for the various sugar programs without describing the political environment from which these programs evolved. The "political economy" for sugar in major areas is explained rather well; but there is an undercurrent of impatience with the relatively large role which political considerations play in the formation of policy. Frequently, the political disagnoses and treatment brought to bear on economic problems are not in one-to-one correspondence with the thinking of economists.

Apropos of this, it is interesting that not one of the five reforms for our sugar program suggested in the book was made when the Sugar Act was amended in 1956. And in the case of one—a ceiling on total subsidized production—the amendment went in the opposite direction by permitting domestic producers to share in the growing market for sugar in the continental United States. To be sure, the book was not out when the new legislation was passed, but the suggested changes are such as have occurred from time to time to economists when looking at protective legislation for sugar.

In the chapter on the Soviet sugar industry, the authors recount its history from the time of the Napoleonic wars to the present. The shocks it has sustained since the revolution are fully documented. Here, as elsewhere, the book would have been greatly improved by the inclusion of some dot maps showing production, and others locating towns and political divisions.

In the final chapter, the authors, with rather devastating effect, train their analytical guns on the International Sugar Agreement. The ISA, they say, has failed to come to grips with the outstanding feature of the world sugar economy in the twentieth century—the gradual erosion of the "free" market, which is characterized chiefly by the expansion of preferential agreements between cane sugar suppliers and major importers.

The ISA, the authors assert, makes no contribution toward helping "free market" suppliers adjust to a lower level of demand without social disaster, lowering the incentive for higher sugar-crop output in high-cost importing countries, or advancing sugar technology in countries that produce for the free market. Politics, more than economics, they conclude, is at the root of the international sugar "problem."

There is an illuminating discussion of the interests of all major producing and consuming countries, with respect to sugar supplies and prices. Cuba's major aim in participating in the ISA, according to the authors, is not primarily a high world price but a halt in the shrinkage of the total free market. A relatively low price would discourage an expansion of production in importing and competing exporting nations, and occasional exports from normally self-sufficient countries. (It must be conceded, however, that sometimes Cuba does not behave as though that were her goal.) On the other hand, the interests of the major importing countries of Europe and North America are revealed as being in high world prices. Domestic protection programs always look better when world prices are high.

Richard D. Butler

Literature of Agricultural Research. By J. Richard Blanchard and Harold Ostvold. University of California Press, Berkeley and Los Angeles. 231 pages. 1958. $5.00.

ANYONE who has occasion to seek information or to carry on research in agricultural libraries will find this book filled with helpful suggestions. In it the compilers, two agricultural librarians, list in broad subject groups the bibliographies, indexes, abstracts, yearbooks, handbooks, directories, and similar publications useful in the control of the rapidly growing literature of agriculture and its related fields. Annotations are provided when the title does not fully describe the character of the listed work.

It would be impossible in a book of 200 pages to list all publications of reference value in so large a field. The compilers therefore confine themselves to "the more valuable reference tools . . . with the hope that they will guide the reader to further sources of information." Section F, Social Sciences, which includes Agricultural Economics, Rural Sociology, and Agricultural Education, is more restricted than the others, owing to the availability of Miss Orpha Cummings' *Important Sources of Information for Work in Agricultural Economics with Special Emphasis on California*, 1956. Nevertheless, it includes 46 titles and refers to 6 listed in other sections and 16 not independently listed.

The 56-page index of authors or titles and subjects in the volume impresses this reviewer as primarily a librarian's index. It is easy to find a particular publication the author or title of which is known, but the subject approach is more difficult. For example, there is only one reference to markets, market, or marketing, and no cross references, although other pertinent titles can be found under United States Agricultural Marketing Service and the name of commodities. Similarly, one must look under United States Bureau of the Census for American censuses of agriculture and under Food and Agriculture Organization of the United Nations and International Institute of Agriculture for the two world censuses. There is no entry for Census and only a reference to the section under Statistics. This point should not be labored unduly as the number of titles in any section is not too large to permit reading it through. In fact, this is probably the best way to use the book.

No two people would ever agree completely on what to include in such a compilation. It is easy for any reviewer to find some favorite of his omitted while some other work of less value to him is included. On the whole, however, the titles appear unusually well selected—there would probably be rather general agreement on a large proportion of them.

This book is announced as the first in a series of bibliographic guides to be sponsored by the University of California libraries and issued by the University Press. We hope that future guides will be speedily forthcoming and will maintain the high standard of the first.

Margaret S. Bryant

Selected Recent Research Publications in Agricultural Economics Issued by the United States Department of Agriculture and Cooperatively by the State Colleges

BARRY GOODLOE, BLACK, W. R., and CHAPOGAS, P. G. EVALUATION OF FIBERBOARD SHIPPING CONTAINERS FOR WESTERN LETTUCE. U. S. DEPT. AGR. MKTG. RES. RPT. 248, 38 PP., ILLUS. JULY 1958.

A limit of 1½ pounds of lettuce per 100 cubic inches of space permits the best economic use of fiberboard shipping containers. To reach this conclusion, researchers inspected the condition of lettuce on arrival in New York City from the West Coast. Tightness of the pack ranged from 1.22 pounds per 100 square inches of container space to 1.69 pounds. Serious bruising averaged less than 3 percent when under 1½ pounds of lettuce were packed in 100 cubic inches; serious bruising ranged from 5 to more than 10 percent when over 1½ pounds were packed in 100 cubic inches.

BERTRAND, A. L. AND HAY, D. G. FARMERS' EXPENDITURES FOR HEALTH CARE IN 1955. U. S. DEPT. AGR. INFORM. BUL. 191, 33 PP., ILLUS. JUNE 1958.

Farm families spent over $1.1 billion for health care in 1955. About a quarter of the total health bill was paid directly to physicians and surgeons, approximately $131 million was paid to dentists, and $150 million directly to hospitals. Farmers paid $200 million for health insurance, $138 million for prescription drugs, $40 million for nonprescribed drugs, and $25 million for vitamins and minerals.

Bird, Ronald, Miller, Frank, and Turner, S. C. resources and levels of income of farm and rural nonfarm households in eastern ozarks of missouri. Mo. Agr. Expt. Sta. Res. Bul. 661, 71 pp., Illus. March 1958.

Analysis of the records of 785 open-country households showed that 32 percent of the rural nonfarm households had incomes of less than $1,000 in 1955. Reasons were the limited ability of the family head to work; too small operating units; and too few resources to provide either full employment for a normal family labor force or satisfactory levels of income.

Bitting, H. W. new developments in frozen food industry—a study of capital requirements. U. S. Dept. Agr. Mktg. Res. Rpt. 236, 24 pp. Illus. May 1958.

The frozen food industry represents a $5¼ billion investment. Growth of capital requirements in this industry has been associated with the adoption of technological improvements and increases in mass marketing, size of operations, and specialization. Growth in mass marketing means that large volumes with uniform quality are needed throughout the year. To achieve uniform quality, additional capital investment is required. Processors have tried to obtain uniform quality through product specifications and contractual arrangements with growers or through direct production of the commodities they are using.

Butler, C. P., and Lanham, W. J. an economic appraisal of the conservation reserve program in area III b, upper coastal plain of south carolina. S. C. Agr. Expt. Sta., Dept. Agr. Econ. AE 135, 59 pp., Illus. February 1958. (Mimeographed).

Shows what is happening on farms whose operators participate in the program and why farmers in some areas are not participating to the extent that might be expected.

Enger, M. R., Breakiron, P. L., and Barger, W. R. efficiency and potential economies of dual-purpose shipping containers for mature-green tomatoes. U. S. Dept. Agr. Mktg. Res. Rpt. 257, 69 pp., Illus. July 1958.

Substantial savings to the tomato shipper and repacker are possible with the use of dual-purpose containers that can carry the bulk fruit from the producing areas to the repacking plant and can later be used as master containers for the tubes of ripened and repacked fruit. The study also determined which size, type, and design of container would produce the most economies in packing, shipping, and repacking operations. To measure these economies, labor-cost studies at the shipping point, and shipping tests were made.

Enochian, R. V., Hunter, J. S., and Harris, R. G. canned cooked rice. the market potential for a new food product. U. S. Dept. Agr. Mktg. Res. Rpt. 249, 49 pp., Illus. July 1958.

Instant rice, a new product developed by the Western Utilization Research and Development Division of the Department of Agriculture, was market-tested in Fresno, Calif. Consumer response was varied, but both housewives and store managers expressed enough interest to warrant taking another look at the new product.

Foote, R. J. analytical tools for studying demand and price structures. U. S. Dept. Agr. Handb. 146, 217 pp., August 1958.

This handbook is designed mainly to acquaint research workers in agricultural economics and related subjects with some of the recently developed methods used in analyzing the factors that affect prices and consumption of individual commodities and in studying their demand and price structures. Conclusions are presented in nonmathematical terms so that the handbook can be used by those not acquainted with higher mathematics but its use presumes a general knowledge of the theories of price and demand and of the standard techniques of regression analysis.

Gavett, E. E. labor used for fruits and tree nuts. U. S. Dept. Agr. Statis. Bul. 232, 52 pp., Illus. June 1958.

Includes statistics of labor used in 1954 for the different kinds of fruits and tree nuts.

Gibson, W. L., Jr., and Loope, K. E. equitable farm leases. Bul. 254, 18 pp. January 1958.

Gibson, W. L., Jr., Ellis, H. H., and Spies, E. G. virginia farm lease guide. Va. Agr. Expt. Sta. Bul. 491, 23 pp. April 1958. (School of Law, Univ. of Va. Cooperating.)

These two bulletins were issued to help meet the need for educating landlords and tenants as to the importance of good farm leases.

Greig, W. S., and Manchester, A. C. costs of peeling potatoes by lye and abrasive methods. U. S. Dept. Agr. Mktg. Res. Rpt. 255, 38 pp., Illus. July 1958.

In commercial peeling of potatoes the lye method is more economical than the abrasive method in an efficiently operating plant with a capacity of 3,000 pounds per hour, except when the price of raw potatoes is extremely low. Differences in fixed, operating, and labor costs were fairly wide among nine plants studied. Many of these differences were due to the use of equipment within the plants. Level of equipment utilization was generally low.

Hamann, J. A., Winter, E. R., Stoyanoff, Robert, and Hester, O. C. electronic bloodspot detection in commercial egg grading. U. S. Dept. Agr. Mktg. Res. Rpt. 239, 65 pp., Illus. June 1958.

An electronic bloodspot detector can discover and reject eggs containing bloodspots twice as effectively as the human eye. Research was conducted in a commercial egg-grading plant chiefly to learn whether the use of an electronic device to detect bloodspots could bring savings in labor and equipment. The cost is 46 cents per case when a person detects and removes eggs containing bloodspots and candles for quality (when 80 to 100 percent of the eggs are of A quality) and 43 cents when eggs of the same high quality are submitted to electronic detection and flash candling.

Henderson, J. M., and Linnenberg, C. C., Jr. shifts in rail and truck transportation of fresh fruits and vegetables. U. S. Dept. Agr. Mktg. Res. Rpt. 237, 52 pp., Illus. June 1958.

Reports of shipments of 8 fresh fruits and vegetables unloaded at 13 major markets reveal that, while total movement of this produce by rail and truck to these markets was about the same in 1954 as in 1951, the truck portion rose from 53 to 56 percent. Net effect of these changes was a shift of almost 14,000 carlots from rail to truck. Individual movements most heavily affected were shipments of Maine potatoes to Boston and Florida citrus and tomato shipments to New York City.

Herrmann, L. F., and Friend, L. F. farm-to-retail price spreads for fluid milk in chicago. U. S. Dept. Agr. Mktg. Res. Rpt. 246, 31 pp., Illus. June 1958.

A sample survey of 733 Chicago families showed that households that purchased milk paid an average price of 21.5 cents a quart. The equivalent farm price was 8.8 cents a quart. The marketing margin based on single quarts of milk delivered to homes increased from 11.5 cents a quart in January 1947 to 16.5 cents in December 1957. More than twice as much milk was bought from stores as from home delivery routes in May 1956; about 1 percent was bought from vending machines.

Hochstim, E. S. homemakers appraise citrus products, avocados, dates, and raisins. U. S. Dept. Agr. Mktg. Res. Rpt. 243, 133 pp. June 1958.

In a sample survey, 2,572 homemakers were interviewed to learn preferences for citrus fruits, avocados, dates, and raisins. Practically all said they had used fresh citrus fruits in the preceding year. This was true in all sections of the country, in homes of all income levels, with and without children, and among people of all educational levels and ages. Avocados were used by only a fourth of the homemakers. Raisins and dates were praised as a substitute for candy and for their contributions to baking.

Hutton, R. F., King, G. A., and Boucher, R. V. a least-cost broiler feed formula method of derivation. U. S. Dept. Agr. Prod. Res. Rpt. 20, 39 pp. May 1958. (Pa. Agr. Expt. Sta. Cooperating.)

The linear-programming model used in deriving the formula is described. A set of nutritive and other specifications of broiler feeds, including restrictions on minimum and maximum amounts of the several ingredients that make up the ration are outlined. A solution for a realistic broiler feed problem under actual price conditions for a given time and place is developed.

Jarvesoo, Elmar, and Fitzpatrick, R. A. marketing the new england rose crop. U. S. Dept. Agr. AMS–257, 9 pp., Illus. July 1958.

The 13 growers in the sample produced 65 to 70 percent of the roses grown in the area; they operated 2.96 million square fect of greenhouse area. Wholesale florists selling roses on consignment were the most important market outlet. Growers marketed 20 percent of their roses through their own wholesale stores, 19 through stalls in Boston Flower Exchange, and 17 direct to retail florists.

Lafferty, D. G., and Cooper, M. R. preprocessing practices and costs of united states textile mills as affected by the cotton bale package. U. S. Dept. Agr. Mktg. Res. Rpt. 253, 17 pp. July 1958.

Shortcomings of the American cotton bale package increase costs in textile mills. The cost of cleaning cotton bale surfaces and other preprocessing costs arising from the condition of the bagging and from cotton sticking to bale covers when they are removed is estimated to have been almost $3 million in 1957. Conventional sampling practices and improper application of bale covers cause many of the complaints against the American cotton bale and of the costs here described.

Levine, D. B. men's preferences for cotton, wool, and other fibers in selected clothing items. U. S. Dept. Agr. Mktg. Res. Rpt. 244, 123 pp. July 1958.

After interviewing 2,379 men, 16 years of age and over, on their preferences for various fibers in summer clothing, researchers have found that the trend is definitely toward more informal items in men's clothing. More than a fourth of the adult males own sport shirts, summer slacks, sport jackets, and special suits for summer wear. Cotton led the fibers for all garments discussed except sport jackets and summer suits. Wool is most preferred for summer suits and for summer and other season sport coats or jackets.

McArthur, W. C., and Carreker, J. R. economic analysis of conservation farming on a cotton-dairy farm in the piedmont area of georgia. Ga. Agr. Expt. Sta. Bul. N. S. 51, 45 pp., illus. March 1958. (Soil and Water Conservation Div., ARS, cooperating.)

Shows the results of 2 cropping plans on a farm management unit established in 1941 on the Southern Piedmont Conservation Experiment Station at Watkinsville, Oconee County, Ga., and carried on in connection with terracing and contour tillage practices. The second plan, which simplified field operations and increased productivity, was more successful. Corn was eliminated from the rotation.

Macomber, A. Z. marketing costs and margins for . . . california lettuce. U. S. Dept. Agr. Mktg. Res. Rpt. 225, 11 pp., illus. June 1958.

Marketing costs for California lettuce sold in New York City increased 60 percent during the period 1946–56. The increase was even greater—75 percent—for California lettuce sold in Chicago. Transportation was responsible for 27 percent of the increase. The report gives a breakdown of the costs and returns, and wholesale and retail margins per carton of California lettuce sold in the two cities.

Nerlove, Marc. distributed lags and demand analysis for agricultural and other commodities. U. S. Dept. Agr. Handb. 141, 121 pp., illus. June 1958.

This report summarizies available literature on the use of distributed lags in the analysis of demand for individual commodities and contributes a substantial amount of new material to the problem of estimating dynamic demand relationships.

U. S. GOVERNMENT PRINTING OFFICE: 1958

Reed, C. E., Clifton, R. E., Schruben, L. W., and Cathcart, W. E. marketing dehydrated alfalfa. U. S. Dept. Agr. Mktg. Res. Rpt. 254, 83 pp., illus. July 1958. (Kansas Agr. Expt. Sta. cooperating.)

The dehydrated alfalfa industry has increased its volume of production more than 400 percent since 1943. Production is seasonal and prices fluctuate widely. This study was made to determine some criteria of marketing efficiency for the dehydrated alfalfa industry. All stages of handling and processing were studied, from the procurement of the raw material through first sales of the finished product.

Spies, E. G. law of farm tenancies in virginia. Va. Agr. Expt. Sta. Bul. 490, 63 pp. June 1958. (Farm Economics Research Division, ARS, and School of Law, Univ. of Va. Cooperating.) (Pub. 29, Southeast Land Tenure Committee.)

Ramifications of the law relating to farm tenancy in Virginia are presented. It is suggested that the Statutes of Conveyances and Frauds be amended to provide that both executed leases for more than 1 year and executory contracts to enter into leases for more than 1 year be required to be in writing; that sections 55–249–252 of the Virginia code be amended to extend the right of emblements to a tenant farmer where the mortgage preceded the lease and was recorded, even if the lease is for more than 1 year; that a detailed study be made of landlords' liens; and that owners, tenants, and croppers be educated to the need for more carefully considered and labeled agreements.

Thuroczy, N. M. marketing long- and medium-grain rice. the influence of supply on wholesale prices and margins. U. S. Dept. Agr. Mktg. Res. Rpt. 251, 30 pp., Illus. July 1958.

This report studies the relationships between the prices of different varieties of rice, variation in price ratios attributed to changes in supply, seasonal price fluctuations, and the effects of Federal programs for rice upon the wholesale price ratios of long- and medium-grain rice.

Tramel, T. E., Crowe, G. B., and Abel, J. F., Jr. investment and operating costs of irrigation in the delta area of mississippi. a progress report. Miss. Agr. Expt. Sta. Bul. 559, 27 pp., Illus. May 1958.

Personal interviews with 145 farmers showed that investment per acre irrigated was $56. Average annual operating costs for all irrigation systems amounted to $15 per acre irrigated. With present practices and techniques and 1956 prices, an increase in yield of 255 pounds of seed cotton, 15 bushels of corn, or 7 bushels of soybeans per acre would be required to cover all costs of 2 irrigations.

U. S. Department of Agriculture. contract farming and vertical integration in agriculture. U. S. Dept. Agr. Inform. Bul. 198, 21 pp., Illus. July 1958.

The meaning and extent of integration are here set forth.

U S. Agricultural Marketing Service. marketing costs for food. U. S. Dept. Agr. Misc. Pub. 708, 14 pp., Illus. Revised March 1958.

Marketing charges accounted for 60 percent of the money consumers paid for food in 1957. The remaining 40 percent represented the farmer's share of the consumer's food dollar. Proportions of the food dollar going for marketing charges and to farmers in 1956–57 were the same as in 1940, immediately before World War II.

U. S. Agricultural Research Service, Farm Economics Research Division. changes in farm production and efficiency. a summary report. U. S. Dept. Agr. Statis. Bul. 233, 32 pp. August 1958.

This is the fifth issue of an annual publication that is designed specifically to present the major statistical series on farm production, production inputs, and efficiency.

Statistical Compilations

U. S. Agricultural Marketing Service. commercial livestock slaughter. number and live weight, by states. meat and lard production, united states, by months 1944–57. U. S. Dept. Agr. Statis. Bul. 231, 143 pp. July 1958.

U. S. Agricultural Marketing Service. the extra-long staple cotton situation. U. S. Dept. Agr. Statis. Bul. 234, 51 pp. July 1958.

U. S. Agricultural Research Service and Agricultural Marketing Service. home baking by households in the united states—by region. U. S. Dept. Agr. Household Food Consumption Survey 1955. Rpt. 13, 130 pp., Illus. June 1958.

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