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A Method for Evaluation of Alternative Milk Pricing Plans

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Acknowledgment

This is a report of research under Department of Agricultural Economics project 590 Dairy Market Adjustment Problems.

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SUMMARY OF PROCEDURES

This research was based on the premise that an intelligent choice among alternative pricing plans would be greatly enhanced by a quantitative estimate of their respective economic results.

Mathematical models were derived which allow aggregate welfare gains (losses) to be measured in dollar values. Empirical data were analyzed and compared to simulated data (i.e., price and quantity relationships in the Ozarks market as they exist were compared with price and quantity relationships that could be expected to exist had a given alternative pricing plan been used). The welfare gains (losses) to both producers and consumers associated with each pricing plan were quantified.

Given various pricing alternatives for reaching a subjective goal, the models provide an optimal solution (i.e., a solution is optimal in the sense that subjective criteria are attained).

THE MILK PRICING PROBLEM AND OBJECTIVES

Agriculture in general, and the dairy segment in particular, has had difficulty in adjusting to the inevitable changes ushered in by scientific and technological innovations. Larger herds and increased production per cow have resulted in fewer, more highly specialized dairy operations.

Increased milk production per cow has been accompanied by a gradual decrease in per capita milk consumption. These two phenomena more than offset the increase in demand due to population growth. Pressure is generated to reduce cow numbers which in turn causes an even greater than proportionate reduction in number of dairy enterprises. Such economic adjustment is disruptive and painful to those involved.

The Problem

Low Farm Income—the Primary Problem. A chronic problem of dairy farmers is low income, reflected by an average income per dairy farm worker of about one-half that of the average income per factory worker. A social problem is posed which has become an integral part of policy. Most of society would agree that labor and other resources committed to the dairy industry should receive returns comparable to those of equally productive resources in other segments of the economy. The difficulty arises over proposed methods of achieving such a goal, and it must be recognized that this goal can only be approached in a dynamic economy that is constantly adjusting to new technology.

Basically, the differences have arisen over whether the low income problem should be treated as a social welfare problem or as a production problem. To revive these questions is not the purpose of this study. A more sophisticated means of formally evaluating various courses of action would be helpful in answering such questions and this is the problem to be attacked.

Pricing Policies—the Secondary Problem. Throughout the Midwestern milk producing areas there is a great deal of interest in economic type formulae for pricing Class I milk. Economic indicators would be used to compute the price of milk.

Eastern milk markets have utilized such a pricing plan for a number of years, and apparently it has certain advantages. One of the disadvantages of authoritative milk pricing has been the time lag between changing economic conditions and subsequent changes in milk prices. A milk-pricing plan based on current economic indicators should adjust milk prices more quickly to current economic conditions than one related to market conditions resulting from past dislocations.

It is a relatively simple matter to select formula movers and combine them in such a way that Class I prices are increased, decreased, or maintained. The major difficulty lies in evaluating the results. It is true that such evaluation is based largely on subjective judgment and nothing proposed in this study will change this basic fact. However, evaluation becomes more objective if the values of certain variables in the system can be estimated when price takes on a given value.

Associated Dairymen, Inc. of Kansas City, Mo., in conjunction with a committee representing several state universities, has formulated a number of economic formulae that could possibly be adopted in Midwestern markets.[1] The basic problem of this study lies in the formulation of a quantitative method applicable to the evaluation of such formulae.

This study attempts to provide the tools by which two basic questions concerning any single pricing plan can be answered.

(1) How much would dairy farm income in any single market be changed by the proposed plan in the long run?

(2) How much would the proposed plan cost society in the long run?

At best, any such calculations are estimates. Even if the absolute error is of considerable magnitude, it may be of little consequence when two or more alternatives are considered since all are subject to the same error.

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1. *An Evaluation of the Level and Alignment of Federal Order Milk Prices for the Area of Associated Dairymen as of 1965.* A Report of the Dairy Marketing Advisory Committee (Kansas City: Associated Dairymen, Incorporated, 1965).

The Objectives

Given the problem of selecting a pricing plan for Class I milk, the objectives of this study were:

(1) To delineate the relationship of Class I and Class II milk markets and to quantify this relationship in terms of the difference in Class I supply and demand as the price of the same is varied.

(2) To use this model to obtain estimates of long-run gains to dairy farmers and long-run losses to society associated with the present pricing plan for Class I milk as opposed to alternative plans.

(3) To estimate future gains and losses associated with a given pricing plan by extrapolation of historical trends.

The Scope and Method

Scope. Since fluid milk markets are divided either formally by Federal orders or informally by spatial or artificial barriers and different supply and demand conditions apply in each market, it would be a gigantic task (perhaps not even meaningful) to study the national market for fluid milk in this context.[2]

The models and methods set forth in later sections are applicable only to a single market. To make them applicable on a national scope involves a consideration of each individual market and an aggregation of results.

The Ozarks market is used for purposes of illustration. There was no particular reason for this selection except that the quantities of milk in it are somewhat smaller than in the other two Federal order markets in Missouri and outside shipments to it are small.

Method. The method used resembles a Monte Carlo technique in that "probabilistic results" are simulated under assumed alternative pricing plans for fluid milk.[3] Individual values are not taken from a table of random numbers; rather, they are calculated via mathematical models. Empirical data are analyzed and compared to simulated data, i.e., price and quantity relationships in the Ozarks market as they existed historically are compared with price and quantity relationships that could have been expected to exist had a given alternative pricing plan been used. Projections are made on the basis of the two sets of data (actual and simulated) and the same comparisons are made.

Probable results are tabulated in terms of dollar gains and losses, i.e., gains in dairy farm income and losses to society resulting from the misallocation of resources.[4]

The approach seems particularly applicable for two reasons:

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2. As of January 1, 1968, there were 76 Federal order markets.

3. J. M. Hammersley and D. C. Handscomb, *Monte Carlo Methods* (New York: John Wiley and Sons, Inc., 1964), p. 8.

4. Social losses are explained later. For present purposes it is sufficient to assume that there is a loss to society when resources are used to produce surplus Grade A milk.

(1) It is impossible to run actual experiments using various pricing plans in a Federal order milk market.

(2) Simulated data can be had with neither the cost nor the complications of conducting a physical experiment.

Definitions of Terms Used

Fluid milk, Class I milk—milk actually consumed in fluid form or in fluid milk products.

Manufacturing milk—milk not eligible for fluid consumption and actually used in manufacturing dairy products.

Grade A milk—milk produced under sanitary regulations and eligible for fluid consumption whether or not so used.

Surplus Grade A milk, Class II milk—milk eligible for fluid use but actually used in manufactured products.

Class I price, Fluid milk price—the producer price of milk actually utilized for Class I purposes.

Blend price—a weighted average price of milk used in Class I and Class II uses.

Manufacturing price—the price paid to producers for milk used in manufactured dairy products. Manufacturing price is also taken to be the surplus Grade A price in this study.

REVIEW OF RELATED EMPIRICAL STUDIES

Although the concepts of consumer surplus and maximum social satisfaction were treated at some length by Marshall, the father of modern economics, empirical studies based on these concepts have been few. There is little doubt that the primary reason for this lack of interest lies in the prevalent pessimism concerning the empirical measurement of utility. Recently, however, there seems to be a mounting interest in these concepts as a tool of policy makers.

Joseph Clawson of the University of California at Los Angeles conducted a study in 1954 in which he attempted to measure the utility and disutility of various quantities of milk.[5] The study was based on 25 interviews in Los Angeles and its suburbs.

The interviewer asked the consumer to place a numerical value on purchases of milk. For example, if the consumer purchased one gallon of milk per week under usual conditions, he was asked if he would be more willing, less willing, or equally willing to purchase another gallon per week. The first purchase was given a rating of 100, the consumer was then asked to express his preference for a second purchase as a percentage of the first purchase. By attaching a numerical rating to various quantities of milk, interpersonal comparisons of the intensity of desire were made in numerical terms.

5. Joseph Clawson, *Is Marginal Utility Measurement the Key to a Comprehensive Theory of Marketing?*, Harvard Studies in Marketing Farm Products, Number 9-14, (Cambridge: Harvard University Press, July, 1954).

The conclusions were: (1) Empirical studies can be safely attempted using the concepts of utility measurement. (2) The findings of the study tentatively confirm "some of the elementary hypotheses of orthodox utility theory."[6]

The same basic idea, although a different method of measurement, was used by R. M. Parish in estimating the social cost of the dairy price support program in Australia.[7] Parish measures losses of utility rather than total utility and such a technique seems advantageous.

Parish assumes that the gross value of a product to society is represented by the area under the demand curve for a given product. He further assumes that the cost to society is represented by the area under the supply curve for the same product. The equation of these two curves maximizes the net social benefits arising from the production and consumption of any given product. Any "artificial" elements within the market causing a deviation from this point of equation has a social cost involved. By capitalizing on the fact that net utility is maximized at the point where supply and demand are equated, Parish was able to greatly simplify the problem.

In order to measure total utility it is necessary to estimate the demand function from zero consumption to the quantity in question. The same would apply to the supply function when measuring total costs. If there were no "artificial" elements in the market, there could be no social losses as defined by Parish. With price supports on dairy products there is a disequilibrium of supply and demand in the Australian dairy industry, i.e., there is a surplus. Parish attempts to measure the social cost associated with this surplus.

The advantage of such a procedure arises from the fact that only the elasticities of supply and demand within the area of equilibrium must be estimated.

The methods used by Parish closely parallel those used in this study in estimating social costs. One further step is taken in this study in that the increased return to the dairy industry associated with a given policy is estimated as well as the social cost of such a plan.

A more recent study concerning social costs was conducted by Paul R. Johnson of North Carolina State University.[8] Johnson attempted to measure the social cost of the tobacco program.

The problem was somewhat different because strict production controls are a part of the tobacco program whereas milk production is not controlled. The departure from maximum welfare conditions lies to the left of supply and demand equilibrium instead of to the right. The loss of welfare does not arise from producing a surplus of tobacco. Welfare losses arise from the restriction of production. Other than this basic difference, the procedure was much the same as that used by Parish.

6. *Ibid.,* p. 58.

7. R. M. Parish, "The Costs of Protecting the Dairy Industry," *The Economic Record,* XXXVII, June, 1962, pp. 167-182.

8. Paul R. Johnson, "The Social Cost of the Tobacco Program." *Journal of Farm Economics,* XXXVII, May, 1965, pp. 242-255.

Parish implicitly assumed constant marginal utility of money. (This assumption is inherent in the following analysis.) Johnson feels that such an assumption is tantamount to ignoring income distribution.[9] If it is assumed that per capita farm income is lower than per capita non-farm income, a downward adjustment of calculated social costs could be justified on the basis that the marginal utility of money is greater in the farm than in the non-farm segment of the economy. This is essentially the reasoning used by Johnson.

Various other studies which are related are cited elsewhere.

A WELFARE CRITERION FOR FLUID MILK PRICING

Apparently little work has been done concerning a criterion for pricing fluid milk. In 1937, Cassels favored a plan based on manufacturing price plus an estimated premium sufficient to cover the extra costs of producing Grade A milk.[10] The rationale of such a pricing plan stems from the fact that both manufacturing milk and fluid milk supplies are subject to the same variables, e.g., weather. Both manufacturing and fluid milk require many of the same resources.

The specific assumptions under which Cassels' conclusions would hold are:

(1) Pure competition at the farm price level of the market.

(2) The supply function can be separated into two additive components of the form $s(q_1 + q_2) + f(q_1)$, where q_1 and q_2 are fluid and manufacturing milk, respectively, and $f(q_1)$ is the marginal cost of producing fluid milk for the industry. Cassels apparently takes $f(q_1)$ equal to a constant.

(3) Equilibrium conditions of the market for manufacturing milk are nearly met in actual practice, so that the observed price in the manufacturing market can be used as a base to determine the fluid price.

Another criterion for fluid milk pricing was suggested by Gaumnitz and Reed—that the tendency for producers to increase production is an indication that the price is set too high.[11] Without giving some consideration to demand, this position is also difficult to defend. However, by considering demand, such a criterion could closely approach that which will be suggested here.

The Agricultural Marketing Agreement Act of 1937, from which present-day Federal order markets derive their legal basis, provided that the Secretary of Agriculture

> . . . shall fix prices as he finds will reflect such factors (price of feeds, available supplies of feeds, and other economic conditions), insure a sufficient quantity of pure and wholesome milk, and be in the public interest.[12]

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9. *Ibid.*, p. 254.

10. J. M. Cassels, *A Study of Fluid Milk Prices* (Cambridge: Harvard University Press, 1937), pp. 171-174.

11. E. W. Gaumnitz and O. M. Reed, *Some Problems in Establishing Milk Prices*, United States Department of Agriculture (Washington: Government Printing Office, 1937), pp. 114-115.

12. United States Department of Agriculture, *Compilation of Agricultural Marketing Agreement Act of 1937*, Agriculture Handbook No. 124, Agricultural Marketing Service (Washington: Government Printing Office, 1958), p. 14.

In authoritative pricing under state law such terms as "just and reasonable," "in the public interest," etc., are often found.

Such general terms tend to be grossly lacking as criteria for price determination, so the following material will establish a criterion for fluid milk pricing. Before moving on, it would be best to state the role to be assigned to price.

Price and Welfare Criteria

A Price Criterion. In a competitive economy, price has two functions. One is to allocate the factors of production. The other is to allocate products to consumers. Neither of these functions is altered by fixing a minimum price; the result of fixing the wrong price is simply a malfunction of the allocative machinery.

There exists a unique opportunity within the fluid milk market to disregard the effects of resource misallocation due to fixing the price too high, since any "surplus" can be dumped on the manufacturing market. If it is assumed that Grade A milk is worth no more than manufacturing milk when used for manufactured products, there is no economic basis for encouraging "surplus" production of Grade A milk through high prices.

No assumptions are made that either the consumer or the producer of fluid milk is better or worse financially endowed. According to T. W. Schultz, policy makers have too often attempted to justify a price on the grounds that nonfarm income per worker is higher than farm income per worker. ". . . as long as the two objectives (social and economic) are linked in the formulation of policies, the policy will be attempting to serve two ends that are economically incompatible."[13]

If this is the case, why bother with a minimum fluid milk price at all?

Fluid milk, like all agricultural products, has a lagged supply response. High fixed costs tend to keep the dairyman producing milk even when all costs are not met, and the time necessary to expand herds tends to hold down immediate increases in supply when prices are high. The oscillations of price and quantity familiar in the cobweb theorem were typical of fluid milk markets before minimum pricing. The role of minimum price in fluid milk markets is here taken to be that of damping these oscillations. We wish to fix a price today so that neither too many nor too few resources are devoted to fluid milk production for a future period.

A Welfare Criterion. Society holds an inventory of resources and these resources can be used to produce numerous consumer goods. It is assumed that the consumer behaves in such a way as to maximize utility (satisfaction); thus, the demand curve for fluid milk reflects not only the marginal utility from consuming various quantities of milk but also the relationship of milk to other consumers' products. A more concise relationship may be shown:

13. T. W. Schultz, *Production and Welfare in Agriculture,* (New York: The Macmillan Company, 1950), p. 19.

$$\frac{MU_a}{P_a} = \frac{MU_b}{P_b} = \cdots = \frac{MU_n}{P_n},$$

where a, b, . . . n are various products.

A similar analysis applies to the producer except that he seeks to maximize income. He will produce the combination of products so that the marginal values of all products produced are equal. That is,

$$\frac{MVP_a}{P_a} = \frac{MVP_b}{P_b} = \cdots = \frac{MVP_n}{P_n}$$

(or any single product must compete for resources).

In general equilibrium:

$$\frac{MU_a}{P_a} = \frac{MVP_a}{P_a} = \frac{MU_b}{P_b} = \frac{MVP_b}{P_b} = \cdots = \frac{MU_n}{P_n} = \frac{MVP_n}{P_n}.$$

Social welfare is at a maximum because all resources are being used to produce the kind and quantity of goods desired by society.[14] It is out of these relationships that Lerner sets forth the following definitions:

1. The Marginal Social Benefit. (msb)
   This is the benefit to society from the particular increment of output considered.
2. The Value of the Marginal Product. (vmp)
   This is the physical increment of output being considered, multiplied by the price paid for it by the consumer. If the increment is exactly one unit of product, the value of the marginal product will be equal the price of the product.
3. The Marginal Private Revenue. (mpr)
   This is the increase in revenue (positive or negative) received by the producer as a result of producing and selling the increment in output.
4. The Marginal Private Cost. (mpc)
   This is the increase in cost incurred by the producer as a result of increasing the quantity of factor he purchases in order to be able to produce the increment of output.
5. The Value of the Marginal Factor. (vmf)
   This is the physical increment of the factor of production (that is needed to make the increment of product) multiplied by the price per unit paid for it and received by the owner of the factor. If the increment is exactly one unit of factor, the value of the marginal factor will be equal to the price of the factor.

14. It is recognized that different income distributions could alter this statement. However, for any given income distribution the statement holds.

6. The Marginal Social Cost. (msc)
   This is the sacrifice to society from having the marginal factor used up here so that it is not available for use elsewhere. It is the "social marginal opportunity cost." It is the alternative social value that the marginal factor could have produced if it had been used elsewhere.[15]

From this group of definitions Lerner derived his welfare equations:

Marginal Social Benefit	=	Value of Marginal Product
Value of Marginal Product	=	Marginal Private Revenue
Marginal Private Revenue	=	Marginal Private Cost
Marginal Private Cost	=	Value of Marginal Factor
Value of Marginal Factor	=	Marginal Social Cost[16]

Or:

msb = vmp = mpr = mpc = vmf = msc[17]

It can be shown that these equations hold only at equilibrium under pure competition and that net social benefits are at a maximum when these equations hold. Given the constraint, social benefits are still maximized at the intersection of the supply and demand curves.

Obviously these equations will not hold in the fluid milk market, however, this does not nullify their value. It only means that something less than optimum must be accepted.

The producer's derived demand curve is accepted as given. No attempt is made to estimate the extent of monopoly elements or their effects in the market. The demand curve as shown and discussed will represent the producer's derived demand, given existing market conditions.

The antilog of maximum net social benefits is minimum net social losses. The latter expression is advantageous in that social losses are more easily measured empirically than social benefits. In any case the results are identical.

In essence, the criterion of minimum net social loss seeks to minimize the deviation of actual price from equilibrium price through time. Let p(t) be the equilibrium price that exists at each point in time; however, it cannot always be achieved in the short run. Then we wish to minimize the expectation,

$$E\,[P - p(t)]^2,$$

where P is the actual price and a random variable subject to some control through pricing policy.

The Measurement of Net Social Losses

One of the major problems facing the social scientist is the empirical measurement of social welfare. The economist uses the term "utility" as a measure of satisfaction; yet he readily admits that utility is not cardinally measurable.

15. Abba P. Lerner, *The Economics of Control* (New York: The Macmillan Company, 1946), p. 75.
16. *Ibid.*, p. 76.
17. *Ibid.*

An ordinal measure is provided through the price system. Given a number of various goods, the consumer selects those quantities of various goods which maximize utility (satisfaction). These choices when aggregated form the demand curve for various goods. The demand curve for fluid milk reflects the importance that consumers place on milk in relation to all other alternatives. This relationship is measurable in terms of quantity and price.

The producer can calculate the cost of producing a good. However, the cost of producing good "A" means very little if an opportunity exists to use available resources to a better advantage in producing good "B." It is assumed, then, that the supply curve of fluid milk also reflects the opportunity costs of producing the milk.

Using these relationships, the following assumptions can be made:

(1) The demand curve of fluid milk represents the aggregate of consumer marginal utility curves from the consumption of fluid milk.

(2) Net social benefits are synonomous with net utility.

(3) Resources used in fluid milk production could be employed elsewhere in the economy with returns at least equal to the cost of utilization.

(4) The long-run supply curve is equal to the aggregate of individual firm marginal cost curves plus opportunity costs of factors fixed in the short-run.

(5) There are no external pecuniary or technical economies in the production of fluid milk.

With these assumptions, the analytical model is applicable to the problem of measurement.

In Figure 1 the market is in equilibrium at point a. The gross social benefits (total utility) from consuming quantity q_1 of fluid milk are $obaq_1$. The social costs (opportunity cost)[18] are $ocaq_1$. Thus, the net social benefit is $obaq_1 - ocaq_1 = cba$.

The major difficulty in any such approach is the problem of obtaining reasonably accurate measures of supply and demand relationships. This is especially true as the quantity approaches zero.

Part of this difficulty can be overcome by the alternative of measuring social losses. Assume that price is fixed at p_2 in Figure 2 with oq_2 produced; oq_1 will move into the fluid milk market and q_1q_2 will move into the manufacturing milk market. The line, ab, represents the blend price, the producer pay price.[19] The blend price for quantity q_2 is calculated:

$$\frac{P_2q_1 + P_1\,(q_2 - q_1).^{20}}{q_2}$$

18. Opportunity cost = the value of forgone alternative products which the resources used in producing milk could have produced.

19. William H. Nicholls, *Imperfect Competition Within Agricultural Industries* (Ames: The Iowa State College Press, 1941), p. 185.

20. The surplus is not priced exactly at manufacturing price in most markets. The Class II price is calculated by butter-powder formulas, etc. However, they approximate manufacturing price very closely.

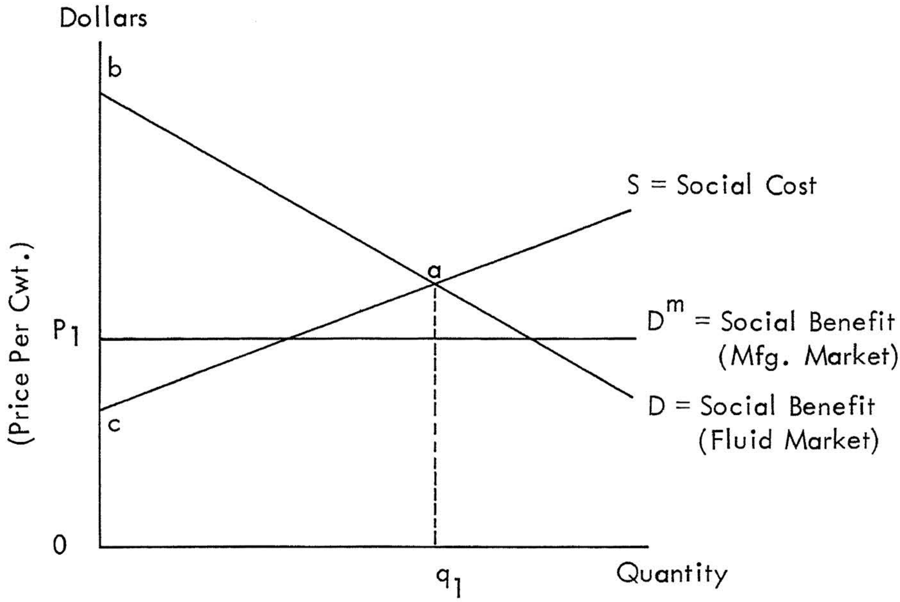

FIGURE 1. A graphical illustration of net social gains.

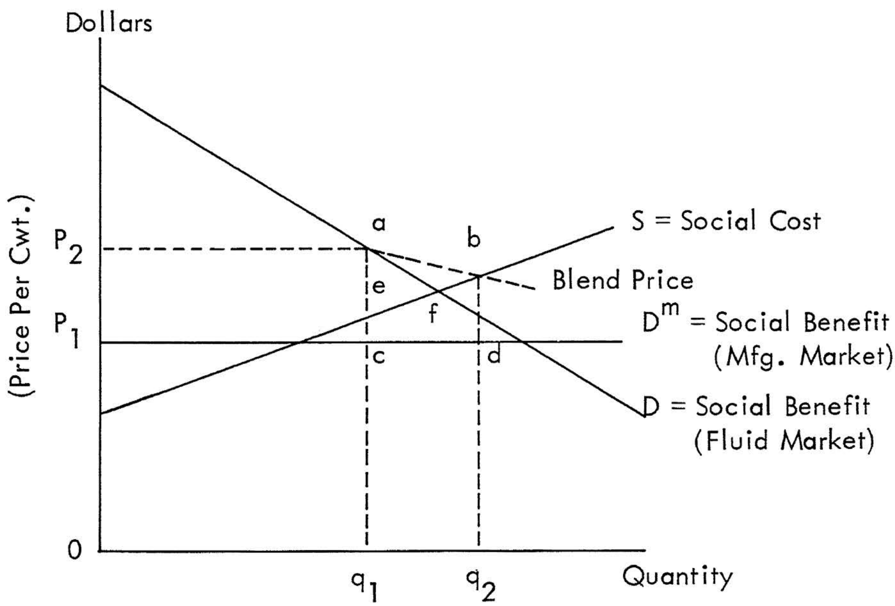

FIGURE 2. A graphical illustration of net social losses.

To measure net social losses, only the supply-demand relationships between q_1 and q_2 are relevant.

Points a and b can be determined from available statistical data; it is only necessary to estimate the elasticities of the curves between q_1 and q_2.[21]

If the producer price is fixed at P_2 in the fluid milk market, the net social loss can be quantified.

The full social cost of producing quantity q_2 has been paid; yet only q_1 is actually consumed in the fluid milk form. Quantity q_1q_2 is consumed in manufactured products where the utility is lower. Thus, social cost (q_1ebq_2) - social benefit (q_1cdq_2) = net social loss (cebd). Or stated mathematically:

$$\text{Net social loss} = \int_{q_1}^{q_2} f(q)\, dq - P_1 (q_2 - q_1),$$

where f(q) denotes the supply function.[22]

Most markets determine prices monthly; there would be 12 such calculations per year with the results aggregated over a long period of time, say five to ten years. Then with reasonably accurate estimates of the supply and demand curves, the aggregate of net social losses provides a quantitative measure by which various pricing plans may be evaluated.

This point will be demonstrated in a later section when net social losses in the Ozarks market under the present pricing plan are compared with net social losses of an alternative plan. More should be said, however, as to why area cebd represents a social loss.

It was assumed that factors could be used elsewhere in the economy with returns at least equal to the cost of utilization. This means that the resources used to produce quantity q_1q_2 of Grade A milk could have been used elsewhere with a return of at least q_1ebq_2. When these resources are used to produce Grade A milk the return was q_1cdq_2. The loss to society was at least cebd; private loss to producers was exactly cebd.

A General Derivation of Social Costs

A more general and straightforward derivation of social losses as defined in this study is given as follows: Let the symbols used in this derivation concur with those used in Figure 2. Then for any q_1 and q_2 determined by a price administered in the fluid market in conjunction with the supply-demand functions (Fig. 2), the net benefit function is

$$B(q_1, q_2) = \int_{O}^{q_1} D(x)\, dx + P_1 (q_2 - q_1) - \int_{O}^{q_2} S(x)\, dx,$$

---

21. Strictly speaking, it is the slopes not the elasticities of supply and demand that we wish to know.

22. Net social loss as here defined is a minimum figure. The rationale of the limited definition is explained in a later section, "Additional Problems of Defining and Measuring Social Costs."

where D(x) is the demand equation for fluid milk and S(x) is the supply equation for all milk. Let q^* be the equilibrium quantity under pure competition (i.e., $q_1 = q_2 = q^*$). Social losses are

$$B(q^*, q^*) - B(q_1, q_2)$$
$$= \int_{q_1}^{q^*} D(x)\,dx + \int_{q^*}^{q_2} S(x)\,dx - P_1 (q_2 - q_1)$$

If we delete the consumers surplus component of social costs given by

$$\int_{q_1}^{q^*} D(x)\,dx - \int_{q_1}^{q^*} S(x)\,dx,$$

this gives the empirical measure

$$\int_{q^*}^{q_2} S(x)\,dx - P_1 (q_2 - q_1) + \int_{q_1}^{q^*} S(x)\,dx$$
$$= \int_{q_1}^{q_2} S(x)\,dx - P_1 (q_2 - q_1).$$

The Measurement of Producer Gains

The empirical measurement of increases in income arising from a simulated pricing plan are much more easily measured than are social losses. The new blend price multiplied by the new quantity minus the original blend price multiplied by the original quantity yields the gross producer gains (or losses) consequent of a simulated pricing plan.

In either case (social losses or producer gains), supply and demand functions must be estimated. It should be noted that we need only consider cases where the fluid milk price is set "too high" because this is merely a minimum price. Market price will rise to ration the limited supply, if the fluid milk price is set "too low."

Conclusions

Under the assumptions set forth, net social losses are measurable in terms of money. The minimization of such losses in the long run may provide a desirable criterion in the problem of pricing fluid milk.

However, if it is believed that situations justify measures which increase the price of milk to provide maximum income to producers, net producer gains are also measurable and may also provide a desirable criterion in the milk pricing problem.

In any case, a quantitative measure of both gains and losses is provided. Neither the criterion of minimum losses nor maximum gains is sufficient within itself, i.e., it would be difficult to justify a pricing plan which increased social losses more than it increased producer income.

No condemnation is offered for using price as a means of improving social welfare; however, the resource allocation problems inherent in such a plan are evident. The whole welfare criterion rests on the assumption that society wishes to maximize welfare from available resources. This study was conducted under the assumption that the only solution to the resource allocation problem "...lies in utilizing the price mechanism...."[23]

EMPIRICAL MEASUREMENT BY ECONOMIC MODELS

Preceding pages present all of the essential theoretical concepts needed to measure the increases in revenue to producers and the net social cost to society consequent of any given pricing plan.[24] The purpose of this section is to reduce these concepts to more precise mathematical relationships. The reader may turn to Tables 8 and 17 to compare the estimated results of various pricing plans.

Model I is adapted to an analysis of actual historical data. Only the slope of the supply function is estimated.

Model II is adapted to an analysis of a simulated price. It is assumed that the values of all variables except those considered in the Model would have remained constant had the simulated price actually been used. The slopes of both the supply and demand curves were estimated.

Definitions and Relationships of Model I

Model I—Definitions

i = year, j = month

Q^f_{ij} = Quantity of Class I milk demanded at the prevailing price

Q^t_{ij} = Total Grade A milk supplied

Q^n_{ij} = Total Grade A milk needed

Q^g_{ij} = Necessary surplus of Grade A milk (.20 x Q^f_{ij})

Q^l_{ij} = Unnecessary surplus of Grade A milk

Q^s_{ij} = Grade A milk sold in the manufacturing market

P_{ij} = Producer price of Class I milk

P^b_{ij} = Producer blend price of Grade A milk

P^m_{ij} = Producer price of manufacturing milk

S_{ij} = Net social cost

s = Slope of the supply function

23. Lerner, *op. cit.*, p. 62.

24. A more complete treatment is presented in a thesis by Ralph Kenneth De Haven, "Economic Evaluation of Alternative Milk Pricing Plans" which is available from University Microfilms Inc., 313 North First Street, Ann Arbor, Mich.

Model I—Relationships

$Q^f_{ij} = f(P_{ij})$

$Q^s_{ij} = Q^t_{ij} - Q^f_{ij}$

$Q^g_{ij} = .20(Q^f_{ij})$

$Q^n_{ij} = Q^f_{ij} + Q^g_{ij}$

$Q^l_{ij} = Q^t_{ij} - Q^f_{ij} - Q^g_{ij}$

P_{ij} = Exogenous variable determined authoritatively

$$P^b_{ij} = \frac{P_{ij}\,(Q^f_{ij}) + P^m_{ij}\,(Q^s_{ij})}{Q^t_{ij}}$$

$$\text{(A)}\ S_{ij} = \frac{P^b_{ij} + P^b_{ij} - s(Q^l_{ij})}{2}\,(Q^l_{ij}) - P^m_{ij}\,(Q^l_{ij}),$$

$$\text{where } P^b_{ij} - s(Q^l_{ij}) \geq P^m_{ij}$$

$$\text{(B)}\ S_{ij} = \frac{(P^b_{ij} - P^m_{ij})}{2}\,\frac{(P^b_{ij} - P^m_{ij})}{s},$$

$$\text{where } \frac{P^b_{ij} - P^m_{ij}}{s} < Q^l_{ij}$$

Both Model I-A and Model I-B are illustrated graphically in Figure 3 and Figure 4 respectively. Model I-A is relevant when the supply curve is above the manufacturing milk demand function for all quantities Q^n_{ij} or greater. Model I-B is relevant when the supply curve is below the manufacturing milk demand curve for some portion of supply greater than Q^n_{ij}.

Estimated Supply Function

In Model I, all values are determined directly from historical data except the slope of the supply function(s). This function is of paramount importance since the magnitude of social costs are largely dependent upon its value.

A great deal of recent work has been directed toward estimating supply functions for milk. No doubt, some of these estimates are more applicable to certain markets than others. This is a question to be determined on an individual market basis. In this study the work of K. G. Cowling and C. B. Baker was used.

Their work is based on a polyperiod linear programming model.[25] The model covers three short-run periods of three years each. This approach seems advantageous in that more than one short run period is considered and supply

25. Keith G. Cowling and C. B. Baker, "A Polyperiod Model for Estimating the Supply of Milk," *Agricultural Economics Research*, XV, January, 1963, 15-23.

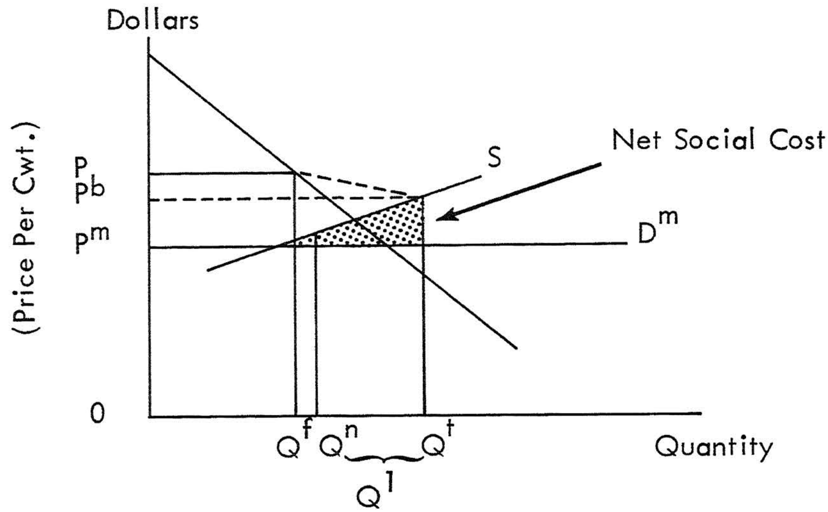

Figure 3. A graphical illustration of the mathematical relationships of Model I-A.

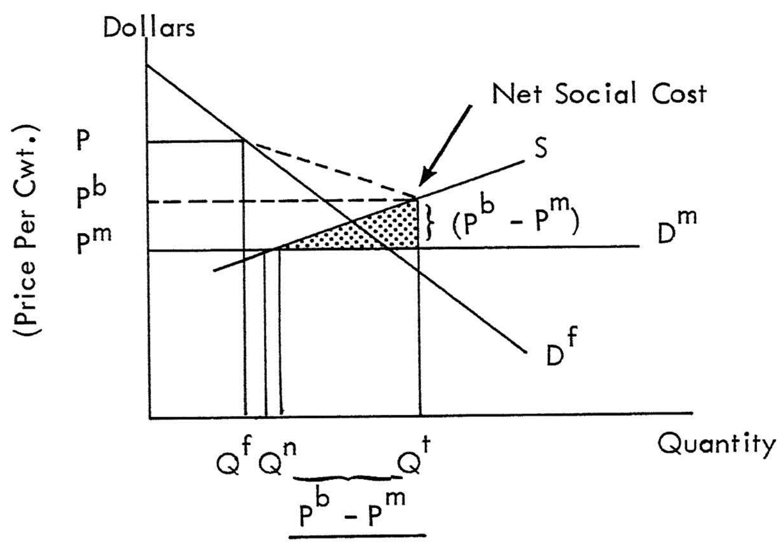

Figure 4. A graphical illustration of the mathematical relationships of Model I-B.

elasticities are estimated at various prices. The results, as shown in Table 1, would be more desirable if the elasticities between periods at a given price were less variable. However, there are no erratic movements in elasticities from price when a mean of the three periods is used.

TABLE 1--SHORT-RUN ELASTICITIES OF MILK SUPPLY WITH RESPECT TO MILK PRICE[a]

Price of Milk	Period 1	Period 2	Period 3
$2.70	.00	1.15	.51
3.50	.35	.28	1.22
3.90	.44	.05	.67
4.30	.00	.00	.00

[a]Cowling and Baker, op. cit.

From these three short run periods a mean elasticity was computed for each price, e.g., at price $2.70 the mean of the three periods is .553. Using these mean elasticities a supply curve was derived for the Ozarks market and is shown by the dashed curve in Figure 5.

To derive this curve, a five year average price and quantity were computed as a starting point; using relevant elasticities, points on the curve were then extended in each direction.[26]

A linear curve was subsequently fitted by least squares. This is shown by the solid curve in Figure 5. Converting the function to a linear relationship was done only in order to simplify the measurement of the area under the curve. If the calculus is used, no such procedure is necessary. It is assumed in the present model that the slope of the supply function remains constant although the position of the curve varies from month to month.[27]

The blend price and the total quantity of Grade A milk supplied in a given market are ascertainable from historical data. The equation of price and quantity must, then, establish one point on the supply curve. By the same method the relevant point on the demand curve for fluid milk can be found.

The assumptions stated in the section "The Measurement of Net Social Losses" apply to all models set forth here.

Empirical Application of Model I

Table 2 presents the total pounds of milk actually used in Class I sales in the Ozarks market during the period shown. Based on a "necessary surplus" of 20 percent of total Class I sales, Table 3 presents the total amount of Grade A milk needed. The total quantity of Grade A milk supplied in the Ozarks market

26. It is recognized that some discrepancy occurs by assuming that elasticities remain constant when moving in opposite directions on the supply curve; however, since any curve is at best only an estimate no correction was made for this factor.

27. In the linear equation, $Y = a + bX$, $b = .389\ (10)^{-6}$.

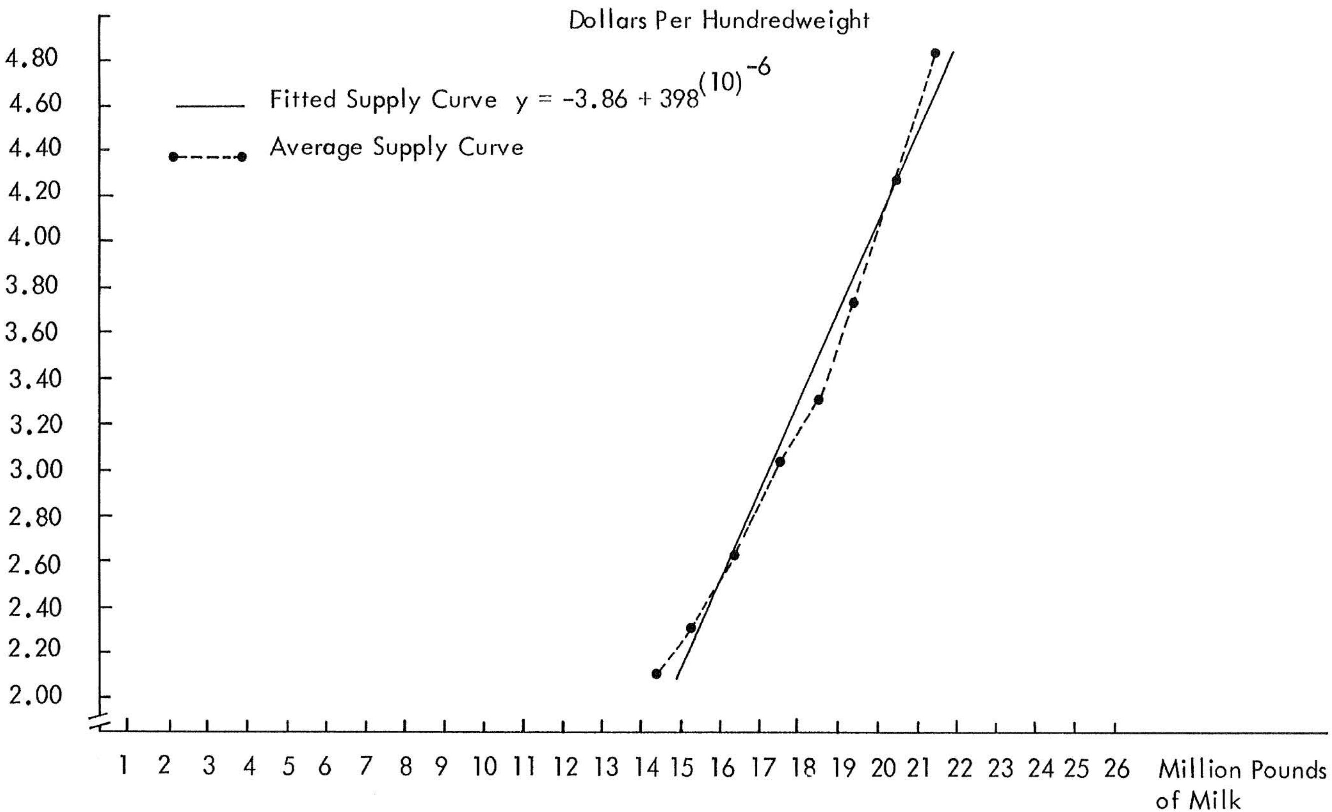

FIGURE 5. Derived average supply curve and fitted supply curve for Grade A milk in the Ozarks market.

is shown in Table 4. Any milk produced in excess of that actually used in Class I sales plus a necessary surplus is unnecessary surplus and the quantity is shown in Table 5. Tables 6 and 7 show blend prices and manufacturing prices respectively. All tables cover the four-year period, 1961 to 1964.

As previously stated, a linear supply function was assumed where $s = .398(10)^{-6}$. Social cost equations (A) or (B) were used throughout the study.[28] To illustrate the use of these two equations, the computations for January and March, 1961, are shown in the application of Model I-A and Model I-B respectively.

Values of variables for January, 1961, (Model I-A):

$Q^f_{ij} = 11{,}450{,}000$

$Q^n_{ij} = 13{,}740{,}000$

$Q^l_{ij} = 72{,}000$

$P^b_{ij} = \$4.25$

$P^m_{ij} = \$3.28$

$s = .398^{(10)^{-6}}$

Social cost for January 1961:

$$\text{(A)} \quad S_{ij} = \frac{P^b_{ij} + P^b_{ij} - s(Q^l_{ij})}{2} (Q^l_{ij} - P^m_{ij} \; Q^l_{ij})$$

$$\text{where } P^b_{ij} - s(Q^l_{ij}) \geq P^m_{ij}$$

$$= \frac{4.25 + (4.25 - .03)}{2} 720 - 3.28 \; (720)$$

$$= \$687.60$$

$$\text{where } 4.22 > 3.28$$

Values of variables for March, 1961, (Model I-B):

$Q^f_{ij} = 11{,}701{,}000$

$Q^n_{ij} = 14{,}041{,}000$

$Q^l_{ij} = 2{,}912{,}000$

$P^b_{ij} = \$3.72$

$P^m_{ij} = \$2.96$

$s = .398^{(10)^{-6}}$

28. Equations A and B are developed in the explanation of Model I.

Social cost for March, 1961:

$$\text{(B)} \quad S_{ij} = \frac{(P^b_{ij} - P^m_{ij})}{2} \; \frac{(P^b_{ij} - P^m_{ij})}{s}$$

$$\text{where } \frac{P^b_{ij} - P^m_{ij}}{s} < Q^l_{ij}$$

$$= \frac{(3.72 - 2.96)}{2} \; \frac{(3.72 - 2.96)}{.398^{(10)^{-6}}}$$

$$= \$7{,}256.10$$

where 1,909,500 < 2,912,000

The appropriate one of the two formulae illustrated here was used to evaluate each market period (the market period is one month) over the four-year period, 1961-1964, in the Ozarks market. The net social costs in each market period are shown in Table 8.

The total net social cost of the present pricing plan was $247,981 for the period, 1961-1964. This figure can, of course, be changed substantially by varying the estimated slope of the supply function. It was felt, however, after a careful consideration of several elasticity studies, that the above estimate can be taken as an intermediate figure.

The total net social cost arrived here ($247,981) is of importance as a point of reference when any alternative pricing plan is considered. It would be difficult to justify a pricing plan which increased net social costs by an amount greater than the expected gains to the producer.

TABLE 2--TOTAL SALES OF CLASS I MILK IN OZARKS MARKET, 1961-1964[a] (1,000 Pounds)

	1961	1962	1963	1964
January	11,450	13,405	14,510	14,855
February	10,571	12,245	13,503	13,877
March	11,701	14,094	15,128	15,229
April	11,155	12,828	13,956	15,453
May	10,773	11,844	13,858	14,631
June	10,371	11,574	13,635	14,609
July	12,353	12,950	14,425	14,755
August	12,758	13,112	15,565	16,358
September	13,277	13,015	15,930	16,927
October	13,383	14,300	16,514	18,122
November	13,023	13,014	14,776	16,583
December	12,878	12,913	14,035	16,329

[a]United States Department of Agriculture, Federal Milk Order Statistics, Annual Summaries for 1961, 1962, 1963 and 1964 (Washington: Government Printing Office).

TABLE 3--TOTAL CLASS I SALES PLUS NECESSARY SURPLUS IN OZARKS MARKET, 1961-1964[a] (1,000 Pounds)

	1961	1962	1963	1964
January	13,740	16,086	17,412	17,826
February	12,685	14,694	16,203	16,652
March	14,041	16,912	18,153	18,274
April	13,385	15,393	16,747	18,543
May	12,927	14,212	16,629	17,557
June	12,445	13,888	16,362	17,530
July	14,823	15,540	17,310	17,706
August	15,310	15,734	18,678	19,629
September	15,932	15,618	19,116	20,312
October	16,059	17,160	19,816	21,746
November	15,627	15,616	17,731	19,899
December	15,453	15,495	16,842	19,594

[a] Ibid.

TABLE 4--TOTAL GRADE A MILK SUPPLIED IN OZARKS MARKET, 1961-1964[a] (1,000 Pounds)

	1961	1962	1963	1964
January	13,812	17,984	18,032	19,343
February	13,589	17,670	16,681	18,997
March	16,953	20,257	19,721	21,336
April	18,851	23,022	23,425	22,664
May	21,720	25,699	25,853	26,683
June	20,572	24,040	23,702	25,193
July	20,488	23,803	23,436	24,656
August	20,550	20,975	21,074	21,499
September	18,740	18,721	18,590	20,793
October	20,124	20,146	17,940	20,096
November	18,213	18,639	17,114	19,090
December	18,119	18,549	17,943	20,306

[a] United States Department of Agriculture, Federal Milk Order Statistics, Annual Summaries for 1961, 1962, 1963 and 1964 (Washington: Government Printing Office).

Total revenue from the sale of Grade A milk in the Ozarks market during 1961-1964 was $36,810,315.[29]

Neither the estimate of net social cost nor the estimate of total revenue is of any inherent value. However, by establishing these estimates the burden of proof for any alternative pricing plan consists of demonstrating more favorable results under identical economic conditions.

The Dairy Marketing Advisory Committee estimated prices that would have

29. Total revenue was calculated by multiplying blend prices by total quantity.

arisen under various pricing plans.[30] These simulated prices were calculated by applying historical values of selected economic "movers." Of the various alternative plans considered one was subsequently recommended.[31] Since this particular pricing plan seemed most promising to the Advisory Committee, the prices simulated by this formula for the period, 1961-1964, were selected for analysis. Social losses and producer gains consequent of this pricing plan were calculated by the methods illustrated in Model II.

TABLE 5--TOTAL UNNECESSARY SURPLUS IN OZARKS MARKET, 1961-1964[a] (1,000 Pounds)

	1961	1962	1963	1964
January	72	1,898	602	1,517
February	904	2,478	538	403
March	2,912	2,852	1,568	3,062
April	5,465	7,629	6,678	4,121
May	8,793	11,487	9,224	9,126
June	8,127	10,152	7,340	7,663
July	5,665	8,263	6,126	6,950
August	5,241	5,241	2,396	1,870
September	2,929	3,103	0	465
October	4,065	2,986	0	0
November	2,630	2,633	0	0
December	2,666	3,054	1,101	712

[a]Ibid.

TABLE 6--BLEND PRICES FOR GRADE A MILK SOLD IN OZARKS MARKET, 1961-1964[a]

	1961	1962	1963	1964
January	$4.25	$3.93	$3.83	$4.01
February	4.15	3.86	3.83	3.97
March	3.72	3.71	3.59	3.73
April	3.60	3.38	3.38	3.52
May	3.48	3.19	3.32	3.33
June	3.46	3.20	3.37	3.36
July	3.59	3.32	3.48	3.41
August	3.89	3.67	3.91	3.97
September	4.01	3.78	4.10	4.07
October	4.14	3.98	4.36	4.53
November	4.22	4.00	4.40	4.49
December	4.07	3.90	4.20	4.20

[a]United States Department of Agriculture, Federal Milk Order Statistics, Annual Summaries for 1961, 1962, 1963 and 1964 (Washington: Government Printing Office).

30. *An Evaluation of the Level and Alignment of Federal Order Milk Prices for the Areas of Associated Dairymen as of 1965*, A Report of the Dairy Marketing Advisory Committee, (Kansas City: Associated Dairymen Inc., 1965).

31. *Ibid.*, Appendix IV, pp. 113-154.

TABLE 7--MANUFACTURING PRICES FOR MILK SOLD IN OZARKS MARKET, 1961-1964[a]

	1961	1962	1963	1964
January	$3.28	$3.22	$3.02	$3.05
February	3.12	3.22	3.02	3.05
March	2.96	3.13	2.87	2.88
April	3.10	2.94	2.87	2.87
May	3.09	2.87	2.87	2.87
June	3.09	2.87	2.87	2.88
July	3.09	2.87	2.87	2.88
August	3.21	2.98	3.03	3.12
September	3.21	3.00	3.12	3.19
October	3.21	2.99	3.06	3.16
November	3.21	3.01	3.05	3.23
December	3.22	3.02	3.05	3.10

[a] Ibid.

TABLE 8--SOCIAL COSTS OF PRESENT PRICING SYSTEM IN OZARKS MARKET, 1961-1964

	1961	1962	1963	1964
January	$ 688	$ 6,333	$ 4,154	$10,012
February	7,684	5,146	4,062	3,385
March	7,256	4,226	6,429	9,077
April	3,140	2,432	3,267	5,307
May	1,911	1,287	2,543	2,658
June	1,720	1,368	3,141	2,894
July	3,141	2,543	4,674	3,528
August	5,809	5,980	9,728	8,976
September	8,040	7,642	0	3,627
October	10,862	12,312	0	0
November	12,812	12,312	0	0
December	9,073	9,728	10,239	6,835

Definitions and Relationships of Model II

Model II—Definitions. Model II retains the same notational definitions of Model I. The following definitions are additional.

Q^F_{ij} = The estimated quantity of Class I milk utilized under simulated price.

Q^T_{ij} = Total Grade A milk supplied under simulated price.

Q^G_{ij} = Necessary surplus of Grade A milk Under simulated conditions.

Q^N_{ij} = Total milk needed under simulated conditions.

Q^L_{ij} = Unnecessary surplus under simulated conditions.

Q^S_{ij} = Grade A milk sold in manufacturing market under simulated conditions.

P^{I}_{ij} = Simulated Class I price.
P^{B}_{ij} = Simulated blend price.
S^{I}_{ij} = Simulated net social cost.
d = Slope of demand curve.

Model II—Relationships

$$Q^{F}_{ij} = Q^{f} + \frac{(P^{I}_{ij} - P_{ij})}{d}$$

$$Q^{G}_{ij} = Q^{F}_{ij} \times .20$$

$$Q^{N}_{ij} = Q^{F}_{ij} + Q^{G}_{ij}$$

$$Q^{L}_{ij} = Q^{T}_{ij} - Q^{N}_{ij}$$

P^{I}_{ij} = Exogenous variable determined by economic formula.

$$Q^{S}_{ij} = Q^{T}_{ij} - Q^{F}_{ij}$$

$$Q^{T}_{ij} = Q^{t}_{ij} + \frac{(P^{B}_{ij} - P^{b}_{ij})}{s}$$

$$P^{B}_{ij} = \frac{P^{I}_{ij}\,(Q^{F}_{ij}) + P^{m}_{ij}\,(Q^{S}_{ij})}{Q^{t}_{ij}}$$

$$\text{(A)}\quad S_{ij} = \frac{P^{B}_{ij} + P^{B}_{ij} - s(Q^{L}_{ij})}{2}\,(Q^{L}_{ij}) - P^{m}_{ij}\,(Q^{L}_{ij})$$

where $P^{B}_{ij} - s\,(Q^{L}_{ij}) \geq P^{m}_{ij}$

$$\text{(B)}\quad S_{ij} = \frac{(P^{B}_{ij} - P^{m}_{ij})}{2}\;\frac{(P^{B}_{ij} - P^{m}_{ij})}{s}$$

where $\frac{P^{B}_{ij} - P^{m}_{ij}}{s} < Q^{L}_{ij}$

Estimated Demand Function

Since the simulated price of Class I milk is to be varied from actual price under economic formula pricing, movements on the demand curve must be taken into consideration. In Model I the point which defined quantity and price on the demand curve was the only point of interest. Under the simulated price, interest centers on the difference between the equation of actual Class I price and quantity and estimated price and quantity under simulated conditions. It is necessary to estimate the demand function.

Anthony S. Rojko, using multiple regression analysis, estimated the elasticity of demand for fluid milk to be –.41 when both farm and nonfarm per capita consumption were considered.[32] Rojko cites seven other studies where elasticities of demand range from –.06 to –.48.[33] Rojko's estimate is based on national demand and thus seems more applicable in general when estimates for the market in question have not been made. This is the case in the Ozarks market, and Rojko's estimated elasticity of demand was selected.

The slope of the demand curve was derived from the elasticity of demand as follows:

$$\text{Elasticity} = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}$$

$$\text{Slope} = \frac{\Delta P}{\Delta Q}$$

$$\therefore \frac{\Delta Q}{\Delta P} \times \frac{P}{Q} = -.41$$

$$-.41 \frac{\Delta P}{\Delta Q} = \frac{P}{Q}$$

$$\frac{\Delta P}{\Delta Q} = -\frac{1}{.41} \times \frac{P}{Q}$$

$$= \frac{1}{-.41} \times \frac{4.11}{13{,}293{,}000} = \frac{4.11}{-5{,}450{,}000}$$ [34]

$$= -.754(10)^{-6}$$

The slope of the demand function, like the slope of the supply function, is assumed to remain constant. Only the position of the curve varies.

Analysis of Simulated Data

The simulation of a price from the historical values of selected variables is not without some limitation in degree of accuracy. However, the methods used by the Dairy Marketing Advisory Committee seem to minimize the possible error in that the three "movers" used in the formula are not greatly influenced by the price of milk.

32. Anthony S. Rojko, *The Demand and Price Structure for Dairy Products*, U.S.D.A. Technical Bulletin 1168 (Washington: Government Printing Office, 1957), p. 105.

33. *Ibid.*, p. 109.

34. $4.11 = four-year average Class I price.
13,293,000 = four-year average Class I quantity.

For purposes of this analysis, it was assumed that all variables remain constant except the quantity of Grade A milk supplied when the price of Class I milk is varied.

Table 9 shows the estimated price of Class I milk in the Ozarks market during the period, 1961-1964, under economic formula pricing as recommended by the Dairy Marketing Advisory Committee. The prices shown in the table were calculated by subtracting 27 cents per hundred pounds from the simulated St. Louis prices for the same period. This is the present system of pricing in the Ozarks market; thus, no new price alignment is assumed.[35]

TABLE 9--ESTIMATED CLASS I MILK PRICES DETERMINED BY ECONOMIC FORMULA FOR THE OZARKS MARKET, 1961-1964

	1961	1962	1963	1964
January	$4.16	$4.17	$4.27	$4.35
February	4.16	4.22	4.27	4.36
March	4.16	4.22	4.25	4.35
April	4.14	4.20	4.26	4.36
May	4.12	4.20	4.26	4.36
June	4.10	4.19	4.28	4.35
July	4.12	4.23	4.31	4.39
August	4.14	4.25	4.31	4.39
September	4.16	4.27	4.31	4.41
October	4.16	4.27	4.34	4.43
November	4.16	4.26	4.34	4.42
December	4.17	4.26	4.32	4.42

Table 10 is merely the difference in price when actual price is subtracted from simulated price in the Ozarks market. Under the assumption that the slope of the demand function is $-.754\ (10)^{-6}$, Table 10 provided the basis for establishing estimated Class I sales under the simulated price. Such calculation for January 1961 is shown.

$$Q^F_{ij} = Q^f_{ij} + \frac{(P^I_{ij} - P_{ij})}{d}$$

$$= 11{,}450{,}000 + \frac{-.25}{-.000000754}$$

$$= 11{,}781{,}000$$

Table 11 shows the Q^F_{ij} values that have been calculated monthly as illustrated above. Q^N_{ij} values are shown in Table 12.

35. The Ozarks market is the one exception in the north to south price alignment pattern in fluid milk pricing. Ozarks price = St. Louis price minus transportation.

TABLE 10--DEVIATION OF FORMULA PRICES FROM ACTUAL CLASS I PRICES FOR THE OZARKS MARKET, 1961-1964

	1961	1962	1963	1964
January	$-.25	$+.01	$+.25	$+.06
February	+.01	+.11	+.26	+.06
March	+.13	+.30	+.44	+.30
April	+.07	+.33	+.38	+.41
May	+.07	+.43	+.41	+.49
June	+.13	+.46	+.41	+.49
July	+.07	+.37	+.32	+.43
August	-.14	+.17	+.11	+.18
September	-.14	+.18	+.08	+.15
October	-.24	+.12	+.09	-.05
November	-.23	+.10	-.03	+.05
December	-.01	+.25	+.05	+.15

TABLE 11--ESTIMATED CLASS I SALES IN OZARKS MARKET UNDER ECONOMIC FORMULA PRICING, 1961-1964
(1000 Pounds)

	1961	1962	1963	1964
January	11,781	13,392	14,179	14,776
February	10,876	12,100	13,159	13,798
March	11,529	13,697	14,545	14,832
April	11,063	12,391	13,453	14,910
May	10,681	11,274	13,355	13,968
June	10,199	10,964	13,092	13,960
July	12,261	12,460	14,001	14,185
August	12,943	12,887	15,420	16,120
September	13,462	12,803	15,824	16,729
October	13,701	14,141	16,395	18,188
November	13,328	12,882	14,815	16,472
December	12,891	12,582	13,969	16,131

Table 13 shows simulated blend prices and were calculated as follows. Calculation of the blend price for January, 1961, is illustrated.

$$P^{B}_{ij} = \frac{P^{l}_{ij}\,(Q^{F}_{ij}) + P^{m}_{ij}\,(Q^{S}_{ij})}{Q^{t}_{ij}}$$

$$= \frac{4.16\ (117{,}810) + 3.28\ (20{,}310)}{138{,}120} = 4.03$$

It should be noted that this method of blend price calculation is biased. Where values $Q^{t}_{ij} > Q^{T}_{ij}$ the bias is negative. For values $Q^{t}_{ij} < Q^{T}_{ij}$ the bias is positive. (It was implicitly assumed that $Q^t = Q^T$ in solving for Q^S.) This bias could be eliminated by determining Q_{ij}^T and P_{ij}^B via simultaneous equations. However, the calculation would be tedious and little if anything would be gained in accuracy when net social costs are aggregated since the plus and minus figures tend to cancel.

TABLE 12--ESTIMATED CLASS I SALES PLUS ESTIMATED NECESSARY SURPLUS IN OZARKS MARKET UNDER ECONOMIC FORMULA PRICING, 1961-1964 (1000 Pounds)

	1961	1962	1963	1964
January	14,534	16,070	17,014	17,731
February	13,051	14,520	15,790	16,557
March	13,845	16,436	17,454	17,798
April	13,275	14,869	16,143	17,892
May	12,817	13,528	16,026	16,761
June	12,238	13,156	15,710	16,752
July	14,713	14,952	16,801	17,022
August	15,531	15,464	18,504	19,344
September	16,154	15,363	18,988	20,074
October	16,441	16,969	19,674	21,825
November	15,993	15,458	17,778	19,766
December	15,469	15,098	16,762	19,357

TABLE 13--ESTIMATED BLEND PRICES FOR GRADE A MILK IN OZARKS MARKET UNDER ECONOMIC FORMULA PRICING, 1961-1964

	1961	1962	1963	1964
January	$4.03	$3.93	$4.01	$4.04
February	3.95	3.90	4.00	4.00
March	3.93	3.86	3.89	3.83
April	3.71	3.62	3.67	3.85
May	3.60	3.45	3.59	3.64
June	3.59	3.47	3.64	3.69
July	3.70	3.58	3.73	3.74
August	3.79	3.75	3.96	4.07
September	3.89	3.84	4.10	4.17
October	3.84	3.89	4.23	4.31
November	3.90	3.87	4.17	4.26
December	3.90	3.86	4.04	4.15

Table 14 shows the difference in the actual blend price and the simulated blend price ($P_{ij}^B - P_{ij}^b$).

The slope of the supply function is assumed to be $.398\ (10)^{-6}$ as in Model I. The total quantity supplied under simulated prices is shown in Table 15. Calculation of Q_{ij}^T for January 1961 is illustrated.

$$Q_{ij} = {}^{T}Q_{ij} + {}^{t}\frac{(P^{B}_{ij} - P^{b}_{ij})}{s}$$

$$= 13{,}812{,}000 + \frac{4.03 - 4.25}{.398(10)^{-6}}$$

$$= 13{,}260{,}000$$

Simulated net social costs for January, 1961, were:

(A)

$$S_{ij} = \frac{P^{B}_{ij} + P^{B}_{ij} - s\,(Q^{L}_{ij})}{2} Q^{L}_{ij} - P^{m}_{ij}\,(Q^{L}_{ij})$$

$$Q^{L}_{ij} = 0$$

$$\therefore S_{ij} = 0$$

TABLE 14--ESTIMATED DEVIATION OF BLEND PRICES IN OZARKS MARKET UNDER ECONOMIC FORMULA PRICING FROM ACTUAL BLEND PRICES, 1961-1964

	1961	1962	1963	1964
January	$-.22	$ 0	$+.18	$+.03
February	-.20	+.04	+.17	+.03
March	+.21	+.15	+.30	+.10
April	+.11	+.24	+.29	+.33
May	+.12	+.26	+.21	+.31
June	+.13	+.27	+.27	+.33
July	+.11	+.26	+.25	+.33
August	-.10	+.08	+.04	+.11
September	-.12	+.06	0	+.10
October	-.30	-.09	-.13	-.22
November	-.32	-.13	-.23	-.23
December	-.17	-.04	-.16	-.05

Simulated unnecessary surpluses are shown in Table 16 and net social costs are recorded in Table 17.

Total net social costs of the "recommended" pricing plan were $321,423. Estimated total revenue to producers was $37,771,582.

Additional Problems of Defining and Measuring Social Costs

Social costs, in the strictest sense of the term, have not been fully measured by the preceding analyses. The analyses are accurate when social costs are defined as the opportunity costs of the resources used in the production of Grade A milk which is actually used in the manufacturing milk market. This is the definition assumed, however, there are other social costs which are not included in this definition.

TABLE 15--ESTIMATED TOTAL QUANTITY OF GRADE A MILK SUPPLIED IN OZARKS MARKET UNDER ECONOMIC FORMULA PRICING, 1961-1964 (1000 Pounds)

	1961	1962	1963	1964
January	13,260	17,984	18,484	19,418
February	13,087	17,770	17,108	19,072
March	17,480	20,633	20,474	21,587
April	19,127	23,625	24,153	23,493
May	22,021	26,352	26,380	27,461
June	20,898	24,718	24,380	26,022
July	20,764	24,456	24,064	25,485
August	20,299	21,176	21,174	21,775
September	18,439	18,871	18,590	21,044
October	19,371	19,920	17,614	19,493
November	17,409	18,313	16,537	18,513
December	17,692	18,449	17,541	20,181

TABLE 16--ESTIMATED TOTAL UNNECESSARY SURPLUS UNDER SIMULATED PRICING PLAN IN OZARKS MARKET, 1961-1964 (1000 Pounds)

	1961	1962	1963	1964
January	0	1,914	1,470	1,687
February	24	3,250	1,318	2,861
March	3,646	4,197	3,020	3,789
April	5,852	8,756	8,010	5,601
May	9,204	12,824	10,354	10,700
June	8,660	11,562	8,670	9,270
July	6,051	9,504	7,263	8,463
August	4,768	5,712	2,670	2,431
September	2,285	3,508	0	970
October	2,930	2,951	0	0
November	1,416	2,855	0	0
December	2,223	3,351	779	824

These additional social costs arise from the restriction of the quantity of fluid milk demanded when Class I price is fixed above the market price as defined by the equation of supply and demand for fluid milk. It must be stressed that the social costs represented by the area to the left of the interesction and between the supply and demand curves, does *not arise entirely because the price is fixed above supply-demand equilibrium.* Some of the social costs represented by this are arise from the monopolistic elements within the market. If Class I prices were fixed at precisely the same level as would prevail in a purely competitive market, the quantity taken would be less than the equilibrium quantity under pure competition. This is true because the demand curve faced by the firm in milk distribution is downward sloping.

Some states have enacted pricing plans which presumably reduce the social costs arising from these monopoly elements. For example, in California both producer and consumer milk prices are controlled by the state. The distributors have a fixed margin on which to work. With the return per unit fixed, distributors maximize profits by selling more units—not by restricting the number of units sold and increasing price.

TABLE 17--ESTIMATED SOCIAL COSTS OF SIMULATED PRICING PLAN IN OZARKS MARKET, 1961-1964

	1961	1962	1963	1964
January	$ 0	$ 6,726	$10,290	$13,496
February	200	7,722	9,490	11,214
March	11,697	5,869	13,066	11,215
April	4,596	5,807	8,040	13,264
May	3,203	4,226	6,512	7,350
June	3,140	4,521	7,350	8,446
July	4,596	7,132	9,293	9,396
August	4,226	7,349	10,980	10,034
September	5,808	8,862	0	7,662
October	4,907	10,175	0	0
November	5,806	9,228	0	0
December	5,807	8,862	6,466	7,333

Summary

The net social cost for the four-year period, 1961-1964, under the present pricing system for Class I milk was $247,981. This figure is exceeded by $73,442 under the simulated conditions of the alternative economic formula pricing system. If a criterion of minimum net social losses were adopted, the present pricing system would seem more attractive.

However, $73,442 over a four-year period in a market that had sales of $36,810,315 during the same period is not a highly significant figure. Total revenue under the simulated conditions was $37,771,582 for the same period. The net increase in total revenue in favor of the economic formula type pricing was $961,267.

The question to be answered by policy makers is whether the gains or losses are more important.

This is not a case where a cost to society of roughly $75,000 returns roughly $1,000,000 to the dairy farmers in the Ozarks market over a four-year period. All of society, the dairy farmer included, suffers an additional $75,000 loss through the misallocation of resources under the original assumptions of the study. Dairy farmers, however, gain roughly $1,000,000.[36] This gain does

36. Note this is not net return (income) to farmers. It is a gross return figure. Additional costs related to the increased production must be subtracted to arrive at net return. If the factor market is assumed competitive, farmer costs would equal $q_2S(q_2)$ in Figure 2. If farmers could act as monopsonists, the cost would be O ^{q_2} S (x) dx.

not in any way arise from a multiplier effect; rather, it has two components. One is a transfer payment—the difference between blend and Class II price times the surplus quantity. The other represents the manufacturing value of the surplus milk produced in response to the higher Class I price.

A strong argument for a pricing system which yields higher milk prices can theoretically be built on the very realistic assumption that per capita farm income is lower than per capita income of non-farmers. Total welfare is increased by transfer payments to farmers since the marginal utility of money is higher in the farm segment of the economy. It must be remembered that these are transfer payments to the dairy *industry*. Since all farmers do not produce identical quantities of milk, there is an income distribution problem within the industry. Farmers with the smallest productive capacity, and consequently the lowest income, benefit least from the transfer payments.

The rebuttal to the argument in favor of transfer payments via the pricing system is that if such action is necessary, there is a welfare problem and not a pricing problem.

PROJECTED SUPPLY-DEMAND RELATIONSHIPS

Analysis in the preceding section centered on supply-demand relationships as historical facts and estimated supply-demand relationships that would have existed under economic formula pricing. The purpose in either case was to select the pricing system which appeared within bounds of statistical practicability to be best suited to future needs.

This section is devoted to projection of supply-demand relationships. Results derived by the application of Models I and II were projected by simple extrapolation. Model III was derived for the purpose of projecting supply-demand relationships. Model III consists of a recursive supply equation with a trend factor and a Class I demand equation. The two equations are used simultaneously.

Derivation of Supply Equation

Several researchers have derived annual supply equations for milk. Such equations leave much to be desired when evaluating month to month supply-demand relationships. If milk production had less seasonal fluctuation, an annual supply equation could be readily adapted.

To overcome this difficulty, a supply function was derived for each month of the year using zero-one (or dummy) variables in multiple regression equations.

Ten years of monthly time series data were divided by month into 12 mutually exclusive classes. For any single month the supply equation is postulated to be of the general linear form

$$Q_{tj} = \alpha_j + B_1X_{1tj} + B_2X_{2tj} + B_3X_{3tj} + B_4X_{4tj} + e_{tj}$$
$$j = 1, 2, 3, \ldots, 12, t = 1, 2, 3, \ldots, 10.$$

The variables were defined as follows:

α_j = the constant term specific to the jth month.

X_{1tj} = total quantity of milk supplied in previous month, i.e., $X_{1tj} = {}_{t,j-1}$ for $_j = 2, 3, 4, \ldots, 12$ and $X_{1t1} = Q_{t-1,\ 12}$

X_{2tj} = 12-month moving average price lagged one month, i.e.,

$$X_{2tj} = \frac{1}{12} \sum_{i=1}^{j} P_{ti} + \sum_{i=j+1}^{12} P_{t-1,\ i},$$

where P_{ti} = price in year t, month i.

X_{3tj} = index of prices paid by farmers in year t, month j (1958 = 100).

X_{4tj} = index of all meat animal prices in year t, month j, (1958 = 100).

e_{tj} = a random component or disturbance term with expectation zero.

Within the multiple regression model used to estimate the parameters of the above equation, a "dummy variable" is introduced for 11 of the 12 months so that for the j^{th} month the variable is assigned a value of unity, but zero for other months. The constant term of the regression is the estimated mean for the month not assigned a dummy variable and the coefficient on the dummy variable is added to the constant term to get the estimated mean for each respective month.[37]

Estimates of the α_j are:[38]

Months	α_j
1	-1719.0
2	-2436.9
3	656.0
4	515.0
5	1077.9
6	-3092.5
7	-1861.6
8	-3514.8
9	-4191.8
10	-2178.7
11	-3149.5
12	-1658.0

37. For a discussion of this method see William G. Tomek, "Using Zero-one Variables with Time Series Data in Regression Equations," *Journal of Farm Economics* LXV (May, 1965), pp. 814-822.

38. α_j = coefficient on dummy variable plus the constant term; therefore, no standard error was computed for this value.

Coefficients on the continuous variables of the equation are:

Variable	Coefficient	Standard Error
X_{1tj}	.968	.0279
X_{2tj}	702.0	776.5
X_{3tj}	.686	.4934
X_{4tj}	-3.92	7.4150

and the coefficient of multiple determination, R^2, was .96.

Since the index of prices paid by farmers is a cost factor, it should logically have a negative coefficient. However, it has a high positive correlation with time ($R^2 = .98$). The fact that production has increased over time, due to increasing returns to scale, etc., while the index of price paid by farmers has also risen, provides an intuitive reason that the coefficient is positive. Due to the extremely high correlation of the index with time, the index is equivalent to a trend variable.

The index of all meat animal prices is not easily projected. In this study, a least squares curve of the index correlated against time was extrapolated. The R^2 value was only .1. It is probable that the alternative of beef production is better than this model indicates since meat animal prices have increased sharply since 1964.

None of the 12 supply equations can be used independently since the quantity in the previous month and a 12-month moving average blend price in the previous month must be entered in the current equation.

Selection of Demand Equation

To derive the blend price it was necessary to use a demand equation. Rojko derived a fluid milk demand equation for the U. S.,

$$Q_f = -5.82 - 17.2\ P_f + .11\ Y,$$

where Q_f = per capita annual consumption of fluid milk.

P_f = retail price of fluid milk in cents per pound.

Y = per capita disposable income.[39]

This formula was used only as a means of checking the trends that had been previously established using least squares methods to fit regression curves to actual and estimated quantities of fluid milk demanded.

Ideally, monthly demand curves should be used in conjunction with monthly supply curves. Attempts to adapt the above annual equation to monthly equations were subject to the same problems as were discussed in connection with supply curves.

The seasonal variation gave no particular problem since consumption is relatively constant throughout the year. It was difficult to ascertain per capita

39. Anthony S. Rojko, *The Demand and Price Structure for Dairy Products,* United States Department of Agriculture (Washington: Government Printing Office, 1957), p. 104.

consumption of fluid milk within the market since dealers sell outside the marketing area.

Another problem arose in attempting to derive a population trend. The length of time between population estimates practically precludes any up-to-date estimate of population trends.

Historical values were used in the equation at different points in time, and the results were comparable with those derived in the previous chapter where quantity of fluid milk taken was estimated when price of the same was changed. This relationship is as it should be since the slope of the demand curve for fluid milk (as used in Models I and II) was taken from the study in which Rojko derived the above demand equation.

Since the results obtained by estimating the slope of the demand curve and calculating the quantity changes effected by a change in price closely paralleled the results calculated by the use of the demand equation, Class I utilization was projected from utilization data previously calculated. These values are shown in Table 20.

Class I prices as calculated by the Dairy Marketing Advisory Committee were projected by extrapolating a least squares trend. There are two methods which could have been used to project these prices. First, the values of the economic "movers" could be extrapolated and the values combined each month to determine the Class I price. The second method is to extrapolate the actual prices derived assuming economic formula pricing had been used in the past. The results were not much different under either method. The latter method was actually used since the calculations were much simpler. These results are shown in Table 19.

Empirical Application of Model III

Additional Definitions

t = year, j = month

Q_{tj} = total Grade A milk supplied in Ozarks market

X_{5tj} = total milk used in Class I sales in Ozarks market

X_{6tj} = total milk sold in the manufacturing market

X_{7tj} = price of Class I milk in Ozarks market

X_{8tj} = price of manufacturing milk in Ozarks market (for purposes of this analysis, the manufacturing price was held constant at $3.10 per hundred pounds)

X_{9tj} = blend price

Relationships

$$Q_{tj} = \alpha_j + .968(X_{1tj}) + 702(X_{2tj}) + .689\,(X_{3tj}) - 3.92(X_{4tj})$$

$$X_{6tj} = Q_{tj} - X_{5tj}$$

$$X_{9tj} = \frac{X_{5tj}\,(X_{7tj}) + X_{6tj}\,(X_{8tj})}{Q_{tj}}$$

X_{7tj} projected value taken directly from Table 19

X_{5tj} projected value taken directly from Table 20

Estimated monthly supply (Q_{tj}) is recorded in Table 18; estimated Class I price (assuming the introduction of economic formula pricing as of January 1965) is recorded in Table 19; estimated Class I sales (X_{5tj}) are recorded in Table 20; and estimated blend prices (X_{9tj}) are recorded in Table 21.

TABLE 18--ESTIMATED TOTAL SUPPLY OF GRADE A MILK IN THE OZARKS MARKET 1965-1968 ASSUMING ECONOMIC FORMULA PRICING (1,000 Pounds)

	1965	1966	1967	1968
January	19,043	19,415	20,744	22,126
February	20,707	18,941	20,312	21,685
March	23,013	21,609	23,007	24,517
April	25,113	24,042	25,451	26,956
May	26,991	26,947	20,367	29,850
June	25,345	25,574	26,994	28,466
July	25,017	25,494	26,917	28,369
August	23,070	23,771	25,190	26,630
September	20,545	21,446	22,862	24,287
October	20,160	21,234	22,646	24,055
November	18,871	20,066	21,468	22,866
December	19,159	20,443	21,835	23,215

TABLE 19--ESTIMATED CLASS I PRICES IN OZARKS MARKET 1965-1968 ASSUMING ECONOMIC FORMULA PRICING

	1965	1966	1967	1968
January	$4.69	$4.77	$4.85	$4.93
February	4.70	4.78	4.86	4.94
March	4.70	4.78	4.86	4.94
April	4.71	4.79	4.87	4.95
May	4.72	4.80	4.87	4.95
June	4.72	4.80	4.88	4.96
July	4.73	4.81	4.89	4.97
August	4.74	4.82	4.89	4.97
September	4.74	4.82	4.90	4.98
October	4.75	4.83	4.91	4.99
November	4.76	4.84	4.91	4.99
December	4.76	4.84	4.92	5.00

Projected Relationships

Extrapolated Trends. Given Model III, two different methods were provided for predicting future supplies of milk. Actual historical supplies and estimated supplies based on the historical data of some previous period were projected using least squares analysis and extrapolating the regression curve in time. The second method of projecting future supplies has been presented in Model III. In this case, certain variables were predicted by extrapolating a least squares regression curve in time for each variable. Quantities in any future period depended on the values of the projected variables plus the quantity and prices of immediately preceding periods. The latter is referred to as a recursive relationship, i.e., derived values for month j-1 become the basis for deriving a new set of values in month j.

Essentially, then, two very different methods were used to project future supplies of Grade A milk. The analysis now centers on the interpretation of results derived from each of these methods.

TABLE 20--ESTIMATED CLASS I UTILIZATION IN OZARKS MARKET, 1965-1968 (1000 Pounds)

	1965	1966	1967	1968
January	16,069	17,281	18,493	19,705
February	16,170	17,382	18,594	19,806
March	16,271	17,483	18,695	19,907
April	16,372	17,584	18,796	20,008
May	16,473	17,685	18,897	20,109
June	16,574	17,786	18,998	20,210
July	16,675	17,887	19,099	20,311
August	16,776	17,988	19,200	20,412
September	16,877	18,089	19,301	20,513
October	16,978	18,190	19,402	20,614
November	17,079	18,291	19,503	20,715
December	17,180	18,392	19,604	20,816

TABLE 21--ESTIMATED BLEND PRICES IN OZARKS MARKET 1965-1968 ASSUMING ECONOMIC FORMULA PRICING

	1965	1966	1967	1968
January	$4.44	$4.58	$4.66	$4.73
February	4.34	4.64	4.71	4.77
March	4.23	4.45	4.53	4.59
April	4.16	4.33	4.40	4.47
May	4.08	4.22	4.27	4.34
June	4.15	4.28	4.35	4.42
July	4.18	4.30	4.37	4.44
August	4.29	4.40	4.46	4.53
September	4.44	4.55	4.61	4.68
October	4.48	4.58	4.65	4.74
November	4.60	4.68	4.74	4.81
December	4.58	4.66	4.73	4.80

In Figure 6, the results shown by the solid lines are based on the simple extrapolation of actual (using present pricing system) and estimated trends. When actual conditions were projected in this manner, equilibrium is reached in June, 1968. (Twenty percent necessary surplus was added to actual quantities of milk demanded.) The equilibrium is shown graphically in Figure 6. An algebraic solution may also be used.

The equation of actual quantities of milk produced fitted by least squares against time is: $Y = 18{,}507 + 74X$. The equation of actual quantities of fluid milk demanded plus necessary surplus fitted by least squares against time is: $Y = 13{,}350 + 131.2X$. Thus, the equilibrium solution may be found by setting these equations equal and solving for X:

$$18{,}507 + 74X = 13{,}350 + 131.2X$$
$$57.2X = 5{,}157$$
$$X = 90.1 \text{ or } 90 \text{ months.}$$

Then 90 months from January 1, 1961, gives an equilibrium solution in June 1968.

The broken-line set of curves in Figure 6 represents the estimated supply and demand situation if economic formula pricing had been introduced in January, 1965. The equation of estimated quantities of milk that would have been produced 1961-1963, under economic formula pricing, fitted by least squares against time is $Y = 18{,}495 + 79.3X$. The equation of estimated quantities of milk demanded under economic formula pricing is: $Y = 13{,}392 + 119.6X$

However, since economic formula pricing was not introduced in 1961, only the slopes of the curves are relevant. If economic formula pricing had been introduced in January, 1965, the estimated slope of the projected supply curve would be 79.3 instead of 74. The projected demand curve would have a slope of 119.6 instead of 131.2. The values for the algebraic equations would be the quantities predicted by the "actual" curves on January, 1965, and the slopes of the "estimated" curves. The equilibrium solution, then, was derived as follows:

$$22{,}059 + 79.3X = 19{,}647 + 119.6X$$
$$X = 59.6 \text{ or } 60 \text{ months.}$$

On the basis of this project, equilibrium would be reached in December, 1969, assuming economic formula pricing was introduced on Jan. 1, 1965. The analysis indicates that the introduction of the economic formula pricing system recommended by the Dairy Marketing Advisory Committee would have shifted the equilibrium of supply and demand from June, 1968, to December, 1969.

Projected Relationships—Model III. The primary objective in developing Model III was to provide a more sophisticated method of estimating future supply-demand relationships. Essentially, the recursive supply equation is the only portion of the Model that is totally new. However, the methods of projection are very different.

The projected quantities supplied when estimated by the application of Model III are shown in Table 18. A least squares trend was subsequently fitted

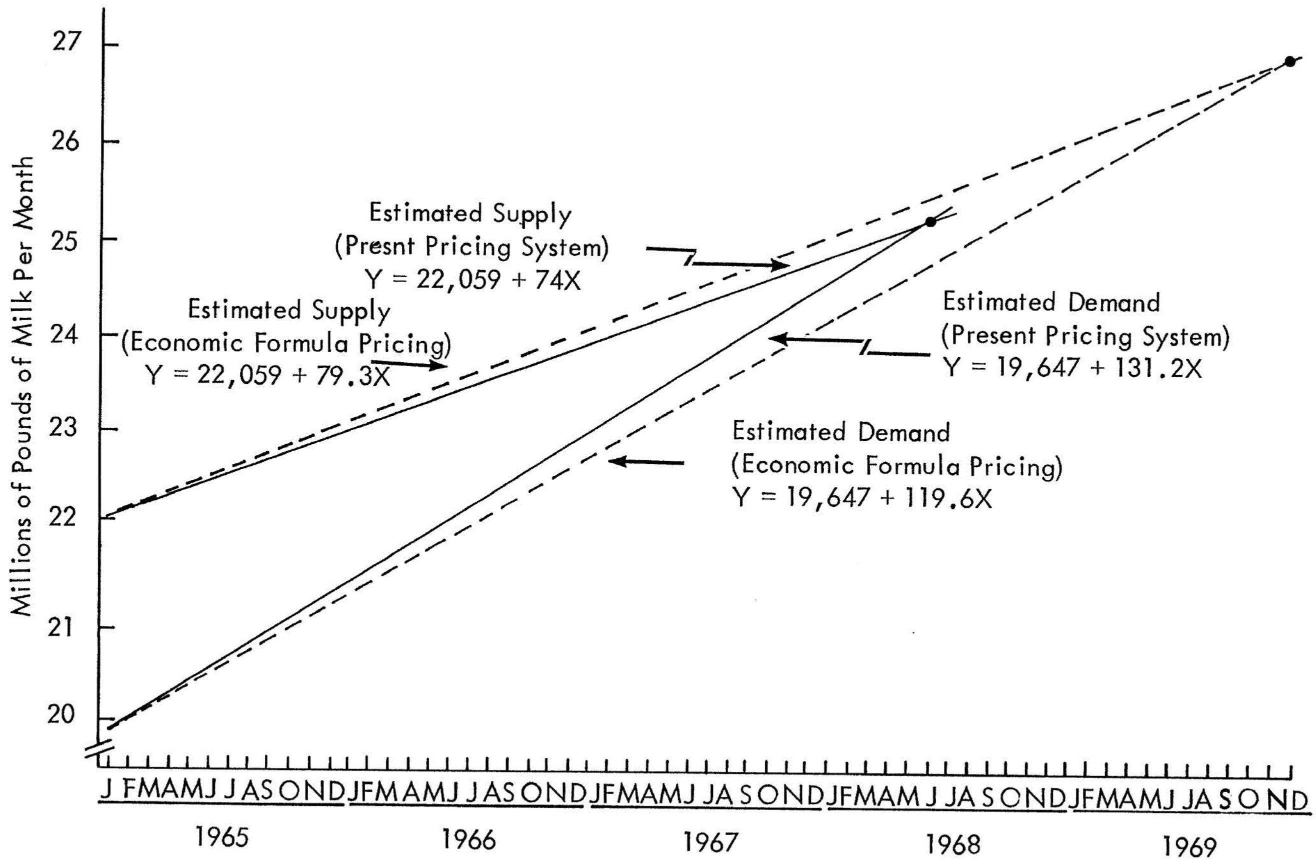

FIGURE 6. Projected supply and demand relationships for Grade A milk in the Ozarks market, 1965 - 1969.

correlating these values with time. The equation of the least squares curve is:

$$Y = 21{,}693 + 71X.$$

The estimated intercept value under the present pricing system was 22,059 and the intercept value of the curve fitted to the estimated values from Table 18 is 21,693. This apparent discrepancy is accounted for by the fact that the December, 1964, value (Q_{tj}) used in the January supply equation was the actual observed value which was below the estimated value. The intercept was shifted upward to intersect the actual supply curve. The slope of the curve remains constant.

When this is done, the equation of the projected supply curve becomes:

$$Y = 22{,}059 + 71X$$

The equilibrium solution is:

$$22{,}059 + 71X = 19{,}647 + 119.6X$$

$$X = 49.6 \text{ or } 50 \text{ months}$$ [40]

This solution indicates equilibrium in February, 1969.

The absolute difference in the two methods of projecting supply-demand relationships to equilibrium is 10 months (59.6 - 49.6). Both methods assumed adoption of economic formula pricing in January, 1965. Time lapse between the assumed date and the actual date of adoption would shorten the time to estimated equilibrium. Using this concept and keeping the analysis in a social cost-benefit framework, the last phase of the analysis is devoted to the problem of providing adequate future supplies of milk with minimal cost.

Alternative Methods of Meeting Future Demands:

The projected equilibrium using the recursive supply equation in Model III under economic formula pricing was 25,579,000 pounds of milk in February, 1969. The projected equilibrium using simple extrapolation of estimated supply under economic formula pricing was 26,820,000 pounds of milk in December, 1969. For simplicity, it was assumed that the goal is 26,341,000 in June 1969 (an intermediate figure).[41]

There are several alternatives for reaching this goal. Perhaps the most obvious method is to continue the present pricing system until equilibrium is and then increase price as rapidly as necessary to achieve the goal.

The estimated Class I price increase between 1961-1964 under economic formula pricing was approximately 21 cents per hundred pounds. This 21 cents increased the slope of the regression curve from 74 to 79.3; or, a net increase of 5.3 thousand pounds per month.

At equilibrium in June, 1968, production is 25,167,000 pounds per month. This must be increased to 26,341,000 pounds per month in June, 1969. Production must increase an average of 97.8 thousand pounds per month. Then, 97.8

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40. The demand equation was calculated: 13,350 + 131.2(48) = 19,647. The 19647 represents the equation intercept assuming formula pricing beginning January, 1965.

41. The goal could be fixed at any level within the physical limits of resource endowment and the time period in question.

minus 74 yields a *net* necessary increase of 23.8 thousand pounds per month.

Assuming that the ratio of increased price to increased supply remains constant, the necessary price increase would be 94 cents per hundred ($\frac{23.8}{5.3}$x .21 = 94 cents per hundred pounds).

The total estimated production for the 12-month period is 309,618,000 pounds. The total increased cost (3,096,180 x .94) is $2,910,409.

Another alternative would be to increase price by something less than 94 cents per hundred one year before equilibrium is reached under the present pricing system, i.e., increase prices in June, 1967.

The estimated supply in June, 1967, is 24,279,000 pounds. To reach the goal of 26,341,000 pounds in June, 1969, monthly production must be increased by 2,062,000 pounds during a 24-month period. Thus, production must increase 85.91 thousand pounds per month. The net necessary increase is 11.91 thousand pounds per month (85.91 - 74). The total production for the 24-month period is 608,458,000 pounds. The total increased cost (6,084,580 x .47) is $2,859,752. Thus, disregarding the discounting problem, the alternative of increasing the price of milk by 47 cents in June, 1967, has a lower cost than the alternative of a 94 cent price increase in June, 1968.

A final alternative considered was that of increasing milk price in June, 1966. The estimated production under the present pricing system is 23,391,000 pounds. To reach the goal of 26,341,000 pounds in June, 1969, production must be increased by 81.96 thousand pounds per month. The net necessary increase is (81.96 - 74.0) or 7.96 thousand pounds per month for a 36-month period. The same methods of calculation show a necessary price increase of 31 cents per hundred in order to reach the goal. Total production for the period is 896,664,000 pounds. The total increased cost of this alternative is $2,779,658. Disregarding discounting problems, a price increase of 31 cents in June, 1966, is a lower cost alternative than either of the two previous alternatives considered. The above analysis is shown in Figure 7.

Social Costs of the Least Cost Alternative

Given the estimated demand of 26,341,000 pounds of Grade A milk in June, 1969, a price increase of approximately 31 cents beginning in June, 1966, provides the least cost alternative of meeting demand estimated approximately three years in advance.

It is possible that the least cost alternative, in terms of reaching the production goal, is not the optimum alternative when the social costs arising from the misallocation of resources are considered. The minimum cost alternative of reaching a production goal is optimum if, and only if, the reduced cost of the alternative is equal to or greater than the increased net social cost of the alternative. The explicit saving in acquiring a given level of production must be at least equal to the implicit opportunity cost of misallocated resources.

Previously net social cost as defined as the opportunity cost of the resources used in producing Grade A milk which is then sold in the manufacturing milk market. The difference in blend price and manufacturing price of Grade A milk used in manufacturing represents the opportunity cost of holding the resources in the production of surplus Grade A milk.

Applying this same basic idea, it is evident that the least cost alternative of reaching the production goal in June, 1969, is also the most expensive in terms of increased net social costs (Fig. 7).

If the alternative of waiting until June, 1968, to increase price is chosen there is no *increase* in net social costs.[42] This is true because after equilibrium is reached, production is only increased at a rate sufficient to meet demand. As the alternatives of increasing price by a lesser amount at an earlier date are considered, the net social costs increase with each earlier date. This is illustrated in Figure 7. The area abc becomes ever larger as point a is moved to the left.

There is an inverse relationship, in this particular case, between net social costs and least cost alternatives for reaching the production goal in June, 1969.

If there is no net increase in social costs associated with the alternative of increasing prices only after equilibrium is reached in 1968, the other alternatives considered must have a lower total cost (i.e., the cost of reaching the production goal in 1969 plus the social cost arising from the action).[43]

If the alternative of increasing price in June, 1966, is indeed the optimum solution, the following conditions must hold:

Increased cost of 1968 alternative > Increased cost of 1967 alternative + social costs > Increased cost of 1966 alternative + social costs

(or)

$$\$2{,}910{,}409 > \$2{,}859{,}752 + \$17{,}040 > \$2{,}779{,}658 + \$32{,}580$$

(or)

$$\$2{,}910{,}409 > \$2{,}876{,}792 > \$2{,}812{,}238$$

where social costs were:

$$\text{(In Figure 7)}\ \frac{\text{area cbd}}{100} \times \$1.00 = \$17{,}040^{44}$$

(and)

$$\frac{\text{area abd}}{100} \times \$1.00 = \$32{,}580$$

The conditions hold and there is no further opportunity to move price increases to an earlier date. Therefore, the June, 1966, alternative must be optimum.

42. No net increase in net social costs means no increase over what would exist if the present system is continued.

43. Social costs as used here still mean the opportunity costs of misallocated resources as defined earlier.

44. The estimated difference between blend price and manufacturing price is assumed to be one dollar.

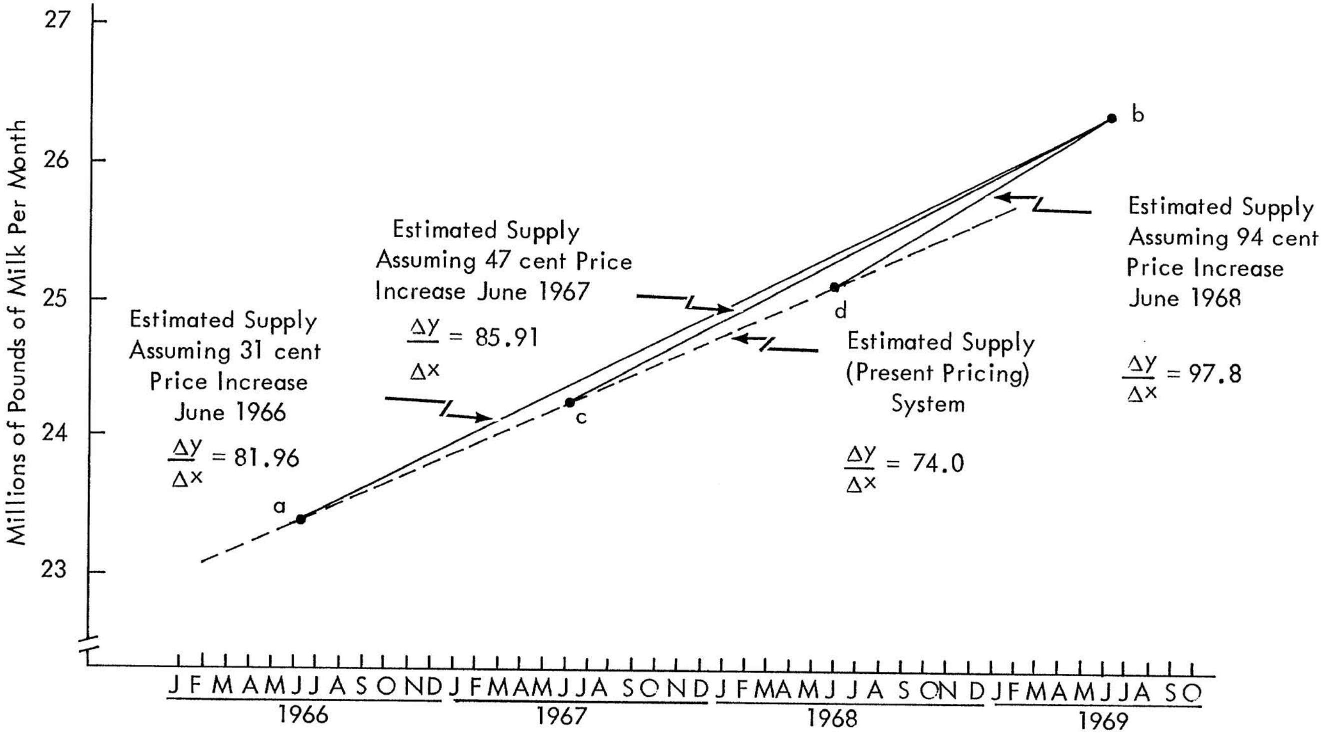

FIGURE 7. Projected supply curve for Grade A milk in the Ozarks market, 1966 - 1969.

Special Problems Encountered

This analysis is based on *estimates*. The best statistical methods available are far from adequate when neither the variables nor the magnitude of those variables can be determined with certainty. Such is the case when projections are made on the basis of historical data. However, certain problems did arise in the study which are not necessarily associated with uncertainty.

It is noted that the projected curve of quantity supplied over time, as estimated by the recursive supply equation assuming economic formula pricing, has a slope of 71. Slope of the comparable curve as projected from actual prices under the present pricing system is 74. Since the Class I price was increased by more than 20 cents per hundred under economic formula pricing, the difference in the two slopes is opposite to that which would be expected, i.e., an increase in Class I price should increase quantity.

In order to make the projections under the present pricing system and the simulated pricing system more comparable, actual prices were used in the recursive supply equation over the four-year period, 1961-1964. The slope of the projected quantity supplied curve was 67.9. The results are more pronounced using this system than where actual quantities were projected using a simple extrapolation. The same procedure was used for a three-year period which yielded a slope of 70.67. For the three year period, 1961-1963, the results are almost identical whether economic formula pricing or actual prices are assumed (i.e., 71.01 compared to 70.67). For the four-year period the results bear out the relationships shown above where a simple extrapolation of actual quantities was used. The slope of the projected curve was 59.6 under economic formula pricing and 67.9 under actual prices.

If an increase in Class I price does decrease quantity, the only logical explanation is that the Class I price has been increased such that the price elasticity of demand for milk is algebraically greater than -1. This being the case, an increase in Class I price would decrease blend price. Since the producer actually sees only the blend price, production would actually be reduced.

Some validity is afforded the results cited above by the results attained when the economic formula system, as proposed, was applied to historical data. In Table 14 it is noted that the estimated blend price for economic formula pricing is below the actual blend price in October, November, and December of 1962, 1963, and 1964 even though estimated Class I prices under economic formula pricing were above actual Class I prices in all these months except November, 1963, and October, 1964.

The estimated supply under economic formula pricing as shown in Figure 6 was extrapolated from the years 1961-1963 only. (These quantities are shown in Table 15.) When the 1964 values are added, the slope of the curve falls to 59.7. This indicates that after the first three years of operation economic formula pricing would reduce the total revenue to farmers and reduce supplies of milk to consumers as compared to total revenue and supplies that would have been forthcoming by continuing the present pricing system.

The previous analysis was conducted on the assumption that price elasticity of demand for fluid milk is inelastic. On the basis of the results of this study, no conclusive statement can be substantiated. However, this is not to say that these preliminary results could not be true.

Roland W. Bartlett in a study of 55 markets in 1964 records the following in the summary of that study:

> . . . This study showed that in markets where the retail price was 20 cents per quart or over, the demand for milk was elastic, namely a decrease in price was accompanied by an increase in milk consumption greater than the proportionate decrease in price . . . it is evident that a downward adjustment in price would be helpful to the dairy industry . . .[45]

The primary objective in developing the recursive supply model was to estimate future supplies of milk. Models I and II were developed to estimate social costs; however, the fact that economic formula pricing as applied to historical data appears to decrease blend prices in those months when Class I prices are highest, coupled with the fact that supplies of milk appear to be reduced under economic formula pricing when the recursive supply equations are used to project future supplies, does raise serious questions.

Whether the elasticity problem as stated above arises from errors in methodology, or whether the preliminary results indicated are actually true are left to the opinion of the reader and further study.

Policy Implications

There probably has been no more controversial facet of agricultural policy than commodity surpluses. Surpluses of most commodities are small or nonexistent. The real question in pricing policy centers around the supply and demand relationships in future periods. The quantity of milk supplied today can be changed little regardless of the price level. Tomorrow's supply, however, does depend on today's price.

If price supports and minimum pricing have any justification, it must lie in the fact that current economic conditions do not provide the proper stimulus for anticipated needs.

The tenor of legislative enabling acts concerned with minimum pricing, etc., has reflected two primary goals: (1) There should be adequate supplies of essential commodities and (2) these supplies should be available at the lowest possible cost. A compatible marriage of these two goals is not easily achieved.

Both economists and laymen tend to use such terms as supply, demand, adequate supplies, surpluses, etc., rather loosely. Perhaps a more rigorous system of definitions would help to cltrify the analysis.

Society tends to look upon surpluses as immutable evidence of price maladjustment. A surplus develops because producers are willing to produce greater quantities than consumers are willing to buy at a given price. In the absence of price supports on manufacturing milk and minimum pricing on fluid milk,

45. Roland W. Bartlett, "Fluid Milk Sales as Related to Demand Elasticities," *Journal of Dairy Science,* XLXII, December, 1964, p. 1318.

the price of milk might drop so low that milk would become economical hog feed. The total quantity supplied would be sold in the market and there could be no surplus.

Under these conditions, the consumer would enjoy a low market price. The producer would argue that prices are below the cost of production. He will cut production severely or stop producing completely so that the subsequent period is marked by scarce supplies and high prices. The consumer then argues that supplies are not adequate. It should be noted that in either case (high or low prices) the total amount produced was sold at the maximum price that consumer demand would allow. To speak of adequate supplies can be a rather meaningless statement.

A producer cannot supply milk over a long period of time at a price which does not cover his average total cost of production. We know that there will be some quantity demanded at a price which corresponds to the average total cost of producing the same quantity. At this quantity, supply and demand are exactly equated. From the economists' point of view, supplies are adequate to meet demand, i.e., the supply of milk is exactly equal to the demand for milk where the price of milk equals the average total cost of production.

Society may decide that the total quantity provided by this equilibrium is not sufficient. If this is true, subsidies or some other incentive will be necessary to encourage the producer to supply greater quantities at an equal or lower price. This is a problem entirely apart from that attacked in the previous analysis.

The problem here was one of how best to achieve the long-run equilibrium described above. The problem of moving from the current supply-demand position (June, 1966) to a long-run equilibrium position in June, 1969. The question of whether or not minimum pricing is justified has already been decided and enacted in law. The only relevant question remaining is the level of such a price.

One might suspect economic irrationality if we slaughter a cow this month because we do not need her milk only to find that her milk is needed next month. Since three years are required to raise a herd replacement (i.e., from conception to production), the logical action would be to increase price in the current month to a level sufficient to keep the cow in production. Obviously, this price will cause a surplus in the immediate period; however, the production of the retained cow will decrease price in all subsequent periods. A similar analysis would apply to all other resources used in producing milk.

On the other hand there is no justification for raising prices in a nonsurplus period if the long-run equilibrium indicates a need for less output.

The analysis of projected long-run equilibrium in the Ozarks fluid milk market indicates that the equation of supply and demand (elimination of surplus) in each market period may be a poor criterion by which to measure long-run efficiency and may even be physically impossible under dynamic conditions. ("Efficiency" is another of those terms that carries many connotations. Here the most "efficient" pricing plan is taken to be the one which provides a long-run equilibrium quantity of milk at the least possible total cost.)

The statistical projections of long-run supply and demand equilibrium and the calculated costs of reaching equilibrium show the alternative which encourages the greatest amount of surplus to be the least cost to society. There is probably nothing that could add more to the analysis than to question this statement.

This statement implies that maintaining short-run competitive equilibrium conditions over time may not be the least cost method of providing a given quantity of fluid milk in the long run. If this is in fact true, we need to take a new look at pricing policies.

There is a time lag between any price increase and an actual rise in production. If twice as much milk is wanted next month it is impossible to increase price enough to encourage producers to double production. It is impossible because it is not physically possible to increase the number of cows, tons of feed, etc., by an amount sufficient to double production. However a relatively small price increase may greatly increase production over a two or three year period. The earlier price is increased the smaller the increase must be to reach any greater level of production in the future. However, the consumer pays the increased price over a longer period of time.

In the analysis of projected supply-demand relationships for the Ozarks market, it was least expensive for the consumer to pay a small price increase over a longer period of time. A 31 cent increase over a three-year period provided a lower cost solution than a 94 cent increase over a one-year period. The level of production in June, 1969, was identical in either case. The surplus was greater under the 31 cent increase. Even after subtracting the social costs of these "misallocated" resources, the total cost was still smaller.

It seems that there is sufficient proof to at least cast some doubt on the significance of short run surpluses as minimum pricing policy indicators.

One final word of caution seems in order. The fact that the alternative pricing plan that encouraged the greatest amount of surplus was also the least cost plan for society was not so *because* of the surplus. It was so *in spite of* the surplus. Levels of surplus could be encouraged which would yield a most expensive solution to the pricing problem.

The important point is that the current position, whether it is one of surplus or deficit supply, is only one of many variables that must be considered in fixing a minimum price. We may need to raise price substantially in surplus periods in order to avoid later shortages.

This position is consistent with the stated goals of minimum pricing. It is not consistent with the stigma that has been associated with surpluses of farm commodities.