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MILK SUPPLY ADJUSTMENTS AND INVESTMENT BEHAVIOR IN ARIZONA AND NEW MEXICO

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MILK SUPPLY ADJUSTMENTS AND INVESTMENT BEHAVIOR
IN ARIZONA AND NEW MEXICO

by

Waly Aboubacar N'Diaye

A Dissertation Submitted to the Faculty of the
DEPARTMENT OF ECONOMICS
In Partial Fulfillment of the Requirements
For the Degree of
DOCTOR OF PHILOSOPHY
In the Graduate College
THE UNIVERSITY OF ARIZONA

1985
As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Waly Aboubacar N'Diaye entitled Milk Supply Adjustments and Investment Behavior In Arizona and New Mexico and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Coza Selby  
Date 6/28/85  

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Robert S. Finan  
Date 6/28/85  

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Robert S. Finan  
Dissertation Director  6/28/85
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Government involvement in the production and marketing of milk and dairy products is more pronounced than in any other agricultural product. The U.S. government administers two major programs that affect significantly the production and marketing of milk throughout the United States. These are the Federal Milk Marketing Order Program and the Dairy Price Support Program. In Arizona, in addition to these two major programs, the United Dairymen of Arizona Cooperative operates a base system that determines how cooperative milk revenues are allocated among producer members. This dissertation discusses some theoretical models that provide some insights into the following questions:

1. How would the dairy industry perform without the historically administered prices?

2. What are the benefits and costs associated with the order program and the base system?

Then, this inquiry focuses on the Arizona and New Mexico dairy sectors. These two southwestern states provide a somewhat unique study area in that the two production sectors are quite similar as are the marketing institutions except for the existence of the base system in Arizona. Milk supply response in Arizona and New Mexico is investigated. Two ways in which supply adjustments can be achieved are identified and empirically investigated.
1. Creation of new dairy facilities or relocation of dairy facilities from other markets. The decision to invest in Arizona or New Mexico is assumed as given, and the probability that the new investor chooses Arizona or New Mexico is estimated using a logit model. It is found that the existence of base system is a significant factor in explaining the location choice of new producers.

2. Expansion in output of existing dairy farms. It is found that dairy farmers in Arizona and New Mexico respond to changes in the farm level price of milk. The short run price elasticity of supply of milk in the region is estimated and found to be 0.6.

The last effort of the empirical investigation is on the consumers' welfare losses due to the regulations of the Arizona and New Mexico dairy markets. It is found that the milk marketing orders and the policies of the UDA Cooperative in Arizona and AMPI in New Mexico, on the average, enforce a tax on Arizona's consumers of fluid milk in the amount of 10 million dollars per year, or 13.5 percent of producers' total revenue, and a tax on New Mexico's consumers of fluid milk in the amount of 5.6 million dollars per year, or 12.6 percent of producers' total revenue.
CHAPTER 1

INTRODUCTION

The U.S. dairy industry is a highly regulated industry. A number of agricultural economists have observed that government involvement in the production and marketing of milk and dairy products is more pronounced than in any other agricultural product (Manchester, 1983).

The U.S. government administers two major programs that affect significantly the production and marketing of milk throughout the United States. These are the Federal Milk Marketing Order Program and the dairy price support program. In addition to these two major programs, there are some state milk control programs and other local marketing arrangements. For instance, The United Dairymen of Arizona cooperative operates a base system that determines how cooperative milk revenues are allocated among producer members.

The major focus of this inquiry is on the formulation of and response to milk market signals in Arizona and New Mexico dairy sectors. The two states provide a somewhat unique study area in that the two production sectors are quite similar as are the marketing institutions except for the existence of the base system in Arizona.

Problem Setting

Milk production is characterized by wide seasonal fluctuations. During the flush production period, more milk is usually
produced than is needed to meet fluid milk demand. Milk in excess of fluid milk needs is then diverted to manufacturing plants where it is processed into cheese and other dairy products.

Before the implementation of the milk order program, the assignment of milk to various uses was made by the milk processors and was entirely arbitrary. Historically, purchasers of raw milk have purchased milk used for fluid milk purposes at a higher price than milk that is used for manufactured products reflecting quality differences and perhaps as well the greater margins available in a less competitive fluid milk market. Where excess high quality raw milk was available, dairy producers were at the "mercy" of milk handlers who had the option to choose whose milk would be purchased as fluid milk and as manufacturing milk. The dairy industry was confronted with an equity problem and individual dairy farmers faced considerable uncertainty about their income. Various means have been developed to deal with this problem, including contractual supply arrangements between milk processors and farmers' cooperatives as well as classified pricing systems.

A classified pricing system is a plan where the price paid by the milk processor is based on the use of the milk, and the returns of all milk sales are pooled by the cooperatives and each farmer receives an average price for his total milk production. Classified pricing was first introduced in the Boston market by the New England Milk Producer's Association about 1918 (USDA/AER No. 393); it expanded rapidly, and was established in nearly all major markets during the 1920's.
Depression conditions of the late 1920's led to a decrease in milk demand and prices at all levels dropped sharply. This led to a breakdown of the classified pricing system, as farmers were in great economic distress and they dropped out of cooperatives perhaps in hopes of negotiating individual contracts at better terms (USDA/AER No. 393).

In the early 1930's, Congress authorized emergency programs for many segments of the economy. Under the Agricultural Adjustment Act of 1933, a program of "licenses" was developed to assist dairy farmers. All milk dealers in a given market were required to pay producers on a classified price basis and to pool the returns to farmers. The Act of 1935 set forth more specifically the terms and provisions that could be used under the program and called the instruments "marketing orders" instead of licenses. The Agricultural Marketing Agreement Act of 1937, while largely a restatement of the provisions relating to marketing agreements and orders of the Act of 1935, provided a framework for long run price and marketing stability. Agricultural economists, in trying to understand the implications of this policy, have used different models to investigate the efficiency of the dairy industry under the order program and the welfare effects associated with it, both at the national and local level.

Scope of this Study

This thesis discusses some theoretical models that provide some insights into the following questions:
1. How would the dairy industry perform without the historically administered (regulated) prices?

2. If government involvement in the industry was needed because of market failure, how should the market be regulated?

3. What are the benefits and costs associated with the order program?

Then, our inquiry will focus on the Arizona and New Mexico dairy sectors. These two southwestern states share some common features with regard to the production and marketing of milk and dairy products:

1. The marketing of milk in both states is performed under federal milk marketing orders.

2. A rapid expansion of milk production is taking place in the two states.

3. Each state has a single milk marketing cooperative that markets the majority of the raw milk.

4. The technology of production of raw milk is drylot dairying, essentially identical in the two states.

Specific objectives of this study include:

1. A review of the Federal Milk Order Program and the main characteristics of the dairy industry.

2. A theoretical analysis of alternative market organizations.

We will investigate the following situations:

a. Producers and handlers as perfect competitors.
b. Handlers as monopsonists in the raw milk market and monopolists in the fluid milk market, while producers are perfect competitors.

c. Handlers and producers both have market power.

3. A theoretical analysis of the effects of the federal milk marketing order upon equilibrium prices and quantities, and the welfare effects associated with it.

4. A theoretical analysis of the cooperative base-quota system and its effects on market signals and welfare.

5. We will then empirically investigate milk supply adjustments in Arizona and New Mexico and the welfare losses due to the regulation of these two dairy markets.

Each one of the postulated market organizations will be analyzed under the framework of static neoclassical models. An attempt will be made to indicate how changes in prices of milk due to fluctuations in demand and supply conditions will be signaled to producers.

**Empirical Approach and Data Sources**

We will assume in this study that raw milk is homogenous at the farm level. However, we will dichotomize milk according to its use into two classes: Class I milk going into fluid milk use, and Class II milk going into manufactured uses. Fluid milk receives the fluid price which is higher than the class II price paid for manufactured milk. In Arizona, raw milk at the farm level is divided into quota milk and over quota milk according to the amount of effective base owned by the producer and amount produced. Milk covered by base
receives the UDA quota price which is higher than the over quota price.

Three ways in which supply adjustments can be achieved are:

1. New investment (entry) or disinvestment (exit) in dairy operations.

2. Relocation of already existing dairy farms.

3. Expansion in output of existing dairy farms.

In the empirical work, we will merge the first two alternatives into one, and we will consider any new dairy in Arizona and New Mexico as new investment in dairy operations. For new facilities, we will assume the decision to invest in Arizona or New Mexico as given, and we will investigate the probability that the new investor chooses Arizona or New Mexico. Data on new producers entering the Arizona and New Mexico sectors and their production have been provided by the Arizona Dairy Commissioner’s office and the UDA cooperative for Arizona and by the regional office of the AMPI cooperative for New Mexico. Due to the fact that these offices do not keep records on individual producers for long periods of time, data are not available prior to 1976. Therefore, the empirical work will be limited to the relatively short time period 1976 - 1983.

**Organization of this Study**

Chapter 2 reviews briefly the Federal Milk Marketing Order Program and the main characteristics of the U.S. dairy industry in general and the Arizona and New Mexico dairy industries in particular. A literature review on issues relevant to the stated objectives is
also provided in Chapter 2. Chapter 3 discusses the theoretical aspects of the hypothesized market organizations. An economic analysis of each postulated model will be conducted and conclusions will be drawn with regard to the welfare effects associated with the model. Chapter 4 investigates milk supply response and investment behavior in Arizona and New Mexico. Chapter 5 estimates consumers' welfare losses due to the regulations of the Arizona and the New Mexico dairy markets. Chapter 6 summarizes the results of the study, and some policy recommendations will be provided.
CHAPTER 2

CHARACTERISTICS OF THE DAIRY INDUSTRY

Milk is about 90 percent water and therefore bulky, and it is a highly perishable commodity since it is subject to bacterial contamination. It must be produced under sanitary conditions, and be marketed by the farmer as quickly as possible. It can be processed for drinking milk (fluid milk) or for soft and solid dairy products (manufactured milk). The relatively high cost of transportation of fluid milk and its perishability have caused many regional markets for fluid milk to develop. Manufactured dairy products are less perishable and are typically distributed in a national market.

At the national level the U.S. dairy industry is characterized by a small number of processing plants, a few retail chains and many milk producers (dairy farmers) represented by a few cooperatives.

U.S. milk production is characterized by some seasonal variation, with production peaking in the Spring and falling in the Fall, while demand for milk is highest in the Fall for most of the U.S. This lack of synchronization between supply and demand and the importance that the general public places on a safe and regular supply of milk has prompted some governmental and other institutional regulations of the industry.

In this chapter we will review briefly the Federal Milk Marketing Order program and the main characteristics of the industry.
that are relevant to the application of economic theory. First, however, we review some of the characteristics of the Arizona and New Mexico production sectors.

Arizona and New Mexico dairy sectors are characterized by the presence of large, specialized dairy farms. The technology of production of raw milk is drylot dairying, quite identical in the two states. Milk production, number of milk cows on farm, and average milk production per cow have been constantly increasing in the two states during the last decade, however they have been higher in Arizona than in New Mexico (Table 1 and Figure 1). Each state has a single milk marketing cooperative that markets the majority of the raw milk produced in the state. In Arizona, it is the United Dairymen of Arizona Cooperative (UDA), while in New Mexico it is the AMPI Cooperative. The UDA Cooperative operates a base system in Arizona in order to effectively control the marketing of its members' milk production, while the AMPI Cooperative in New Mexico did not operate a base system during the period of this study. The marketing of milk in both states is performed under the Federal Milk Marketing Order. Arizona has a three-use classification system (Class I, Class II, Class III), while New Mexico has a two-use classification system (Class I, Class II). Class I milk utilization in both states has been fluctuating during the last ten years, but in general declining (Table 2). The minimum Class II price set by the Federal Milk Marketing Order and the blend price have been generally increasing in the two states (Table 2 and Figure 2).
Table 1. Milk Production, Number of Cows, and Milk per Cow - Arizona and New Mexico (including independent producer-handlers).

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Milk Produced (million lbs)</th>
<th>Number of Milk Cows (1000)</th>
<th>Milk Produced per Cow (lbs)</th>
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<td>507</td>
<td>72</td>
</tr>
<tr>
<td>1980</td>
<td>1031</td>
<td>602</td>
<td>75</td>
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<tr>
<td>1981</td>
<td>1133</td>
<td>670</td>
<td>77</td>
</tr>
<tr>
<td>1982</td>
<td>1202</td>
<td>812</td>
<td>81</td>
</tr>
<tr>
<td>1983</td>
<td>1237</td>
<td>938</td>
<td>83</td>
</tr>
</tbody>
</table>

Source: Milk Production, Disposition and Income - USDA - Annual Summary.
Table 2. Class I Utilization, Minimum Class I Prices, Blend Prices - Arizona and New Mexico.

<table>
<thead>
<tr>
<th>Year</th>
<th>Milk used in Class I as a percent of all</th>
<th>Minimum Class I Prices ($ per 100 lbs)</th>
<th>Blend Prices ($ per 100 lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AZ</td>
<td>NM</td>
<td>AZ</td>
</tr>
<tr>
<td>1972</td>
<td>76.0</td>
<td>79.0</td>
<td>7.53</td>
</tr>
<tr>
<td>1973</td>
<td>73.0</td>
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<td>67.0</td>
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</tr>
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<td>1980</td>
<td>62.7</td>
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</tr>
<tr>
<td>1983</td>
<td>55.4</td>
<td>61.5</td>
<td>15.05</td>
</tr>
</tbody>
</table>

Figure 1. Milk Production (million pounds)
Arizona □
New Mexico △

Figure 2. Minimum Class I Prices and Blend Prices ($/cwt)
Minimum Class I Prices - Arizona □
Minimum Class I Prices - New Mexico △
Blend Prices - New Mexico ▲
Blend Prices - Arizona ■
The Federal Milk Marketing Order Program

The Agricultural Marketing Agreement Act of 1937 authorizes federal milk orders. A federal milk marketing order is a legal instrument issued by the Secretary of Agriculture, to regulate the terms of trade of Grade A milk in a specified geographic area. The objectives of federal milk orders, as described by the Act of 1937, are as follows:

1. To provide dairy farmers with adequate income through the establishment of minimum milk prices.
2. To assure an orderly and adequate supply of milk.
3. To supervise the terms of trade in milk markets so as to achieve more equality of bargaining between processors and handlers.

A marketing area is defined by the order and is intended to include all of a geographic area where the same milk distributors compete with each other for sales of milk.

Functions of a Federal Milk Order

Among the varied functions of milk marketing orders, some can be identified as common to all orders. They are: classifying milk according to its use, establishing minimum producer prices, defining marketing areas, pooling, and providing a thorough and impartial audit to insure payments to dairy farmers and to verify reported utilization of milk.

It should be pointed out that a marketing order regulates only processors located in the marketing area defined by that order. The
class prices established by an order apply to the milk delivered to regulated processors by the milk producers located in that particular marketing area. For milk coming from other sources, a specific allocation procedure is set forth by the administrator of that order.

An order establishes prices by classes according to the use of milk. Most of the milk orders establish three-use classifications: Class I milk for fluid uses, Class II and Class III milk for manufacturing uses. A few orders include all manufacturing uses in a single class. As noted by Babb, et al. (1983), a three-class system is used in 41 of the existing 49 orders. Class I uses generally include products packaged for fluid consumption such as whole milk, skim milk, lowfat milk, buttermilk and flavored milk drinks. For the three-class system, Class II usually includes cream, yogurt, cottage cheese, and ice cream; Class III includes butter, cheese, and nonfat dry milk.

The Agricultural Marketing Agreement Act authorizes the Secretary of Agriculture to establish milk prices: 1) that reflect certain economic factors, 2) that assure a sufficient quantity of pure and wholesome milk and 3) that are in the public interest. The Act states that the Secretary shall set prices at levels which will reflect "... the price of feeds, the available supplies of feeds, and other economic conditions which affect market supply and demand for milk or its products in the marketing area... and which will insure a sufficient quantity of pure and wholesome milk and be in the public interest." No authority for supply limitations is provided for in the Act. Price is the only device that is provided to affect supply and demand.
For all market orders, the price paid by regulated processors for the milk used in manufactured dairy products is based upon the Minnesota-Wisconsin (M-W) price. The M-W price is calculated by surveying on a monthly basis 110 cheese, butter, and nonfat dry milk manufacturing plants (Babb, et al., 1983). Prices from these plants are used to make monthly adjustments to the benchmark price. The benchmark price is determined by reports from 275 similar plants in these two states. It is believed that prices paid by these plants are determined by competitive supply and demand conditions for milk used in manufacturing. The minimum Class I price set forth by the order in any marketing area is the price paid for manufacturing milk plus a fixed differential. The differential is set at a level which will produce a blend price high enough to encourage adequate supplies of fluid milk. The Class I price set by an order is a price floor (minimum price). Producers can increase the effective Class I differentials by negotiating over-order payments (the difference between federal order minimum and prevailing Class I prices in any market). Starting in 1974, the over-order payments became more widespread and captured almost all federal order markets (Manchester, 1983). Over-order payments are usually explained by the following factors:

1. If the differential does not cover actual transportation costs, part of the over-order payments will reflect the discrepancy.

2. Producer's cooperatives are now performing functions that were previously carried out by processors--such as standardizing milk fat, transporting milk from farm to
processor's needs, and maintaining facilities for handling reserve supplies. This has shifted the procurement and market servicing costs to the cooperatives, and payment for these services is negotiated between producers and processors.

3. Over-order payments are regarded by some people as the result of market power on the part of cooperatives within a particular region (Fallert, 1980). However, a study by Babb and Bessler (1983) did not find a relationship between size of over-order payments and market power of cooperatives as measured by cooperative concentration.

The Agricultural Marketing Agreement Act provides for pooling returns to producers. Pooling describes the way total returns from sales of milk are distributed among producers. There are two methods of pooling: market-wide pooling and individual handler pooling. Under "market-wide" pooling the total money value of all milk delivered by all producers to all processors is combined in one pool, and the pool is divided by the total amount of producers' milk that is priced under the order. Producers are paid the same uniform or blend price for their milk shipments. Under "individual-handler" pooling, the producers delivering milk to a particular processor receive a blend price that reflects the Class I utilization of that particular processor only. Usually, producers supplying one processor will receive a blend price that differs from that paid to producers supplying another processor since the proportion of milk used in the different classes varies among processors. Because of this disparity in
prices received by producers, use of individual-handler pooling has been very limited.

Organization and Structure of the Dairy Industry

Some vertical linkages have been established between various segments of the marketing system. These vertical linkages have facilitated the marketing of a highly perishable product like milk.

The dairy industry is characterized by the existence of supply contracts at different levels:

1. Supply contracts exist between producers and their cooperatives, requiring each member producer to deliver his total milk production to the cooperative or to specific processors designated by the cooperative.

2. Supply contracts exist between processors and cooperatives, establishing the proportion of processor milk needs that will be supplied by the cooperatives.

3. Supply contracts exist between manufacturers, including cooperatives and retail chains, requiring independent manufacturing plants to deliver all of their production to the marketing firm.

4. Supply contracts exist between fluid milk processors and retailers of fluid milk who require a safe supply of fluid milk to be packaged under their private label.

The overall structure of U.S. dairy farms can be characterized as a large number of small producers. Most dairy farmers in the U.S. remain family-operated units using mostly family labor and have
between 30 and 100 cows. Very large farms utilizing a significant number of hired laborers exist in Arizona and New Mexico.

In the last two decades, producer bargaining cooperatives have become dominant influences in the dairy industry. Producer cooperatives vary in structural complexity from the most basic form, the pure bargaining associations, to operating marketing cooperatives. The sole function of the pure bargaining cooperative is to negotiate price and other terms of trade for the total production of its members. However, the role of bargaining cooperatives in the U.S. dairy industry has undergone major changes. Most cooperatives have established supply arrangements with the processors, requiring cooperatives to perform some of the marketing functions. For example, in Arizona UDA supplies the needs of the processors excluding producer handlers such as Shamrock Farms, for milk for Class I and Class II uses, while most of the remaining production is diverted to its own facilities for manufacturing uses; in New Mexico, AMPI delivers milk to processors for their Class I and Class II uses. Of the 250 U.S. dairy cooperatives identified as associations that bargain for their members' sales of raw milk, one-third of them maintain processing facilities and take physical possession of the raw milk (Harris, et al, 1983).

As cooperatives take over the task of coordinating the marketing of raw milk, substantial economies are realized. Some marketing costs formerly borne by the processor are now borne by the cooperatives and evidence exists that total costs are reduced. This has increased efficiencies in milk marketing and cooperatives have grown and acquired increased market power.
It has been alleged that the existence of large regional cooperatives impose some constraints on free producer entry and exit. Some view the existence of producer contracts by cooperatives as a restriction to the freedom of producers. The larger the cooperative is, the more market power it has. Indeed, if all producers are required to be members of the cooperative in order to sell milk, then they have no freedom to choose not to belong, and the processors have no source of supply other than the cooperatives. Such a situation would give substantial market power to the cooperatives. We are not sure if such a situation describes the reality of any milk market in the U.S. For Arizona, a producer has to be member of UDA in order to have access to the quota milk market. However, he has the freedom to choose not to belong to UDA if he can find an independent buyer. Such freedom of choice on the part of the producer exists also in New Mexico. Whatever the situation, a valid counterargument is that a well coordinated marketing system is required in order to meet the standard sanitary conditions, due to the peculiarities of raw milk (high perishability, ease of bacterial contamination), and the lack of synchronization between production and consumption.

Cooperatives have used various methods to successfully provide a steady supply of milk. In Arizona, UDA operates a base-quota plan as milk supply management plans. A "milk base" is a measurement, expressed in pounds, of the right to market every day through the UDA at the UDA quota price. A "base quota system" is the method by which a quota for UDA quota price is assigned to individual members of UDA. Each member's quota is a percentage of the amount of his base owned.
For milk marketed within his quota, a member producer receives the UDA quota price which is generally less than the Class I price but greater than the "blend price." For milk marketed in excess of his quota, a member producer receives the UDA over quota price which is usually equal to the manufacturing price (Class III price).

UDA grants "milk base" to members according to their production in base earning periods. The amount of base owned by individual members differs among them. New producers have the option of becoming UDA members and building up their own bases in base earning periods, or purchasing base from UDA members.

As we mentioned earlier, UDA has entered supply arrangements with most of the processors in Arizona. Under such arrangements, UDA requires processors to deal exclusively with it. An independent (non UDA member) producer who wants to market his milk in Arizona, must sell his milk to UDA at the over quota price, if he cannot find a processor-buyer.

Almost all dairy farmers within the Central Arizona milk marketing area are members of UDA. UDA members produce nearly all of the milk pooled in Central Arizona federal orders pool. The total UDA pooled milk in Central Arizona during the last five years accounted for about 90 percent of the total quantity of milk pooled in Central Arizona. A significant portion of the remaining quantity of milk pooled in Central Arizona is produced by Shamrock Farms - a non-UDA member.

The use of base plans is usually seen as a barrier to entry into the industry and a means to restrict supply in order to achieve
higher prices. In fact, base plans may be designed to accomplish specific objectives by altering the following provisions of the plans (Fallert and Lough, 1976):

1. Length of the base earning periods.
2. Time interval between base revisions, which may range from yearly or multi-year plans to practically no revisions.
3. How the base is revised. New base may be assigned to producers, or base may be held constant and base holders may be allotted any increases in fluid milk sales by marketing quotas.
4. Restrictions on base transfers: whether they can be transferred, who they can be transferred to. UDA allows the transfers of base, only if the member-seller promises either not to own, operate or manage a dairy farm in the state of Arizona for seven years (AZ vs. UDA, 1980).

Thus, depending on the provisions, base plans can be used as effective barriers to entry and supply management tools. Whether or not the use of base plans serves the public interest, remains a debatable question. One might argue that an increased movement of producers into and out of the market may introduce difficulties in maintaining product quality and in achieving a successful market coordination. We wish to provide insights on this question following our empirical work.

Review of Previous Work Assessing Federal Milk Marketing Orders

At this point, it is appropriate to review briefly how
previous studies have assessed the performance of federal milk marketing orders. Much of the assessment of marketing orders is on two of its objectives: Market stability and the improvement of farmers' income through classified pricing.

Market Stability

The Agricultural Marketing Act of 1937 specifies that federal milk orders should "establish and maintain such orderly marketing conditions as will provide in the interests of producers and consumers an orderly flow of the supply thereof through its normal marketing season to avoid unreasonable fluctuations in supplies and prices." Orderly marketing is one of the most cited justifications for federal milk orders. Masson, Masson and Harris (1978) argue that "orderly marketing" implies an absence of certain competitive practices, i.e. use of predatory practices (practices of using cost advantages to drive competitors out of the market by cutting prices). Dobson and Buxton (1977) interpret the terms "unreasonable fluctuations in prices" as referring to extreme, erratic, or unpredictable milk price movements. Babb, et al. (1983) pointed out the difficulty of defining "orderly marketing." They attempted to define "disorderly marketing" as the "lack of coordination between buyer and seller at any stage of the vertical marketing system for milk. They argued that disorderly marketing involves short-run behavior and long-run strategies which reduce the operational efficiency, equity or innovation of the marketing system.
There is a consensus that, in federal order markets, the disorder and price instability associated with seasonal variations in milk production are lower than in the past (Dobson and Salathe, 1979; Babb, et al., 1983; Harris, 1958). A relevant question one might ask, is such a situation desirable from the point of view of efficiency? If price is to play its allocation mechanism role, it must reflect supply and demand conditions. Thus, seasonal variations in supply should lead to some fluctuations in prices.

Undue Price Enhancement


Buxton (1979) cites evidence that suggests differentials between Class I and manufacturing milk prices in federal order milk markets have been too large. The National Consumers' Congress (Capper Volstead Committee, 1976) contends that certain Class I premiums negotiated by milk cooperatives constitute undue price enhancement in
violation of the Capper Volstead Act. Eisenstat, Masson, and Roddy (1976) charge that some cooperatives operating in federal order markets have employed predatory, noncompetitive practices to obtain Class I premiums. Many of the opponents of the federal milk order program view the classified pricing as a form of price discrimination. They argue that the underlying principle of the orders is price being raised for fluid or Class I uses of milk where marginal revenue is low, and the rest of the supply being dumped into manufacturing uses where marginal revenue is higher (Masson and Eisenstat, 1980 and Harris, 1958).

Proponents of the program reject the price discrimination argument, arguing that fluid milk is not an identical product in economic terms to manufacturing milk. The sanitary standard requirements make fluid milk more costly to produce than manufacturing milk. They also contend that premiums over federal order minimum Class I prices constitute the basis for many of the social costs and transfers calculated by some studies. Such premiums, they say, result from many factors and include costs of providing services to processors, temporary shortages in supply, temporary surges in demand. How does one know if prices have been enhanced? Manchester (1977) suggests to look at the consequences of prices higher than those justified by economic conditions.

If the supply of the agricultural commodity in question is controlled, the consequence of prices that are too high will be excess profits. If the supply is not controlled, prices that are too high will stimulate excess supply. There are no restrictions on milk
production in any market of the United States. Moreover, there is no mechanism under milk orders to achieve supply controls or even to prohibit milk producers in any geographic location from selling milk under an order in another region. Thus, if excess profits were generated by prices that are too high, surpluses of milk would result. Therefore, any test to determine whether undue price enhancement exists, must be based on an analysis of milk supply in particular markets.

Market Performance of the Dairy Industry

Market performance is usually measured by:

1. Relative efficiency of production.
2. Price relative to average cost of production.
3. Sizes of sales promotion.
5. Technical progressiveness of firms and industry.

We will use profitability of milk production to assess the market performance of the industry. In profitability, we capture some of the effects of production efficiency and price-cost relations.

Comprehensive figures showing the profitability of dairying in the U.S. seem to be lacking. However, there are some good studies of individual dairy markets, which all seem to suggest that dairying is a relatively profitable operation. For instance, a study by Manchester (USDA AER N. 402, 1978) showed dairy farm returns, measured in terms of returns to operator and family labor, management, and equity in
investment, for New York and Wisconsin. This study showed that in 1976, returns on New York dairy farms ranged from $10,000 on farms with 31 cows to $64,000 on farms with 200 cows. Wisconsin dairy farmer returns ranged from $7,200 on farms with 24 cows to $49,000 on farms with 142 cows. In a study comparing farmer returns from dairying with alternative enterprises in Illinois for the period 1971-75, and the years 1977 and 1978, Cook and Hayenga (1981) showed lower returns from dairying than from grain, hogs and beef on medium size farms, and less than grain and hogs on small farms. However, during the latter part of the 1971-75 period, the prices of each of the other commodities inflated faster and further than the price of milk, which very likely affected the relative returns. In 1977, dairy was the only one of these alternatives to show a positive return to labor and management in Northern Illinois. In Southern Illinois, dairy had the highest returns both in 1977 and 1978. A more recent study (Buxton, et al, 1984) comparing profitability of milk production in four states - Arizona, New Mexico, Minnesota and Washington - concluded that the annual rate of return to investment in dairy farms varies from 1.53 percent for a 52-cow Minnesota dairy to 19.86 percent for a 200-cow New Mexico dairy. In Arizona the rate of return was estimated at 14.64 percent on the 1,436-cow dairy, and in Washington it was 7.29 percent for the 140-cow dairy.

Cook and Hayenga (1981) reported that profits for dairy processing firms in the last 20 years were generally comparable to those for all food manufacturing firms, as well as those for retail food chains. Jones and Lasley (1980) found that net margins per dollar of
sales of fluid milk processor-distributors were 2.48 and 2.67 cents in 1977 and 1978. Babb (1983) found that returns on equity before taxes was 19.7 percent for a sample of 44 Wisconsin cheese plants in 1978. Cheese appears to be the most profitable segment of the industry, followed by butter and powder manufacturing, with fluid milk distribution coming in last. However, comprehensive profit analyses are not available to fully document this judgment.

In conclusion, we may say that a positive feeling about the performance of the industry exists among researchers. The regulations to which the industry is subjected, have contributed significantly to its performance. In the next chapter, we will attempt to analyze the economic effects of these regulations, and to investigate some alternative marketing arrangements.
CHAPTER 3

SOME THEORETICAL ASPECTS OF THE DAIRY INDUSTRY

This chapter is devoted to an economic analysis of alternative market organizations of the dairy industry. We will first consider the case where we assume that producers and processors are perfect competitors. Then, we will relax the assumption of perfect competition and consider the case where processors are monopsonists in the input market and monopolists in the output market. A third alternative is the situation where producers are organized into cooperative associations, i.e., they have some market power, and the marketing of milk is regulated by the Federal Order program. Finally, we will analyze the case where a base-quota system is added to the third alternative. For each postulated market organization, we will attempt to analyze the equilibrium price-quantity, the social costs associated with that particular market organization, and how the fluctuations in demand for processors' products will be signaled to the producers.

Producers and Handlers are Perfect Competitors

The purpose of this section is to attempt to develop a perfectly competitive model where there is no government intervention.

This hypothetical model will provide an analytical framework to assess the working of the industry in the absence of regulations and the exercise of market power by the different participants in the market. To develop such a model, we will make some behavioral...
assumptions with regard to the different participants in the market. We will assume that milk producers and milk processors behave competitively.

The conditions that will ensure a perfectly competitive model can be summarized as follows:

1. All producers sell products (milk) that have identical physical characteristics. Even though milk sold by producers can find different uses, we will consider that it is homogeneous when sold by farmers, i.e., milk used for fluid milk and manufacturing milk is exactly the same commodity.

2. The sales of individual farmers are so small relative to the total volume of sales in the market that no one farmer can affect the price of milk, i.e., producers are price takers.

3. Free entry and exit -- there are no barriers to entry and exit from the market. Abstraction is made with regard to the highly specialized investment in dairy production and the family labor nature of dairying, and we postulate that the mobility of resources is not restricted.

4. All sellers and buyers possess perfect information concerning the price paid for milk.

We will further assume that milk producers and processors are profit-maximizers.
Single Product

We will first consider the case where there is only one use of milk. The aim here is to analyze what the equilibrium price and quantity will be.

Short Run Analysis

In the short run, there is no exit or entry into the industry. The individual farmer is assumed to maximize profit \( \Pi \).

\[
\text{Max } \Pi = Pq - TC(q,N) \quad 3.1
\]

The solution of the above unconstrained optimization problem suggests a general formulation of the mathematical model for the short run analysis for a representative firm model as:

\[
P = dTC(q,N)/dq = \text{MC Individual Firm Supply} \quad 3.2
\]

\[
Q = Nq. \quad \text{Aggregate Supply} \quad 3.3
\]

\[
P = D(Q) \quad \text{Aggregate Demand} \quad 3.3
\]

\[
N = N^* \quad \text{Industry Size} \quad 3.4
\]

where:

\( P \) is the price of milk,

\( q \) is the quantity of milk produced by the individual farm,

\( Q \) is the total quantity of milk produced,

\( N \) is the number of firms in the industry.

Figure 3a shows the short run equilibrium of the competitive model. It is assumed that each firm has identical costs and upon maximizing profits produces the same amount, \( q \).

\( D(Q) \) and \( \text{SRMC} \) represent the industry demand and supply of milk at the farm gate. \( D(Q) \) reflects the demand for milk net of processing
Figure 3a. Short Run Equilibrium of the Competitive Model and transportation costs expressed as a function of the farm gate price. SRMC shows the horizontal summation of the marginal costs of production for all producers. The costs implicit in this supply curve represent market prices or opportunity costs for the inputs used in the production of milk.

The intersection of D(Q) and SRMC represents the industry equilibrium. At the equilibrium price individual farmers may wind up with some profits or some losses. In Figure 3a, at $P_e$ and $q_e$ the representative firm is making zero economic profit.

Suppose there is an increase in the demand for milk. The demand curves D(Q) and D(Q)/N in Figure 1a shift out. As the result of this increase in demand, the price of milk increases, the quantity of milk produced by the individual farmer (q) and the aggregate supply of milk (Q) increase. The representative farmer is making positive economic profit.
Long Run Analysis

In the long run, there is exit from or entry into the industry, i.e., the industry size is not fixed anymore. A general formulation of the mathematical model for the long run analysis is:

\[ P = \frac{dT C (q,N)}{dq} = MC \]  
Individual Firm Supply 3.5

\[ Q = Nq \]  
Aggregate Supply 3.6

\[ P = D(Q) \]  
Aggregate Demand 3.7

\[ P = \frac{TC}{q} = ATC \]  
Long Run Equilibrium 3.8

Figure 3b illustrates the long run equilibrium of the competitive model. In response to profits, firms will enter thereby increasing aggregate output until price is driven down to the minimum point of the ATC curve. The firm is making zero economic profit. In Figure 3b, the upward shift in ATC and MC curves is due to resource costs being bid up. However, firms' cost structure might not change if the industry is small. The shape of the long run supply curve

![Figure 3b. Long Run Equilibrium of the Competitive Model](image-url)
(LRMC in Figure 3b) depends on the industry cost structure. It could be horizontal over a considerable range if firms enter for sometimes without any increase in input prices. As a result of entry into the industry, the size of the industry \((N)\) increases, the aggregate supply of milk \((Q)\) increases, price of milk decreases, and the quantity of milk produced by the individual farmer may or may not change depending on the shift in the firm's cost structure.

On the other hand, if farmers were to incur losses at the prevailing market price, we would expect some farmers to quit dairying if these losses persist in the long run. This will cause an inward shift of the supply curve leading to an increase in the market price. This exit process from the industry will end when zero economic profits are made. Thus, the long run equilibrium price and quantity of this model are given by \(P_e\) and \(Q_e\) in Figure 3b, and the representative farm is producing \(q_e\) units of milk.

This competitive model describes the behavior of suppliers of raw milk under our assumptions. Any fluctuation in the demand for milk will be reflected by a shift in the industry demand curve which will lead to an increase or decrease in the equilibrium price \(P_e\). Depending on whether the new equilibrium price will generate substantial profits or losses in the industry, entry or exit will take place.

Two Products: Fluid Milk and Manufactured Milk

We consider here the case where milk produced by farmers is used as fluid milk and manufacturing milk. We still assume that raw milk is a homogeneous product, i.e., no distinction is made at the
farm level between milk marketed as fluid or manufacturing milk. Then the demand for milk is derived from the demand for fluid milk and the demand for manufacturing milk. The standard procedure to derive the total demand for milk would be to sum horizontally the quantities of milk demanded in each market (fluid milk and manufacturing milk) for every price.

![Diagram of Competitive Model]

**Figure 4. Competitive Model**

A general formulation of a mathematical model for this case is:

\[ P = \frac{dTC(q,N)}{dq} = MC \quad \text{Individual Firm Supply} \quad 3.9 \]

\[ Q = Nq \quad \text{Aggregate Supply} \quad 3.10 \]

\[ Q_I = Q_I(P) \quad \text{Fluid Milk Demand} \quad 3.11 \]

\[ Q_{II} = Q_{II}(P) \quad \text{Manufacturing Milk Demand} \quad 3.12 \]

\[ Q = Q_I + Q_{II} \quad \text{Total Milk Demand} \quad 3.13 \]

\[ P = \frac{TC}{q} = ATC \quad \text{Long Run Equilibrium} \quad 3.14 \]

where \( Q_I \) and \( Q_{II} \) are respectively the quantity of fluid milk and
manufacturing milk demanded expressed in terms of the farm gate price for raw milk.

Figure 4 shows the model where milk is marketed by processors as fluid and manufacturing milk. In Figure 4b, \( D_I \) is the demand for milk used as fluid milk; it is derived from consumers' demand for fluid milk and it is expressed as a function of the raw milk price at the farm gate. \( D_{II} \) in Figure 4c is the derived demand for milk used as manufacturing milk, and it is also expressed as a function of the raw milk price at the farm gate. It is assumed that the demand curve for fluid milk is more inelastic than the demand curve for manufacturing milk over the price range we are looking at (since inter-region competition is more likely in the manufacturing milk market due to lower transport costs and more elastic final demand for manufacturing milk). To derive the total demand for milk at the farm gate, we need to sum horizontally the two demand curves, represented as \( D \) in Figure 4d. In Figure 4d, \( S \) is the total supply of milk.

As seen in the one product case, the individual farmer will produce at the profit maximizing level of output (where \( P = MC \)), i.e., he will produce \( q_e \) units of milk, as shown in Figure 4a. The total quantity of milk produced is \( Q_e \), as shown in Figure 4d, where the industry supply curve meets the industry demand curve. In Figure 4b, \( Q_I \) quantity of milk is used as fluid milk, and the remainder of the total supply of milk, shown in Figure 4c as \( Q_{II} \), or \( Q - Q_I \), is used as manufacturing milk. The price of milk at the farm gate is \( P_e \), regardless of its use.
Suppose now that the consumers' demand for fluid milk increases. The immediate consequence would be an outward shift in the demand for milk used as fluid milk, shown as $D_f$ in Figure 4b, which in turn, would lead to an outward shift in the industry demand curve, shown as $D$ in Figure 4d. As a result, more milk will be produced, shown as $Q'$ in Figure 4d, more milk will be diverted to fluid use, shown in Figure 4b as $Q_f'$ and the price of milk at the farm level will increase to $P_e'$. In our diagram, the quantity of milk for manufacturing purposes is decreased in the short run. The extent to which the change in milk production due to an increase in price is allocated between milk used for fluid purposes and milk used for manufacturing purposes depends on the relative elasticity of the two market demand curves. Profits are realized by farmers as a result of the price increase, therefore the entry process that we described in the one product case will take place.

In conclusion, the abstract competitive model that we have just analyzed offers some very appealing features. It is efficient from the point of view of mobility of resources. The existence of substantial economic profits in the industry attracts new investment or entry, leading to the disappearance of these profits. Vice versa, if losses are incurred, an exit process will take place, until zero economic profit is again realized in the industry. The model does not assume a "reserve pool" of milk that is usually thought to be needed to meet fluctuations in fluid milk demand or to meet fluid milk demand during periods of short supply of milk. However, one might ask if a "reserve pool" is really needed. We have seen that the model handles
any fluctuation in fluid milk demand by increasing the incentives to produce more milk and by rationing the total supply of milk. Moreover, as suggested by Hammond, Buxton, and Thraen (1979), an alternative for a "reserve pool" of milk is to use reconstituted milk as the source of reserve milk, thus making the "reserve pool" issue totally irrelevant.

Processors are Monopsonists in the Input Market and Monopolists in the Output Market

In this section, we relax the assumptions that milk processors are perfect competitors, and consider the case where they exercise some market power both in the input (raw milk) and product market. Indeed, there are few processors relative to producers, and in some local markets a large single processor is the only buyer of the farmers' milk. If we ignore inter-regional competition, then it becomes evident under our assumption of profit maximization, that this local handler could affect the buying price of raw milk, i.e., he will behave as a monopsonist at least to the point where it becomes profitable to ship to another market.

Therefore, in the absence of regulations and any marketing arrangement, the single processor in a local market is more likely to be characterized by a price maker rather than price taker at least up to the point where it is possible to ship processed milk in from another market or to ship raw milk out.

Consider the situation where the processor (buyer of raw milk) is a monopsonist in the input market and monopolist in the output market and faces competitive producers (sellers of raw milk).
The monopoly processor in the short run would face a market specified as follows:

\[ P_f = \frac{\partial TC(q,N)}{\partial q} = MC \]  

\[ Q = Nq \]  

\[ P_r = D(Q) \]  

\[ N = N^* \]  

where:  

- \( P_f \) is the farm level price of raw milk,  
- \( P_r \) is the retail price of milk expressed as the farm gate price plus any monopoly profit.

The processor is assumed to maximize profits (\( \Pi_i \)) with respect to \( Q \) with the processor acting as a price taker in the raw milk market, i.e., \( P_f \) is given.

\[ \text{Max } \Pi_i = P_r Q - P_f Q \]

Maximizing profit with respect to output, results in:

\[ \Rightarrow (\frac{dP_r}{dQ})Q + P_r = MR = P_f \]  

\[ \Rightarrow \]  

**Figure 5a. Monopoly Model**
Since the first term in the LHS of equation 3.18 is negative \( \frac{dP_r}{dQ} < 0 \), it follows that the marginal revenue is less than the retail price of milk \( (P_r) \). Graphically, the monopoly model can be represented by Figure 5a which considers the one product case.

The curve D in Figure 5a is the industry (processor) demand curve. The curve MR is the processor's marginal revenue curve. The curve SRMC is again the horizontal summation of the producers' marginal cost curves and is the processor's short-run marginal cost curve. The processor monopolist will set the quantity of milk produced at \( Q_e \) where marginal revenue is equal to marginal cost. The price paid for milk is \( P^e_T \) and the retail price of milk is \( P^e_r \).

Suppose there is an increase in the demand for milk. The long run response to this increase in demand for milk is illustrated in Figure 5b.

![Figure 5b. Illustration of the Long Run Response to an Increase in the Demand for Milk](image-url)
The demand curve and the marginal revenue curve will both shift out. As a result, the producer price of milk and the retail price of milk will increase. If individual farmers are now making above normal profits, then the entry process we described in the previous section will take place, shifting the processor's marginal cost curve to the right until zero economic profit is again realized by the marginal dairy producer. In Figure 5b, the long run adjustment to an increase in the processor's demand for milk shows an increase in the farm level price of milk, an increase in the retail price of milk and an increase in the total quantity of milk produced.

Consider now a situation where there is a single processor purchasing from farmers but competing with many other firms in the retail market and therefore price takers at retail.

In the short run analysis:

\[ P_f = \frac{dTC(q,N)}{dq} = MC \quad \text{Individual Firm Supply} \]
\[ Q = Nq \quad \text{Aggregate Supply} \]
\[ P_r = D(Q) \quad \text{Aggregate Demand} \]
\[ N = N^* \quad \text{Industry Size} \]
\[ \text{Max}_Q \, P_i = P_rQ - P_fQ \quad \text{Maximum Profits for Monopsony} \]

The marginal cost of milk for the processor is given by:

\[ MC_m = \frac{d[P_f(Q)Q]}{dQ} = (dP_f/dQ)Q + P_f \]

Since the first term in the RHS of the above expression is positive \([dP_f(Q)/dQ > 0]\), it follows that the marginal cost of milk clearly exceeds the producer price of milk for all levels of
utilization of milk. Graphically, the monopsony model is illustrated in Figure 6a.

The curve D is the processor's demand curve for milk. The curve SRMC is the short run supply curve of milk. The curve MCₘ is the processor's marginal cost curve defined here with respect to the quantity of milk bought by the processor. The profit-maximizing monopsonist will purchase Qₑ units of milk at a price of Pₑ. The retail price of milk is Pₑ R.

Again, suppose there is an increase in the demand for milk. The demand curve D will shift out. As a result, the farm level price of milk and retail price of milk will both increase. Dairy farmers are now making above normal profit. Entry will take place, shifting the supply curve and the processor’s marginal cost curve to the right until zero economic profit is again realized by dairy farmers.

Figure 6a. Monopsony Model
Figure 6b illustrates the long run response to an increase in the processor's demand for milk. It shows an increase in the total quantity of milk bought by the processor and an increase in the retail price ($P_r$) of milk.

Consider now a sole processor in the retail market and the sole purchaser of raw milk.

In the short run, the processor will face the following market conditions:

$$P_f = \frac{dT_C(q,N)}{dq} = MC$$  Individual Firm Supply  3.25
$$Q = Nq$$  Aggregate Supply  3.26

Figure 6b. Illustration of the Long Run Adjustment Process to an Increase in the Demand for Milk with Monopsony Processor

$$P_r = D(Q)$$  Aggregate Demand  3.27
$$N = N^*$$  Industry Size  3.28
The marginal cost of the monopsony-monopoly processor as for monopsonist is:

\[ MC_m = \frac{dP_f}{dQ}Q + P_f \]

and its marginal revenue as for the monopolist is:

\[ MR = \frac{dP_r}{dQ}Q + P_r \]

The profit-maximizing monopsonist will equate its MR with its MC or

\[ \max P_i = P_r(Q)Q - P_f(Q)Q = \frac{dP_r}{dQ}Q + P_r \]

\[ [(\frac{dP_r}{dQ}Q)(P_r/P_r)] + P_r = [(\frac{dP_f}{dQ}Q)(P_f/P_f)] + P_f \]

\[ [(\frac{dP_r}{P_r})/(dQ/Q)]P_r + P_r = [(\frac{dP_f}{P_f})/(dQ/Q)] P_f + P_f \]

or, in elasticity form, as

\[ P_r(1 + 1/E^d_X) = P_f(1 + 1/E^S_Q) \]

where:

- \( E^d_X \) is the elasticity of demand for fluid milk,
- \( E^S_Q \) is the elasticity of supply for raw milk.

From the last expression it can be seen that, if the processor was not a monopolist in its output market, i.e., if the elasticity of demand for fluid milk was very high (approaching perfect competition), then \( 1/E^d_X \) would be very low (almost zero), and the left-hand side reduces to \( P_r = MC_m \).

The monopsony-monopoly model is illustrated in Figure 7 which considers the one product case, i.e., raw milk is used for fluid purposes.
The curve D is the industry demand curve for milk which is the processor's average revenue curve expressed in terms of raw milk. The curve MR is the processor's marginal revenue curve. The curve SRMC is the processor's average cost of milk curve. It is obtained by summing the individual producer marginal cost curves. The curve MC\textsubscript{m} is the processor marginal cost of milk. The marginal cost of milk is the rate of change of its total costs with respect to the quantity of milk bought by the processor.

The monopsonist-monopolist will equate its MR with its MC and buy the quantity of milk Q\textsubscript{e}. He will pay the dairy farmers the price P\textsubscript{f} which will cover their average costs of production and sell fluid milk at the price P\textsubscript{r}. The processor profit is given by the area defined as (P\textsubscript{r} - P\textsubscript{f}) Q\textsubscript{e}. If we assume that the different market
structures have the same cost curves, then the monopsonist-monopolist processor’s purchases of milk are at a level lower than the monopsony ($Q^m$) and perfect competition ($Q^c$) and to pay farmers a price ($P_f$) that is lower than the monopsony ($P^m_f$) and perfect competition ($P^c_f$). Indeed, there is a transfer from the producers to the processor ($P^m_f - P_f Q_e$). In addition, there is a net welfare loss of ABC, due to monopsony only.

Suppose that we have an increase in the final demand for fluid milk. The D curve and the MR curve (in Figure 7b) will both shift out. The processor will increase its purchases of raw milk and will pay farmers a higher price. Farmers are now making positive economic profits. Entry will take place in the farming sector. The short-run supply curve SRMC and the MC curve ($MC_m$) will both shift out and milk prices will go down until zero economic profits are realized again in the industry. If, on the other hand, there was a decline in the demand for fluid milk, the D and the MR curves will both shift in. The processor will then decrease its purchases of raw milk and pay farmers a price lower than $P_f$. Farmers will be making negative economic profits. Exit will take place until zero economic profits are realized.

Now, let’s consider the case where milk is marketed by a single local processor as fluid and manufacturing milk. We still assume that the processor is monopolist in the fluid milk market, competitive in the manufacturing milk market, and raw milk is homogeneous at the farm level. The analysis emphasizes the monopolistic rather than the monopsonistic behavior of this local processor, since
the introduction of a Class II market that is perfectly competitive eliminates the possibility of the local processor exercising a monopsonistic power. Producers can always ship to other Class II processors.

The short run mathematical model for the monopoly-monopsony in a two-product market is:

\[ P_f = \frac{\partial TC(q,N)}{\partial q} = MC \quad \text{Individual Firm Supply} \quad 3.30 \]
\[ Q = Nq \quad \text{Aggregate Supply} \quad 3.31 \]
\[ P_I = D(Q_I) \quad \text{Fluid Milk Demand} \quad 3.32 \]
\[ P_{II} = D(Q_{II}) \quad \text{Manufacturing Milk Demand} \quad 3.33 \]
\[ Q = Q_I + Q_{II} \quad \text{Aggregate Demand} \quad 3.34 \]
\[ N = N^* \quad \text{Industry Size} \quad 3.35 \]

The monopsony-monopolist processor is assumed to maximize profits \((P_i)\).

\[ \max P_i = P_I Q_I + P_{II} Q_{II} - P_f Q \quad 3.36 \]
\[ \frac{\partial P_i}{\partial Q_I} = (\frac{\partial P_I}{\partial Q_I}) Q_I + P_I - P_f = 0 \]
\[ \frac{\partial P_i}{\partial Q_{II}} = P_{II} - P_f = 0 \]
\[ \Rightarrow MR_I = P_f \]
\[ MR_{II} = P_{II} = P_f \]

The two-product case is illustrated in Figure 9.

The curve \(D_I\) is the processor's derived demand for fluid milk. The curve \(D_{II}\) is the demand curve for manufacturing milk. The LRMC is again the horizontal summation of producers' MC curves. To maximize profit, the processor will set the level of his purchases of raw milk so that \(MR_I = MR_{II} = P_f\); i.e., he will purchase \(Q\) quantity of raw milk and will use \(Q_I\) quantity of it as fluid milk. The farm level price of
milk is shown equal to \( P_f = P_{II} \) in Figure 8, regardless of the use of milk. The retail price of fluid milk (\( P_r \)) is equal to \( P_I \). The monopolistic profit is given by the area \( P_I ABP_f \). This profit is a transfer from Class I consumers to the fluid milk processor and the Class II consumers.

Suppose there is an increase in the demand for fluid milk. The curves \( D_I \) and \( MR_I \) will both shift out. As a result, the price and quantity of fluid milk will both increase. The farm level price of milk will stay the same unless the magnitude of the increase in fluid milk demand is such that more milk is needed to be produced.

An increase in the demand for Class II milk will shift out the demand curve \( D_{II} \). As a result, the farm level price of milk (\( P_f = P_{II} \)) will increase. The marginal firms are now making above normal profits. Entry will take place.
Processors are Monopolists and Producers are Organized into Cooperative Associations

Now, we relax the assumption made in the previous section that producers are perfect competitors, and we assume that they are organized into cooperative associations that have some market power. As late as the early 1900's, dairy farmers dealt with one or few local processors who then determined milk prices. To offset the monopsonistic power of processors, dairy farmers began as early as 1910 to organize themselves into cooperative associations in some local markets. The cooperative movement was further encouraged by the passage by Congress of the Clayton Act of 1914 and the Capper-Volstead Act of 1922 (USDA - AMS No. 27, 1981).

In this section, we will analyze the situation where both the processors and producers have some market power. We will concentrate on the two-product case, i.e., milk is marketed as fluid and manufacturing milk by processors. We still assume that raw milk is a homogeneous product, that processors are monopolists in the fluid milk market, perfect competitors in the Class II milk market and that the producers' cooperative association controls the raw milk and can bargain with the processor, although the cooperative does not directly control production.

Figure 9 is an illustration of the situation where the cooperative negotiates the farm level of price \( P_f \) with the processor. This case looks exactly like the monopoly case we analysed in the previous section, with the exception that \( P_f \) is no longer equal
to $P_{II}$. The curves in Figure 9 are derived exactly like those in Figure 8.

The producers through their cooperative and the processor will engage in price bargaining to determine the price of raw milk.

**Figure 9. Monopoly Processor and Cooperative Organized Producers**

Figure 9 illustrates a wrestling of monopsony power from the processor. The actual outcome resists analysis in that it depends strictly on the relative bargaining strength of the two parties. All we can say is that the negotiated price of raw milk will lie somewhere between $P_{II}$ and $(P_{I}Q_{I} + P_{II}Q_{II})/(Q_{I} + Q_{II})$, where $Q_{I}$ is the profit maximizing level of fluid milk for the monopolist processor. This situation is different from the bilateral monopoly situation in that the cooperative cannot control output without some base program. Indeed, any increase in the farm level price of milk that the cooperative negotiates will be responded to with greater output by the
producers regardless of whether the added revenue is distributed directly as a price increase, greater cooperative dividends, or more highly subsidized services. In all cases, profits are increased and entry will be encouraged until the marginal farmers are making again normal profits. However, just as a monopsony Class I processor could not be expected to prevent producers from shipping to the Class II market leaving its monopsony position ineffective, the cooperative in this example would not be expected to be able to prevent Class II processors from transshipping to Class I processors, thereby leaving the cooperative without effective market power.

In conclusion, market power by the processor results in output below the perfectly competitive level and consequently results in some resource misallocations regardless of whether the power is characterized as monopoly, monopsony or both.

**The Marketing of Milk is Performed Under Federal Milk Marketing Orders Without Cooperative Base-Quota System**

The same assumptions made with regard to the participants in the market in the previous section hold in this section: processors have some market power, producers are organized into cooperative associations which have some market power, raw milk at the farm level is homogeneous. Now, we again consider the situation where milk is marketed by processors as fluid and manufacturing milk, and the marketing of raw milk is regulated by the Federal Milk Marketing Order program. This situation describes the marketing of milk in New Mexico during the period studied.
Each Federal order specifies minimum prices to be paid for fluid and for manufacturing milk. Processors are required to pay at least the federally specified prices. The Federal milk market administrator would then multiply the quantity of fluid (Class I) milk and manufacturing (Class II) milk sold times their respective prices and divide by the total milk sold to arrive at a weighted average or "blend price" for milk and pays this blend price to farmers who receive this blend price regardless of the use of each farmer's milk.

In this section, we will analyse the "blend price" situation. Attempts will be made to analyse the effects of this regulation on prices and quantities, as well as the welfare costs associated with it. We will then analytically investigate how fluctuations in demand will be signaled to producers.

By means of the equalization scheme which is explained above, each farmer receives a "blend" or average price $P_B$ regardless of the use of his milk.

The blend price is given by:

$$P_B = (P_I Q_I + P_{II} Q_{II})/(Q_I + Q_{II})$$

where:

- $P_B$ is the blend price,
- $P_I$ and $P_{II}$ are Class I and Class II prices,
- $Q_I$ and $Q_{II}$ are quantities of Class I and Class II milk sold to processors.

The supply function of raw milk in its simplest form can be expressed as a function of $P_B$. 


At the farm level, milk is demanded either for fluid use or for manufacturing use. Therefore, we will have two demand curves which can be expressed as:

\[ Q_I = Q_I(P_I) \]  
\[ Q_{II} = Q_{II}(P_{II}) \]

We will again assume the demand for manufacturing milk to be infinitely elastic, i.e., each individual order taken separately produces a small portion of milk that goes into the manufacturing of dairy products consumed in the U.S.

The demand for fluid milk at the farm level is generally accepted to be on the inelastic portion of the demand curve. We will use the common assumption of linear supply and demand schedules (Kessel, 1967; Kwoka, 1977; Ippolito and Masson, 1978; Dahlgran, 1980), although it might be expected that some nonlinearity exists in the various demand and supply schedules.

In reviewing the literature, conflicting information exists with regard to the effects of marketing orders. Kessel (1967) implies that farm rents are maximized in regulated areas. Ippolito and Masson (1978), using elasticity estimates, conclude that the Class I price \( P_I \) is below the rent-maximizing price. The same result is obtained by Kwoka (1977). These conflicting results are mainly due to the approach followed in estimating the rent-maximizing price. The use of an aggregate U.S. elasticity to estimate the rent-maximizing price has been questioned (Prato, 1973; Dahlgran, 1980; Gardner, 1984). One argument given by Dahlgran (1980) and Gardner (1984) is that a
marketing order may increase the price in the order area, compared to no order; however, a system of marketing orders can decrease the average price in all areas taken together. Their argument is illustrated in Figure 10.

Consider a two-market model where market 1 is a high cost area producing initially only Class I milk, and Class II milk is imported from market 2. Market 2 produces only Class II milk. The introduction of a marketing order in market 1 increases the Class I milk price from $P_I$ to $P'_I$ thereby shifting the effective demand curve to AR. The blend price is $P_B$ and the total quantity of milk produced increases from $Q_I$ to $Q_S$. The quantity of milk used as Class I milk is now $Q'_I$ with the excess milk used as Class II milk whose price is set by market 2. In market 2, the demand for Class II milk is now reduced from $D_{II}$ to $D'_{II}$, resulting in a lowering of Class II milk price from $P_{II}$ to $P'_{II}$. Therefore, the result of the introduction of an order in

![Figure 10. A Marketing Order in Market 1 Reduces the Average Price of Markets 1 and 2 and Increases Aggregate Output](image-url)
market 1 for the two markets aggregated is lower average farm prices and larger output. This result occurs if the supply curve in market 1 is sufficiently more elastic than in market 2, and there is a large enough quantity of milk in market 2. This result suggests that a disaggregate model is needed to analyze the effects of a marketing order and that prior aggregate results are inclusive.

The existence of a Class I milk and a competitive Class II milk market limits the ability of the cooperative to exercise any market power without regulatory help because Class II milk processors could always sell to Class I milk processors.

The model of an order with over-order payments is illustrated in Figure 11a. $D_I$ and $D_{II}$ are respectively the demand curves for Class I and Class II milk. The curve LRAC is the long run supply curve or the long-run average cost of milk curve. The curve AR in Figure 11a is the average revenue or blend price function due to pooling. Even though we have assumed linear demand and supply schedules, the blend price relationship (AR-curve) would be curvilinear and asymptotic to the manufacturing demand schedule.

It is assumed that the minimum Class I price set by the order is below the processor's net retail price of Class I milk and is not the price that maximizes producers' net returns. Then, to maximize producers' net returns, the cooperative would have to negotiate a price higher than the minimum price set by the order. This is done by negotiating an over-order payment (difference between $P_{I}^{\text{min}}$ and $P_{I}^{\text{farm}}$ in Figure 11a), which will capture some of the monopoly profit realized by the processor. The effective Class I price is $P_{I}^{\text{farm}}$ which
Figure 11a. Model of an Order with Over-Order Payments

Figure 11b. Unregulated Monopolistic Class I Processor
is the processor's marginal cost for Class I milk. Thus, to maximize profit, the Class I milk processor will set $P_{\text{farm}}$ equal to $MR_I$ and will buy $Q_I$ quantity of Class I milk. The total supply of milk in this instance is $Q_S$ and each farmer receives a blend price that is determined by the intersection of the LRMC curve and the AR curve for each unit of his production. The remainder of the total supply of milk ($Q_S - Q_I$) is used as Class II milk.

Compared to the unregulated model, regulation increases the total supply of milk, decreases the quantity of milk used as Class I milk, increases the quantity of milk used as Class II milk. Farmers receive an average (blend) price which is higher than the marginal value of milk $P_{II}$, and the processor's monopoly profits are decreased. Compared to the competitive model as a standard against which to assess welfare costs, the regulated model has increased producers' revenues from $OP_{IIA}Q$ to $OP_{B}BQ_S$ (Figure 11a). To the extent that production of milk is increased up to the point where the marginal value of milk is below the marginal cost of production, some economic inefficiencies result from the blend pricing. The deadweight loss associated with the blend pricing technique is given by the triangle ABC. Another deadweight loss associated with the price discrimination is the triangle EFG.

Suppose there is an increase in the demand for fluid milk. The demand curve $D_I$ and the marginal revenue curve $MR_I$ will both shift out. The processor's Class I retail price will increase. The blend price will increase if the cooperative can bargain for larger over-order payments.
The situation we wish to analyze in this section describes the marketing of milk in Arizona.

As we mentioned earlier, Arizona dairy producers are organized into one cooperative association, the United Dairymen of Arizona (UDA), whose responsibility includes marketing functions such as picking up the milk at the farm level, testing for butterfat content, supplying the needs of the processors and its own processing facilities (UDA manufactures dairy products such as butter, unfinished cheese, and powdered milk). UDA operates base-quota plans. Base can be built up in base earning periods or purchased from UDA members. Data on sales of base show that the price of base in Arizona has increased significantly during the last 10 years.

To understand the substantial increase in base values observed in Arizona during the last ten years, we need to analyze the economic effect of marketing quotas. We should emphasize that we are concerned with marketing quotas defined in terms of access to certain class prices (UDA quota milk prices), thus regulating the amount of milk that can be marketed as quota milk.

Economic Effects of Introducing a Base Plan in a Federal Order

The analysis distinguishes between short run effects and long run effects in that the short run assumes no entry or exit while the long run allows entry or exit. The assumptions underlying the analysis are the following:
1. Individual producers are base-price takers.
2. There is no restriction on the sales or purchases of base.
3. Individual producers are profit maximizers with regard to the sales or purchases of base.

Short Run Effects

We will consider a two-part market for milk — a quota milk market and an over-quota milk market. It is assumed that base is allocated according to Class I utilization. The ownership of base allows access only to the quota milk market. The quota price of milk is equal to the Class I price, while the over-quota price is equal to the Class II price.

The short run economic effect of introducing a base plan is illustrated in Figure 12a.

Prior to the introduction of the base plan, the typical firm in Figure 12a is making zero economic profit. It is producing a total quantity of q units of milk and is getting the blend price of $P_B$ for each unit of milk.

![Figure 12a. Short Run Effect of a Base Plan](image-url)
Now assume that a base plan is introduced to allow $q_B$ quantity of quota milk. The immediate effect of introducing a base system is the upward shift in his average cost curve that results from the opportunity cost of the investment in base. As a result, the size of the firm will be reduced, thereby reducing the firm's total milk production. The marginal short run supply response to the introduction of the base plan is to the over-quota milk price. Indeed, firms will decrease production of milk, increasing the blend price from $P_B$ to $P'_B$. The introduction of base has enabled the producer to get access to the higher blend price $P'_B$ and the windfall gains that this blend price yields. The base present value in this instance is equal to the discounted stream of the annual rents measured by $P_B^{AP}P_{II}^{R}$.

Long Run Effects

In the long run, there would be some entry into or exit from the industry. The long run firm equilibrium is illustrated in Figure

![Figure 12b. Long Run Effect of a Base Plan](image.png)
12b. The typical firm is shown in Figure 12b making zero economic profit. Supply adjustment has taken place in the industry through base transfer and exit or entry. The long run average cost curve of the individual producer would be higher than the long run average cost curve of the unrestricted model, since there are some costs involved in base ownership. Even though normal profits are again realized in the long run, firms are not producing at the minimum of the average cost curve.

A More Rigorous Analysis of Introducing a Base Plan

Under a marketing order, the price paid by processors for milk sold in the Class I market is determined by the minimum price of Class I milk set by the order (plus any over-order payment). The quantity of milk going to the Class I market will be determined by the demand curve (marginal revenue curve in the monopoly case), therefore \( Q_I \) is determined exogenously. Hence \( Q_I \) and \( P_I \) are treated as constants, \( Q_I^* \) and \( P_I^{\min} \), in the models that follow.

\[
P_{II} = \frac{dTC(q,N)}{dq} \quad \text{Individual Firm Supply} \quad 3.41
\]

\[
Q = Nq \quad \text{Aggregate Supply} \quad 3.42
\]

\[
Q_I = Q_I^* \quad \text{Fluid Milk Demand} \quad 3.43
\]

\[
P_{II} = D(Q_{II}) \quad \text{Manufacturing Milk Demand} \quad 3.44
\]

\[
Q = Q_I + Q_{II} \quad \text{Aggregate Demand} \quad 3.45
\]

\[
P_B = \frac{(P_I^{\min} Q_I + P_{II} Q_{II})/(Q_I + Q_{II})}{Q_I + Q_{II}} \quad \text{Blend Price Relationship} \quad 3.46
\]

The unknowns in this multi-equation model are \( q, N, Q_I, Q_{II}, \)

\( P_B, P_{II} \).
The quota milk price is assumed to be equal to the Class I price set by the order. The over quota milk price is equal to the Class II price. The Class II price is determined by demand and supply conditions at the national level and by the price support program, and each market order taken separately is assumed to be so small that it cannot affect the Class II price. As a result equation 3.44 will specify the Class II price. Given 7 equations and 7 unknowns, the system is then determined.

Figure 13 illustrates the application of the analysis of introducing a quota plan to a federal milk market order. Before the introduction of the base plan, an abbreviated mathematical representation of the model is:

\[ dTC(q,N)/dq = P_B \]  \hspace{1cm} \text{Individual Firm Supply} \hspace{1cm} 3.47

\[ qN = Q_I^* + Q_{II} \]  \hspace{1cm} \text{Aggregate Supply} = \hspace{1cm} 3.48

\[ TC(q,N)/q = P_B \]  \hspace{1cm} \text{Aggregate Demand} \hspace{1cm} 3.49

\[ P_B = \frac{P_{min}^I Q_I^* + P_{II}^* Q_{II}}{Q_I^* + Q_{II}} \]  \hspace{1cm} \text{Industry Size} \hspace{1cm} 3.50

\[ \text{Blend Price Relationship} \]

Before the introduction of the base plan, the industry was producing \( Q \) units quantity of milk. \( Q_I^* \) quantity of milk was used as fluid milk and the remainder of the total supply \( (Q - Q_I^*) \) was used as manufacturing milk. Each farmer was getting the blend price \( P_B \) for each unit of his total production \( (q) \). The marginal farmer is shown making zero economic profit in Figure 13.

Now introduce a base quota plan to achieve \( Q_I^* \) quantity of quota milk at the price \( P_{min}^I \). The market supply curve shifts to the
left because of the increase cost structure of firms due to the fixed cost of base ownership rights. This will lead to a decrease in the industry's total milk production and an increase in the blend price $P_B$.

![Diagram](image-url)

**Figure 13. Long Run Equilibrium Following Introduction of Base Plan**

Compared to the model of an order without a base system, the introduction of base decreases the total supply of milk, decreases the total supply of manufacturing milk, and increases the average price of milk received by the individual base holder. The effect of introducing the base plan on the size of the individual firm and number of firms is uncertain and depends on the relative shift of the firms' average cost curves.

Entry and exit is still free under a base program although in order to receive the quota price for any milk the producer would first
have to purchase base accordingly. The possibility of entering the industry without base makes it possible for firms of various cost structures to coexist, further complicating the determination of the size and number of firms.

In terms of efficiency, we have seen in the previous section that the order program increases the total supply of milk compared to the competitive model. The addition of base plan to the order program decreases the total supply of milk. However, at this level of analysis, we cannot assert whether or not the addition of base program moves the industry equilibrium closer to the perfectly competitive industry. This question is an empirical issue that is not investigated in this thesis.
Milk production during the last decade has increased more rapidly in Arizona and New Mexico than anywhere else in the U.S. (Buxton, McGuckin, Selley and Willet; 1984). An important factor in understanding this expansion of milk production in these two states is the relative profitability of producing milk in Arizona and New Mexico. A recent study comparing the profitability of milk production in Minnesota, Arizona, New Mexico and Washington showed that the rate-of-return to investment in dairy operations is highest in New Mexico and Arizona (Buxton, McGuckin, Selley and Willet; 1984). The study also predicts the higher returns in New Mexico and Arizona to continue in the future, even though the difference in rate-of-return may be squeezed by increasing water costs and feed costs.

A distinctive feature of milk production in Arizona and New Mexico is the presence of large, specialized dairy farms utilizing corral feeding of cows with purchased feeds. This type of dry-lot production organization is quite common throughout the Southwest. The production unit can be thought of as a processing unit, transforming raw materials into milk. The major raw material is feed. If a dairy farm specializes completely in milk production, and depends on feed purchased off the farm which represents more than half of the
production costs, then one would expect a variation in feed costs to affect significantly the returns. The dairy farmer may be confronted with the locational choice of where to operate, i.e., should he locate or move near the sources of cheaper feed supplies. The investment in base in Arizona has frequently approximated the cost of the cow if sufficient base were purchased to deliver all of her production as Class I (quota milk). As a result, the existence of a base plan would be expected to influence locational choice.

In this chapter, we consider milk supply response in Arizona and New Mexico with emphasis on the response to changes in the profitability of milk production. Both Arizona and New Mexico have operated under a marketing order during the study period with a base plan in Arizona and no base plan in New Mexico.

**Milk Production in Arizona and New Mexico: Past, Present and Future Outlook**

U.S. milk production during the last ten years has known some fluctuations, but it has been steadily increasing since 1979. The number of milk cows on farms has been declining up to 1979, then steadily increased. The average milk production per cow has been continuously increasing.

In contrast to the U.S. trends, milk production, number of milk cows on farm, and average milk production per cow have been constantly increasing in Arizona and New Mexico during the last decade (Milk Production, Disposition, and Income USDA - Ann. Summary).

An important factor that affects consumption of milk and dairy products is population. Arizona population as of April 1, 1970, was
1.7 million, it was 2.7 million as of April 1, 1980, and is predicted to be 3.7 as of April 1, 1990 (Arizona’s Economy, May 1984). This means that population growth in Arizona remains strong with an expected 37 percent increase in population in the state in 1990 over 1980, compared with an expected 9.7 percent increase in U.S. population. New Mexico population as of April 1, 1970, was around 1 million, and it was 1.3 million as of April 1, 1980 (1980 Census of Population). Expected continued rapid population growth in Arizona and New Mexico suggests that the consumption levels of milk and dairy products can be expected to increase rapidly in these two states.

In the face of an expected increase in market demand for milk and dairy products and assuming a continuation of the present institutional arrangement of the marketing of milk and pricing structure in Arizona and New Mexico, the relevant question becomes how and to what extent will supply adjust. There are several ways in which supply adjustments can be realized.

One way supply adjustments can take place is the creation of new dairy farms. A second way adjustments can take place is through the relocation of dairies from other markets. Observations by dairy experts suggest that some dairy production units have been moved from California to Arizona and New Mexico over the last decade. Relocation of dairy farms may be caused by many factors. The most obvious factor is urbanization. It applies pressures on farms to relocate through conflicts between dairy farmers and their residential neighbors over animal noises, odors, and flies. To avoid these conflicts, dairy
farmers have the choice of undertaking costly programs to control the sources of complaints, thus squeezing their return, or of relocating to less populated zones. Urbanization also encourages relocation through inflation of land values, increasing the opportunity costs of dairying in particular areas. Evidence exists that dairies in the Los Angeles County have been under pressures to relocate for several years (Fletcher and McCorkle, 1962). Another important factor encouraging relocation is the comparative advantage in dairying in specific geographical areas, due to regional price advantage, climate, etc.

A third way in which supply can be adjusted is through the expansion in output of existing dairy farms, which can be accomplished by increasing milk production per cow, or by increasing the number of milking cows.

We will investigate these alternatives of supply adjustments in Arizona and New Mexico in the next sections. Due to the fact that complete information on the background of newly established dairies in Arizona and New Mexico is not available to us, i.e. we could not dichotomize these dairies into newly created or relocated, we will merge the two first alternatives into one category.

Location of New Production Facilities in Arizona and New Mexico

The following questions are under consideration in this section:

1. What are the factors that make the Arizona and New Mexico dairy subsectors attractive to new investors.
2. Assuming that a new investor has already made a decision to enter the Arizona or New Mexico dairy subsectors, what is the probability that he chooses Arizona and what is the probability that he chooses New Mexico.

Assuming the objective of a dairy producer is to maximize profit, and given that Arizona and New Mexico offer very similar conditions in regional characteristics and in applicable technology, we will assume that profit is the main factor affecting the decision to locate in Arizona or New Mexico.

Profitability Variables

Net return or profit is defined as revenues minus costs.

Milk sales are the most important source of revenues for a dairy farm. Other sources of revenue for a dairy farm include sales of young stock (calves) and cull cows.

Total costs include ownership costs, overhead costs and direct production costs. Ownership costs include insurance on buildings and equipment, taxes, depreciation and interest on those investments. Overhead costs include accounting and legal fees, liability insurance and management and supervision. Direct production costs are costs directly related to the production of milk. These costs include feed costs, labor costs, replacement costs, utilities, fuel and interest on operating capital. Feed costs account for a large part of direct production costs. In Arizona and New Mexico, feeds typically are not produced on the dairy farm, but purchased. Replacement costs arise because cows need to be replaced with new stock after a certain period
and because of deaths. Replacement cost per cow is the cost of a new animal minus the salvage value of the cow replaced adjusted for death rates. However, most replacement cows are raised on the farm.

Location Choice of New Dairy Producers

We will consider the decision to invest in the Arizona or New Mexico dairy sectors as given, and we will investigate the probability that a new investor chooses Arizona or New Mexico, and how the location choice is related to the profitability variables.

Theoretical Framework

The essence of the treatment is the behavioral assumption that a dairy producer is a rational decision maker who chooses the location that gives him the maximum expected profit subject to some capital constraints.

On both the revenue and cost side, we need to consider only those cost items that affect the relative profitability of dairying in Arizona and New Mexico. For instance, evidence exists that investment costs per cow in Arizona are very similar to those in New Mexico (Buxton, McGuckin, Selley and Willett, 1984). The major difference is the value of milk base in Arizona which was non-existent in New Mexico during the period studied. Therefore, we will assume that the same capital investment is required to set up a comparable new dairy in Arizona or New Mexico except for the investment in base. Given the similarity in technology and regional characteristics between Arizona and New Mexico, we will assume that some of the overhead costs such as insurance on buildings and equipment, depreciation, and some of the
direct production costs such as labor costs and maintenance costs are identical in the two states. We will further assume that all replacement cows are raised on farms, thus making replacement costs irrelevant since they are captured by feed costs and maintenance costs.

Given the above assumptions, an abbreviated formulation of profit of the firm at period \( t \), \( P_t \), can be expressed as:

\[
P_t = P_{Mt}Q_{Mt} - (P_{Ct}Q_{Ct} + P_{Ht}Q_{Ht} + r_tP_B + (r_t + PT_t)PL_tL_t + (r_t + PT_t)OI_t)
\]

where:

- \( P_{Mt} \) is the average price of milk at period \( t \).
- \( Q_{Mt} \) is the quantity of milk produced during period \( t \).
- \( P_{Ct} \) is the price of concentrate at period \( t \).
- \( Q_{Ct} \) is the quantity of concentrate during period \( t \).
- \( P_{Ht} \) is the price of alfalfa hay at period \( t \).
- \( Q_{Ht} \) is the quantity of alfalfa hay during period \( t \).
- \( r_t \) is the average interest rate at period \( t \).
- \( P_B \) is the price of base at period \( t \).
- \( PT_t \) is the property tax rate at period \( t \).
- \( B_t \) is the amount of base at period \( t \).
- \( PL_t \) is the market value of land at period \( t \), per acre.
- \( L_t \) is the number of acres of land at period \( t \).
- \( OI_t \) is the dollar value of other investment subject to property tax.

The first term on the right-hand side of equation 1 defines the revenue from sales of milk. Revenues from young stock sales are assumed to be proportional to milk production.
The next two terms in the cost expression define the cost of feed. The third term in the cost expression is interest payments on base acquisition which define the cost of owning base. The next two terms in the cost expression define the rent of land, real estate taxes, and property taxes on other capital investments. Other costs are assumed to proportional to milk production.

The new producer is interested in maximizing the after tax profit. The problem facing this new producer can be formulated as:

$$\text{Max} \ (1 - z_t^i)p_t^i = (1 - z_t^i)[p_{Mt}^i Q_{Mt}^i - p_{Ct}^i Q_{Ct}^i - p_{Ht}^i Q_{Ht}^i - r_t^i p_t^i B_t^i - (r_t^i + p_t^i)P_t^i L_t^i - (r_t^i + p_t^i)O_t^i]$$

Subject to:

$$Q_{Mt}^i = G[Q_{Ct}^i, Q_{Ht}^i, L_t^i, O_t^i]$$

where: \(i = 1,2\) \(i = 1\) if Arizona,

\(i = 2\) if New Mexico.

A production relationship between output, \(Q_{Mt}^i\), and concentrate, hay, land and other capital is assumed.

\(Q_{Mt}^i = G[Q_{Ct}^i, Q_{Ht}^i, L_t^i, O_t^i]\)

\(z_t\) is the income tax rate at period \(t\).

The dairy producer is assumed to maximize after tax profit over the whole period for which he is in business. However, product and factor prices at time \(t\) are assumed to be representative of those prices over time so that expected profits over the firm life are directly proportional to profits in time period \(t\).

The decision variables in this problem are \(Q_{Mt}^i, Q_{Ct}^i, Q_{Ht}^i, B_t^i, L_t^i,\) and \(O_t^i\), given \(i \ldots\)

It is assumed the producer would first maximize profits with respect to input and output levels given prices and then decide where
to locate based upon the maximum profit-factor-product mix at each location.

Dropping the time and location subscripts for convenience and assuming the level of base to be equal to the production of milk in Arizona and zero in New Mexico, maximizing profit would require that all derivatives of (4.2) with respect to the decision variables be set equal to zero.

\[(1 - z)(P_M - rP_B) - y = 0\]  \[4.3\]
\[(1 - z)P_C - y(dG/dQ_C) = 0\]  \[4.4\]
\[(1 - z)P_H - y(dG/dQ_H) = 0\]  \[4.5\]
\[(1 - z)(r + PT)P_L - y(dG/dL) = 0\]  \[4.6\]
\[(1 - z)(r + PT) - y(dG/dOI) = 0\]  \[4.7\]

where \(y\) is a Lagrange multiplier on the constraint \(Q_M = G[Q_C, Q_H, L, OI]\). Solving for \(y\) and substituting for \(y\) results in four remaining equations to determine \(Q_C, Q_H, L, \) and \(OI\):

\[(P_M - rP_B)(dG/dQ_C) = P_C\]  \[4.8\]
\[(P_M - rP_B)(dG/dQ_H) = P_H\]  \[4.9\]
\[(P_M - rP_B)(dG/dL) = (r + PT)P_L\]  \[4.10\]
\[(P_M - rP_B)(dG/dOI) = (r + PT)\]  \[4.11\]

The above equations represent the equations of the unit cost of each input with their marginal value product. Note that the income tax rate does not affect the profit maximizing input-output ratios.

The above equations would be solved simultaneously for \(Q_C, Q_H, L, \) and \(OI\) and substituting back into \(G\) would determine the profit maximizing level of output. Output and input levels will in general be a nonlinear function of \(P_C, P_H, (r + PT)P_L, (r + PT), \) and \(P_m -\)
Maximum after tax profits will be a nonlinear function of the above variables after tax.

The Econometric Model

We define occurrence as the location of a new facility in New Mexico. Nonoccurrence means that the new facility is located in Arizona. We assume that the location choice is a function of profit, i.e., the probability to locate in New Mexico or Arizona is a function of the expected profit in New Mexico or Arizona.

Thus, letting \( y_i \) be a dichotomous random variable which takes on the value one if the facility is located in New Mexico, and zero if it is located in Arizona, we can express the following functional relationship referred to as a linear probability model:

\[
y_i = F(V^1, V^2)
\]

where:

\( V^1 \) is after tax profit in Arizona, and

\( V^2 \) is after tax profit in New Mexico.

\[
V_i = V_i[(1 - z_i)P_i^C, (1 - z_i)P_i^H, (1 - z_i)(r_i + PT_i)P_i^L, (1 - z_i)(z_i + PT_i), (1 - z_i)(P_i^M - r_iP_i^B)]
\]

Equation 4.12 can be written as:

\[
P_y(y_i = 1) = F(V^1 - V^2)
\]

Thus, equation (4.13) can be interpreted as describing the probability that a new facility will be located in New Mexico, given the after tax profitability in New Mexico and Arizona. The logit model provides a possible functional form for estimating equation (4.13). The logit model is based on the cumulative logistic probability distribution function and is specified as:
\[ P_{r}(y_{i} = 1) = F(B'x_{i}^i) = 1/[1 + (\exp(-B'x_{i}^i))] = P_{i} \quad 4.14 \]

The logit function is bounded between 0 and 1.

Equation (4.14) can be transformed by first multiplying both sides by

\[ 1 + \exp(-B'x_{i}^i) \]

to get

\[ (1 + \exp(-B'x_{i}^i))P = 1 \]

Dividing both sides by \( P_{i} \) and then subtracting 1, we get:

\[ \exp(-B'x_{i}^i) = (1/P_{i}) - 1 = (1 - P_{i})/P_{i} \]

but

\[ \exp(-B'x_{i}^i) = 1/\exp(B'x_{i}^i) \]

using the inverse transformation, we get:

\[ \exp(B'x_{i}^i) = P_{i}/(1 - P_{i}) \]

taking the logarithm of both sides leads to:

\[ \log P_{i}/(1 - P_{i}) = B'x_{i}^i \quad 4.15 \]

Thus, a logit specification of equation (4.13) is

\[ \log P/(1 - P) = F(v^1 - v^2) \quad 4.16 \]

where \( F \) is a linear function of after tax prices.

Because of limited degrees of freedom, the difference between after tax prices is used in the empirical results reported here. In particular, let

\[
\log \left[ \frac{P_{jt}}{(1 - P_{jt})} \right] = a^* + B_1P_{Mt}^* + B_2P_{ct}^* + B_3P_{Ht}^* + B_4P_{Lt}^* + E_t^* \quad 4.17
\]

where the right-hand variables are defined below:

\[
P_{Mt}^* = (1 - z_{t}^2)P_{Mt}^2 - [(1 - z_{t}^1)(P_{Mt}^1 - r_{Mt}P_{B}^1)]
\]

\[
P_{ct}^* = (1 - z_{t}^2)P_{ct}^2 - (1 - z_{t}^1)P_{ct}^1
\]
$P_{Ht}^* = (1 - z_t^2)P_{Ht}^2 - (1 - z_t^1)P_{Ht}^1$

$P_{Lt}^* = (1 - z_t^2)(r_{Lt}^2 + P_{Lt}^2) - (1 - z_t^1)(r_{Lt}^1 + P_{Lt}^1)\)

$E_t^*$ is the disturbance term at period $t$.

In Equation (4.17), we drop the annual costs on other investments because of the expected high correlation with the annual costs on land acquisition. The same indexes (property tax and interest rate) are indeed contained in both explanatory variables.

$P_j$ is the probability that the $j^{th}$ producer at period $t$ will locate in New Mexico.

Thus, equation (4.17) can be interpreted as describing the log of the odds that the $j^{th}$ producer will locate in New Mexico, given the after tax prices in New Mexico and Arizona.

Methods of Estimation

We shall now consider the procedures that can be used to estimate the coefficients in the logit specification discussed above.

The use of least squares to estimate (4.12) is usually recommended for the purpose of obtaining quick estimates in a preliminary stage, due to its computational simplicity (Amemiya, 1981). However, the use of the least squares method is not made without cost in that $F$ in equation 4.12 is not constrained to fall between zero and one, thus raising the possibility of violating the probability limits. Least squares can be used to estimate (4.17), but there is the prospect of heteroscedasticity, i.e., the variance of the error term is not constant for all observations. However, the presence of heteroscedasticity results in a loss of efficiency but does not in itself
result in either biased or inconsistent parameter estimates. The standard errors of the parameter estimates are biased, however.

The maximum likelihood procedure is the most suitable estimation technique for the logit model. Let's consider equation (4.14):

\[ Pr(y_i = 1) = 1/[1 + \exp(-B'x_i)] = F(B'x_i) = \pi_i \]

let \( i = 1, \ldots, n \) individual observations.

The likelihood function of the model is:

\[ L = \prod_i \pi_i^{y_i}(1 - \pi_i)^{(1 - y_i)} \tag{4.18} \]

The logarithm of the likelihood function is:

\[ \log L = \sum_i y_i \log \pi_i + \sum_i (1 - y_i) \log (1 - \pi_i) \tag{4.19} \]

The ML estimator \( B \) is the value of \( B \) that maximizes equation (4.19). To obtain \( B \), we differentiate \( \log L \) with respect to \( B \) and set the result equal to zero:

\[
\frac{d\log L}{d B} = \sum y_i/\pi_i * d\pi_i/(d B) - \sum (1-y_i)/(1 - \pi_i)*d \pi_i/(d B) = 0 \tag{4.20}
\]

Since equation (4.20) is nonlinear, the ML estimator \( B \) is obtained using an iterative technique. The ML estimator \( B \) is consistent and asymptotically efficient.

The ordinary least squares estimator \( B_{OLS} \) for equation (4.12) and the maximum likelihood estimator \( B_{ML} \) for the logit model (4.17) were obtained using the BMDP computer programs (1983).

Data

Data on new dairy facilities brought into production in Arizona and New Mexico sectors have been provided by the Arizona Dairy Commissioner and by the regional office of AMPI in Texas.
A list of other variables used in these models and the sources of data are presented below.

<table>
<thead>
<tr>
<th>Items</th>
<th>Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Price of Milk - AZ (quota milk)</td>
<td>United Dairymen - official monthly publication of the UDA</td>
</tr>
<tr>
<td>2. Price of Milk - NM (AMPI price)</td>
<td>AMPI - Regional office in Texas</td>
</tr>
<tr>
<td>3. Feed Costs</td>
<td></td>
</tr>
<tr>
<td>Hay ( P_H )</td>
<td>Agricultural Prices (Annual summary) AMS, USDA</td>
</tr>
<tr>
<td>Concentrate 14% ( PC )</td>
<td></td>
</tr>
<tr>
<td>4. Cost of Milk Base</td>
<td>Interviews with lending institutions in Arizona</td>
</tr>
<tr>
<td>5. Land Prices ( P_L )</td>
<td>Real Estate Market Developments USDA - ERS</td>
</tr>
<tr>
<td>6. Income Tax ( z )</td>
<td>Statistical Abstract of the United States</td>
</tr>
<tr>
<td>7. Property Tax ( PT )</td>
<td>Real Estate Market Developments USDA - ERS</td>
</tr>
<tr>
<td>8. Interest Rates ( r )</td>
<td>Agricultural Statistics USDA</td>
</tr>
</tbody>
</table>

Most of the indexes used are season averages, except for the price of hay in Arizona and New Mexico which is the average of the cost of hay during the months of February through June and October through November for Arizona, and during the months of May through October for New Mexico. Dairymen avoid purchasing hay during the remaining periods due to quality differences. Price of milk in New Mexico is the AMPI price received by farmers while price of milk in Arizona is the UDA quota price. We are implicitly assuming that all
new facilities in Arizona include sufficient base to receive the quota price for all milk.

A total of 96 new facilities were brought into production in New Mexico and Arizona from 1976 to 1983.

The Results

Equation (4.17) is estimated using data deflated by their own deflator (1977 = 100) and non-deflated data. Deflated data are used to see if the variability in the observations will be reduced.

The estimation results using the 2 methods described before are given below with t statistics for the regression coefficients in parentheses.

1. Linear Probability Model (Non-deflated data)

\[ Y_{it} = -0.02 + 0.6 P_{Mt}^* - 0.017 P_{Ct}^* + 0.04 P_{Ht}^* - 0.013 P_{Lt}^* \]

\[ (1.6) \quad (-1.67) \quad (2.07) \quad (-.95) \]

\[ R^2 = 0.06 \]

2. Logit Model (Non-deflated data)

\[ \log[P_{it}/(1 - P_{it})] = -2.02 + 2.53 P_{Mt}^* - 0.075 P_{Ct}^* + 0.166 P_{Ht}^* - 0.05 P_{Lt}^* \]

\[ (1.63) \quad (-1.68) \quad (1.97) \quad (-0.95) \]

\[ \text{Goodness of fit Chi-sq} = 4.272 \quad \text{p-value} = 0.234 \]

\[ \text{Goodness of fit Chi-sq (D. Hosmer)} = 0.541 \quad \text{p-value} = 0.91 \]

\[ \text{Goodness of fit Chi-sq (C.C. Brown)} = 3.371 \quad \text{p-value} = 0.185 \]

The summary description of observed proportion and predicted probability computed by the BMPD program for the eight years is shown below.
<table>
<thead>
<tr>
<th>Number Arizona</th>
<th>Number New Mexico</th>
<th>Observed Proportion</th>
<th>Predicted Prob. of AZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>7</td>
<td>.2222</td>
<td>.2249</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>.2500</td>
<td>.5038</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>.2941</td>
<td>.3462</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>.4000</td>
<td>.3039</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>.4444</td>
<td>.5410</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>.5714</td>
<td>.5048</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>.6000</td>
<td>.5779</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>.7143</td>
<td>.5548</td>
</tr>
</tbody>
</table>

Letting the observed proportion be $y$ and the predicted proportion be $y'$ and reordering by year, we have:

<table>
<thead>
<tr>
<th>Year</th>
<th>$q$</th>
<th>$y$</th>
<th>$y - y'$</th>
<th>$(y - y')^2$</th>
<th>Res.</th>
<th>$(\text{Res.})^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.5548</td>
<td>.7143</td>
<td>.2772</td>
<td>.0769</td>
<td>.1595</td>
<td>.0254</td>
</tr>
<tr>
<td>2</td>
<td>.5410</td>
<td>.4444</td>
<td>.0073</td>
<td>.00005</td>
<td>-.0966</td>
<td>.0093</td>
</tr>
<tr>
<td>3</td>
<td>.2249</td>
<td>.2222</td>
<td>-.2148</td>
<td>.0462</td>
<td>-.0027</td>
<td>.000007</td>
</tr>
<tr>
<td>4</td>
<td>.3039</td>
<td>.4000</td>
<td>-.037</td>
<td>.0014</td>
<td>.0961</td>
<td>.0022</td>
</tr>
<tr>
<td>5</td>
<td>.5779</td>
<td>.6000</td>
<td>.163</td>
<td>.0265</td>
<td>.0221</td>
<td>.0049</td>
</tr>
<tr>
<td>6</td>
<td>.5048</td>
<td>.5714</td>
<td>.1343</td>
<td>.018</td>
<td>.0666</td>
<td>.0044</td>
</tr>
<tr>
<td>7</td>
<td>.3462</td>
<td>.2941</td>
<td>-.1429</td>
<td>.0204</td>
<td>-.0521</td>
<td>.0027</td>
</tr>
<tr>
<td>8</td>
<td>.5038</td>
<td>.2500</td>
<td>-.187</td>
<td>.035</td>
<td>-.2538</td>
<td>.0644</td>
</tr>
</tbody>
</table>

$\bar{Y} = .43705$

$R^2 = 1 - (.1159/.2244) = .484$
3. Linear Probability Model (deflated data)

\[ Y_{it} = 1.094 + 0.22 P_{Mt}^* - 0.0124 P_{Ct}^* + 0.03 P_{Ht}^* + 0.0054 P_{Lt}^* \]

\[ R^2 = 0.033 \]

4. Logit Model (deflated data)

\[ \log \left( \frac{P_{it}}{1 - P_{it}} \right) = 2.56 + 0.95 P_{Mt}^* - 0.053 P_{Ct}^* + 0.124 P_{Ht}^* + 0.0235 P_{Lt}^* \]

\[ \text{Goodness of fit Chi-Sq} = 6.613 \quad p\text{-value} = 0.085 \]

\[ \text{Goodness of fit Chi-Sq (D. Hosner)} = 5.32 \quad p\text{-value} = 0.26 \]

\[ \text{Goodness of fit Chi-Sq (C.C. Brown)} = 4.902 \quad p\text{-value} = 0.09 \]

The summary description of observed proportion and predicted probability computed by the BMDP program for the eight years is shown below:

<table>
<thead>
<tr>
<th>Number</th>
<th>Number</th>
<th>Observed Proportion</th>
<th>Predicted Prob. of AZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arizona</td>
<td>New Mexico</td>
<td>Arizona</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>.2222</td>
<td>.3370</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>.2500</td>
<td>.2601</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>.2941</td>
<td>.4822</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>.4000</td>
<td>.4179</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>.4444</td>
<td>.5285</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>.5714</td>
<td>.4049</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>.6000</td>
<td>.5615</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>.7143</td>
<td>.5467</td>
</tr>
</tbody>
</table>
letting again the observed proportion be \( y \) and the predicted proportion be \( \hat{y} \) and reordering by year, we have:

<table>
<thead>
<tr>
<th>Year</th>
<th>( y )</th>
<th>( \hat{y} )</th>
<th>( y - \hat{y} )</th>
<th>( (y - \hat{y})^2 )</th>
<th>Res.</th>
<th>( (\text{Res})^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.5467</td>
<td>.7143</td>
<td>.27725</td>
<td>.0769</td>
<td>.1676</td>
<td>.0281</td>
</tr>
<tr>
<td>2</td>
<td>.5285</td>
<td>.4444</td>
<td>.0073</td>
<td>.00005</td>
<td>-.0841</td>
<td>.0071</td>
</tr>
<tr>
<td>3</td>
<td>.3370</td>
<td>.2222</td>
<td>-.2148</td>
<td>.0462</td>
<td>-.1148</td>
<td>.0132</td>
</tr>
<tr>
<td>4</td>
<td>.4179</td>
<td>.4000</td>
<td>-.037</td>
<td>.0014</td>
<td>-.0179</td>
<td>.0003</td>
</tr>
<tr>
<td>5</td>
<td>.5615</td>
<td>.6000</td>
<td>.163</td>
<td>.0265</td>
<td>.0385</td>
<td>.00148</td>
</tr>
<tr>
<td>6</td>
<td>.4049</td>
<td>.5714</td>
<td>-.1343</td>
<td>.018</td>
<td>.1665</td>
<td>.0277</td>
</tr>
<tr>
<td>7</td>
<td>.4822</td>
<td>.2941</td>
<td>-.1429</td>
<td>.0204</td>
<td>-.1881</td>
<td>.0354</td>
</tr>
<tr>
<td>8</td>
<td>.2601</td>
<td>.2500</td>
<td>-.187</td>
<td>.035</td>
<td>-.0101</td>
<td>.0001</td>
</tr>
</tbody>
</table>

\[ y = .43705 \]
\[ R^2 = 1 - (.1134/.2244) = .495 \]

Although the focus of this empirical inquiry is on the location choice of new producers, it should be of interest to point out the similarities between the above methods of estimation in the models.

The signs of each of the coefficients in the OLS and logit estimates are in the same direction. Except for the price of hay and the cost of land, the signs of the coefficients are as expected. The values of the t-statistics are surprisingly quite similar in the two techniques. The low values of the \( R^2 \) (0.033 and 0.06) of the OLS technique in the two models have limited validity as a measure of goodness of fit since the assumed dependent variable is 0 or 1. In
the classical linear model, we wish to obtain an $R^2$ close to 1, indicating a good fit. However, in the LP model we are predicting the probability that a given choice will be made. We are likely to predict an outcome of 1, i.e., the choice will be made if the predicted probability is greater than 0.5, and 0, i.e., the choice will not be made if it is less than 0.5. Therefore, the LP model is not likely to yield an $R^2$ close to 1. Morrisson (1972) showed that the upper limit of an $R^2$ of 1/3 when the true probabilities of an event occurring are uniformly distributed across a given interval.

In the first model (with non-deflated data), all the coefficients estimated by the two techniques are significant at the 0.01 level except for the price of milk and the rent on land. But the estimated coefficient of the price of milk is significant at the 0.02 level.

In the second model (with deflated data), only the estimated coefficient of the cost of hay is significant at the 0.02 level; however, it has a wrong sign.

The three goodness-of-fit chi-square tests for the logit model reported for the two models, all indicate that the logistic model is adequate for the data, since their p-value is different from zero. The goodness-of-fit chi-square and the "C. C. Brown" goodness-of-fit are both used to test the hypothesis that the logistic model fits the data adequately. The "Hosmer" goodness-of-fit is used to test the hypothesis that the predicted values fit the observed values well.

To recapitulate, the comparison of the two methods of estimation shows a remarkable similarity between the logit-ML and the
LP-OLS estimates. Such similarity is also obtained by Wilensky and Rossiter (1978) in their study of a physician location choice.

However, since the logit model is more reliable than the LP model due to the problems mentioned earlier, we will use it to interpret the empirical findings.

The good performance of the logit model can be shown not only through the three goodness-of-fit tests discussed above, but also through the summary observed proportions and predicted probabilities computed by the BMDP program for the eight year period and shown above with the $R^2$.

The results of (4.22) show all the estimated coefficients except for rental cost of land ($P_{Lt}^*$) to be significant at the 0.02 level ($P_{Mt}^*$ and $P_{Ht}^*$). Again, all the signs are as expected, except for the cost of hay. Since equation (4.22) shows better performance than equation (4.24), we will use it to interpret the empirical findings.

Care must be taken in interpreting the parameters of equations (4.22), since the left-hand side of those two equations are the logarithm of the odds of probability, not the actual probability. Equation (4.22) implies that a ceteris paribus increase of $P_{Mt}^*$ by 1 will lead to a 2.53 increase in the logarithm of the odds that a new facility will be located in New Mexico, and a ceteris paribus increase of $P_{Cl}^*$ by 1 will lead to a .07 decrease in the logarithm of the odds that a new facility will be located in New Mexico. To interpret the effect of these changes on the actual probability of locating in New Mexico, we need to solve for:

$$\log \left[ \frac{P}{(1 - P)} \right] = \text{(variable)}$$
but,
\[
\log \left[ \frac{P}{(1 - P)} \right] = \Delta \left( \log P - \log (1 - P) \right) \\
= [1/P + 1/(1 - P)] \Delta P \\
= \Delta P / P(1 - P)
\]

let \( \Delta P^*_{Mt} = 0.10 \); but \( P^*_{Mt} \) was defined in equation (4.17) as the difference in the price of milk in New Mexico and the net price of milk (adjusted for rental cost of base) in Arizona. Therefore, to have an increase in \( P^*_{Mt} \) by 0.10, the milk price in New Mexico has to increase or the net milk price in Arizona to decrease. The latter can be obtained by an increase in the rental cost of base.

\[
\left[ \frac{1}{P(1 - P)} \right] P = 0.253 \quad \text{or} \quad \Delta P = 0.253[P(1 - P)]
\]

If we use the mean, i.e., we assume that there is a 50/50 chance of locating in Arizona or New Mexico, then \( P = .5 \). Thus, an increase in \( P^*_{Mt} \) by 0.1 will lead to an increase in the probability that a new facility locates in New Mexico by 0.0633. Using the same calculations and letting \( P^*_{Mt} \) increase by 1 leads to a decrease in the probability that a new facility will locate in New Mexico by 0.004.

Returning again to the first explanatory variable, we want to know by how much the cost of base in Arizona has to increase in order to generate an increase in \( P^*_{Mt} \) by 0.10. For example, suppose the actual price of base is $20/lb, interest rate \( (r) \) is 15% and tax rate \( (z) \) is 8%. Given the definition of \( P^*_{Mt} \) in equation (4.17), a 4% ceteris paribus increase in the actual price of base (80 cents) will lead to an increase in \( P^*_{Mt} \) by 0.10 and to an increase in the probability that a new facility locates in New Mexico by 0.0633.
In conclusion, the performance of the two models is satisfactory. They show that the existence of milk base in Arizona is a powerful element in explaining why a new facility will most likely locate in New Mexico.

**Supply Response of Existing Dairies**

The objective of this section is to investigate supply response through expansion in output of existing dairy facilities. The emphasis is again on the impact of the profitability variables on the supply of raw milk in Arizona and New Mexico. An attempt is made to understand the extent that dairy producers in Arizona and New Mexico react to changes in the profitability of milk production.

Expansion in output of existing dairies can be achieved in several ways. One way in which expansion in output can be accomplished is by increasing milk production per cow. This can be achieved by improving the genetics of the dairy herd, or by improving the feeding and management practices. A second way in which expansion in output is achieved is by increasing the number of milking cows. Output expansion through increasing cow numbers and feed per cow is more rapidly achieved than through genetic improvement. However, expanding cow numbers involves capital investment as well as increased operating expenditures while increased feeding and improved breeding can usually be achieved without added capital purchases. Increased output can also be achieved by improving health and other management practices.
Several previous studies have investigated milk supply responses. Halvorson (1958) and Wipf and Houck (1967) used the partial adjustment model to estimate milk supply response in the U.S. Chen et al. (1972) used a polynomial lag formulation to measure milk production response. Prato (1973) used a simultaneous equations model to estimate cow numbers and average production per cow in the U.S. Milligan (1978) used bimonthly observations in a single equation to estimate milk supply response for six California regions. Chavas and Klemme (1984) built a model of population growth in which the dairy herd is considered as a capital stock to estimate milk supply response in the U.S. Empirical results obtained from these studies have varied, however. In general, most of the studies found the short run elasticity of milk supply to be small, between 0.07 and 0.16, while the long run elasticity of supply estimates varied from 0.4 (Halvorson) to 2.53 (Chen et al.) to 6.69 (Chavas and Klemme). These wide variations in the long run elasticity of supply estimates suggest that a closer look at the dynamics of milk supply adjustment is needed.

The aim here, however, is to build a framework to study short run milk supply adjustments in Arizona and New Mexico.

Theoretical Framework of the Model

We again rely heavily on the behavioral assumption that a dairy producer wishes to maximize profit. We will be concerned here only with the revenues and costs directly associated with expansion of production with existing facilities. In other words, initial plant and
equipment investment costs are not relevant here since they are sunk costs.

In contrast, therefore, to the expression of profit provided in equation (4.1), expansion of output with an existing parlor would normally not include the consideration of purchases of additional land, for example. In some cases, output expansion will require additional investment and hence added interest and personal property tax. Land costs will therefore be omitted from the model, but other investment costs retained. Equation (4.1) omitted a number of profitability variables that were expected to be common to Arizona and New Mexico and were therefore omitted in considering the decision of where to locate. Labor costs, for example, were assumed to be the same in Arizona and New Mexico. Many decisions to expand output will require additional labor however, and changes in the wage rate will affect the profitability of increasing output from an existing facility.

As argued earlier, income taxes will not affect the profit maximizing factor product mix and hence tax rates will not be considered.

Since the focus here is upon the short run output response of existing firms to changes in the milk price and input prices, and output of new entrants is known separately, a theoretical framework will be developed to estimate output response of firms excluding output resulting from new entry.

Consider again an industry made up of N representative firms of the size $q$, where $q$ is a function of milk price and input prices.

The aggregate output can be expressed as:
\[ Q = Nq \]

and the short run supply response of existing firms to a change in the milk price becomes

\[ \frac{dQ}{dP} = N(\frac{dq}{dp}) \]

Substituting back in for \( N \) results in

\[ \frac{dQ}{dP} = (\frac{Q}{q})(\frac{dq}{dp}) \]

so that the response of aggregate output is the proportional increase in the individual firm's output times the original aggregate output level. The percentage increase in the individual firm's output in response to an increase in milk price can thus be estimated assuming the level of response is constant over the study period. The same line of reasoning can be used to arrive at an analogous approach to estimating output response to factor price changes.

Aggregate output response is as a result in direct proportion to the initial output level and data for Arizona and New Mexico for various years can be pooled without additional considerations for shifts in the aggregate supply function due to entry or difference in the size of the industry between the two states. An econometric model is provided below.

The Econometric Model

Output will be assumed to respond to lagged product and factor prices. Output response will be estimated for aggregate output for New Mexico and for aggregate over quota milk for Arizona. The over quota milk price and the blend price will be used for Arizona and New Mexico respectively. Since base is fixed in aggregate, the price of
base should not affect the quantity of over quota milk to be produced in aggregate although individual firms may buy and sell base. Therefore, cost of milk base will be excluded from the model. However, we will add the cost of replacement cows in the model, which includes annual interest and depreciation cost.

Although economic theories do not specify the length of a lag structure, one might argue that producers respond to prices lagged two or more years. Because of the degree of freedom problem we face, due to a very limited number of observations, it is necessary to avoid long lags.

Dairymen can respond fairly quickly to milk and concentrate prices by modifying the amount of grain in the ration. As a result the current prices of milk and concentrate are included in the model. Adding cows however and bringing them into production requires more time. Additional labor and hay will be closely related to the added cows. As a result, labor, hay and the annual cost of replacement cows would be expected to have a lagged response.

Assuming a linear functional form for the milk supply response function, let aggregate output be specified in relation to previous output and lagged prices as follows:

\[ Z_t = \frac{Q_t}{Q_{t-1}} = a + B_1 P_{Mt} + B_2 P_{Ct} + B_3 P_{Ht-1} + B_4 P_{Rt-1} + B_5 W_t - 1 + E_t \]

4.28

where:

- \( P_{Rt} \) is the annual investment cost for a replacement cow
- \( W_t \) is the average wage rate at period t.

All the other variables are defined as before.
One would expect a ceteris paribus increase in the price of milk to have a positive effect on the quantity of milk produced, while a ceteris paribus increase in the cost of the other independent variables to have a negative effect on the quantity of milk produced.

Methods of Estimation

We shall now consider the method to be used to estimate the coefficients in equation (4.21).

Again sufficient observations are not available to estimate separately supply responses in Arizona and in New Mexico. Therefore, we are obliged to combine the Arizona and New Mexico data, and estimate milk supply response for the region. In doing so, we are pooling cross-section and time-series observations, which adds a new dimension of difficulty to the model specification problem. The difficulty arises because the behavior of the cross-section disturbances might be different from the behavior of the time-series-related disturbances, which suggests that the disturbance term of the pooled model consists of cross-section disturbances, time-series disturbances, and a combination of both.

The regression equation for the pooled model can be written as:

\[ z_{it} = a + B_1 P_{Mi,t} + B_2 P_{Ci,t} + B_3 P_{Hi,t-1} + B_4 P_{Ri,t-1} + B_5 W_{i,t-1} + E_{it} \]

for \( i = 1, 2 \)

\[ t = 1, 2, 3, \ldots, 8. \ (1976 \text{ to } 1983) \]
i = 1 for Arizona
i = 2 for New Mexico

The sample data are then represented by observations on 2 cross-section units (Arizona and New Mexico) over 8 periods of time, or altogether 16 observations.

There are essentially two approaches to pooling of cross-section and time-series data. The first approach is to use dummy variables which allow for the constant term to vary over cross-section units and over time. This approach, called the covariance model, is an attempt to specify a model with a disturbance term that has zero mean. The model assumes that each cross-sectional unit and each time period are characterized by their own intercept. This feature is introduced into the regression model. However, there are several problems associated with the use of covariance model (Pindyck and Rubinfeld, 1981, Chapter Nine; Maddala, 1971; Wallace and Hussain, 1969). First, the use of dummy variables does not directly identify the variables that might cause the shifts in the regression line, and the coefficients of the dummy variables are difficult to interpret. Second, the use of dummy variables involves a loss of many degrees of freedom, which may decrease considerably the statistical power of the model.

The second approach is to recognize possible correlations among the disturbance terms and impose some restrictions on the variance-covariance matrix of the disturbances to account for these correlations, in order to increase the asymptotic efficiency of the estimates of the coefficients. Specific assumptions on the behavior
of the disturbance terms will lead to specific restrictions on the variance-covariance matrix of the disturbance terms.

We will use the second approach to estimate the model. In doing so, we will assume that the disturbance term of the pooled model is composed of three independent disturbance terms — a cross-section disturbance term, a time-series-related disturbance term, and a disturbance term which combines both. In other words, we are assuming that the disturbances terms of the pooled model are correlated across cross-section units and across time. This model is the so-called error-components model.

The model is specified as:

\[ Z_{it} = a + B_1 P_{Pi,t} + B_2 P_{Ci,t} + B_3 P_{Hi,t-1} + B_4 P_{Ri,t-1} + B_5 W_{it}, t-1 + E_{it} \]

\[ E_{it} = u_i + v_t + W_{it} \]

where the \( u_i \), \( v_t \) and \( W_{it} \) components of the disturbance term \( E_{it} \) are all random.

\( u_i \sim N(0, \sigma_{u}^2) \) is the cross-section disturbance term.
\( v_t \sim N(0, \sigma_{v}^2) \) is the time-series disturbance term.
\( W_{it} \sim N(0, \sigma_{w}^2) \) is the combined disturbance term.

It is assumed that \( u_i \), \( v_t \) and \( W_{it} \) satisfy the following conditions:

\[ E(u_i v_t) = E(u_i W_{it}) = E(v_t W_{it}) = 0 \]
\[ E(u_i u_j) = 0 \text{ for } i \neq j \]
\[ E(v_t v_{t'}) = 0 \text{ for } t \neq t' \]
\[ E(W_{it} W_{jt}) = E(W_{it} W_{jt'}) = E(W_{it} W_{jt'}) = 0 \]

for \( i \neq j \) and \( t \neq t' \)
In other words, the individual disturbance terms are not correlated with each other and are not auto-correlated.

It is more convenient to rewrite the model in matrix notation as:

\[ y = (1, X) \left( \begin{array}{c} \alpha \\ \beta \end{array} \right) + E \]

where \( y \) is a 16 x 1 column vector, \( 1 \) is a 16 x 1 column vector, \( X \) is a 16 x 5 matrix, \( \alpha \) is scalar, \( \beta \) is a 5 x 1 column vector, and \( E \) is 16 x 1 column vector of disturbances terms. They are defined as follows:

Given the assumptions we made about the random disturbance vector \( E \), its variance-covariance matrix can be written as (Wallace and Hussain, 1969):

\[ r(EE') = \alpha = s^2_{w16} + s^2_{uA} + s^2_{vB} \]

where \( \alpha \) is a 16 x 16 matrix, \( I_{16} \) is a 16 x 16 identity matrix, and \( A \), \( B \) are both 16 x 16 matrices defined as follows:
where \( J_8 \) is an \( 8 \times 8 \) matrix of ones, and \( I_8 \) is an \( 8 \times 8 \) identity matrix.

If the variance-covariance matrix \( (\sigma^2) \) was known, then the Aitken's generalized least squares formula can be used to get the best linear, unbiased estimates of \( B \):

\[
B = (X' \sigma^{-1}X)^{-1} (X' \sigma^{-1}Y)
\]

The elements of the variance covariance matrix \( (\sigma^2) \) can be estimated as follows (Kmenta, 1971, Chap. 12):

\[
\hat{\sigma}_w^2 = \frac{1}{(N-1)(T-1)} \sum_{i=1}^{t} \sum_{j=1}^{N} (e_{it} - \frac{1}{T} \sum_{j=1}^{T} e_{jt})^2
\]

\[
\hat{\sigma}_u^2 = \frac{1}{T} \left( \frac{1}{(N-1)T} \sum_{i=1}^{N} \left( \sum_{j=1}^{T} e_{jt} \right)^2 - \hat{\sigma}_w^2 \right)
\]

\[
\hat{\sigma}_v^2 = \frac{1}{N} \left( \frac{1}{N(T-1)} \sum_{i=1}^{T} \left( \sum_{j=1}^{N} e_{jt} \right)^2 - \hat{\sigma}_w^2 \right)
\]
where: \( N = 2 \) for our model
\( T = 8 \) for our model

e_{it} is the residuals obtained by applying ordinary least squares method to the pooled data.

These estimates of the variance components are used to find the variance covariance matrix.

\[ \Omega = s^2I + s^2A + s^2B \]  

Replacing \( \Omega \) in the equation 4.33, we obtain estimates of the regression coefficients that are asymptotically unbiased, consistent and efficient.

The two-stage estimates of the regression coefficients that we have just described were obtained using the Regression Analysis of Time Series (RATS) software package. RATS is a computer package for the analysis of time series, small cross-section and panel data sets, developed by the VAR Econometrics (Copyright 1984).

Data

Annual milk production of existing dairies in Arizona and New Mexico has been obtained by subtracting production of newly established dairies from the total milk production in the states, and for Arizona by further subtracting milk delivered as quota milk. Discussions with dairy experts suggest that a period of at least six months should be considered as an establishment period for a new dairy before it can operate at or near full capacity. Therefore, dairy farms created between January and June of each year are considered new dairies for that year only; dairy farms created between July and
December of each year are still considered new dairies for their second year, unless their second year milk production equals or exceeds their third year milk production.

Production data for new dairies in Arizona have been provided by the UDA office in Phoenix, Arizona. Total milk production and milk delivered as quota milk in Arizona were obtained from United Dairymen.

Production data for new dairies in New Mexico and the total milk production in the state have been provided by the regional office of AMPI in Arlington, Texas.

The UDA over-quota milk price is used for Arizona, and the AMPI price is used for New Mexico.

The annual investment cost for a replacement cow ($P_{Rt}$) is obtained by adding the annual depreciation cost to the annual average interest payment on the purchase price of a cow. It is assumed a zero salvage value for a cow and a thirty percent depreciation. The annual purchase prices for replacement cows used for Arizona and New Mexico are annual average prices and are obtained from Agricultural Prices (USDA - CRB - ESCS - annual summary).

Wage rates are obtained from farm labor (USDA - ESS).

The sources of the other data used in this model are listed in the previous section. All prices used in the model are constant (1977 = 100) prices, deflated by their own index.

The Results

Many regression equations using different lag structures on the independent variables and within the limits of the available
degrees of freedom were run in order to obtain a model that satisfies both the expected signs of the coefficients and an acceptable level of significance of the estimated coefficients. It was not possible to obtain such regression equation. The best estimated regression coefficients as far as the expected signs of the coefficients were concerned, were obtained when dropping from the model either the price of hay or the price of concentrate. One possible explanation was that these two variables are highly correlated. However, when we ran the price of hay on all the other variables to check for multicollinearity, we found that the price of hay was mostly correlated with the cost of a replacement cow. We ran the same regression using the cost of concentrate as a dependent variable, and the same result was obtained, i.e., the cost of concentrate was highly correlated to the cost of a replacement cow. The model including the price of concentrate and excluding the price of hay is retained not only because of better empirical results, but it is known that dairy farmers use more concentrate if they wish to obtain more milk.

The estimation model is given below with t-statistics for the regression coefficients in parentheses. The coefficients of multiple determination ($R^2$) and the Durbin-Watson (DW) statistic are also reported.

1. The model including the price of hay:

$$Z = 0.14 + 2.36 P_{Mt} + 0.037 P_{Ct} + 1.35 P_{Ht-1} - 0.17 W_{t-1} - 0.052 P_{Rt-1}$$

$$R^2 = 0.715$$

2. The model excluding the price of hay:
\[ Z_t = 0.16 + 10.38 P_{Mt} - 0.082 P_{ct} - 0.023 W_{t-1} - 0.039 P_{Rt-1} \]

\( R^2 = 0.542 \quad DW = 2.31 \)

All the signs of the regression coefficients are as expected in the second model. However, only the coefficient of the price of milk is significant at the 5 percent level. At the one percent and 5 percent levels, the DW value falls in the indeterminate region.

The coefficients of the variables, except of the price of milk are very low, although theory indicates that dairy farmers in Arizona and New Mexico do react to changes in the cost of feed, wage rates and cost of cows. The sample size is apparently insufficient for those variables to show statistical significance. The coefficient of the milk price is relatively high and is significant at the 5 percent level.

The model suggests that a ceteris paribus increase in the price of milk by 1 will increase Z by 10.38. Note that Z is the ratio of current to last year milk production, i.e., an increase in the current price of milk by $1 per cwt will increase the current year production over 10 percent. The own price elasticity of milk was estimated and found to be 0.6 which is in line with estimates obtained from other studies. We will not interpret the other variables given the low significance level of their coefficients.

In conclusion, this model shows that dairy farmers in Arizona and New Mexico respond to changes in the farm level of milk price. Given that dairy farms in Arizona and New Mexico are large and specialized, one might expect that they would have a long run response to
alterations in input costs. It was not possible to investigate the long run supply response in the region, due again to the degree of freedom problem.
CHAPTER 5

WELFARE COSTS DUE TO THE REGULATIONS OF THE ARIZONA
AND NEW MEXICO DAIRY MARKETS

In Chapter 3, we analyzed graphically the welfare costs associated with the different postulated market organizations. We showed graphically the deadweight losses associated with the classified pricing and base quota used in Arizona and New Mexico, compared to a perfectly competitive model and to a monopoly model.

The objective of this chapter is to estimate the welfare effects of regulations upon the Arizona and New Mexico dairy markets. The concept of consumer's surplus is used and an attempt is made to estimate quantitatively the changes in consumer welfare due to the regulations of the Arizona and New Mexico dairy markets.

The concept of consumer surplus has been used frequently to quantify welfare changes resulting from actual policies. In the dairy literature, many studies have used supply and demand schedules to define areas of economic surplus and show the net welfare effects of regulations (Dahlgran, 1980; Ippolito and Masson, 1978; Kwoka, 1977; Buxton and Hammond, 1974; Blakley and Riley, 1974; Kessel, 1967). The use of the Marshallian (market) demand curve provides a reliable estimate of economic surplus if and only if the income elasticity of demand is zero or close to zero (Currie, Murphy, and Schmitz, 1971). The income elasticity of demand for fluid milk was estimated to be

100
0.11 (Hallberg and Fallert, 1976). We will use in this study the competitive market equilibrium as a standard by which to assess consumer welfare changes resulting from dairy market manipulations.

**Measurement of Consumer Welfare Change**

Alternative measures of consumer welfare change are found in the welfare literature. These are consumer surplus (CS), compensating variation (CV), equivalent variation (EV), Paasche variation (PV) and Laspeyres variation (LV). The debate on the merit of each one of these measures has dominated much of the welfare literature since Marshall (1920) referred to a first description of the notion by Dupuit (1844) as consumer surplus. Consumer surplus was and still is defined as the area below the market demand curve and above the price line. The idea that is reflected in the definition is that a consumer pays less for the consumption of a commodity than the maximum amount he/she would pay rather than forgo the consumption of that commodity.

Compensating variation is defined as the amount of compensation, paid or received, that will leave the consumer in his initial welfare situation ($u_0$) following the change in price if any quantity of the commodity can be bought at the new price. Equivalent variation is defined as the amount of compensation, paid or received, that will leave the consumer in his subsequent welfare situation ($u_1$) in the absence of the price change if he is free to buy any quantity of the commodity at the old price.

Laspeyres variation is the exact change in income required to allow the purchase of the original quantities of all goods after
prices have changed. Paasche variation is the exact change in income required to allow the purchase of the subsequent set of goods when facing the initial price situation.

The relationship among these alternative measures of consumer welfare change is illustrated in Figure 21 for a single price decline.

Figure 14. Illustrations of CV, EV, PV, LV for the Case of a Price Decline

In Figure 14, attention is limited to a consideration of a commodity under investigation called x and a composite-commodity-"money" called M. Let $M_0$ represent the consumer's income. At the initial price $P_0$, this consumer achieves equilibrium at point A on indifference curve $U_0$. He is consuming $Q_0$ quantity of x. Now suppose
the price of x falls from \( P_0 \) to \( P_1 \). Given the same income, the consumer achieves tangency solution at point B on indifference curve \( u_1 \). He would have to be given a reduced income of \( BB_1 \) dollars to restore him to his initial welfare position (point c on \( u_0 \)). Therefore, \( BB_1 \) represents the compensating variations measure of consumer's welfare change. This value corresponds to the area \( P_0EGP_1 \) in the price-commodity space of Figure 14. \( D_m \) is the Marshallian or market demand curve, while \( D_C \) and \( D_E \) are compensated demand curves. For the consumer initially in equilibrium at point A on indifference curve \( u_0 \), he would have to be given an income increment of \( AA_1 \) in order to achieve the utility level \( u_1 \) when facing the price \( P_0 \) (point D). \( AA_1 \) represents the equivalent variation measure of consumer's welfare change, or \( P_0FKP_1 \) in the price-commodity space. The change in consumer surplus due to the decline in price of good x is given by the area \( P_0EKP_1 \). Comparing these three measures for the case of a price decline yields the relationship, \( CV < CS < EV \). For the case of a price increase, the inverse relationship will hold, i.e., \( EV < CS < CV \). Laspeyres variation is represented by \( AA_2 \) or \( P_0EHP_1 \), while Paasche variation is given by \( BB_2 \) or \( P_0JKP_1 \) in the price-commodity space. It follows that, for the case of a price decrease, \( LV \) is less than \( CV \), while \( PV \) is greater than \( EV \). Thus, the following relationship among the five alternative measures of consumer welfare change is obtained for the case of a single price decrease, \( LV < CV < CS < EV < PV \).

The Choice Between Alternative Measures of Consumer Welfare Change

The choice of an appropriate measure of consumer welfare
change must be made on the ground of both theoretical and practical considerations. Although it is generally accepted that compensating and equivalent variations measures of consumer welfare change are more accurate and superior measures from a theoretical point of view, since they indicate whether or not a policy change is a potential Pareto improvement (Mishan, 1976; Meade, 1972), some authors (Hicks, 1943) had suggested that the distinction among these alternative measures would be of very little importance in applied studies. It should be noted that the use of CV or EV to estimate consumer welfare change requires more information than the use of the other alternative.

To decide whether or not to choose the theoretically less desirable measures of consumer welfare change, one must know the magnitude of the potential error of the estimate and the relationship between this error and the policy making decision. Willig (1976) established the following guidelines under which consumer surplus can be used unapologetically to approximate compensating and equivalent measures of consumer welfare change in applied studies:

\[
|\text{CS}/m | E_s/2 | \leq .05 \text{ and } |\text{CS}/m | E_r/2 | \leq .05
\]
\[|\text{CS}/m | \leq .9\]

If these two conditions are met, then the rules for error for the case of a single price increase are:

\[
|\text{CS}/m | E_s/2 | \leq (CV - \text{CS})/\text{CS} \leq |\text{CS}/m | E_r/2
\]
\[|\text{CS}/m | E_s/2 | \leq (\text{CS} - CV)/\text{CS} \leq |\text{CS}/m | E_r/2
\]

For the case of a single price decrease, the rules for error are:

\[
|\text{CS}/m | E_s/2 | \leq (\text{CS} - CV)/\text{CS} \leq |\text{CS}/m | E_r/2
\]
\[|\text{CS}/m | E_s/2 | \leq (EV - \text{CS})/\text{CS} \leq |\text{CS}/m | E_r/2
\]
where CS is the consumer’s surplus, CV is the compensating variation, EV is the equivalent variation, m is the consumer’s income, $E_s$ and $E_L$ are respectively the smallest and largest values of the income elasticity of demand in the region under consideration. However this approach of estimating the error requires a lot of information. Indeed, we need to know the income elasticities of demand, the consumer’s surplus and the consumer’s income.

A second approach is to approximate CV and EV using the easily computed Paasche variation (PV) and Laspeyres variation (LV). Cory et al. (1981), using the bounding properties of PV and LV, derived additional rules of thumb for approximating CV and EV with either CS or PV or LV. Assuming a linear demand curve over the range under consideration, they showed for the case of a price decrease that:

\[
\frac{(CS - LV)}{CS} \leq y \text{ when } |dQ| \leq \frac{2y}{(1-y)} Q_o
\]

\[
\frac{(PV - CS)}{CS} \leq y \text{ when } |dQ| \leq \frac{2y}{(1-y)} Q_o
\]

where $Y$ is a specified percentage of error, $dQ$ is change in quantity demanded resulting from the price change, and $Q_o$ is the original quantity demanded. It follows from these formulas that LV and PV can be used unapologetically to approximate CV and EV whenever the changes in quantity demanded are less than 10%, since they will be within 5% of CS. Notice that this approach of estimating the error does not require information about income elasticity of demand or consumer’s income. Then, the authors suggested a pragmatic approach to estimate consumer welfare change in applied studies. First, compute the Paasche and Laspeyres measure of consumer welfare change. These two measures provide a range in which the actual value of the consumer
welfare change will lie. Next, assuming a direct linear path of price-quantity adjustment, the midpoint of this range is the estimate for the change in consumer welfare.

This two-step procedure will be used in the empirical estimation of welfare costs due to regulations of the Arizona and New Mexico dairy markets.

Estimates of Consumer Welfare Change

Since this investigation is concerned with welfare costs within markets, estimation must be performed on individual markets. Therefore we will estimate the welfare costs associated with the use of milk marketing orders and base system in Arizona and the welfare costs due to milk marketing orders alone in New Mexico. We will use the hypothetical perfectly competitive market equilibrium as a standard against which actual market equilibria resulting from actual dairy policies will be assessed. The perfectly competitive equilibrium, reflecting a pareto optimum is the best available standard for measuring resource misallocation and change in consumer welfare.

We showed in Chapter 3 that, in absence of any regulation and assuming that raw milk is homogeneous at the farm level, the price of milk paid to farmers would be the same regardless of the use of milk. For Arizona, the farm price of milk would then approximate the UDA over quota price or Class III price, while for New Mexico it would then approximate the Class II price. We will assume that, in an unregulated environment, the farm level price of milk would be equal to the Class III price in Arizona, and to the Class II price in New
Mexico. Therefore the differential between Class I and Class III prices of milk in Arizona, and between Class I and Class II prices of milk in New Mexico are strictly due to regulation. We will further assume that these differentials are reflected in the retail price of fluid milk.

Estimates for the measures of consumer welfare change were made for 1976-1983 period in each of these two markets, using the two step procedure described in the previous section. Estimates of the price elasticities of demand for fluid milk in Arizona and in New Mexico were unavailable. We set the fluid milk price elasticity in the two states at -0.20, based on estimate by Dahlgran and George and King for the U.S. The percentage of total milk marketed that is used as fluid milk in New Mexico and the total quantity of raw milk used as fluid milk in Arizona were obtained from the Federal Milk Order Market Statistics.

Estimation Results

The total loss in consumers' welfare in Arizona and New Mexico over the eight-year period are summarized in Tables 3 and 4. Estimates of consumer welfare losses by year are also recorded, as well as the estimates of Paasche and Lapayres Variation.

In Table 3 are estimates for Paasche Variation, Lapayres Variation and consumers' welfare losses by year for Arizona. It is estimated that the total welfare loss experienced by Arizona's fluid milk consumers over the eight year period amounts to 120 million dollars. Welfare loss in the first year (1976) amounts to 14 million
dollars and increases to a level of 17 million dollars in the last year (1983). Welfare losses as dollar per cwt of milk and as percent of total revenue are also reported. It should be noticed that these estimated losses are not net welfare losses due to regulations of the fluid milk market. They are losses in Marshallian consumers' surplus experienced by fluid milk consumers in Arizona and represented by the area $P_{II} P_{min}^I FG$ in Figure 10 of Chapter 3. The net welfare loss due to the regulations of fluid market would be smaller, since gains in producers' surplus should be subtracted.

In Table 4 the same estimates are recorded for New Mexico. It is estimated that the total loss in Marshallian consumers' surplus experienced by fluid milk consumers in New Mexico over the eight year period amounts to 67.5 million dollars. Welfare loss in the first year (1976) amounts to 6 million dollars and increases to 13 million dollars in the last year (1983).

In conclusion, the manipulation of the dairy markets in Arizona and New Mexico enforce a significant tax on fluid milk consumers in these states. It is not claimed that the estimated figures give the exact amount of this tax, but are a rough approximation of it. The estimates suggest that, on the average, regulations of the dairy market enforce a tax on Arizona's consumers of fluid milk in the amount of 10 million dollars per year, and a tax on New Mexico's consumers of fluid milk in the amount of 5.6 million dollars per year. On the average, these welfare losses amount to 1.66 dollars per cwt or 13.5 percent of producers' total revenue for Arizona and 1.52 dollars per cwt or 12.6 percent of producers' total revenue for New Mexico.
More accurate estimates would certainly be obtained using elasticities of demand for Arizona and New Mexico. Estimation of these price-elasticities of demand were beyond this investigation. However, this does not diminish the validity of these estimates as a guide for policy analysis.

In the theoretical and empirical analysis of Chapters 3 and 4, it was shown that the use of base plan in Arizona not only decreases the total quantity of milk produced by the existing dairies, but also decreases the likelihood of a new facility being located in Arizona. One could argue that without a base plan, the size of the Arizona dairy industry would be larger than what the unrestricted model assumes, and the size of the New Mexico dairy industry relatively smaller. In that sense, the estimates for the measures of consumer welfare (ones recorded for Arizona may be very conservative and biased downward, and those for New Mexico biased upward. The base plan in Arizona can then be viewed as a transfer from Arizona milk consumers to New Mexico milk consumers. It was also shown in the theoretical analysis of Chapter 3 that regulations of the milk markets increase producers' revenues. The increase in producers' revenues due to the order program and the base system has been illustrated graphically in Figures 11a and 12a. In Figure 11a it was assumed the processor to be a monopolist, and it was shown the cooperative being able to wrest some of the monopoly profit because of the order program, and some negotiated over-order payments. The order program and the base system are then viewed as an income transfer from milk processors to dairy farmers.
<table>
<thead>
<tr>
<th>Year</th>
<th>Paasche Variation</th>
<th>Lapayres Variation</th>
<th>Consumers' Welfare Losses</th>
<th>Consumers' Welfare Losses $ per cwt</th>
<th>Consumers' Welfare Losses % of Total Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>13.67</td>
<td>14.40</td>
<td>14.03</td>
<td>1.81</td>
<td>18</td>
</tr>
<tr>
<td>1977</td>
<td>13.01</td>
<td>13.67</td>
<td>13.34</td>
<td>1.67</td>
<td>16</td>
</tr>
<tr>
<td>1978</td>
<td>12.73</td>
<td>13.27</td>
<td>13.00</td>
<td>1.65</td>
<td>15</td>
</tr>
<tr>
<td>1979</td>
<td>14.13</td>
<td>14.70</td>
<td>14.41</td>
<td>1.75</td>
<td>14</td>
</tr>
<tr>
<td>1982</td>
<td>16.54</td>
<td>17.13</td>
<td>16.84</td>
<td>1.59</td>
<td>11</td>
</tr>
<tr>
<td>1983</td>
<td>16.78</td>
<td>17.39</td>
<td>17.08</td>
<td>1.56</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>117.49</td>
<td>122.29</td>
<td>119.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Paasche Variation</td>
<td>Lapayres Variation</td>
<td>Consumers' Welfare Losses</td>
<td>Consumers' Welfare Losses $ per cwt</td>
<td>Consumers' Welfare Losses % of Total Revenue</td>
</tr>
<tr>
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<td>------------------</td>
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<td>--------------------------</td>
<td>-------------------------------------</td>
<td>---------------------------------------------</td>
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<tr>
<td>1976</td>
<td>6.16</td>
<td>6.46</td>
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<tr>
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<td>6.57</td>
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<tr>
<td>1979</td>
<td>6.73</td>
<td>6.97</td>
<td>6.85</td>
<td>1.43</td>
<td>12</td>
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<tr>
<td>1980</td>
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<td>7.42</td>
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<td>9.93</td>
<td>1.55</td>
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</tr>
<tr>
<td>1982</td>
<td>11.28</td>
<td>11.64</td>
<td>11.46</td>
<td>1.47</td>
<td>10</td>
</tr>
<tr>
<td>1983</td>
<td>12.47</td>
<td>12.87</td>
<td>12.67</td>
<td>1.40</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>66.32</td>
<td>68.68</td>
<td>67.50</td>
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CHAPTER 6

SUMMARY AND CONCLUSIONS

The objective of this study was to analyze theoretically some alternative market organizations of the dairy industry, and to investigate empirically milk supply adjustments and consumers' welfare changes due to the regulations of the dairy markets in Arizona and New Mexico. We argued that it is a bit naive to think of the dairy industry as a perfectly competitive industry because it is more likely to be characterized by a price-making behavior on the part of the processor in absence of regulations. Then we analyzed the situation where the processor is monopsonist in the raw milk market and monopolist in the output market but faces competitive dairy producers. We first looked at the monopoly processor and considered the one product case, i.e., raw milk finds only one use. It was shown that, under the assumption of profit maximizing, the processor realizes some monopoly profits by purchasing milk at a price well below his net retail price. The long run response to an increase in the demand for the processor milk was illustrated to be an increase in the retail price of milk, an increase to the farm level price of milk, and an increase in the total quantity of milk produced due to entry into the dairy industry. The monopsony processor was then analyzed and it was shown that some monopoly profits are again realized by the processor who can exercise market power in the purchase of raw milk. An increase in the
processor's demand for milk was considered and the result was shown to be an increase in the farm level price of milk and the retail price of milk. We then considered the case where the processor is a monopolist-monopsonist. To maximize profits, he will equate MR with MC and set his purchases of milk at a level lower than the monopsony alone or the monopoly alone, and will pay farmers a price lower than the monopoly alone or the monopsony alone. We then relaxed the assumption of one product and considered the case where milk is marketed by the processor as fluid and manufacturing milk. We argued that the introduction of a Class II market that is perfectly competitive makes it difficult for the local processor to behave as a monopsonist in his raw milk market, unless producers could not ship their milk outside the area to other processors in the Class II market. We showed that the processor will pay farmers the same price for their milk regardless of its use and will allocate the total purchase of raw milk between fluid and manufacturing uses so that marginal revenues in the two markets are equal.

We then relaxed the assumption that the dairy farmers are perfect competitors and considered the situation where the two market participants (dairy producers and milk processors) have some market power. We concluded that this type of situation, similar to the bilateral monopoly, resists analysis in that the outcome depends strictly on the relative bargaining strength of the two parties involved. We took the analysis one step further and considered the monopoly case where the marketing of raw milk is regulated by the Federal Milk Marketing Order program. Such a situation probably
approximates the marketing of milk in New Mexico. Under the order program, processors are required to pay at least the federally specified prices for Class I and Class II milk. All the receipts from the sale of milk are put into a pool, and each dairy farmer receives an average or "blend" price for his total milk production regardless of its use. We showed that the order program increases the price of fluid milk and the total supply of milk. The quantity of fluid milk is diminished and the supply of manufacturing milk is increased. Regulation also increases producers' revenue since farmers are receiving a blend price which is higher than the marginal value of milk. To the extent that production of milk is increased up to the point where the marginal value of milk is below the marginal cost of production, some economic inefficiencies result from the blend pricing technique.

Finally, we considered the situation where the marketing of milk is performed under milk marketing orders coupled with a cooperative base-quota system. Such a situation describes the marketing of milk in Arizona. Arizona dairy producers are organized into one cooperative association, the United Dairymen of Arizona (UDA), which operates a base-quota system. Under such a system, raw milk at the farm level is divided into quota milk and over-quota milk according to the amount of effective base owned by the producer. Milk covered by base receives the UDA quota price which is higher than the over-quota price. We showed that the acquisition of base enables the dairy producer to receive a higher average or "blend" price for his total milk production and the profits that this price yields.
Next, we empirically investigated milk supply adjustments in Arizona and New Mexico.

Three ways in which supply adjustments can be achieved were identified: new investment or disinvestment in dairy operations, relocation of already existing dairy facilities, and expansion in output of existing dairy farms. We merged the first two alternatives into one and we considered any new dairy in Arizona and New Mexico as new investment in dairy operations. For new facilities, we assumed the decision to invest in Arizona or New Mexico as given, and we investigated the probability that the new investor chooses Arizona or New Mexico. We found the cost of milk base being a significant variable in explaining the location choice of new producers between Arizona and New Mexico. For instance, if we assume that there is a 50/50 chance of choosing Arizona or New Mexico, then a reduction by 4 percent in the cost of milk base in Arizona leads to a decrease in the probability of choosing New Mexico by approximately 0.06. On the third alternative (expansion in output of existing dairy farms), we found the short-run price elasticity of supply of raw milk in the region to be 0.6. The estimated coefficients of the input costs were very insignificant, which suggests that our sample was too small to obtain significant estimates. However, given the large and specialized dairies in the two states, one might suspect the long run supply responses to changes in product and input prices to be significant.

The last effort of this empirical investigation was on the consumer welfare change due to the regulation of the Arizona and New Mexico dairy market. We found that regulations on average enforce a
tax on Arizona's consumers of fluid milk in the amount of 10 million dollars per year, or 13.5 percent of producers' total revenue, and a tax on New Mexico's consumers of fluid milk in the amount of 5.6 million dollars per year, or 12.6 percent of producers' total revenue. It was estimated that the total loss in Marshallian consumers' surplus experienced by Arizona's fluid milk consumers over the eight year period of this study amounts to 120 million dollars, while it amounts to 67.5 million dollars for New Mexico's fluid milk consumers.

We concluded, however, that these estimated figures might be biased downward for Arizona and upward for New Mexico on the presumption that the base plan in Arizona is a transfer from Arizona milk consumers to New Mexico milk consumers. It was also argued that regulations of the Arizona and New Mexico dairy markets can be viewed as an income transfer from milk processors and Class I consumers to dairy producers.

Conclusions and Recommendations

In reviewing the dairy literature, two views on U.S. dairy policy generally emerge. First, the price discrimination view -- that government involvement in the marketing of milk serves the interests of dairy farmers at the expense of consumers by raising the price of raw milk used as fluid milk, and second, the price stabilization view -- that government intervention serves the joint interests of producers and consumers by eliminating the possibility of price instability that might result from seasonal fluctuations in milk production. Government involvement in economic activities is usually praised when
there is a need to correct for certain market failures. Conditions that existed during the pre-order period justify government assistance to dairy producers: monopsonistic or oligopsonistic behavior of milk processors, disorderly market conditions, etc. A relevant question, do these conditions still exist to warrant a further government involvement in the marketing of milk?

The theoretical analysis of the different market organizations shows the competitive model to be the most efficient model, in that it eliminates resource misallocations. However, the dairy industry is not an instance of perfect, atomistic competition. In absence of any regulation, the industry is more likely to be characterized by a monopoly and collective bargaining. Are dairy farmers better equipped now to deal with milk processors? One is tempted to answer yes, given the existence of large specialized dairy farms (mostly in the Southwest), the existence of regional cooperatives with significant market power, and the regional nature of today's milk markets due to technological breakthrough in milk storage and transportation. This is not to say that current dairy policy should be abolished. To arrive at such a conclusion, one must first weigh the benefits of the current dairy policy against the costs. Many studies have estimated the costs of the milk order program, but estimates of the benefits are virtually nonexistent. If stabilization is viewed as a benefit, then an immediate task should be an attempt to quantify its effects.

The existence of private value placed on the ownership of quota rights in Arizona suggests that the Arizona dairy sector is profitable. But, the empirical investigations show that the use of
base system restricts the supply of milk in Arizona by discouraging new investment in the Arizona dairy sector in favor of New Mexico, and by discouraging expansion of already established dairy farms. The use of base system is also seen as a device to transfer income from dairy producers. The results of the empirical investigations suggest also that the Southwest region with large, specialized dairies exhibits very inelastic short run responses to changes in input and product prices.

Although the results of the statistical estimations are in accordance with the findings of other studies on milk supply responses, it has not claimed absolute precision in the estimates. We believe that a research of this magnitude should be supported by many more observations than were available to us, and demand elasticities for the region should be computed.

Recommendations for Future Research

Future research directions fall into different areas. An investigation of the long run supply response may be useful for policy purposes given the nature of the dairies in this region. The results of this research imply a small short run supply elasticity which suggests that changes in product and input prices may not create noticeable changes in the supply of raw milk. However, the long run effects of such changes may be costly because, once these large and specialized dairies in the region have expanded or contracted their facilities, it may be a difficult task to eliminate any supply disequilibrium.
Estimation of the milk demand elasticities for Arizona and for New Mexico would allow a more precise estimation of the consumers' welfare losses associated with the regulations of the dairy markets. An investigation of the welfare implications of the base plan and the order program in Arizona and New Mexico under the framework of risk and uncertainty is another area of research that deserves some attention.
### APPENDIX

#### DATA USED IN THE STATISTICAL ESTIMATIONS

Table A1. Milk Production Data: Part I

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Milk Production</th>
<th>Production of New Producers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arizona <em>a</em></td>
<td>New Mexico <em>b</em></td>
</tr>
<tr>
<td>1976</td>
<td>775,541</td>
<td>333,348</td>
</tr>
<tr>
<td>1977</td>
<td>797,349</td>
<td>392,063</td>
</tr>
<tr>
<td>1978</td>
<td>786,619</td>
<td>428,503</td>
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<tr>
<td>1979</td>
<td>822,270</td>
<td>478,725</td>
</tr>
<tr>
<td>1980</td>
<td>908,197</td>
<td>564,129</td>
</tr>
<tr>
<td>1981</td>
<td>1,009,928</td>
<td>642,047</td>
</tr>
<tr>
<td>1982</td>
<td>1,062,414</td>
<td>781,863</td>
</tr>
<tr>
<td>1983</td>
<td>1,092,110</td>
<td>905,007</td>
</tr>
</tbody>
</table>

*a* Source: United Dairymen  
*b* Source: AMPI - Texas
### Table A2. Milk Production Data: Part 2
(1000 lbs)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Production of Existing Producers</th>
<th>Milk Used as Class I a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arizona</td>
<td>New Mexico</td>
</tr>
<tr>
<td>1976</td>
<td>74,772</td>
<td>330,242</td>
</tr>
<tr>
<td>1977</td>
<td>77,063</td>
<td>383,380</td>
</tr>
<tr>
<td>1978</td>
<td>77,444</td>
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<tr>
<td>1979</td>
<td>80,787</td>
<td>437,952</td>
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<td>1980</td>
<td>88,030</td>
<td>555,434</td>
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<td>1981</td>
<td>92,794</td>
<td>586,181</td>
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<tr>
<td>1982</td>
<td>104,660</td>
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</tr>
<tr>
<td>1983</td>
<td>108,953</td>
<td>896,717</td>
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</table>

a Source: Federal Milk Order Market Statistics - USDA
Table A3. Price Data: Part 1

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<tr>
<th>Year</th>
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<th>3b</th>
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<th>5d</th>
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<th>7b</th>
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1. Year
2. Milk Cows ($/head)
3. Land ($/acre)
4. Milk base ($/lb)
5. Interest Rate, Average on Loans Outstanding (Mountain)
6. Income Tax (percent)
7. Property Tax (per $100 of assessed valuation)

a Source: Agricultural Prices - USDA
b Source: Real Estate Market Developments - USDA
c Source: Interviews with Lending Institutions in Arizona
d Source: Agricultural Statistics - USDA
e Source: Statistical Abstract of the United States
Table A4. Price Data: Part 2 (Arizona Seasonal Average)

<table>
<thead>
<tr>
<th></th>
<th>Milk Prices $/cwt</th>
<th>Feed Prices $/Ton</th>
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<tr>
<td></td>
<td>UDA a quota</td>
<td>UDA a over-quote</td>
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<tr>
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<td>10.33</td>
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<td>1978</td>
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<td>9.57</td>
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<tr>
<td>1979</td>
<td>12.66</td>
<td>10.91</td>
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<tr>
<td>1980</td>
<td>13.51</td>
<td>11.88</td>
</tr>
<tr>
<td>1981</td>
<td>14.39</td>
<td>12.57</td>
</tr>
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<td>12.49</td>
</tr>
<tr>
<td>1983</td>
<td>14.31</td>
<td>12.49</td>
</tr>
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</table>

a Source: United Dairymen - UDA
b Source: Agricultural Prices - USDA
Table A5.  
Price Data:  Part 3  
(New Mexico Seasonal Average)

<table>
<thead>
<tr>
<th>Year</th>
<th>AMPI a</th>
<th>Class I b</th>
<th>Class II b</th>
<th>Feed Prices</th>
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</thead>
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<tr>
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<td></td>
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<td>$/Ton</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
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<td>1980</td>
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<td>14.83</td>
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<td>14.88</td>
<td>12.64</td>
<td>88.66</td>
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</tbody>
</table>

a  Source:  AMPI - Texas  
b  Source:  Federal Milk Order Market Statistics - USDA  
c  Source:  Agricultural Prices - USDA
Table A6. Other Data Used in the Statistical Estimations

<table>
<thead>
<tr>
<th>Year</th>
<th>$P_M^*$</th>
<th>$P_C^*$</th>
<th>$P_H^*$</th>
<th>$P_L^*$</th>
<th>WageRate ($/hr)</th>
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<tbody>
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</tr>
</tbody>
</table>

*a* Variables defined as in equation 4.17

*b* Source: Farm Labor - USDA
REFERENCES


