COMPETITIVENESS OF VIRGINIA DAIRY PRODUCERS IN A NATIONAL SETTING GIVEN CHANGING MARKETING AND POLICY CONDITIONS

by

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The objective of this study is to determine Virginia dairy producers' competitiveness in an industry that is experiencing changing policy and marketing conditions. The competitiveness of Virginia dairy producers is examined in a National Dairy Model that compares both producers' cost of production across market areas and spatial relationships among producers and consumers. The National Dairy Model (NDM) is a mathematical programming model that minimizes the total costs of producing milk and the assembly costs of shipping dairy products to the final consumer.

A state's cost of production in the NDM is determined with a translog cost function. The cost functions are estimated with data collected in the 1989 and 1993 dairy versions of the Farm Costs and Returns Survey (FCRS). The supply and demand information in the NDM is annual data for 1994. Transportation costs are determined with current hauling rates and actual mileage between supply and demand points. Once the costs of production and spatial components of the NDM are formulated, the NDM is solved using the General Algebraic Modeling System (GAMS).

The NDM is evaluated under the guidelines of several different scenarios. For

example, some alternative marketing scenarios that provide important information about the future of the dairy industry are (1) simulations where the hauling rates are varied, (2) scenarios in which the U.S. becomes a major participant in the export market, and (3) situations where the marketing environment leads to increasing costs of production. Another alternative scenario involves only the spatial dimension of the NDM.

Given the current marketing conditions in the dairy industry, the results of the NDM indicate that Virginia dairy producers are competitive in a marketing environment where the location of milk production is determined by a producer's costs of production and location advantages. Using Virginia's translog cost function, the cost per cwt. at the mean of the FCRS production data is $10.60. The cost estimate applies to Virginia's representative dairy farm where the average herd size is 91 cows and annual production per cow is 14,160 pounds. With these estimates and the fact that Virginia producers are near large population centers, the results of the NDM show that Virginia dairy farms are competitive in a deregulated market.

This research is dedicated to Dr. David Weisenborn, one of the people who know me better than I know myself. As I was completing my undergraduate degree in June of 1991, he told me that I would not stop until I received my doctorate. At that time, five more years of school seemed to be a ridiculous idea. Fortunately for me, Dr. Weisenborn was right!

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TABLE OF CONTENTS

page

CHAPTERS

1 INTRODUCTION

2 LITERATURE REVIEW

3 THEORETICAL IMPLICATIONS OF GOVERNMENT INTERVENTION

4 MODEL DEVELOPMENT

5 ALTERNATIVE SCENARIOS AND RESULTS

6 SUMMARY AND CONCLUSIONS

LIST OF TABLES

page

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

Virginia Dairy Industry

Unlike most of the national dairy industry where producers are associated with a Federal Milk Marketing Order, Virginia dairy producers are regulated by a state milk commission. The Virginia milk market is disaggregated into three sales areas: (1) Southwest, (2) Eastern, and (3) Western. The average Class I sales in the Virginia marketing areas have increased at a rate of approximately one percent annually since 1983 (*Va. Agr. Stats.*). On a regional basis, interregional trade is dominated by shipments of raw milk to and from West Virginia, Pennsylvania, and Maryland. Very little Virginia produced milk flows into the Delaware, Tennessee, or North Carolina market areas. Most dairy producers in Virginia are associated with one of six cooperative organizations. The processing of raw milk is handled by eight plants located throughout the state. According to 1994 statistics, cash receipts for Virginia produced milk ranked third among all commodities with $272 million (*Va. Agr. Stats.* 1994). With the dairy industry an important component of Virginia agriculture, changes in national dairy policy could have tremendous ramifications for the Virginia economy and dairy producers.

In the past 20 years, the Virginia dairy industry has experienced considerable structural change. As shown in Figure 1-1, in 1983 there were 1,678 grade A dairy farms with an average herd size of approximately 85 cows per farm. As producers tried to decrease costs by obtaining economies of scale, the average number of cows per farm began to rise. Like many

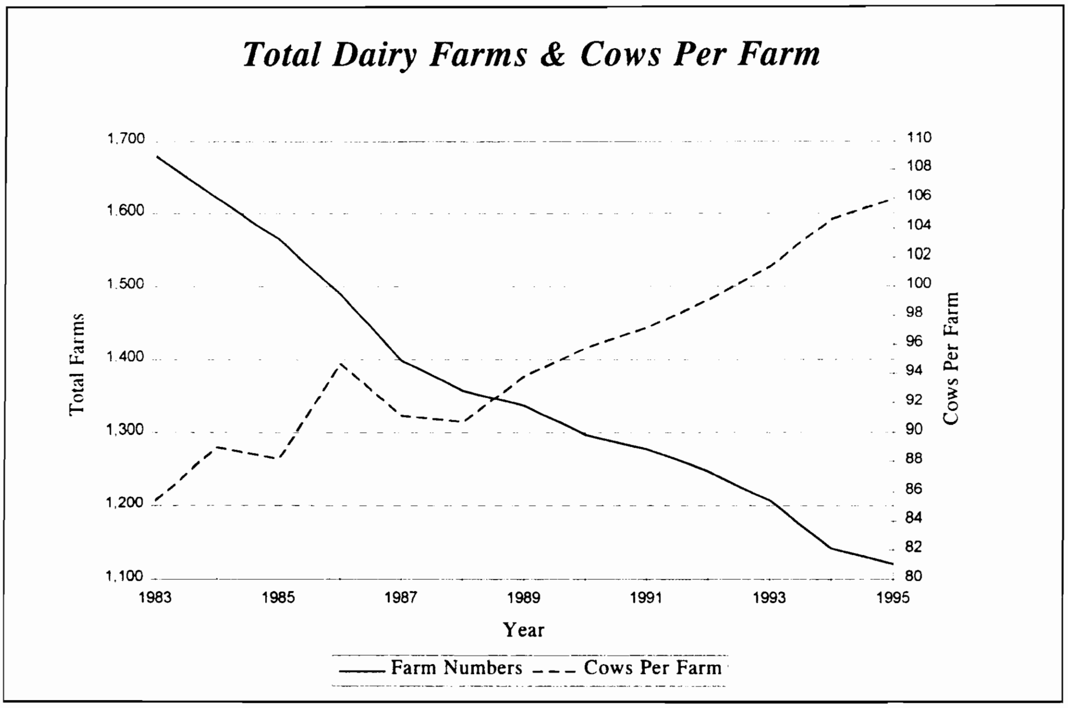

Figure 1-1: Virginia Dairy Farm Numbers & Cows Per Farm, 1983-1995
Source: Virginia State Dairymen's Association

agricultural sectors, the increase in farm size is accompanied by a steady and predictable decline in total farm numbers. As large farms became more efficient, some small producers were unable to compete. By 1995, the number of dairy farms had fallen to 1,121 and the average herd size for a Virginia dairy farm reached 106 cows (Figure 1-1).

When comparing dairy herds on a regional basis using USDA data, Virginia's average dairy farm is slightly smaller than farms in the surrounding states. Figure 1-2 compares the average herd size for Maryland, North Carolina, Pennsylvania, and Virginia. The largest average dairy herd in 1995 among regional states belongs to Maryland (85 cows). Based on cows per farm, the dairy industry in North Carolina appears to be undergoing considerable structural change. In 1992, North Carolina's average herd size was approximately 80 cows, the largest in the region. By 1995, North Carolina ranked second among regional states with

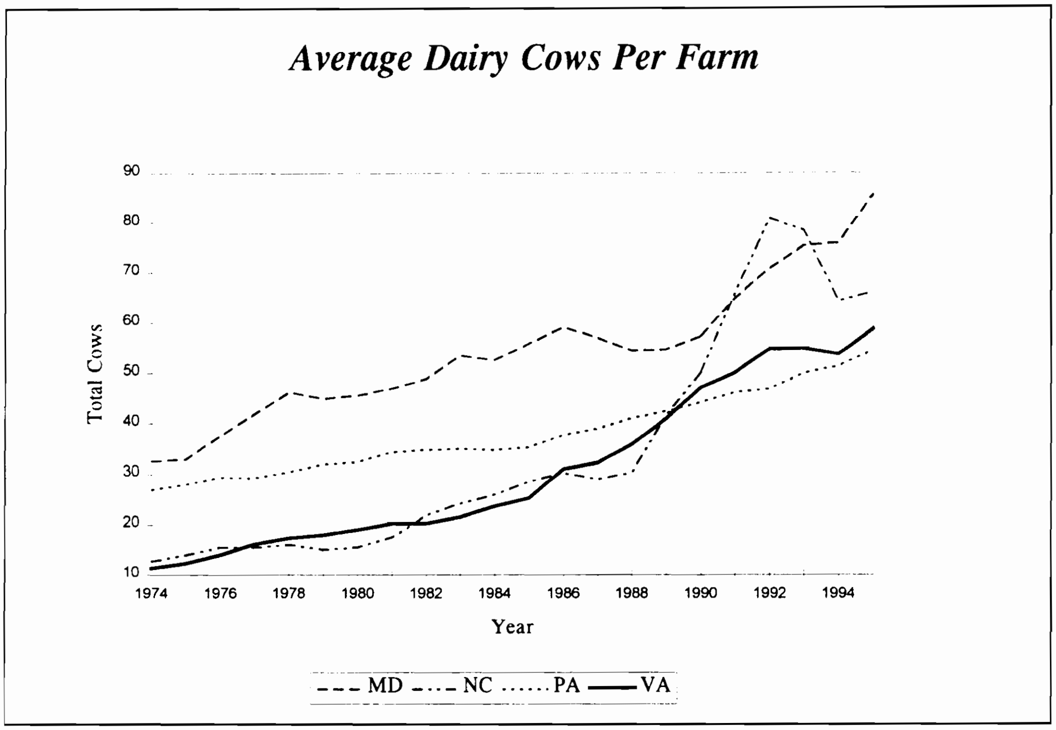

Figure 1-2: Average Dairy Cows Per Farm In Maryland, North Carolina, Pennsylvania, and Virginia (1974-1995)
Source: USDA *Milk Production, Disposition, and Income*

an average herd size of 66 cows, representing a 17.50% decrease in herd size over three years. As shown in Figure 1-2, Virginia's 1995 average herd size of 58 cows ranked third among regional states. Like Maryland, Virginia's average herd size is steadily increasing. One possible reason for the increase in herd size is that farms are getting larger as the total number of dairy farms decreases. Finally, the smallest herd in the region belongs to Pennsylvania, with 54 cows per farm. On a national basis, the average herd size of the regional states are extremely small when compared with the dominant milk producing state in the country. In 1995, California's average herd size of 380 cows was the largest in the country.

The USDA defines a dairy operation as "any place having one or more head of milk cows on hand at any time during the year" (*Milk Production, Disposition, and Income*).

Because of the broad definition, USDA data may overstate the number of dairy producers competing in the market place. If the USDA estimate is too high, an average herd size calculated from this data would be too low. According to estimates from the Virginia State Dairymen's Association, the average herd size of a Grade A dairy farm in Virginia was 106 cows on September 1, 1995 (*The Virginia Dairyman* 1995). Furthermore, the majority of Grade A milk is produced by large farms located in a few Virginia counties (Table 1-1). As shown in Table 1-1, the top five milk producing counties in Virginia accounted for approximately 49% of Grade A milk marketed in 1993. Since 1985, Grade A milk marketed by the top five counties has been steadily increasing. Rockingham county has consistently been the top producing county in Virginia. Other counties consistently in the top five include Augusta, Fauquier, and Franklin.

Table 1-1: Grade A Production Marketed By Virginia's Top Five Counties From 1985-1993 (Million Pounds)

County/Year	1993	1992	1991	1990	1989	1988	1987	1986	1985
Augusta	178.4	183.5	176.7	171.2	169.1	169.3	162.6	165.3	162.3
Fauquier	85.1	84.9	78.3	77.6	78.5	83.7	88.3	98.7	83.5
Franklin	181.0	179.9	172.0	166.3	155.8	156.7	152.0	152.6	143.8
Rockingham	437.0	422.4	416.4	401.1	391.4	379.1	362.5	364.7	349.7
Wythe/Wash.	70.5	72.8	70.9	66.9	66.9	71.4	75.5	73.7	68.9
Total	952.1	943.7	914.5	883.2	861.9	788.9	765.6	855.1	739.5
State Total	1,941	1,986	1,977	1,930	1,907	1,919	1,912	2,023	1,944
Percentage	49.1	47.5	46.3	45.8	45.2	41.1	40.0	42.3	38.0

Source: Virginia Milk Commission Statistical Summary

Virginia, like most states throughout the country, must contend with the seasonality problem in milk production (Figure 1-3). During the months of June through November, Virginia producers are faced with environmental and biological constraints placed upon milk production. During these months, the heat and humidity have an adverse effect on milk

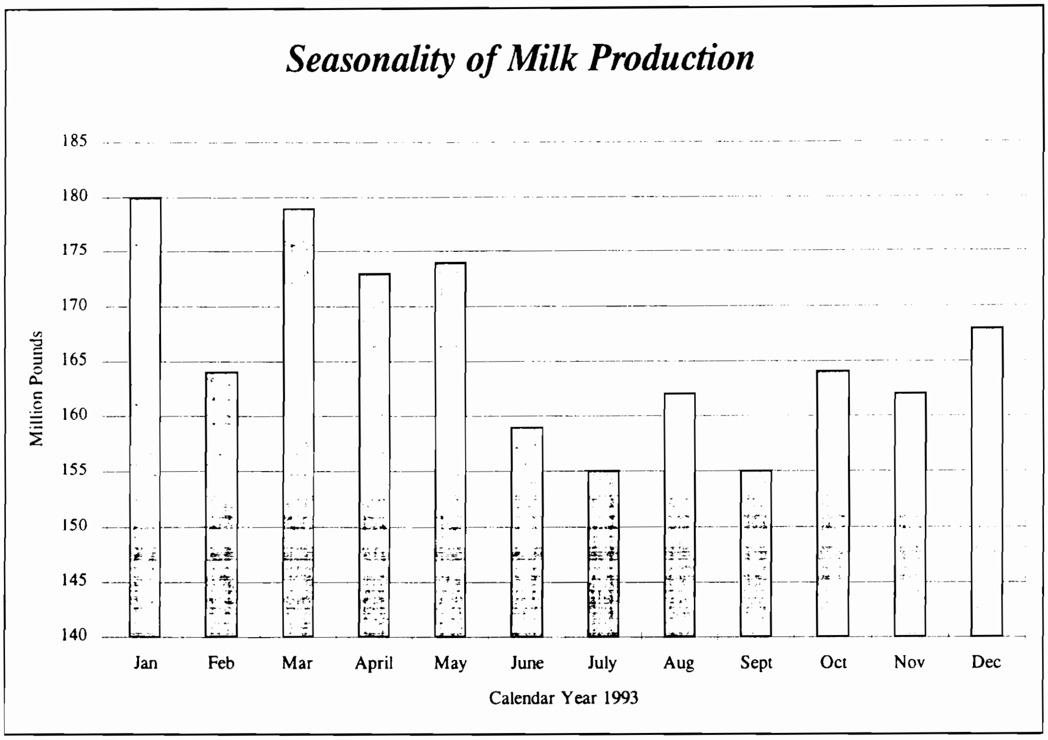

Figure 1-3: Virginia Milk Production By Month For 1993
Source: 1993 *Virginia Agricultural Statistics*

production and conception rates (Kilmer *et al.* 1992). Cows calving during these months are not as productive as those freshening in the winter and spring.

With the exception of February, December through May are the surplus months for the Virginia dairy farmers. The increase in milk production is a direct result of the reduced heat and humidity (Kilmer *et al.* 1992). Conditions improve so much that the variation between the high and low production months (January and July, respectively) is approximately 25 million pounds, which is a 16% difference in production.

Problem Statement

The marketing environment for Virginia dairy producers, and for producers throughout the country, is becoming increasingly unstable. Some aspects of the dairy industry that could be responsible for the unstable marketing conditions are (1) changes in federal policy resulting in less regulation of the dairy industry, and (2) changing costs of production associated with variable inputs and environmental compliance. If producers are going to remain competitive given uncertain marketing conditions, research is needed to determine what adjustments may be necessary.

Changes In Federal Policy

The dairy industry in general is facing the possibility of deregulation in the future as the government takes a less visible role. In a June 29th, 1994 speech to the House Agriculture Subcommittee, Keith Collins, acting USDA Assistant Secretary for Economics, forecasted lower milk prices for 1994/95 as both production and government removals increase. Figure 1-4 shows

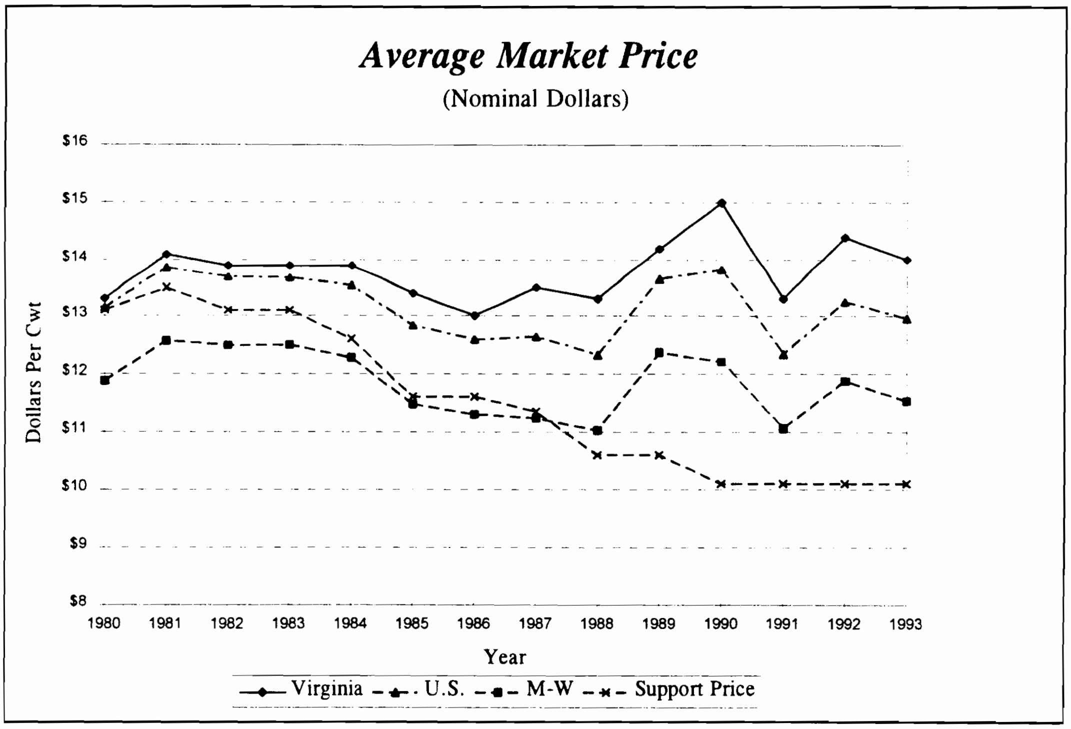

Figure 1-4: Average Virginia, U.S., M-W, and Support Price From 1980-1993 (Nominal Dollars)
Source: USDA *Milk Production, Disposition, and Income*

that the Minnesota-Wisconsin (M-W) market price, and subsequently the Virginia price, has been relatively stable until 1988 because the support price was consistently above the market clearing price. With a high support price, price volatility in the dairy sector is reduced and producers are not subjected to uncertain marketing conditions resulting from unexpected price swings.

Beginning in 1988, the government support price fell below the market clearing price, and the M-W price started to reflect the seasonality of milk production. This trend resulted in a volatile M-W price that ranged from $14.93 in December of 1989 to $10.02 in March of 1991. Although Virginia producers have been subjected to more volatile prices, the price per hundredweight (cwt.) has averaged $13.80 since 1980, and the Virginia price is consistently above the U.S. average. Even with the seasonal price swings, the price line in Figure 1-4 does not illustrate a significant downward trend in nominal milk prices.

Although nominal prices have remained relatively stable, the prices adjusted for inflation tell a different story. In Figure 1-5 the average M-W, Virginia, and U.S. prices since 1980 are

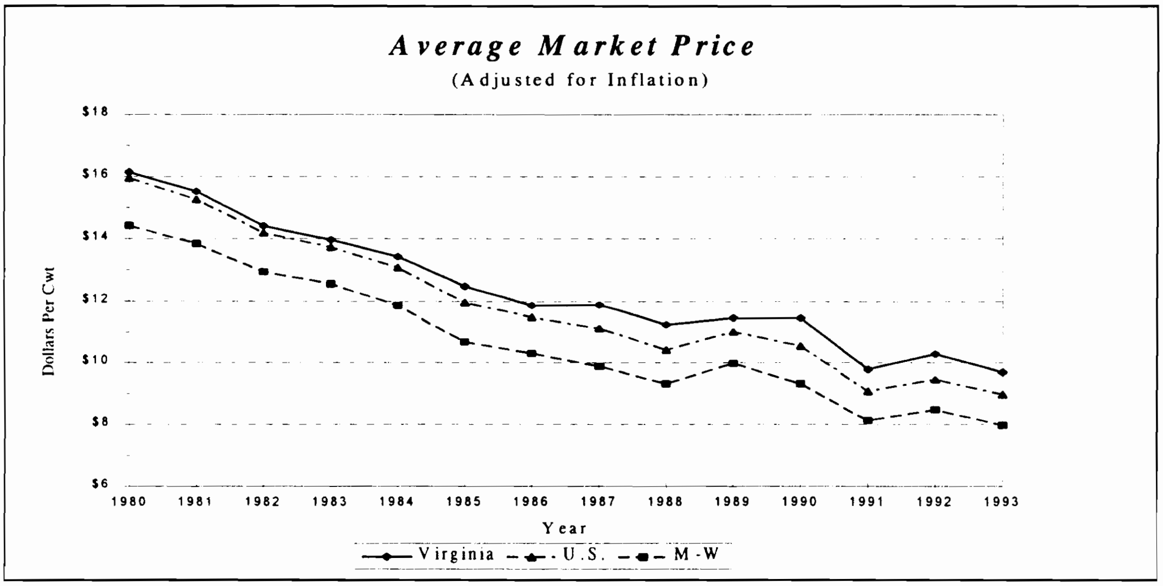

Figure 1-5: Average Virginia, U.S., and M-W Prices From 1980-1993 (Real Dollars)
Source: USDA *Milk Production, Disposition, and Income*

adjusted by the Consumer Price Index. The results of this adjustment are prices in terms of 1982-84 dollars. One can see that the real price of fluid milk has been steadily decreasing during the past 14 years for Virginia producers and producers throughout the country. Although the real M-W price of fluid milk has decreased 44.6% since 1980, the change in Virginia producers' income may not reflect the severity of the price decrease. As real prices have decreased, the production per cow has increased due to technological advances (Figure 1-6). The increase in production per cow reduces costs, offsets the lower prices, and has a compensating effect on Virginia producers' income. As time progresses, production per cow will not necessarily be able to compensate for the decreases in price.

With less regulation, the dairy industry is going to be subjected to market forces that could result in increased price volatility. Along with an uncertain price, producers may experience a level of competition that is surpressed in a regulated market. For example, a long-term objective of dairy policy is to guarantee a steady supply of fluid milk to all consumers. In

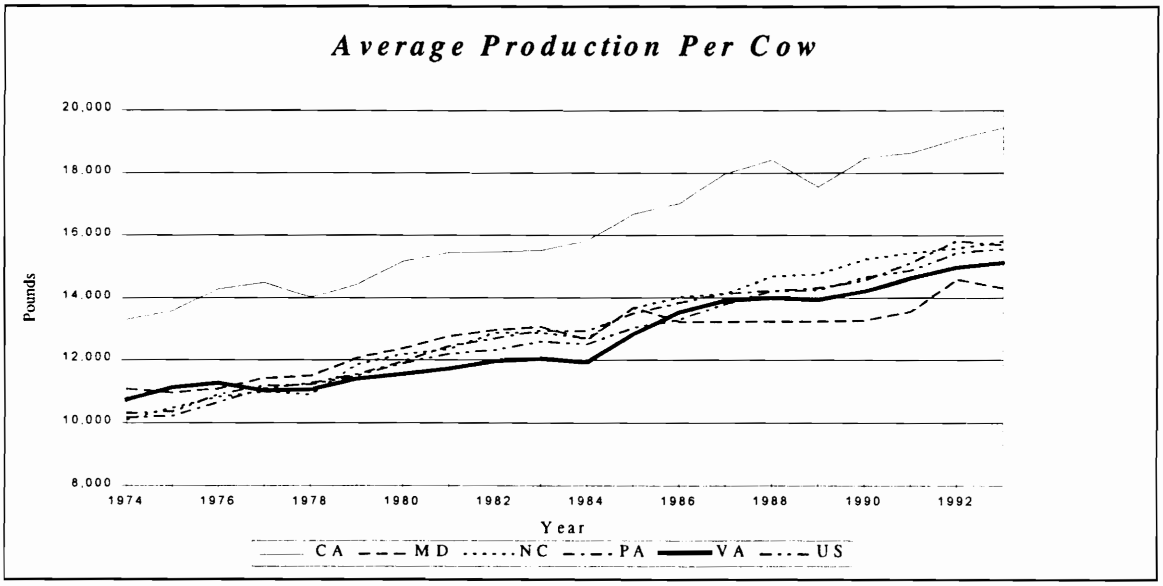

Figure 1-6: Average Production Per Cow For CA, MD, NC, PA, VA, and US (1974-1993)
Source: USDA *Milk Production, Disposition, and Income*

some cases, this objective is satisfied by promoting milk production in high-cost areas. As dairy policy becomes more market-oriented, supply decisions are going to be based on producers' comparative advantages. As the dairy industry becomes deregulated, the location of milk production throughout the country could be affected as producers compete for market share. In an industry experiencing increasing costs of labor, machinery, and other inputs, declining milk prices accompanied by increasing competition could be detrimental to Virginia producers' long-run competitiveness.

Costs Of Production Issues

Another area that may help create an unstable marketing environment is changes in producers' costs of production. In Figure 1-7 the cost of production and price are compared for the Appalachia region.[1] Although cash costs remain below price, a comparison between economic or full costs of production and price reveals a different story. The differences between economic costs and cash costs are allowances for capital replacement, operating capital, land, and unpaid labor. With these additional expenses included, the total economic costs of producing milk have consistently remained above the price paid to producers. In fact, economic costs for the Appalachia region have remained above selling price since early 1987. Since 1988, producers in the Appalachia region have experienced negative returns to management and risk (USDA *Economic Indicators of the Farm Sector* 1995). If this trend continues, the changing costs of production accompanied by the declining real milk prices could have a tremendous impact on producers and the dairy industry in Virginia and other states.

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[1] The Appalachia region is defined by the USDA and consists of Kentucky, North Carolina, Tennessee, and Virginia.

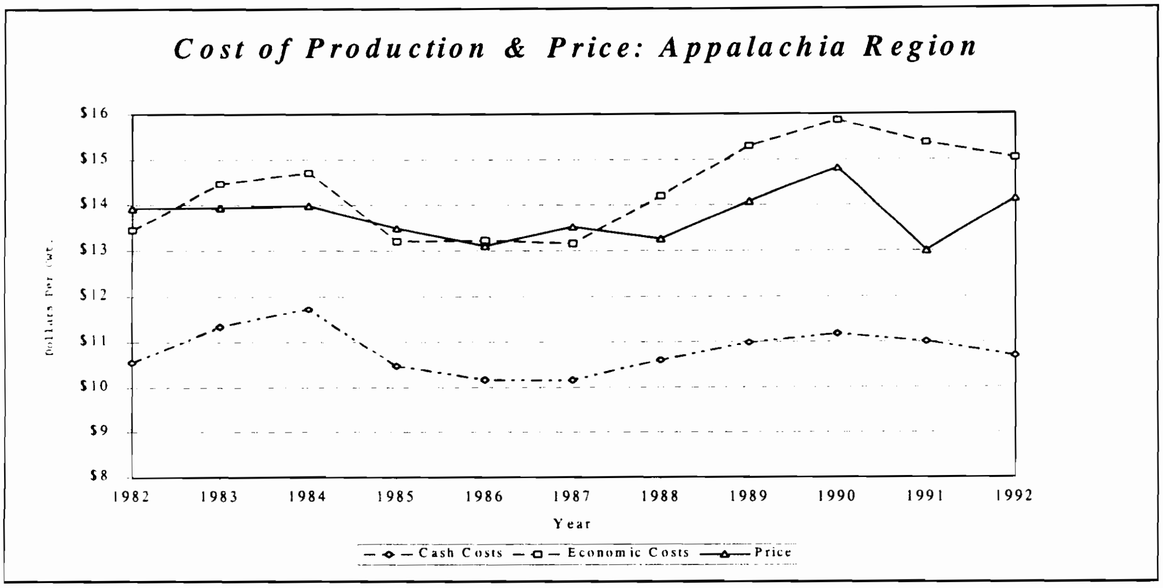

Figure 1-7: Cost Of Production & Price For the Appalachia Region, 1982-1992
Source: USDA *Economic Indicators of the Farm Sector*

Two cost variables that could be responsible for future negative returns to management and risk in the Virginia dairy sector are (1) feed inputs and (2) environmental compliance. Virginia is increasingly deficit as a feedgrain producing state. Feedgrain acreage and production are steadily declining, while consumption by the Virginia livestock and poultry sectors is consistently over 60 million bushels per year (Kenyon *et al.* 1991). On the average U.S. dairy farm in 1993, feed inputs accounted for 64% of total variable costs (*U.S. Milk Production Costs and Returns 1993*). Given the weather conditions in the recent past, producers have been faced with increasing costs of feed inputs. Because the price of milk is sensitive to the higher costs of feedgrains, the prices paid to dairy producers are also increasing. These higher milk prices are temporary and should not be interpreted as the beginning of a long-run trend in the market. The primary concern of producers should be remaining competitive in an industry experiencing higher costs of feed inputs, and not on high milk prices that are the result of temporary adjustments in the market.

Another issue that will be important and which affects costs of production is environmental compliance. As the society becomes more environmentally conscious, dairy producers are likely to be subjected to increased environmental regulation and enforcement. For example, the National Pollutant Discharge Elimination System is a set of national regulations designed to control pollution from concentrated animal feeding operations. Estimated costs of compliance with these regulations for a herd size of 200 range from $100 to $700 per cow (Tiar 1994). The anticipated moves to a less regulated market could make it difficult for dairy producers to recover the capital investment needed for environmental compliance. Given the many environmentally sensitive areas in Virginia, producers and industry representatives should be interested in how increased regulation and/or changed enforcement will affect the structure of the Virginia dairy industry. In a deregulated industry where market share is directly related to costs of production advantages, the new capital investments needed to comply with environmental policies of the future could affect the relative competitiveness of dairy producers on a regional or national basis.

Objectives

The general objective of this study is to analyze Virginia dairy producers' competitiveness in a deregulated industry where the location of milk production is based on producers' costs of production and transportation costs of shipping dairy products from supply areas to consumers. Some specific objectives are to:

1. Determine a range of costs of production per cwt. that illustrates Virginia producers' competitiveness in a scenario where costs of production are increasing due to rising input costs and/or compliance with environmental regulations.

2. Identify the spatial advantages or disadvantages of Virginia dairy producers in a marketing environment where regional boundaries are expanding or contracting due to fluctuations in hauling rates.
3. Determine the overall effectiveness of the Federal Milk Marketing Orders in achieving the most cost-efficient distribution of milk production by comparing the combined total costs of production and transportation costs from alternative scenarios.

Overview Of Dissertation

Chapter two examines the previous work in specific areas related to the dairy industry. The literature review is divided into three sections: (1) historical perspective, (2) policy changes, and (3) technological advancements. The reviews in each section are extensive and cover areas dealing with models as well as basic information on the dairy industry.

Chapter three addresses the theoretical implications of changes in the dairy policy. Discussion in this chapter focuses mostly on (1) price and output effects and (2) spatial impacts of marketing orders. The impacts on the dairy industry of classified pricing, allocation provisions, and transportation differentials are specific areas that are developed in this chapter.

The empirical model used in the current study is developed in chapter four. In the beginning sections, the discussion involves the methodology and data used to estimate a state's translog cost function. The remainder of the chapter develops the mathematical programming model that is used to simulate alternative marketing scenarios. The final sections of chapter four identify what data are required to operationalize the model.

Chapter five discusses the alternative scenarios and the results of the study. The solutions of each simulation are compared and contrasted in order to determine Virginia's competitive position in a deregulated market. The final chapter in the dissertation summarizes the results of the study. Following the summary, conclusions from the study are presented in the final section of chapter six.

CHAPTER 2
LITERATURE REVIEW

Since the early 1980's, dairy policy at the federal level has changed a number of times. Each proposed change in dairy policy brings about a new set of congressional hearings and research projects that hope to describe how the proposed change in policy will affect the dairy industry. Subsequently, additional research that analyzes the actual impact of the new policy becomes available. The background information, modeling techniques, and results of these past research projects are extremely useful when the task at hand is evaluating the competitiveness of Virginia dairy producers given changing marketing conditions.

The literature review focuses on two major areas of the dairy sector that have been responsible for changes in the industry during the past 15 years. The first section of the literature review investigates changes in dairy policy since 1980. For example, this section includes a discussion of the dairy termination and buyout programs, and related sections of the 1985 and 1990 Farm Bills. The policy section also examines proposed changes in the 1995 Farm Bill, including increased environmental enforcement. The final section of the literature review looks at the effects of changes in technology on the dairy industry. Specifically, the impacts of bovine somatotropin (bST) and reverse osmosis are discussed.

Historical Perspective Of Dairy Policy

Throughout the country, dairy policy consists of federal marketing orders, price support programs, import quotas, and export incentive programs. The origins of the federal dairy program can be traced to the Agricultural Adjustment Act of 1933. With the Act of 1933, dairy import quotas were implemented under Section 22.

The next major contribution to dairy policy was formulated with the Agricultural Marketing Agreement Act of 1937. The Act of 1937 created Federal Milk Marketing Orders (FMMOs). During the late 1800's and early 1900's, dairy producers were operating in markets dominated by a few large processors. Allegations of price collusion were common. Producers' attempts to regain market power by forming producer owned cooperatives were unsuccessful (Novakovic and Boynton 1984). Given the marketing environment faced by dairy producers, the primary goal of the FMMOs was to establish orderly marketing conditions so that producers could receive a fair price for their commodity (Blaney *et al.* 1995).

In 1960, there were 80 federal marketing orders that regulated 43% of all milk marketed. By the end of 1993, approximately 70% of total milk marketings within the United States were regulated by 38 federal orders (Blaney *et al.* 1995). Although the number of orders is declining, the size of the remaining federal orders is increasing. A federal order can only be established by the approval of dairy producers within the region in question. Once established, a market administrator within each order regulates milk that meets qualifications for fluid consumption (Grade A milk) by (1) classifying milk based on utilization, (2) establishing minimum class prices paid by handlers, (3) pooling milk payments and then determining the uniform or blend price to be paid to producers, and (4) providing other marketing services such as testing, auditing, and information.

Milk sales in a market order are composed of the producers' Class I, Class II, and Class III sales. Class I sales are represented by the percentage of total production that is utilized for beverage purposes. Soft products, such as ice cream and yogurt, represent Class II sales. Class III milk is manufactured into cheese, butter, and nonfat dry milk. These products are better known as storable milk products.

For marketing orders east of the Rocky Mountains, class prices are based on the price paid by unregulated processors for manufacturing grade milk (Grade B) in the Minnesota-Wisconsin region. This base point represents a marketing area where local production exceeds consumption throughout the year. Minnesota-Wisconsin producers are, therefore, a supplemental source of raw milk during deficit months in other marketing areas. In all marketing orders, the class price is related to the M-W price. For example, a federal order's Class III price is generally the M-W price. The Class II price is the M-W price plus a price differential that usually totals $0.25 per hundredweight (Schiek 1991). Finally, the Class I price is the M-W price plus a Class I differential that is set by the USDA. The differences in prices reflect the additional costs (i.e., transportation and sanitary requirements) associated with marketing Grade A, or fluid milk. In 1994, the Class I differentials from Eau Clarie, Wisconsin, which is the geographic center of the Minnesota-Wisconsin supply region, to Chicago and Miami were $1.40 and $4.18, respectively (Federal Order Statistics 1994). According to testimony presented by Emerson Babb to the House Agriculture Subcommittee in 1991, these differentials represent about 60% of the cost of transportation from the base point to regions that require supplemental milk (Babb 1990). Since the differential does not cover the cost of transportation, dairy cooperatives negotiate an over-order payment with processors. The over-order payment reimburses the cooperatives for the additional costs associated with obtaining supplemental milk during the deficit months.

The Agricultural Act of 1949 established the Dairy Price Support Program. This program supports the price paid to dairy farmers by allowing the Commodity Credit

Corporation (CCC) to purchase at announced prices butter, nonfat dry milk, and cheddar cheese. Until the 1980's, CCC purchases were relatively small. Because of high support prices and changes in production technology, milk output increased dramatically. The milk surpluses resulted in record levels of government removals (Figure 2-1). In 1983, government programs spent $2.6 billion to remove a record 17 billion pounds of surplus milk from the market (Blaney *et al.* 1995).

In an effort to control the cost of the dairy program and decrease milk production, some major changes in the program occurred in the 1980's. For example, the Agriculture and Food Act of 1981 separated the support price from the parity price concept. The Act also linked changes in the support price to projected CCC purchases. Other programs that attempted to reduce the supply of milk were the 1984 Milk Diversion Program and the 1986 Dairy Termination Program. Recent studies have suggested that these supply control programs

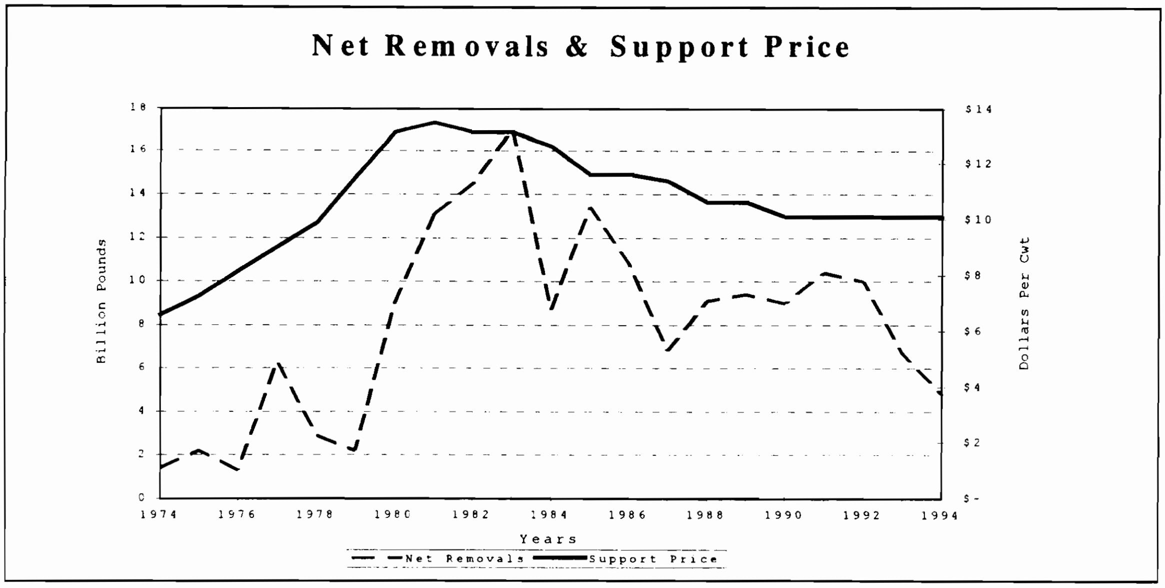

Figure 2-1: Government Removals By the Commodity Credit Corporation & Support Price Levels, 1974-1994
Source: Blaney *et al.*, 1995

were ineffective because they primarily removed dairy cows and not dairy farmers (Gale 1990). Finally, beginning in 1983, producers were assessed a $0.50 deduction per cwt. on all milk marketings. These budget reduction assessments were an attempt to make the producers more responsible for the costs of the program. In recent years, the assessments have been substantially less then the original $0.50, and the 1990 deficit reduction agreement allows producers to receive refunds of the assessments if milk marketings have not increased from the previous year.

Dairy policy of the future is most likely going to continue the trend started in the 1985 Farm Bill. In an effort to reduce the government budget deficit, funding for the price support program will be reduced as the dairy market moves in the direction of less regulation. The trend of less regulation is also evident in the NAFTA and GATT trade agreements. These agreements outline minimum access requirements and convert existing quotas on dairy imports into tariff rate quotas. Over time, the minimum access requirements will increase from three to five percent of the domestic market as the tariffs decrease (Olson 1995).

Changes In Dairy Policy

During the early and mid 1970's, agriculture in general was experiencing a tremendous growth period as commodity prices reached record levels. Many policy makers thought that these "golden years" of agriculture reflected a permanent change in the market. With agriculture doing so well, the government decided to implement new market-oriented policies that determined prices by relying more on market supply and demand. Unfortunately, the high prices of the 1970's disappeared in the early 1980s as a result of decreased export demand and over-production (Knutson *et al.* 1990). In an effort to stabilize prices and income, the government once again became an active participant in agricultural markets and the costs of the farm program started rising.

Beginning in the 1980's, major changes in dairy policy were implemented with hopes that federal expenditures could be reduced by making dairy policy more market-oriented. The first evidence of deviation from traditional dairy policy surfaced in the Agriculture and Food Act of 1981. The Act of 1981 separated support prices from the parity price concept. Parity pricing overstates the value of raw milk by not taking into account the technological and structural changes that have occurred within the dairy industry over time. Parity pricing was a contributing factor in keeping the support price above market clearing levels. Another notable provision of the Act was the linking of the support price to the level of CCC purchases.

The next departure from traditional policy was outlined in the Omnibus Budget Reconciliation Act of 1982. The provisions of this Act were the first attempt to make dairy producers reimburse the taxpayers for some of the costs associated with the dairy program. A supply control program was one feature of the 1982 Act. The details of this program, along with other supply control measures, are the subject of the next section.

Supply Control

As mentioned previously, the first supply control policy was outlined in the Reconciliation Act of 1982. Under the guidelines of this policy, all producers were assessed a deduction per cwt. on milk marketed beginning in September 1983. Although the deductions were mandatory and not identified as part of a supply control program, clearly the objective of the program was to make producers pay for increasing output at a time of record levels of CCC purchases (Figure 2-1). Although a formal study on the effectiveness of this policy measure has not been conducted, similar deductions are still in effect today. In fact, 1993 refunds totaled $80.3 million and the 1994 deduction was set at $0.1928 per cwt (Blaney *et al.* 1995).

Although the deductions were a mandatory, long-term policy tool, there has been major voluntary supply control programs with the objective of immediately decreasing milk supply. These programs were the Milk Diversion and Dairy Termination Programs. The Milk Diversion Program (MDP) is outlined in the Dairy and Tobacco Adjustment Act of 1983. Under the MDP, dairy producers voluntarily contracted to reduce production from 5% to 30% from a specified base period. The program allowed producers to receive $10.00 per cwt. for their reduction in output. The MDP was in effect from January 1984 through March 1985. An estimated 7.5 billion pounds of milk on an annual basis were removed from the market (Dixon *et al.* 1991).

The Dairy Termination Program (DTP) was authorized by the Food Security Act of 1985. With the DTP, producers agreed to suspend milk production and activities related to milk production for five years. Producers that enrolled in this program agreed to slaughter or export their dairy herd as well as to keep production facilities idle throughout the contract period. To qualify for this program, producers submitted bids that were accepted on a competitive basis. Of the bids accepted, the high was $22.50 per cwt (Gale 1990), or $24.10 in inflation adjusted dollars using the Consumer Price Index (82-84 base period). With an average bid of $15.00 per cwt., the dairy industry experienced a loss of 11.3 billion pounds of annual production capacity from April 1986 through August 1987 (Dixon *et al.* 1991).

Supply control programs appear to be a popular tool among policy makers when trying to reduce excess capacity in agriculture. Although a popular tool, the effectiveness of past supply control programs needs to be evaluated before similar measures are utilized in the future. Many studies are available that try to determine the success of the MDP and DTP. The results of a few of these studies are discussed in the paragraphs that follow.

The effectiveness of future supply control programs is dependent on what type of participants are attracted to these programs. In a 1990 study conducted by Gale, the objective was to identify the characteristics of producers in North Carolina and Virginia that had a greater willingness to participate in the DTP. Of all producers in these two states, 24% submitted bids. Unlike previous studies (Carley *et al.*1988; Kirkland and Smith 1987; and Simler *et al.* 1987), Gale used farm level data on accepted, rejected, and non-participants of the DTP. Another attractive feature of Gale's study was the analysis of family transfer as a demographic influence on participation decisions. Family transfer means that there is a family member who is willing to manage the farm when the current owner retires.

Gale used ordinary least squares to estimate equations that explain the probability of bidding and the level of the bid for the DTP. Some demographic variables included in the model that were expected to influence the bid level were education, dairy experience, management practices, off-farm work experience, age, herd size, production per cow, and existence of a family member willing to maintain the dairy operation after the primary owner retired. The results of Gale's analysis showed that the DTP was most attractive to older producers that were marginally productive and were not planning a farm transfer to another family member. The younger, more productive farmers that utilized sophisticated management techniques did not participate in the program. Gale suggested that the DTP removed producers that would be exiting the industry in the near future regardless of any government buyout program. If the objective of a program is to remove excess capacity from the dairy industry, Gale concludes that the DTP and similar programs will have limited long-term effectiveness.

The study recommends that future supply control programs should target the young, more productive dairy farmer.

Another study that attempted to analyze the effectiveness of dairy supply control programs was conducted by Dixon *et al* (1991). In this study, the impacts of both the MDP and DTP were examined for 21 major milk producing states in the United States. The concerns of Dixon *et al.* were partially due to the projected increased milk supply as a result of the introduction of bovine somatotropin. If milk production increases, knowing the effectiveness of past supply control programs is useful, since these programs are likely candidates for attempts at reducing surplus milk production in the future. In order to determine the impacts of the supply control programs, Dixon *et al.* specify and estimate a two equation random coefficient regression model. The equations specified in the model are yield per cow and cow numbers. The authors used time series and cross sectional data collected from 1983 through June 1988 for each of the 21 states in the study. Given the length of the two programs (13 and 17 months, respectively, for MDP and DTP), monthly data provide a more accurate measure of the effects of the two programs.

The conclusions of the study by Dixon *et al.* are similar to those of Gale (1990). Although the impact of the MDP and DTP varies by state and region, the general result is that both programs temporarily reduce production, and subsequently surplus milk. According to Dixon *et al.*, twelve months after the end of the MDP, production levels had recovered approximately 50% of the reduction attributed to the MDP. The quick recovery in total production gives credibility to Gale's conclusion that only marginal producers are attracted to these voluntary buyout programs. As expected, the effectiveness of the DTP is longer term and the recovery in production is not as dramatic as that of the MDP.

As mentioned previously, the impacts of the programs vary across states. With the MDP, Dixon *et al.* estimated that 10.32 billion pounds were removed from the milk market. Minnesota removed the most production (1.174 billion pounds) while Wisconsin producers increased production by 214 million pounds. Participation in MDP by Virginia producers resulted in a total removal of 179 million pounds. Dixon *et al.* estimate total removals under the DTP at 12.685 billion pounds. The range by state was 81 million (Vermont) to 2.762 billion (Wisconsin) pounds. Total participation in the DTP by Virginia producers equaled 156 million pounds. Dixon *et al.* emphasize that the different regional impacts of these programs could require coordination at a state level to achieve the desired effect of similar policies in the future.

A study that complements the work of Dixon *et al.* was conducted by Bausell, Belsley and Smith. Like many of the previous studies, Bausell *et al.* were interested in analyzing the effects of the MDP and DTP in order to determine their usefulness if considered for future policy. Another policy of the 1980's that was included in the analysis was the lowering of the support price. The results of the study are determined by using an eight equation, nonlinear econometric model of the dairy sector. The three components of the model are supply, demand, and government programs. The equations are estimated using nonlinear three stage least squares with quarterly data from 1976:1 to 1988:1. From the results of the model, Bausell *et al.* estimate each program's net benefit to the government, producers, and consumers.

Although the long-term effects of the MDP and DTP are minimal, each program reduced excess supply of milk for a limited time. Bausell *et al.* estimated that the MDP reduced government purchases by 13.56 billion pounds from 1984 to 1987:3 and the DTP reductions totaled 36.06 billion pounds from 1986 to 1990. In a six year span beginning in 1985, reduced supply from the lower support price is estimated at 36.44 billion pounds. Of the three programs, Bausell *et al.* show that the support price reductions are the most effective tool for reducing costs to government and consumers while lowering transfers to producers. If the goal of policy is to reduce government and consumer expenditures and decrease excess supply of milk, Bausell *et al.* conclude that a more aggressive program that concentrates on reducing price supports is necessary.

Market Orientation

One trend in dairy policy is the movement towards market oriented programs. As shown in Figure 2-1, the support price peaked at $13.49 per cwt. in 1981. Through various legislative acts from 1981 to 1990, the support price has been lowered to its current level of $10.10 per cwt. The M-W price has been above the support price since 1988. As discussed previously, movements in the support price are triggered by projected CCC purchases. For example, the Food Security Act of 1985 set the target level of CCC removals between 2.5 and 5 billion pounds (milk equivalent). If projected removals were below 2.5 billion pounds, the support price was increased. On the other hand, when projected purchases exceeded 5 billion pounds, the support price was decreased. These target levels remained in effect until the Food, Agriculture, Conservation, and Trade Act of 1990. The 1990 Act changed the lower target level from 2.5 to 3.5 billion pounds. The new target levels remained in effect until 1995.

As dairy policy moves in a direction of less regulation, producers, milk handlers, and legislators are more interested in research that attempts to determine the structure of the dairy industry that prevails in a competitive equilibrium. In this section of the literature review, several studies that evaluate the dairy market under alternative policy scenarios are discussed.

In a 1990 study, Emerson Babb evaluated the geographic price structure for federal marketing orders that would be expected under competitive conditions. Babb's testimony at the national milk marketing order hearings concentrated on identifying locations that should be used as base points and on what price-distance relationship should be established among orders (Babb 1990). The stability of base point locations and price-distance relationships was evaluated under various supply and demand elasticities, Class I reserve requirements, transportation costs, and different time periods. The model that Babb used was a competitive, spatial equilibrium model. Supply and demand points corresponded to the existing marketing order as of January 1990. The supply and demand functions were log-linear with constant elasticities. Since the choice of elasticity and functional form influences the price and quantity in a market, Babb analyzes the differences in price levels across markets, not the actual price level (Babb 1990). The solution to the model determines the market clearing prices at the lowest total consumer expenditures.

Given that base points are identified when prices between marketing areas differ by less than transportation cost, the results of Babb's study show that the Upper Midwest order is consistently a base point for regions east of the Rocky Mountains in most of the scenarios (Babb 1990). In experiments where the Class I reserve requirements and transportation cost were changed, there was little impact on the geographic price structure identified in the base model. When comparing the differences in equilibrium prices from the model and current Class I differentials, Babb showed that differences in equilibrium prices are at or near transportation costs while Class I differentials reflect about 60% of transportation costs (Babb 1990). In conclusion, the results of Babb's study indicate that a single base point in the Upper

Midwest is generally consistent with the price structure identified using competitive pricing (Babb 1990). Babb suggests that deviations from competitive prices are caused by the level of Class I prices and supply plant pooling provisions, not base points and Class I differentials (Babb 1990).

A more recent study that analyzes alternative dairy policy proposals was conducted by Cox in 1995. Like Babb, Cox presented his results to the House of Representatives' Committee on Agriculture. The policy scenarios that Cox evaluated are (1) terminate marketing orders but retain support price, (2) flat $2.00 Class I differential, (3) flat $2.00 differential pooled nationally, and (4) national order with utilization based differentials (Cox 1995). Although not included in Cox's testimony, Chavas *et al.*(1993), using the same regional model as Cox (1995), analyzed a competitive scenario where both price supports and marketing orders are terminated.

The model used in both the Cox and Chavas studies is a interregional competition model (IRCM) of the U.S. dairy industry. The competitive, spatial equilibrium model has been in development at the University of Wisconsin-Madison since 1988. The IRCM divides the U.S. dairy industry into 13 regions. The price dependent supply and demand functions in each region are assumed to be linear (Chavas *et al.* 1993). The objective function of the IRCM is to maximize the sum of producer and consumer welfare. The results indicate the equilibrium levels of production, prices, and trade flows across regions. An innovative aspect of the dairy IRCM is the consideration of farm level component pricing of butterfat, protein, and lactose (Cox 1995).

Although the study addressed many different scenarios, the results of a only a few scenarios are of interest here. For example, the implications of terminating the marketing orders while maintaining a price support are of interest as government policy moves towards deregulation. Cox shows that this scenario results in large price declines in all market orders east of the Rocky Mountains except the Upper Midwest (Cox 1995). In Virginia, which is included in the South Atlantic region, the predicted farm level price in this scenario is $13.20 per cwt., a decrease of 4.8% from the base solution (Cox 1995). As fluid milk prices fall by 12%, the supply of milk for manufacturing declines as fluid consumption increases. The end result is considerable benefits to regions that supply milk for primarily manufacturing (Cox 1995). Using different time periods, Chavas *et al.* report similar results when both marketing orders and price supports are removed (Chavas *et al.* 1993).

The other scenario that is of interest to the dairy industry is the simulation that incorporates a national order with utilization based Class I differentials. The results of this scenario show that changes in farm level price and production are relatively small when compared with the base (Cox 1995). For example, the price in the South Atlantic region decreases only 0.2% in this scenario instead of the 4.8% decline when marketing orders are terminated (Cox 1995). The most dramatic change is an increase in price for the Upper Midwest. When compared with other scenarios, Cox identifies the national order strategy as a "quiet scenario" (Cox 1995).

The final article included in this section of the literature review is authored by Hallberg *et al.* (1978). Although the study was conducted in 1978, Hallberg *et al.* were attempting to answer some of the same questions asked by policy makers today. For example, some of the scenarios evaluated in the study include (1) a national milk order, (2) regional milk orders, and (3) modified Class I differentials including a flat Class I pricing plan. Notice that some of the scenarios in the Cox study are very similar to those analyzed by Hallberg *et al.* in 1978. One should not be surprised that policy makers are still searching for answers to questions that were asked 17 years ago.

Like Babb (1990) and Cox (1995), Hallberg *et al.* used a spatial equilibrium model. The objective of the model was to maximize net social payoff. Hallberg *et al.* define net social payoff as the sum of producer and consumer surplus minus the costs of interregional shipments (Hallberg *et al.* 1978). This objective function is similar to that of the dairy IRCM used by Cox. The dairy market is divided into 28 supply regions and 39 demand regions. The supply and demand functions for each region are price independent, linear functions. The results of the model identify the levels of price, quantity, utilization rate, and trade flows for each region.

The results of the Hallberg *et al.* study disagree with those of both Babb (1990) and Cox (1995). For example, a comparison of the equilibrium solution to actual market conditions in 1975 revealed substantial differences. The authors concluded that these differences were the result of establishing a single basing point in the Upper Midwest (Hallberg *et al.* 1978). The study indicated that two additional base points are necessary in marketing orders east of the Rocky Mountains, one in the Northeast and one in the South (Hallberg *et al.* 1978). When compared to the equilibrium solution, the national order scenario increased both consumer expenditures and producer receipts (Hallberg *et al.* 1978). This scenario also caused substantial changes in the geographic structure of prices and interregional shipments of milk. Both of these results contradict those found in the national scenario simulated by Cox (1995).

In this section, the results of studies conducted by three well known economists using similar spatial equilibrium models have been discussed. The results of the studies are inconsistent. These inconsistencies can be attributed to model specification, aggregation techniques, and other assumptions. Even without a popular consensus among dairy economist, results of studies like these continue to influence dairy policy. In the next section, the 1995 farm bill and proposed changes in dairy policy are discussed.

1995 Farm Bill

In the 1995 Farm Bill, changes to dairy policy are being proposed by Steve Gunderson, a representative from Wisconsin. Although no proposals have been drafted into a formal bill at the time of this review, sources close to the farm bill debate indicate that the Gunderson proposal appears to be the only plan being drafted into a bill. The formal title of the Gunderson proposal is the 21st Century Dairy Policy Transition and Reform Act. The major provisions of the Act deal with the price support program and the federal milk marketing orders.

In the Gunderson proposal, the major change to the price support program is the removal of butter and nonfat dry milk from support on January 1, 1996. The price of cheese products will continue to be supported at $10.10 per cwt. until the year 2000. Although this part of the proposal may seem revolutionary, one needs to be reminded that the Grade B price of milk has been above the price support since 1988. The trend in Grade B prices and declining CCC purchases are evidence that the proposed changes in the price support program will have little impact on the current price structure in the industry. Other provisions that affect the program are the requirements that the USDA continue to purchase 2.4 billion pounds of milk equivalent dairy products (Gunderson 1995). Depending on whether the 2.4 billion pounds is a maximum or minimum level of purchases, we could see a possible shift in the demand curve for milk products. For example, if the required purchases are a maximum level, one might see the demand for milk products shift to the left since government purchases have been consistently above 2.4 billion pounds. On the other hand, if the level is a minimum, the demand should remain unchanged. The final change to the price support program is the discontinuance of excess purchase and budget reduction assessments. Currently these assessments total approximately $0.18 per cwt.

The most significant changes proposed by Representative Gunderson deal with the federal marketing orders. In the Gunderson Proposal, all federal and state marketing orders are consolidated into one national order for Grade A and B milk. The proposal identifies five marketing regions that could be used to determine the price of Class I milk. Although the boundaries are still in the development stage, Gunderson suggests that regions should be as follows: (1) California, (2) Western states, (3) Upper Midwest, (4) Northeast, and (5) Southeast (Gunderson 1995). Under the guidelines of the proposal, state marketing orders are preempted, and unregulated milk is not permitted. Given this provision, the fact that California is a region by itself should come as no surprise. Virginia producers, which are also regulated by a state milk commission, are included in the Southeast region.

The Gunderson proposal also calls for multiple components pricing of all classes of milk. The M-W pricing series will be replaced with a end-product pricing formula. The pricing of Class I milk will no longer be based on fixed differentials. Gunderson suggests using a dynamic formula that prices Class I milk based on regional utilization rates. The proposed Class I differential is calculated as follows: $1.00 + ($3.50 * prior year Class I utilization rate). From Class I revenues, $1.00 per cwt. will be contributed to a national pool so that producers in low utilization orders share in the returns of high Class I utilization orders.

Since details of the Gunderson proposal are not yet available, commenting on the changes in the marketing orders and price mechanism is difficult. Even without complete information, some general comments based on the summary of the proposal can be made. For example, dividing the dairy market into only five regions is going to be difficult. First, state milk commissions are going to resist the provision concerning state marketing orders and unregulated milk. Representative Gunderson has recognized this problem and with hopes of gaining the support of the largest producing state in the country has suggested that California represent a region. Also, producers in high utilization markets (i.e., Georgia and Florida) will most likely oppose any legislation that groups them in a market that results in a lower regional utilization rate. Using the dairy IRCM and incorporating changes outlined in the Gunderson proposal, economists at Wisconsin show that the average farm level price for the U.S. increases approximately $0.13 when compared with the base solution (Gunderson 1995). Producers that benefit from the proposed changes are located in the Upper Midwest and Pacific regions. All other regions will experience a decline in farm level prices.

The final version of the 1996 Farm Bill was signed into law by the President on April 4, 1996. In general, the 1996 Farm Bill is considered to be a bill that makes substantial progress towards more market-oriented farm programs. Of all the commodities, the provisions of the dairy program were among the most controversial provisions of the 1996 Farm Bill. The major changes in dairy policy outlined in the Farm Bill are discussed in the following paragraphs.

The 1995 Farm Bill eliminates budget assessments on producers' milk marketings. In the past, these assessments helped reduce the cost of government purchases. Effective immediately, budget reduction assessments are discontinued. The Farm Bill also phases out the support price on cheese, butter, and non-fat dry milk. Until December 31, 1999, the support price is reduced $0.15 per cwt. annually. After 1999, the support price is eliminated until

2002. In 2002, permanent parity-price provisions will become effective and a recourse loan will be implemented at $9.90 per cwt. The consolidation of Federal Milk Marketing Orders is probably the most substantial change in the dairy title of the 1996 Farm Bill. This provision requires that the number of orders be reduced from 33 to no more than 14, but not less than 10. The consolidation of the federal orders must be completed by 2000. Finally, markets for U.S. dairy products will continue to be developed with the Dairy Export Incentive Program (DEIP). Overall, the dairy provisions of the 1996 Farm Bill are one more step in the direction of less government regulation in the dairy industry. This policy trend has been building since the early 1980's, therefore the changes in dairy policy should come as no surprise.

Environmental Policy

Environmental policy is becoming more of an issue that dairy producers must consider in their decision making process. In the 1990s, environmental concerns have changed the structure of the dairy industry in several states. For example, producers in Florida, Texas, and Minnesota have been subjected to more stringent dairy waste regulations as the general public voiced concern about the environmental costs of milk production (Knutson *et al.* 1993). If the trend of increased environmental enforcement is extended to other states, the economic impact on producers and the local economy of large producing regions is uncertain.

Sources of environmental pollution can be nonpoint or point sources. Nonpoint sources of pollution cannot be legally identified as a source of the pollutants. On the other hand, pollution from a point source is traceable. Examples of point sources are industrial plants or sewer systems. With a few exceptions, agriculture has been identified as a nonpoint source of pollution (Lanyon 1994). The exceptions to the nonpoint classification are directed towards concentrated animal feeding operations. Large dairy and swine operations fall into this category since the source of pollution is easily recognized. The problem with the classification system is defining what constitutes a concentrated animal feeding operation (Knutson *et al.* 1993). According to the National Pollutant Discharge Elimination System, a dairy operation milking more than 700 cows is classified as a concentrated feeding operation. Dairy operations in this class must first develop a nutrient management system that prevents discharges up to a 25 year/24 hour storm event. Once this system is in place, the dairy operation can receive a permit from the Environmental Protection Agency. In special cases, the EPA can require small producers (i.e., 200 cows or less) to obtain a permit when direct discharge is evident (Knutson *et al.* 1993).

The problem with dairy waste is the high levels of nitrogen and phosphorus. With the traditional dairy farms, the nitrogen and phosphorus were used as fertilizer when preparing crop land for planting. The success of the waste management plan of these farms is linked to the soil characteristics, history of fertilizer use, and sources of animal feed (Lanyon 1994). As technology changes the size and structure of dairy farms, the traditional waste management plan is not as effective. For example, a trend emerging in the industry is the purchasing of feed inputs rather than on-farm production. As the production of feed inputs decreases, the remaining on-farm outlet for waste disposal may not be sufficient to properly dispose of the manure (Lanyon 1994). As the larger dairy operations purchase more feed inputs, utilization of waste nutrients on the farm is less effective and compliance with environmental regulations becomes more of an issue.

In order to show the impact of EPA waste management guidelines, Knutson *et al.* used the FLIPSIM policy simulator to calculate the profitability of a representative farm in Texas and Florida. The average herd size of the farms in the study is 476 cows. The results of the study show that dairy operations with cash flow problems are put out of business sooner if forced to comply with EPA regulations (Knutson *et al.* 1993). Of the farms included in the study, the average startup costs for machinery, equipment, and installation were $50,920, or $106.97 per head (Knutson *et al.* 1993). Applying a similar model to dairies located in other states once again revealed that cash flow was a major obstacle when trying to comply with environmental regulations. States included in this analysis were Missouri, Georgia, Washington, Wisconsin, New York, and Vermont. Some specific costs per head for environmental compliance are (1) Georgia: $20.29, (2) Wisconsin: $273.60, (3) New York: $253.62, and (4) Vermont: $264.14 (Knutson *et al.* 1993). The study implies that relatively profitable dairy operations should not have problems complying with EPA regulations.

The results of the Knutson *et al.* study suggest that some farms will be forced out of business due to costs associated with waste management systems (Knutson *et al.* 1993). One area that is neglected deals with the impact of environmental policy on the local economy of large producing regions. Because of the environmentally sensitive areas in Okeechobee County, Florida, some interesting studies are available that access the impact of dairy operations on local economies in Okeechobee county. One such study was conducted by Clouser *et al.* in 1994.

Located in south Florida is the Everglade National Park and Lake Okeechobee, the largest fresh water lake in Florida. Also located in the same general area are approximately 47,000 dairy animals, which accounted for about 25% of Florida's fluid milk production in 1986 (Giesy 1987). As nitrogen and phosphorous levels started increasing in the Lake Okeechobee drainage basin, new environmental regulations aimed at reducing nonpoint sources of pollution were passed. The new policy, which was known as the Dairy Rule and Dairy Easement Program, required producers in the Lake Okeechobee region to invest in new facilities for herd management and wastewater control (Clouser *et al.* 1994). In order to make the program more effective, the state helped fund new investments. Rather than building new facilities, the program had a buyout provision that paid $602 per cow to producers that halted production throughout the easement program (Clouser *et al.* 1994). The buyout offer was accepted by 19 dairy operations, effectively removing 15,000 cows from the region (Clouser *et al.* 1994). Given the outcome of the regulatory program, the objective of Clouser *et al.* was to determine the economic implications beyond the farm gate.

In order to determine the impact of fewer dairy operations in Okeechobee county, Clouser *et al.* estimated county level multipliers with the Regional Input-Output Modeling System of the U.S. Department of Commerce. With these multipliers, the authors were able to determine the direct, indirect, and induced impact of less dairy farms. The base solution shows that prior to the Dairy Rule and Easement Program, the dairy industry in Okeechobee county resulted in $158.6 million in total fluid milk sales, 1549 full-time equivalent jobs, and approximately $29.8 million of earnings in the local economy (Clouser *et al.* 1994). With the reduction in total cows resulting from the adoption of the environmental policy, Clouser *et al.* estimate a decline in total milk sales of $54.3 million. Other impacts include a loss of 531 full-time equivalent jobs and $10.2 million in lost earnings.(Clouser *et al.* 1994). Although a cost-benefit study more accurately shows the impact of increased environmental enforcement, Clouser *et al.* emphasize that the costs associated with regulation do not stop at the farm gate.

The environmental issues faced by Florida producers are not specific to that region. Virginia dairy producers are in a similar situation. For example, the largest producing region in Virginia is the Shenandoah Valley. This region is the same location of major tributaries that empty into the Chesapeke Bay. Although environmental regulation has not reached the levels observed in Florida, Virginia regulation does require producers to develop a waste management plan. How vigorously this regulation is enforced depends on who is being asked. For now, Virginia producers should recognize the possibility of higher costs of production as environmental enforcement becomes more stringent.

Technological Advancements

Like changes in dairy policy, there are also some technological issues that are impacting the structure of the dairy industry. For example, bovine somatotropin and reverse osmosis are technological advancements that have the possibility of changing where and how milk is produced throughout the country. In the sections that follow, the impacts of these technological advancements on the dairy industry are discussed in some detail.

Bovine Somatotropin

Advancements in genetic engineering have allowed researchers at Monsanto Corporation to artificially manufacture bovine somatotropin. Bovine somatotropin (bST) is a protein produced in cows that regulates and stimulates milk production. Some experimental herds have shown an increase in milk production that has ranged from 23.3% to 41.2% (Schmidt 1989). The Animal Health Institute has reported increases in production ranging from 10% to 25% (Tauer and Kaiser 1991). Although the production response to bST varies across the country, the potential impact of the use of bST is causing much controversy throughout the dairy industry. Some of the questions being asked by producers, consumers, and policy makers are (1) How will dairy policy need to be changed in order to accommodate the expected increase in milk production?, (2) What impact will bST have on the local economy and the profitability of dairy operations?, and (3) How will bST affect consumer's demand for milk products? Answers to these questions, and others, are found in the literature.

One study that tries to determine the optimal dairy policy with bST was conducted by Tauer and Kaiser (1991). In the study, Tauer and Kaiser determine the adjustments in dairy policy that are needed to maximize social welfare in the presence of bST. The model used by the authors was a discrete dynamic optimization model of the national dairy sector. Policy control variables in the model are milk support price and a supply control program. In reference to the adoption rate of bST, the authors allowed this variable to be endogenous and dependent on the profitability of its use (Tauer and Kaiser 1991).

Tauer and Kaiser modeled three scenarios: (1) producers do not use bST and the government continues current policy, (2) producers use bST, assuming a 13.5% increase in production, and the government continues current policy, and (3) the government implements a buyout program as bST usage increases. The results of these three scenarios show that the benefits to producers and consumers are maximized when the government uses a buyout program to control the increase in production from bST (Tauer and Kaiser 1991). In both scenarios where bST is adopted, consumers' social welfare increases as a result of lower milk prices and greater milk consumption (Tauer and Kaiser 1991).

The impact of bST on farm profitability is different across scenarios. For example, the study shows that real profits per cow are highest when producers do not use bST. If bST is adopted and the government does not change dairy policy, producers experience a short run decline in profits per cow as the price of milk falls (Tauer and Kaiser 1991). In this scenario, the adoption rate for bST is only 50%. Although the scenario with a government buyout program is not the most profitable, this scenario does result in a bST adoption rate of 72% (Tauer and Kaiser 1991). In the long-run, all three scenarios result in approximately the same profit level per cow.

In a study very similar to that of Tauer and Kaiser, McGuckin and Ghosh (1989) used an optimal control model to determine the level of dairy price supports needed to stabilize government purchases after the introduction of bST. The objective function in the model minimizes variability of government purchases from a policy target of 3.75 billion pounds (McGuckin and Ghosh 1989). The only control variable in the model is the support price of milk. The bST adoption rate is exogenous.

McGuckin and Ghosh used both a high and low adoption rate in their study. Results from a survey of dairy farmers suggested that the projected adoption rate varied between 55% and 90% (McGuckin and Ghosh 1989). Adoption rate appeared to be dependent on the frequency of injection. High rates of adoption were reported if bST was administered through implants, while only half of the respondents would use bST if daily injections were required (McGuckin and Ghosh 1989). The results of the model suggest that both rates of adoption increase CCC purchases and lower the support price to approximately $7.00 per cwt. The only difference in the scenarios is how quickly the support price falls. With lower support prices, the model predicts a steep decline in dairy cow inventory (McGuckin and Ghosh 1989).

McGuckin and Ghosh show that the provisions of the current dairy policy are inadequate to handle the surplus milk resulting from the adoption of bST. If the support program is inflexible and prices are not allowed to adjust, government purchases of surplus milk will rise significantly (Tauer and Kaiser 1991). Although the rate of bST adoption plays a major role in changing industry structure, both the Tauer and Kaiser and McGuckin and Ghosh studies show that the impact of bST depends mostly on adjustments in dairy policy.

The adoption of bST is going to cause impacts beyond the farm gate. Studies like Tauer and Kaiser have shown that producers should expect lower prices as the adoption rate of bST increases. What these studies neglect is the impact on local economies from this change in technology. If bST is widely adopted, the farm and retail prices of milk will fall as total milk production increases. Since cows injected with bST require more feed (Schmidt 1989), the market could see an increase in the demand for feed inputs. Finally, the demand for milk could be affected depending on consumers' perception of changes in product quality. Given these expected impacts beyond the farm gate, Parsons and Johnson attempt to evaluate the regional and state impact of bST adoption in Virginia.

Parsons and Johnson use IMPLAN, an input-output model, to determine the regional impacts on other sectors of the economy from the dairy industry's adoption of bST. The authors evaluate the extreme situation where all producers utilize bST. Both scenarios in the study assume a 10% increase in milk production. The only difference is that one of the scenarios also allows a 5% decrease in demand. The results of the scenarios show a decline in returns to dairy operations at both the county and state levels. Furthermore, Rockingham county and Virginia can expect reduced industrial output, personal income, property income, and jobs if bST is adopted by Virginia producers (Parsons and Johnson 1994).

Reverse Osmosis

The complicated pricing mechanisms in the dairy sector are needed because milk is a homogeneous product that is costly to transport. The spatial differences between large producing regions and the final consumer determine the market boundaries. As the cost of transportation decreases, market boundaries expand and the spatial aspect of milk marketing becomes less important. Reverse osmosis is a new technology in the dairy industry that could result in expanded marketing areas for producers. Reverse osmosis (RO) is a technology that can remove at least 50% of the water from milk (Schiek and Babb 1989). In Figure 2-2, the impacts of reduced transportation costs from technology associated with reverse osmosis are illustrated graphically.

In the example in Figure 2-2, the average costs of production for a given dairy farm is \$9.00 per cwt., or COP_{DF}. This dairy farm is located 200 miles from market A and 1200 miles from market B. The price per cwt. in markets A and B is \$10 and \$12, respectively. If one assumes transportation cost is \$0.25/cwt./100 miles, line TPC_O represents the increase in transportation cost as milk is shipped from the dairy farm to distant markets. The vertical distance between TPC_O and COP_{DF} is the increase in transportation cost as distance from the dairy farm increases. The sum of TPC_O and COP_{DF} is the farm-to-market total cost faced by producers. If the dairy farms sells output in market A, the profit per cwt. of milk for a farm located 200 miles from market A is \$0.50. The costs of transportation to market A is \$0.50 per cwt.

If P_b is the price in market B, a dairy farm located 1200 miles from market B cannot profitably compete with a market price of \$12.00 per cwt. Because transportation cost to market B is \$3.00 per cwt., the dairy farm breaks even when selling output in market B. If some technology is made available that reduces the transportation cost per cwt. of milk, this makes market B a more profitable alternative for a farm located 1200 miles away. Graphically, the new technology represents a downward rotation of the TPC line (TPC_N). With the lower

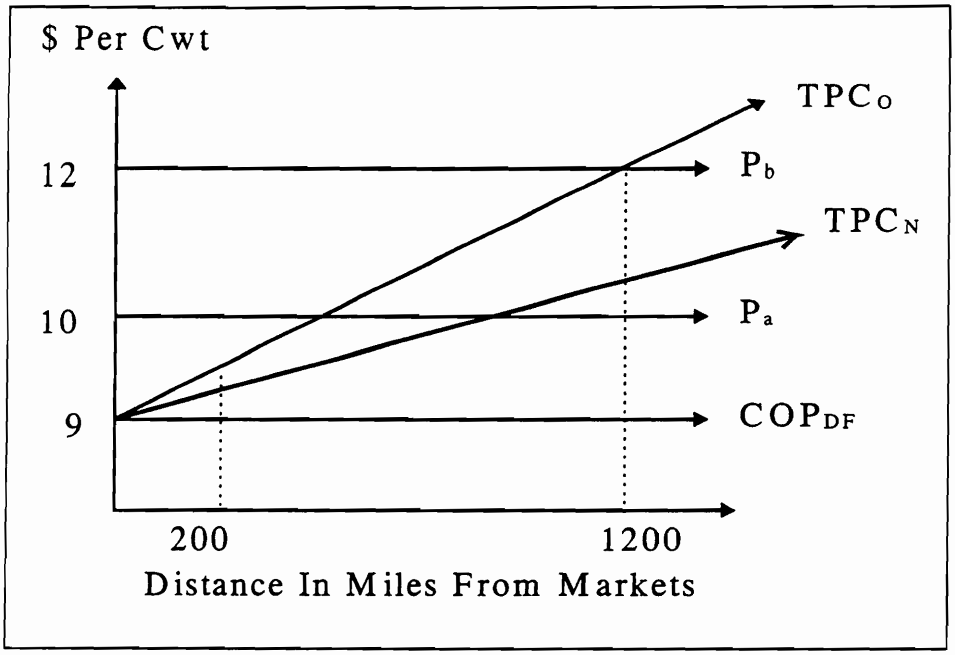

Figure 2-2: Graphical Example Of a Producer's Marketing Decision When Hauling Rates Are Decreasing As a Result Of Reverse Osmosis

hauling rates, the dairy farm is profitable in both markets. Since the new technology reduces the effectiveness of trade barriers created by distance, the deciding factor of where production will be located is cost of production. As the price in region B declines in response to an increase in supply, less efficient producers in region B may be forced to exit the industry.

If one needs a practical application of Figure 2-2, just think of producers in Florida and Wisconsin. In general, producers in Wisconsin can supply milk cheaper than Florida producers. The only barrier separating the Florida and Wisconsin markets is transportation cost. If this barrier is removed due to reverse osmosis, Florida and Wisconsin producers are essentially competing in the same market. In the long-run, low-cost producers will dominate the market as price responds to changes in supply.

By removing 50% of the water from raw milk prior to shipment, RO technology reduces interregional transportation costs. Since Class I differentials are needed to offset the transportation cost between surplus and deficit producing regions, acceptance of this new technology may reduce price differences across the country. The use of RO is currently limited to skim milk since the fat components in whole milk cause complications in the RO process (Schiek and Babb 1989).

Schiek and Babb completed a study that examined the impact of RO technology in marketing orders east of the Rocky Mountains. The results of the study identified changes in procurement patterns and costs, interregional price relationships, production, consumption, and farm and retail prices (Schiek and Babb 1989). The model used in the study is the Federal Milk Market Order Policy Simulator (FMMOPS). The FMMOPS solves for the least-cost movements of milk from the producer to the final consumer. Schiek and Babb examined two different pricing scenarios that priced RO milk at Class I and Class III levels. The estimated cost of transportation for RO milk was 2.6 cents plus 0.15 cents per mile, per cwt., which is half the cost associated with raw milk (Schiek and Babb 1989).

The results of the study indicate that pricing RO milk at Class I levels does not cause dramatic changes in procurement patterns. Of all the marketing orders in the study, only the Florida orders alter procurement patterns significantly (Schiek and Babb 1989). This scenario also results in only minor changes in consumer and producer surplus. Only consumers located in Florida benefited from the availability of RO milk (Schiek and Babb 1989). The results of the scenario where RO milk is priced at Class III levels is substantially different from the Class I scenario. In this scenario, producers experience substantial losses resulting from lower farm prices, consumers benefit from lower retail prices, and procurement patterns are altered in several marketing orders (Schiek and Babb 1989). Federal orders affected the most by this scenario were located in Florida, Georgia, and New Orleans. If priced at the lower Class III prices, RO technology has the potential to reduce farm and retail prices as well as alter procurement patterns. On the other hand, pricing RO milk at Class I levels will not result in substantial changes in prices or interregional shipment patterns (Schiek and Babb 1989).

CHAPTER 3
THEORETICAL IMPLICATIONS OF GOVERNMENT INTERVENTION

Introduction

The federal government has been involved in the dairy industry since 1933. Before government intervention, the industry was dominated by milk handlers who behaved as monopsonists. With the federal milk marketing orders and the price support program, the government hoped to establish orderly marketing conditions that approximated a competitive market (AAEA 1986). A major problem with this objective is the lack of a base period for comparison. Since the dairy industry has never approached a competitive market, no one is sure what market equilibrium would prevail under competitive conditions. Without the advantage of a base period, economists cannot identify at what point dairy policy has satisfied its objectives. Some legislators, industry representatives, and economists believe that the dairy surplus problems of the 1980s are evidence that dairy policies have failed to reach a competitive equilibrium in the marketplace.

The need to determine the impact of less regulation on the dairy industry arises from concerns that the federal orders and price support program have resulted in a marketing environment that relies little on traditional price discovery mechanisms and too much on classified pricing and the monopoly power of producer cooperatives (Masson and Eisenstat 1980). As the dairy industry moves towards less government regulation, primary concerns of producers are the impact on farm and retail prices, the level and geographic distribution of milk production, producer income, and the role of cooperative organizations. Economists have been using economic theory to determine the potential effects of milk marketing orders and price support programs since the early 1930's (Garver 1933; Gaumnitz 1963; and Kessel 1967). A thorough review of this literature will outline the structure of the dairy industry in the absence of government intervention.

Price and Output Effects

The tools of dairy policy that impact the price and quantity of milk products are the classified pricing system and the price support program. The classified pricing system supports the price of milk used in fluid products while the price support program maintains a price floor for Grade B milk, milk processed into manufacturing products. Although the market effects of these policy tools are not mutually exclusive, examining separately the market implications of these programs allows one to see the direct impact of each policy tool.

Impact Of Price Support Program

The government supports the price of manufacturing grade milk by operating a price support program that places a price floor under the Minnesota-Wisconsin price. If market analysts predict that the M-W will fall below the support price, the government will purchase a mix of butter, cheese, and nonfat dry milk in order to maintain a minimum price for Grade B milk (Buxton 1979). Figure 3-1 helps illustrate the impact of the price floor on the dairy industry.

The graphical illustration in Figure 3-1 shows the effect on price and quantity of placing a price floor under the M-W price. The impact of a price floor is dependent on the current market equilibrium. For example, if the price floor is below the market equilibrium,

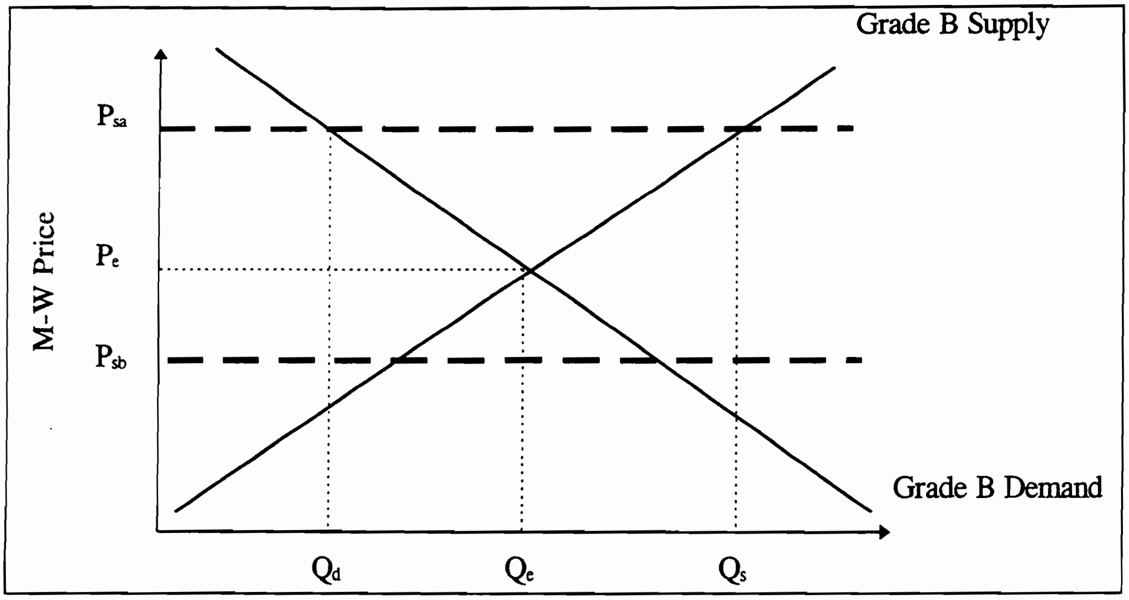

Figure 3-1: Impact Of Price Supports That Are Set Above Or Below a Competitive Equilibrium

there will be no effects on the price and quantity of Grade B milk. This situation is represented in Figure 3-1 with price support level P_{sb}. With the price floor below the market equilibrium, the Grade B market clears at price P_e and quantity Q_e. The current price floor in the dairy industry is $10.10 per cwt. and the last time the M-W price reached the price floor was in 1988.

The alternative situation is having the support price set above the equilibrium price. This scenario is illustrated in Figure 3-1 with the price floor at P_{sa}. At price support level P_{sa}, Q_d is the quantity demanded in the commercial market, but producers' profit maximizing level of output is Q_s. By placing a price floor above the equilibrium price, producers face a perfectly elastic demand curve for quantities above Q_d. The support price, P_{sa}, is both the marginal revenue and the demand curve faced by Grade B dairy farmers. Individual producers maximize profits by producing up to the point where their marginal cost is equal to P_{sa}, and the aggregated quantity is Q_s in Figure 3-1. With a support price above the market clearing price, a surplus of milk equal to $Q_s - Q_d$ is produced in the market. In order to maintain the high support price as output expands, the CCC purchases the surplus milk (Gaumnitz 1963). The effects of the price floor being above the market clearing price is a decrease in quantity demanded in the commercial market ($Q_e - Q_d$) and higher farm and retail prices for manufactured dairy products. The large CCC purchases of the 1980's is a direct result of the support price being above the market clearing M-W price.

Even though the effects of the price support program have been explained, the question still remains: What will be the impact on the dairy industry of removing the price floor? Based on the current market conditions in the dairy industry, the price floor of $10.10 per cwt. is not stabilizing the price of milk used in manufactured products. Therefore, if the support program is removed, one does not expect substantial changes in the current market equilibrium. Since the government still purchases small amounts of manufactured products for domestic programs, there may be a small decrease in demand if these programs are discontinued in the absence of a price support program. Another concern deals with the risk aversion of dairy producers. Even with a price floor below the equilibrium price, some elements of price risk are reduced for producers. With a price floor, producers know there is a minimum price that they will receive for their output. Given that dairy producers are generally thought of as risk adverse (Tauer 1986), a market with more price variability due to the lack of a price support program could result in a small decrease in the supply of milk as the more risk adverse producers exit the industry or reduce output as a means of discounting for the uncertainty.

Impact Of Classified Pricing

Federal milk marketing orders regulate the sale of Grade A milk. Any processor that distributes milk to an area that is regulated by a marketing order is required to pay a minimum price based on how the milk is utilized (Buxton 1979). Grade A milk can be used in the production of any dairy products. If the milk is used for fluid products, it is designated as Class I and receives a Class I price. The minimum Class I price for a marketing order is determined by adding the order's Class I differential to the M-W price. Milk used for Class II products receives the M-W price plus a fixed differential while the minimum value of milk designated as Class III is the M-W price. The revenue from each of these sales categories is pooled and a uniform or blend price is paid to all dairy farmers participating in the marketing order. The blend price is the average revenue of all Grade A sales within a specific marketing order (Ippolito and Masson 1978). The objectives of classified pricing and pooling regulations of federal orders are orderly marketing conditions, an adequate supply of fluid milk, and to increase farmers' income (Masson and Eisenstat 1980). The effectiveness of classified pricing in achieving these objectives has been questioned since the beginning of marketing orders in 1937.

Economic theory suggests that producers selling a homogeneous raw material in a competitive market will receive the same price for their commodity regardless of the commodity's end use. A classified pricing system where the price of a commodity is dependent on end use is a form of price discrimination that leads to a misallocation of milk between its alternative uses (Ippolito and Masson 1978). Figure 3-2 illustrates the effects of classified pricing on both the Grade A and B milk producers.

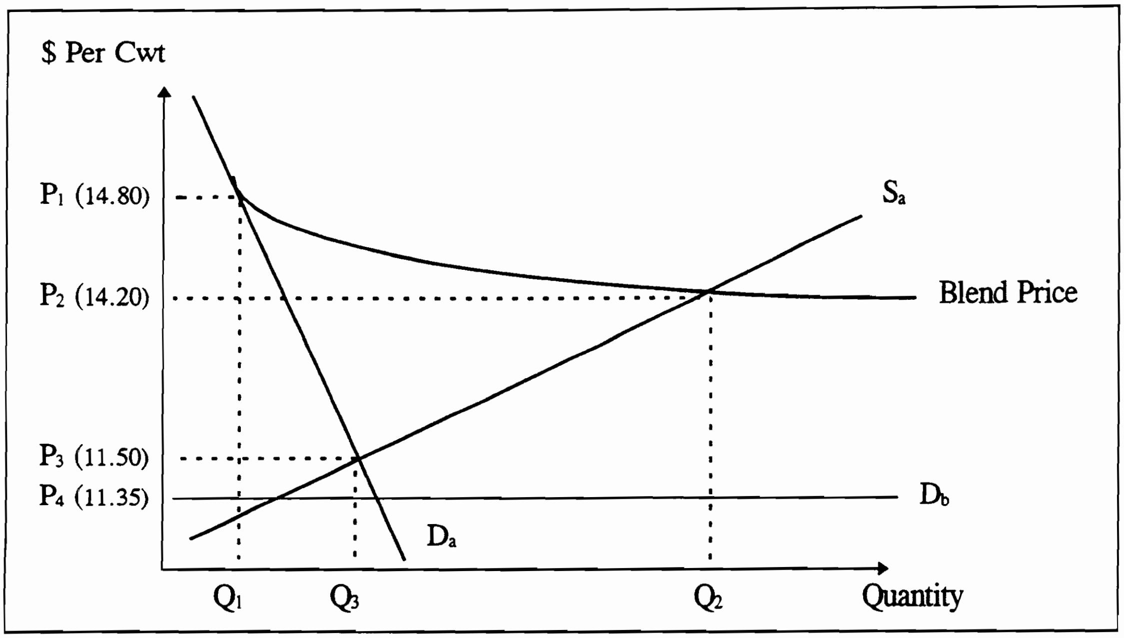

Figure 3-2: Price and Quantity Equilibrium For Fluid and Manufactured Milk In a Market With Classified Pricing
Source: Kessel 1967

The classified pricing system tries to increase the income of Grade A producers by taking advantage of the relatively inelastic demand of fluid milk products (Ippolito and Masson 1978). With an inelastic demand, price can be increased without resulting in a substantial decrease in quantity demanded. In Figure 3-2, D_a and S_a represent the demand and supply curves, respectively, for Grade A milk within a single federal market order. If the market were unregulated, the price and quantity supplied of fluid milk are represented by points P_3 and Q_3, respectively. With a competitive market, P_3 is the price for all milk eligible for fluid use and the slightly lower price of P_4 would prevail for manufactured milk (Kessel 1967). The price P_4 is the support price of fluid milk under an effective price support program. The higher price for fluid milk reflects the additional costs of production associated with sanitation requirements. The differences in costs of production have been estimated at $0.15 per cwt. (Ippolito and Masson 1978), so P_3 less P_4 would be about $0.15 per cwt.

In order to assure an adequate supply of Grade A milk for all marketing areas, class pricing encourages local production by raising the price of fluid grade milk (Buxton 1977). In Figure 3-2, the higher Class I price is represented by P_1. The immediate effect of the higher Class I price is a decrease in quantity demanded of fluid grade milk. As the classified pricing system raises the price of Grade A milk from P_3 to P_1, quantity demanded falls from Q_3 to Q_1. From the consumers' perspective, class pricing raises the price of fluid milk products at the retail level (Kessel 1967).

With the higher class prices and the pooling provisions of the market order, producers of Grade A milk receive the blend price (Figure 3-2) for all units of output. Assuming a constant Class I utilization rate for a market, the blend price line slopes downward and to the right as more output is produced. For dairy farmers associated with a marketing order, the profit maximizing level of output is where marginal cost is equal to the blend price. In Figure 3-2, the unique Grade A market equilibrium given S_a and D_a occurs at price P_2 and quantity Q_2. As long as the blend price (P_2) is higher than the price received by farmers in competitive conditions (P_3), the supply of Grade A milk increases from Q_3 to Q_2 (Kessel 1967). Because of the increase in quantity supplied and the decrease in quantity demanded, a surplus of fluid milk equal to Q_2 - Q_1 develops in the Grade A market. Some of the surplus milk satisfies reserve requirements, thereby helping to reduce Grade A price volatility that could result from supply shortages in local markets (Buxton 1979). Because of the infinitely elastic demand for Grade B milk (D_b in Figure 3-2), the majority of the Grade A milk surplus is sold in the manufacturing market at the M-W price (Kessel 1967).[2] If the M-W price is above support price levels, the

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[2] Assuming that the M-W price is the same as the government support price, the demand for Grade B milk is infinitely elastic.

surplus of Grade A milk will decrease the M-W price as the total supply of Grade B milk increases. Regardless of the current M-W price level, Grade B producers are faced with a depressed price for their output due to the classified pricing of federal orders (Buxton 1979).

Economists generally agree that market orders, through class pricing and pooling provisions, have a tendency to increase prices paid to dairy farmers (AAEA 1986). The higher Grade A prices have contributed to a surplus of fluid milk, lower manufacturing prices, higher incomes for Grade A producers, and a conversion of farms from Grade B to Grade A production (Kessel 1967). Most of the problems associated with class pricing and pooling provisions deal with the blend price. In a market order, there is a difference between the price dairy farmers receive for their output and the actual value of the output in the marketplace. At times when there is a surplus of Grade A milk in the market, these producers receive the blend price, but the additional milk is valued at the much lower Class III price. The difference between blend price and actual market value gives inaccurate price signals to both Grade A and B producers and results in expanded output on all farms (Buxton 1979).

Although some economists speculate that the Class I price differentials are the source of the industry's problems (Buxton 1979; Dobson and Salathe 1979), Babb (1990) concluded that price differentials that are less than the full cost of transportation across markets do not create a surplus of Grade A milk. Although minimum prices set in the orders attempt to stabilize the fluid market, market forces are allowed to "fine tune" these prices since the Class I differentials are less than transportation costs from Eau Claire, Wisconsin (Babb 1990). If the Class I differentials are not the source of high prices, another alternative is the support price. From 1970 to 1989, the support price increased 164% while the average Class I differential as a percentage of the M-W price decreased from 44.6% to 20.8% (Babb 1990). Since Class I prices are the sum of the M-W price and the Class I differential, producers' output decisions appear to have been influenced more by the support price than Class I differentials. With the M-W price above the support price since 1989, the industry is now in a position where economists can try to determine the impact of classified pricing in the absence of a dominant price support program.

Although there is no consensus on the direct impact of the price support program or Class I differentials, many economists and industry representatives agree that the market order's classified pricing and pooling provisions have attained the original objectives of (1) an adequate supply of fluid milk, (2) an increase in the income of Grade A producers, and (3) stabilize farm and retail prices of fluid milk products. If these programs are eliminated, fluid milk prices would be more volatile, the surplus of Grade A milk would decline, and manufacturing milk prices might increase (Dobson and Salathe 1979).

Spatial Impacts Of Marketing Orders

If the federal marketing orders are to accomplish their objective of maintaining orderly marketing conditions, special provisions are needed to accommodate the sale of non-regulated milk in regulated markets. For example, allocation provisions discourage regulated plants from purchasing milk from unregulated producers (Kessel 1967). Any provision that discourages these types of sales could have a negative impact on the geographic distribution of milk production. Other provisions of the federal marketing orders that distort the spatial equilibrium of the dairy industry are pooling provisions and transportation differentials. These regulations could influence the assembly patterns of raw milk as well as the geographic distribution of milk production. Since the objective of this chapter is to describe the dairy industry in the absence of regulation, a thorough review of the literature will help determine the spatial effects of allocation provisions, transportation differentials, and pooling provisions.

Allocation Provisions

Classified pricing is a discriminatory pricing mechanism that could result in higher prices than what would prevail in a competitive market (AAEA 1986). When prices are higher in federal orders, provisions are needed to prevent regulated handlers from buying raw milk from non-regulated producers for use in Class I products. In order to discourage this transaction, regulated handlers are required to allocate local production to the higher valued uses before any non-regulated milk can receive a price higher than the Class III price. This allocation provision is commonly known as down-allocation. If there were no restrictions on the allocation of regulated and non-regulated milk, handlers would prefer to allocate low-cost, non-regulated milk to fluid use and then allocate locally produced milk to the Class II and III markets. This allocation scheme would benefit the low-cost producers in the Upper Midwest at the expense of local producers. Since down-allocation forces the handlers to price non-regulated milk at the lower manufacturing prices, there is usually no economic incentive for non-regulated producers to ship milk to distant regulated handlers (Kessel 1967).

Another source of less expensive milk that could impact the effectiveness of the federal marketing orders is producers located in other marketing orders that have low Class I utilization rates. In orders where the Class I utilization rate is low, the blend price is near the manufacturing price. Without allocation provisions, some regulated handlers would find it profitable to ship the lower valued milk to their market for use in Class I products. Since this scenario deals with producers in another marketing order, down-allocation is not applied to the supplemental milk. Instead, regulated handlers who purchase low valued milk from other orders must allocate this milk across uses based on the local utilization rates. In essence, supplemental milk from other marketing orders receive the same price as locally produced milk (AAEA 1986). The allocation provisions and the additional transportation costs from shipping milk from distant producers serve as a deterrent for regulated handlers wanting to take advantage of the lower prices in other marketing orders.

Allocation provisions are needed so that the federal marketing orders can achieve their objectives of higher incomes for Grade A producers and a stable supply of fluid grade milk in local markets. Without these provisions, producers located in the Northeast, South, and West would be competing more with the low-cost producers of the Upper Midwest, Corn Belt, and Great Plains (Fallert and Buxton 1978). The increased competition would result in lower prices and income for local producers as handlers purchased a larger percentage of milk from distant sources. In the absence of allocation provisions, one might see a decrease in local production as more product is supplied from those areas with a comparative advantage in milk production (Kessel 1967). As production shifts to the more traditional milk producing areas, the supply of Grade A milk could become unstable in deficit producing regions.

Transportation Differentials

Transportation differentials are an important component of the federal milk marketing orders. In fact, the orders rely on the differentials to help assure an adequate supply of fluid grade milk in local markets. These transportation differentials are known as location or zone differentials.

Within a marketing order, the location differential is a function of how far a producer is from the metropolitan area or base point. The differential increases with distance and reduces the blend price that is paid to producers. The original purpose of the location differential was to establish a supply region for a market and to allow processors within these markets to purchase milk at the same price, net of transportation costs (AAEA 1986). The differentials establish a boundary around a marketing area so that there are no price incentives for producers or processors located in other regions to compete outside of their local market (AAEA 1986). The problem with location differentials is that they artificially establish market boundaries that reduce competition among producers and processors across federal orders (Kessel 1967). If these differentials do not accurately reflect the farm to market transportation costs, marketing efficiency could be reduced as processors adjust their milk assembly patterns to take advantage of location differentials that are set too high. On the other hand, if the differentials are set too low, a processor's supply region is reduced and producers near the metropolitan areas have a competitive advantage over distant producers. In a competitive environment, market forces would determine the supply region and the possibilities of arbitrage would result in the most efficient movements of raw milk.

Pooling Provisions

Producers associated with a marketing order receive the blend price for each unit of output. The blend price is the result of marketwide pooling where the revenue from each sales class is summed together and divided by the total quantity of Grade A milk sold to regulated handlers. In order to qualify for the marketwide pool of a particular marketing order, producers must ship a certain percentage of their output to the order's regulated handlers for use in the Class I market (Buxton 1979). Because of the minimum shipments required to qualify for the pool, in some instances marketwide pooling can result in inefficient movements of raw milk.

Marketwide pooling creates inefficient milk assembly patterns most often when distant producers located near alternative manufacturing plants are pooled in an order. In many instances, local producers in deficit regions find it necessary to pool additional milk in order to satisfy supply contracts. At the same time, the distant producers are attracted to the deficit producing order because of higher blend prices and Class I utilization rates. Pooling provisions require a certain percentage of the pooled milk to be shipped to the Class I market each month. During a marketing order's surplus producing months, this provision results in milk being shipped from distant locations to regulated handlers even though there is a surplus of local production (AAEA 1986). The shipments of milk during flush months result in inefficient milk assembly patterns and raise a marketing order's total cost of transportation. Because of the cost minimizing behavior of milk handlers, these types of milk assembly patterns would be very unusual if the dairy industry was deregulated.

Market Power

Since Congress passed the Capper Volstead Act of 1922, dairy farmers have been collectively bargaining with milk handlers through cooperative organizations. Over the years, the membership in these cooperatives has increased to the point where a substantial portion of the nations milk supply is marketed through dairy cooperatives (Babb 1989a). Although many of these cooperatives are regional, some of the larger dairy cooperatives that have national recognition are American Milk Producers Inc. (AMPI), and Mid-America Dairymen. The primary role of dairy cooperatives is to perform marketing services for member producers.

These marketing services include milk assembly, testing, advertising, record keeping, market analysis, and most importantly, obtaining supply contracts with individual processors. As the supply of milk marketed by local cooperatives increased, milk handlers let these dairy cooperatives do their short-term and seasonal balancing of supply with demand (Gaunmitz 1963). For example, some of the services provided to the milk handlers are disposal of milk in excess of fluid requirements, arranging for an adequate supply of fluid milk on a supplemental or continuing basis, and providing standardized milk by performing quality control functions (Babb 1989a). For these services, milk handlers pay cooperatives over-order payments. Some have suggested that these over-order payments are an indication of cooperatives' increasing market power resulting in part from the federal milk marketing orders (Masson and Eisenstat 1980; MacAvoy 1977). The problem is determining what portion of the over-order payment is economically justified in competitive marketing conditions.

One of the objectives of marketing orders is to increase the income of producers. Dairy policy achieves this objective with the help of classified pricing, pooling and allocation provisions. Although there are no regulations that directly benefit cooperatives, critiques of the federal order system suggest that the regulations indirectly lead to market power by preventing competition in local markets (Kessel 1967). For example, the classified pricing system in federal markets needs pooling provisions in order to regulate the flow of milk and to prevent unnecessary shipments of milk into these markets. These pooling provisions, which are discussed in the previous section, provide larger dairy cooperatives with the opportunity to increase market share in areas that are more competitive. Dominant cooperatives that operate in several markets can use the pooling provisions to decrease the blend price and eliminate competition from other dairy cooperatives (Masson and Eisenstat 1980) . Assuming that the utilization rates remain stable in the competitive market, the dominant cooperative can pool additional milk on the order and force the blend price down. If the cross market pooling (also known as pool loading) depresses the blend price for an extended period of time, small cooperatives will be unable to compete. As competition is reduced, the dominant cooperative will allow the blend price to increase by pooling less milk on the order. The end result is that the larger cooperative, by manipulating pooling provisions, increases market share by expanding into new markets and taking on new members. As competition is reduced, the dominant cooperative becomes the major source of raw milk for regulated handlers in the local market. This situation provides the cooperatives with an opportunity to negotiate over-order payments in excess of what would prevail in a competitive market.

Masson and Eisenstat (1980) argue that once a dairy cooperative is the dominant supplier of milk in a region, monopoly premiums can be obtained from milk handlers due to the lack of a stable supply of raw milk from other sources. An alternative theory is that the federal orders and the price relationships among orders create an environment where the monopoly premiums are independent of the concentration of dairy cooperatives (Babb 1989b; Christ 1980; Jesse and Johnson 1985). In a 1989 study, Babb estimated over-order payments as a function of cooperative concentration, the presence of a major cooperative in a market, price relationships among orders, utilization rates, cost of milk services, product concentration, and processor concentration. Babb used cross sectional data for the years 1970-1987. The results of Babb's study showed that the estimated coefficients for cooperative concentration and the presence of a major cooperative were generally not statistically different from zero (Babb 1989b). The impacts of both processor and cooperative concentration on the level of over-order payments were found to be relatively small (Babb 1989b). Variables that did have a significant impact on over-order payments were the price relationships among orders and the cost of raw milk services (Babb 1989b). The study revealed that over-order payments had a positive relationship with cost of milk services and the cost of milk from alternative sources. Although these results do not indicate that cooperative concentration does not have any impact on over-order payments, the results do support the theory that variables related to federal regulations impact these payments more than structural variables.

Even though pooling and allocation provisions may help create a market where sellers of raw milk are heavily concentrated, there is no evidence that the over-order payments are not economically justified. Federal orders set the minimum prices in a market, but these prices are not meant to be the effective prices. Cooperatives find the effective price in a market by negotiating for additional payments that result in competitive conditions across markets (Babb 1989b). In order for dairy cooperatives to obtain monopoly premiums, they would need to control production and where producers sell their output (Blakley 1980). By controlling production, cooperatives could exert market power by denying milk handlers a supply of raw milk (Christ 1980). Even in this situation, the market power of cooperatives would be limited due to the alternative supplies of milk on the open market. In the absence of federal marketing orders, do not expect widespread decreases in the levels of over-order payments.

The provisions of the federal marketing orders may create an operating environment where cooperatives can exert market power. If this market power does exists, the costs of producing and shipping the national milk supply could be above the costs of these services in a competitive market. As pooling and allocation provisions are relaxed, dairy cooperatives could become less concentrated and more competitive across markets. Cooperatives that are more competitive could result in a more cost-efficient geographic distribution of milk production.

Summary

The primary objective of the price support program and the federal milk marketing orders is to promote a stable supply of fluid milk throughout the dairy industry. During the 40 years that these programs have been operating, a stable fluid milk supply has reduced Class I price variability. These programs have also contributed to the increase in aggregate net returns of dairy producers and reduced problems associated with the seasonality of milk production (Dobson and Slathe 1979). Clearly, federal marketing orders and the price support program have satisfied their original objectives. The one question that remains unanswered is are these programs still necessary. When the dairy policies originated, the producer's market was extremely limited due to the lack of efficient transportation alternatives. Today, the milk market is a national market and there have been considerable technological advancements throughout the industry. Given these changes in the structure of the industry and the surplus problems in the recent past, the need for marketing orders and price support programs is being questioned.

As dairy policy moves towards less regulations, a primary concern throughout the dairy industry is what marketing environment would prevail in the absence of government regulation. Tentative conclusions are as follows: (a) the price differences between milk used for fluid and manufacturing purposes would narrow to reflect only differences in costs of production; (b) the supply of fluid grade milk would decrease as dairy farmers based output decisions on the market value of additional milk and not the higher blend price; (c) prices at the farm and retail levels would become more volatile in some of the deficit producing regions; (d) the geographic distribution of milk production would change as inefficient producers exit the industry and as low-cost producers increase output; (e) producers that depend on local markets could see an increase in competition from distant, low-cost producers; and (f) more efficient movements of raw milk would prevail as pooling requirements are abandoned.

CHAPTER 4
MODEL DEVELOPMENT

Empirical Model

The primary objective of this study is to determine the impact of a deregulated dairy industry on Virginia producers. The objective can be accomplished with several different types of empirical models, but before an empirical model is developed, one must decide on how to demonstrate the effects of deregulation. Federal Milk Marketing Orders are controversial because opponents claim the orders promote production in inefficient production areas and elevate the price of fluid milk while depressing the price of manufacturing grade milk. Given these areas of concern, a study that attempts to analyze the impacts of deregulation must consider the effects on location of production or on price.

A review of the literature shows several types of empirical models that illustrate the effects of deregulation via price impacts. For example, both Cox (1995) and Babb (1990) use a spatial equilibrium model to predict price levels in a competitive market. Although studies that predict price levels are informative, the accuracy of the results is very sensitive to the elasticity values of supply and demand in the model. Babb recognized this limitation and reported only differences in price levels across markets. Econometric models are another type of empirical model that can be used to estimate the effects on price of the dairy program (Helmberger and Chen 1994; Dixon *et al.* 1991; and Ahmad and Bravo-Ureta 1995). These types of models can be good indicators of the social costs of government programs, but they lack the capability to incorporate the spatial dimension of the dairy industry.

What is missing in the literature is a study that focuses on where milk is produced as the dairy industry becomes more competitive. If federal marketing orders guarantee a steady supply of fluid milk by promoting local production in high-costs areas, then one might expect to see production moving to low-costs production areas in a deregulated market. Regardless of market structure, the decision of where to produce milk is not independent of transportation costs. In the current study, the effects of deregulation and other market scenarios are examined through changes in market share, which for the purposes of this study, is a state's percentage of national milk production. Another variable that will be useful in assessing the impact of alternative scenarios is how a state's milk supply is distributed to consumers (i.e., fluid and/or manufactured products).

The location of milk production throughout the country is dependent on many variables. Processing capacity, transportation costs, location of consumers, and cost of production advantages are a few economic forces that help determine where milk is produced in a competitive market. Of all these forces, the competitiveness of dairy producers is directly related to the producer's cost of production and distance from the consumers. Assuming that milk handlers operate in a competitive output market where minimizing total costs implies that profits are maximized, the location of milk production in a deregulated market will be determined primarily by dairy producers' costs of production and the industry's transportation costs of shipping dairy products to the consumer. In this study, the empirical model is developed around these two cost variables. The competitiveness of Virginia dairy producers is examined in a National Dairy Model (NDM) that compares both cost of production across market areas and spatial relationships among producers and consumers. The NDM is a math programming model that minimizes the total costs of producing milk and the assembly costs of shipping dairy products to the final consumer. The methodology, components, and data requirements of the dairy model are detailed in the sections that follow.

Cost Of Production

A dairy producer's costs of production are a critical component of the NDM. If all other factors are equal across farms, those farms with lower costs of production are more competitive in the marketplace. If a deregulated market results in more production and subsequently, lower prices, the farms with cost advantages are more likely to remain profitable. In order to capture these cost advantages in a way that could be incorporated into the mathematical programming model, the cost functions for a number of states are estimated econometrically with data collected from the USDA's Farm Costs and Returns Survey.

Before estimating a cost function, one must make assumptions about the structure of technology. The technology assumptions are directly related to the choice of functional form. For example, explicitly additive functional forms like the Cobb-Douglas and the Constant Elasticity of Substitution (CES) have been popular in years past. The problem with these functional forms is that they place *a priori* restrictions on the structure of technology. The Cobb-Douglas, for instance, imposes an elasticity of substitution and own-price elasticity that remain constant at one. A restriction of the CES is that partial elasticities of substitution between all pairs of factors are equal, which rules out complementarity between any pair of factors (Burgess 1975). Since the results of empirical analysis are valid only within the confines of the functional form, functions like the Cobb-Douglas and CES are too restrictive for most applied cost analyses. Given the limitations of convenient functional forms, a new class of functional forms that is flexible and places fewer *a priori* restrictions on the technology is now available for application in empirical research. The new class of functions is known as flexible functional forms (Chambers 1988).

According to Chambers (1988), the choice of functional form should depend on its use. In the NDM, the purpose of the cost function is to differentiate production areas by their costs differences. The math programming model will then use the cost functions to help identify low-cost production areas that may be in a position to expand output in a competitive market. With this objective in mind, the functional form should be general and not too restrictive on the outcome (Chambers 1988). Unlike the Cobb-Douglas, CES, and Leontief, flexible functional forms place fewer restrictions on the underlying technology. Based on Diewert's (1971) definition of flexibility, a functional form is flexible if the function has parameter values such that the function and its first and second order derivatives are equal to the arbitrary function and its derivatives for any point in the domain. Functional forms that are Diewert-flexible are known as second-order differential approximations. Besides placing fewer restrictions on the underlying technology prior to estimation, flexible functional forms satisfy the theoretical requirements of convexity (concavity), monotonicity, and homogeneity (Thompson 1988). Some disadvantages of flexible forms are that they can limit the range of technologies and the function may not satisfy the curvature properties over the entire range of the sample observations (Chambers 1988). Even with the limitations of flexible functional forms, however, the ability of these functions to provide a second-order local approximation to an arbitrary underlying function is an overwhelming advantage in empirical research when compared to traditional functional forms.

A flexible form that is very popular in empirical studies is the transcendental logarithmic function (translog). In the current study, a translog cost function is used to approximate the technology on dairy farms across states. If specified appropriately, the translog cost function provides a second-order differential approximation to the actual cost function even if the functional form does not represent the actual underlying technology (Chambers 1988). The general form of the translog cost function is specified as

$$\ln c(w_i,y) = \delta_0 + \gamma_y \ln y + \frac{1}{2}\gamma_{yy}(\ln y)^2 + \sum_{i=1}^{n}\alpha_i \ln w_i + \sum_{i=1}^{n}\alpha_{iy}\ln w_i \ln y + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\alpha_{ij}\ln w_i \ln w_j \,, \tag{4-1}$$

where $c(w_i,y)$ = some measure of total costs;

y = quantity of output;

w_i = input prices (i = 1,..n); and

δ, γ, α = parameter values.

In order for the translog function to have the property of linear homogeneity, the following parametric restrictions are incorporated into the model's specification:

$$\sum_{i=1}^{n}\alpha_i = 1 \qquad \text{and} \qquad \sum_{i=1}^{n}\alpha_{iy} = \sum_{j=1}^{n}\alpha_{ij} = 0\,.$$

In addition to the parametric restrictions for homogeneity, symmetry is imposed by allowing $\alpha_{ij} = \alpha_{ji}$ in all cases. After all of these restrictions are incorporated into the model, estimating the translog cost function results in $\{1+n+½\cdot(n+1)\cdot n\}$ parameters.

Given that the choice of functional form is the translog cost function, the next step is to decide on what inputs should be included in the model and then formulate the translog cost function with these inputs. When deciding on what dairy inputs are important enough to include in the model, one must weigh the potential benefits of additional information against the costs of inputs in terms of degrees of freedom in the statistical estimation process. For instance, with three inputs the translog model includes 10 parameters. If a fourth or fifth input is added, the total number of parameters estimated by the model increases to 15 and 21, respectively. Because data limitations are always an issue with flexible functional forms, the decision criterion when choosing the number of inputs is to include only those inputs that appear to be most responsible for changes in variable costs as the output of a dairy farm is changed.

Variable costs for a typical dairy operation include such expense categories as feed, milk hauling, veterinary and medicine, repairs on machinery and buildings, hired labor, fuel and lube, and supplies. As total milk production on a dairy operation changes, these expense categories account for the changes in variable costs. For the translog cost function to approximate the technology used across dairy farms, several of these inputs need to be included in the model's specification. By using the input's share of total variable costs, one can identify what combination of inputs account for the majority of variable costs on a typical dairy farm. USDA periodically publishes livestock cost of production estimates for different regions of the U.S. Regional cost of production estimates per hundredweight of milk are detailed in Table 4-1.

Table 4-1 helps identify which inputs should be included in the cost function. If the objective is to identify those inputs with a relatively large share of total variable costs, the dominant expense categories are feed, hauling, and hired labor. On average, these three inputs account for approximately 77% of variable costs on all U.S. dairy farms. The average shares of feed, hauling, and hired labor for all dairy farms are 64%, 7%, and 6%, respectively. At the regional level, the share of variable cost for this combination of inputs is: Corn Belt 75%; Northeast 73%; Pacific 85%; Southeast 83%; Southern Plains 84%; and Upper Midwest 74%.

Table 4-1: 1993 Cost Of Production Estimates For U.S., Corn Belt, Northeast, Pacific, Southeast, Southern Plains, and Upper Midwest

	U.S.	Corn Belt	Northeast	Pacific	Southeast	Southern Plains	Upper Midwest
Cash Expenses							
Feed	6.92	7.10	6.73	6.55	7.73	7.35	7.11
Hauling	0.73	0.73	0.95	0.73	1.13	0.88	0.52
Vet & Med	0.34	0.40	0.37	0.17	0.37	0.20	0.45
Fuel & Lube	0.50	0.55	0.65	0.27	0.34	0.47	0.59
Repairs	0.71	0.82	0.89	0.28	0.57	0.40	0.96
Hired Labor	0.69	0.66	0.66	0.66	1.50	0.87	0.65
Supplies	0.38	0.37	0.46	0.35	0.49	0.32	0.35
Misc.	0.54	0.65	0.67	0.34	0.27	0.24	0.65
Variable Costs	10.81	11.28	11.38	9.35	12.40	10.73	11.28

Source: *U.S. Milk Production Costs and Returns, 1993*

Although these costs shares could be increased by including additional inputs, the remaining variables are not as closely related to output as feed, hauling, and hired labor. For example, repairs on buildings and machinery of all U.S. dairy farms account for approximately 6.5% of variable costs. Even with a relatively large share of variable costs, repairs on buildings and machinery are not included in the cost model because expenses on this input are not directly associated with the farm's quantity of milk production. For these reasons, the inputs in the translog cost model include only feed, milk hauling, and hired labor.

After identifying what inputs are included in the estimation process, the final step is to formulate the translog cost model with the three inputs. A detailed illustration of the cost function also shows how the parametric restrictions are incorporated into the model. Once equation (4-1) is expanded to include three inputs and the restrictions for linear homogeneity are imposed, the translog cost function is specified as

$$
\begin{aligned}
(4-2)\qquad \ln c(w_i,y) - \ln P_l = {} & \delta_0 + \gamma_y \ln Y + \frac{1}{2}\gamma_{yy}(\ln Y)^2 + \alpha_f(\ln P_f - \ln P_l) + \alpha_h(\ln P_h - \ln P_l) + \\
& \ln Y * \{\alpha_{fy}(\ln P_f - \ln P_l) + \alpha_{hy}(\ln P_h - \ln P_l)\} + \alpha_{ff}\{\frac{(\ln P_f)^2}{2} - \\
& \ln P_f * \ln P_l + \frac{(\ln P_l)^2}{2}\} + \alpha_{fh}\{\ln P_f * \ln P_h - \ln P_f * \ln P_l - \ln P_h * \ln P_l \\
& +(\ln P_l)^2\} + \alpha_{hh}\{\frac{(\ln P_h)^2}{2} - \ln P_h * \ln P_l + \frac{(\ln P_l)^2}{2}\} ;
\end{aligned}
$$

where P_l = input price of hired labor;

P_f = input price of feed; and

P_h = input price of milk hauling.

With three inputs, a translog cost function has 15 parameters. After imposing the parametric restrictions for linear homogeneity, equation (4-2) contains only 10 parameters. These parameter values are used to define the translog cost functions for the NDM. Before the results of the econometric model are discussed, a detailed explanation of the cost function's data requirements is presented in the following section.

Data Requirements

The translog costs system requires farm-level data for total costs, output, and prices of feed, hauling, and hired labor. To estimate cost functions for a market area, these types of data are needed at the state level.[3] One option is to obtain these data from different organizations within each state whose purpose is to provide cost of production estimates at the firm-level. This option has two major problems: (1) most states do not maintain farm-level cost of production estimates for dairy operations, and (2) the methodology used to collect costs of

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[3] In this study, each of the 48 contiguous states represents a market area that has a supply and demand point.

production data is not consistent across states. Assuming that enough state-level data could be found, the inconsistencies in data collection would result in parameter estimates that are not comparable across states. Because a key component of the NDM is the comparison of state-level cost functions, the cost data must be collected with a consistent methodology. Given this requirement, data collected only from a national survey would result in consistent measures of cost variables across states. Two sources of consistent state-level data are Dr. Ronald D. Knutson's cost study at Texas A&M and the USDA's Farm Costs and Returns Survey. Because of confidentiality restrictions, the Texas A&M data are not available for public use. The only data that satisfy the requirements of the current study and are available for public use are the data from the USDA's Farm Costs and Returns Survey.

Farm Costs & Returns Survey

The Agriculture and Consumer Protection Act of 1973 mandates dairy cost of production estimates. These cost estimates are updated annually based on data collected from the USDA's Farm Costs and Returns Survey (FCRS). The FCRS data are confidential data that can be accessed only after special permission is granted from individuals at the Rural Economy Division of the Economic Research Service (ERS). Once permission is obtained, use of the database is confined to regional offices of the National Agricultural Statistical Service or the ERS office located in Washington, D.C.

The FCRS uses a multiframe stratified random sample. In this sample, each farm included in the survey represents a number of similar farms (Short 1996). The survey expansion factor, which is the inverse of the probability of the sampled farm being selected, determines how many similar farms are represented by a farm that is surveyed (Hanson *et al.* 1989). The survey is conducted every four years with the most recent years being 1993 and

1989. The data collected with the survey are farm-level cost of production data for the major dairy producing states. The 1989 survey obtained data from 1,037 dairy producers located in 26 states. As a result of budget constraints, the 1993 survey obtained data from only 695 dairy producers located in 15 states. After the expansion factor is applied to the 1993 survey, the 695 respondents represent 105,230 dairy producers (Short 1996).

In order to more accurately approximate the technology on today's dairy farms, the 1993 FCRS data are used to estimate the translog cost function for most market areas. Because the 1993 survey did not include any states in the Appalachia region, cost functions for states in this region, as well as some states in other areas of the country, are estimated using 1989 FCRS data that have been indexed up to 1993 levels using USDA Prices Paid Indexes. The states and some characteristics of the farms that are included in the 1989 and 1993 FCRS database are detailed in Table 4-2.

The FCRS is used to obtain farm-level data for input prices, output, and total costs. Total costs, the dependent variable in the translog cost model, represents a firm's total cash expenses. Based on the USDA's definition, total cash expenses include expenditures on feed, veterinary and medicine, artificial insemination, DHIA, milk hauling, marketing, bedding, dairy assessments, fuel, hired labor, general farm overhead, taxes, insurance, and interest.

Even though the USDA survey provides detailed cost estimates that are consistent across states, there are some caveats about the data that justify a brief discussion. For instance, the FCRS database used in this study is developed with 1,001 respondents located in 27 states. Some people may suggest that the FCRS data are not representative of the national dairy industry because 21 of the contiguous states are excluded from the survey. Although the survey includes only 56% of the contiguous states, these 27 states accounted for approximately

Table 4-2: Summary Statistics For States Included In the 1989 and 1993 FCRS Database

State	# of Farms in FCRS	Avg. Herd Size	Avg. Production Per Cow (lbs)	Number of Dairy Farms
Arizona	18	NA	NA	72
California	40	586.51	15,378.54	2,468
Connecticut[1]	9	NA	NA	370
Florida	26	858.09	13,797.25	210
Georgia	33	178.33	14,096.11	603
Idaho[1]	16	NA	NA	1,987
Illinois[1]	45	54.19	14,399.88	3,143
Indiana[1]	28	47.47	12,925.50	3,196
Iowa	30	51.46	13,774.26	5,113
Kentucky[1]	31	48.92	11,436.69	3,492
Maine[1]	14	NA	NA	827
Massachusetts[1]	4	NA	NA	589
Michigan	54	67.41	13,820.74	5,221
Minnesota	68	52.48	13,912.43	12,228
Missouri	27	50.88	11,361.63	4,393
New Hampshire[1]	11	NA	NA	294
New York	88	66.62	14,848.61	10,878
North Carolina[1]	40	109.47	14,434.14	874
Ohio	40	43.83	15,145.93	6,530
Pennsylvania	80	52.99	15,201.48	12,191
South Dakota[1]	32	50.44	13,391.07	2,329
Tennessee[1]	34	64.55	12,706.29	2,152
Texas	39	185.52	13,696.52	2,311
Vermont	39	72.99	13,828.20	2,285
Virginia[1]	42	91.34	14,160.10	1,359
Washington	33	103.91	16,899.39	2,727
Wisconsin	80	56.56	14,544.61	25,226

[1] Indicates a state surveyed in 1989, but not 1993.

NA = Mean not reported due to low number of observations.

86% of national milk production in 1993. Because such a large percentage of national milk production is represented in the database, the FCRS database can be used with confidence to develop state-level cost functions that allow the study to have a national interpretation.

Another issue when using the FCRS data is missing observations. The three inputs in the translog cost function are labor, feed, and hauling. Although all respondents reported feed expenses, not all producers reported expenses related to hired labor and/or hauling. The reasons these expenses were not reported for some observations are (1) the operation is small enough so that the owner can manage the day-to-day responsibilities of the dairy farm without any hired labor, and (2) the dairy operation owns the equipment needed to transport milk off the farm. Observations that reported no labor and/or hauling expenses result in input prices for these two variables equal to zero. Any input price that is equal to zero is treated as a missing observation. Since there are a limited number of data for each state, these missing observations are not deleted from the FCRS database, however. The FCRS database is edited for missing observations related to input prices by using the average price paid for hired labor and hauling. An operation that did not report any expenses related to custom hauling or hired labor apparently did not consider the opportunity cost of their time and equipment. For each state, the average input price for hired labor and hauling is determined from data provided by the remaining respondents and the missing observations are replaced. By using this procedure, the number of observations within each state remains at the total number of original respondents (Table 4-2).

Results of Cost Function Estimation

In relation to cost functions, the objective is to estimate individual cost functions for each state included in the 1993 and 1989 FCRS databases. Originally, the observations in the FCRS databases were separated by state in order to form 27 state-level databases. Because of the large number of parameters in a translog cost model, degrees of freedom are an issue once the data are separated by state. Out of 27 states, only 9 states have 40 or more observations (Table 4-2). In order to determine if 40 or more observations from the FCRS are sufficient when estimating a translog cost model, cost functions are estimated for New York, Michigan, Pennsylvania, Wisconsin, California, Minnesota, and Ohio. For all six states, the parameter values estimated from state-level databases result in cost curves (e.g., total, marginal, and/or average cost curves) that are not consistent with theoretical expectations. For example, the average and marginal cost curves are concave to the horizontal axis instead of convex. Based on these results, there are not sufficient degrees of freedom to estimate a translog cost function from a state-level database.

An alternative to state-level databases is pooling the data. Pooling the FCRS data overcomes the degrees of freedom issues and still allows one to identify a separate cost function for each of the 27 states. The farm-level data for input prices, output, and total costs are pooled across states within the same survey year, resulting in two databases. The 1993 database contains 695 observations and represents 15 states while the 1989 database has 307 observations from 12 different states. The 1989 database represents states that were not surveyed in 1993. The parameters for the translog cost function illustrated in equation (4-2) are estimated with an econometric model that is programmed in SAS.[4] In both the 1993 and 1989 databases, slope and intercept dummy variables are used to help determine the influence of quantity produced and location of production on the firm-level cost functions. The characteristic that is used to determine the value of the intercept dummy variable is the location of the respondent. A slope dummy variable is introduced into the model through *ln* Y, equation (4-2). For both dummy variables, New York is the base in the 1993 database, and Virginia is the base in the 1989 database. Once the dummy variables are included in the

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[4] The SAS program used to estimate the parameter values for the translog cost function is provided in Appendix A.

translog cost model, SAS determines the parameter estimates by using ordinary least squares (OLS).

The theoretical implications of pooling data across firms require some attention when using the FCRS database. The FCRS data are cross-sectional, firm-level data, which means that data were collected for one or more variables at one point in time. In order to estimate the cost functions, the FCRS data must be pooled across firms. A potential problem is that pooling data across firms requires certain assumptions with regard to technology to hold for all firms. If a cost function is estimated with pooled data, the researcher is implicitly assuming that all firms have linear and parallel production expansion paths (Appelbaum 1982). The marginal costs for all firms also must be constant and equal across these expansion paths. By using the pooled data to estimate cost functions, the assumptions of identical technology across firms and constant returns to scale must hold in order to obtain unbiased parameter estimates. If these assumptions are too restrictive for the dairy industry, estimating cost functions with pooled data may lead to a loss of information, which could result in less efficient parameter estimates (Chambers 1988).

In the current study, an assumption is that the underlying technology for dairy producers located across states is homogeneous. The larger, more cost efficient farms account for the majority of milk production in the U.S. Technological advancements that are common on these large farms include automatic milking machines, computerized feeding and monitoring systems, manure handling equipment, and mechanized feed and forage handling (Short and McBride 1996). The most noticeable differences in technology across farms occur with smaller farms. As farm size decreases, hired labor is a substitute for capital investments. Other common denominators among large farms in the U.S. are feed and labor efficiency.

Regardless of location, large farms have greater feed and labor efficiency due to feed management programs, genetics, ration and herd composition, and herringbone milking parlors (Short and McBride 1996). Although herd size and climate account for some differences in technology across farms, the larger, more productive farms are, in general, utilizing the same technology. Therefore, the required technological assumptions for pooling data are assumed to be valid in the translog cost model.

The results of the estimation process are provided in Table 4-3. The translog cost functions have 15 different parameters. The values of 10 parameters are estimated with the translog cost model (Table 4-3). The values of the remaining five parameters are found by using the parametric restrictions needed to maintain linear homogeneity for the translog cost function.

Table 4-3: Estimated Parameter Values In the Translog Cost Function For States Included In the 1989 and 1993 FCRS[1]

	δ_0	γ_y	γ_{yy}	α_f	α_h	α_{fy}	α_{hy}	α_{ff}	α_{fh}	α_{hh}
1993 Data	-0.519	1.156	0.032	-0.325	0.854	0.101	0.021	0.026	0.085	0.065
	(5.03)	(0.65)	(0.05)	(0.93)	(0.53)	(0.06)	(0.03)	(0.11)	(0.07)	(0.04)
1989 Data	-8.295	0.435	0.112	-2.803	-0.176	0.117	0.033	-0.148	-0.058	0.060
	(6.88)	(0.73)	(0.05)	(0.60)	(0.88)	(0.04)	(0.05)	(0.12)	(0.05)	(0.04)

[1] The estimates for δ_0 and γ_y are the values for the base. The differences from the base for the remaining states are listed in the SAS results of Appendix A. The value in parentheses is the standard error.

Along with each state's mean values for input prices, the parameter estimates from the econometric models can be used to graph the cost curves. When the mean values for input prices and parameter estimates are inserted back into equation (4-1), the total costs at different levels of output can be determined with the help of a spreadsheet. Figures 4-1, 4-2, and 4-3 illustrate the total, marginal, and average cost curves for three states in the FCRS database that show significantly different cost curve characteristics.

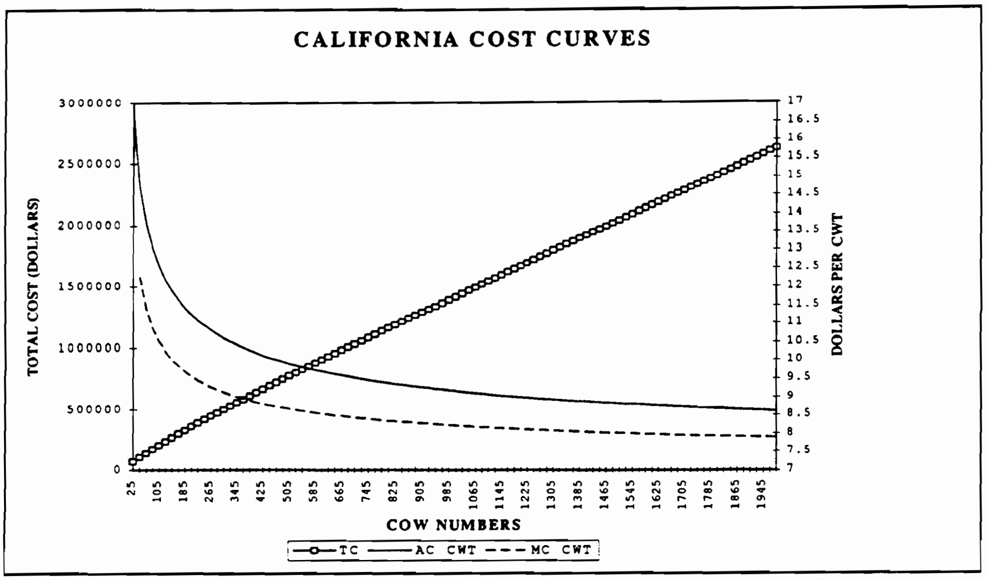

Figure 4-1: Total, Marginal, and Average Cost Curves For California

The horizontal axis in these figures is an indication of herd size at different levels of output. The range of the horizontal axis corresponds to the minimum and maximum production levels identified by respondents for the particular state in the FCRS. An indication of the number of cows needed to achieve a certain level of output is found by dividing the states average production per cow into total output. The average production per cow is also obtained from the FCRS data (Table 4-2).

California's cost curves are presented in Figure 4-1. These curves indicate economies of size throughout the range of the total output. Along with California, Georgia and Ohio also have marginal and average cost curves that are steadily decreasing. The majority of the states in the FCRS database, however, have cost curves that resemble those of Michigan (Figure 4-2). Michigan's average and marginal cost curves have the traditional "U" shape described in many economics textbooks.

Figure 4-3 is a final example of the type of cost curves obtained from the translog model. In 11 out of 27 states, the average and marginal curves are steadily increasing and do

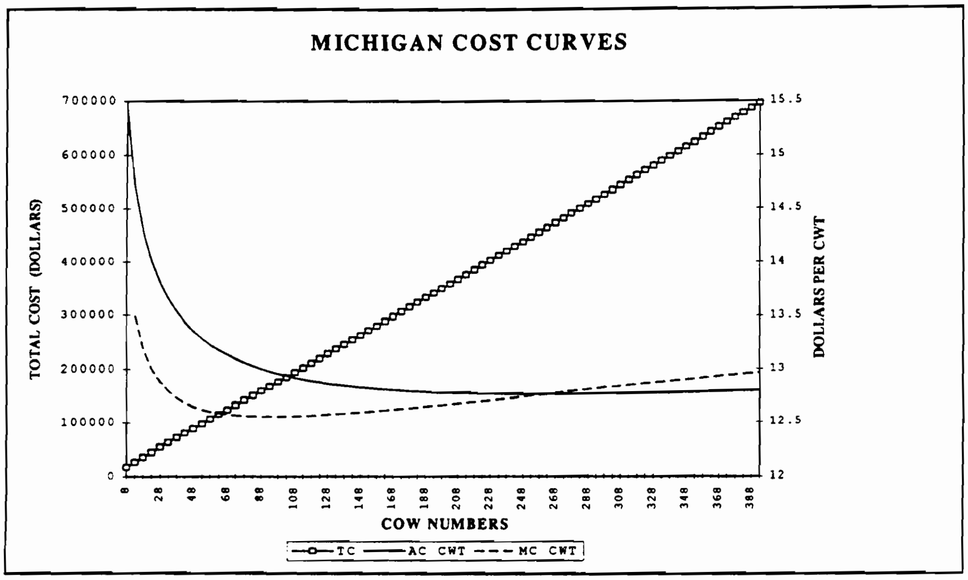

Figure 4-2: Total, Marginal, and Average Cost Curves For Michigan

not intersect over the range of the data. These 11 states are Florida, Idaho, Iowa, Maine, Missouri, New Hampshire, Pennsylvania, South Dakota, Texas, Virginia, and Washington.

Although the shapes of the marginal and average cost curves in these 11 states are not consistent with theoretical expectations, the total costs curves are increasing throughout the

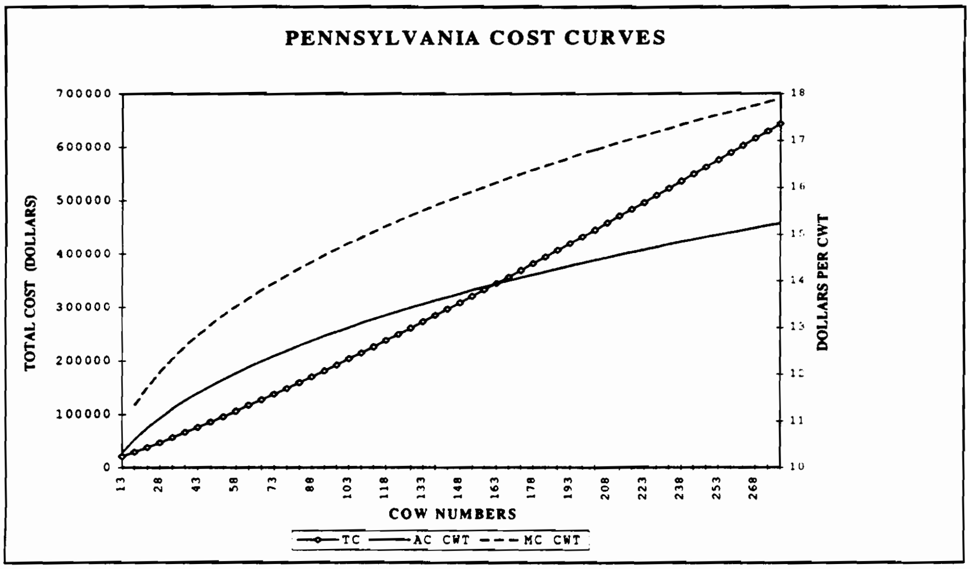

Figure 4-3: Total, Marginal, and Average Cost Curves For Pennsylvania

range of the data and this is a necessary condition for using the cost curves in the NDM. Through sensitivity analysis, the optimum solution of the NDM should indicate if the cost curves for these 11 states result in a competitive disadvantage for producers located in these areas.

National Dairy Model

As discussed in the introduction of this chapter, the NDM is a math programming model that minimizes the total costs of producing milk and the assembly costs of shipping dairy products to the final consumer. Components of the NDM include translog cost functions, regional supply areas, consumption centers, transportation costs, and milk exports. The objective function and the constraints needed to complete the NDM are illustrated in equations (4-3) through (4-12).

$$TMC = \sum_{A=1}^{50} [HAUL_A + COP_A] \tag{4-3}$$

$$\begin{aligned} HAUL_A &= \sum_{D=1}^{50} [QFT_{SD} * D_{SD} * FHR + QMT_{SD} * D_{SD} * MHR] + \\ &\sum_{X=1}^{4} QXT_{SX} * D_{SX} * XHR \qquad \text{A} = 1, \ldots, 50 \end{aligned} \tag{4-4}$$

$$\begin{aligned} COP_A &= \{\delta_0 + \gamma_y \ln QS_A + \frac{1}{2}\gamma_{yy} (\ln QS_A)^2 + \sum_{i=1}^{3} \alpha_i \ln w_i + \sum_{i=1}^{3} \alpha_{iy} \ln w_i \ln QS_A \\ &+ \frac{1}{2} \sum_{i=1}^{3} \sum_{j=1}^{3} \alpha_{ij} \ln w_i \ln w_j\} * FNUM_A \qquad \text{A} = 1, \ldots, 50 \end{aligned} \tag{4-5}$$

$$\sum_{A=1}^{50} QS_A * FNUM_A = \sum_{D=1}^{50} [QFD_D + QMD_D] + \sum_{X=1}^{4} QXD_X \tag{4-6}$$

$$\sum_{S=1}^{50} QFT_{SD} = QFD_D \qquad D = 1, \ldots, 50 \tag{4-7}$$

$$\sum_{S=1}^{50} QMT_{SD} = QMD_D \qquad D = 1, \ldots, 50 \tag{4-8}$$

$$\sum_{S=1}^{50} QXT_{SX} = QXD_X \qquad X = 1, \ldots, 4 \tag{4-9}$$

$$QS_A * FNUM_A = \sum_{D=1}^{50} [QFT_{SD} + QMT_{SD}] + \sum_{X=1}^{4} QXT_{SX} \qquad A = 1, \ldots, 50 \tag{4-10}$$

$$QS_A * FNUM_A \leq PROD_A * PF \qquad A = 1, \ldots, 50 \tag{4-11}$$

$$QS_A, QFT_{SD}, QMT_{SD}, QXT_{SX}, HAUL_A, COP_A \geq 0 \tag{4-12}$$

TMC = Total Marketing Costs of the U.S. dairy industry;

$HAUL_A$ = Total transportation costs of manufactured and fluid products for market area A;

COP_A = Total costs of production for market area A;

QFT_{SD} = Pounds of fluid milk shipped from supply point S to consumption center D;

D_{SD} = Distance in miles from supply point S to consumption center D;

FHR = Fluid hauling rate per mile, per pound of fluid milk;

QMT_{SD} = Pounds of manufactured product on a milk equivalent basis shipped from supply point S to consumption center D;

MHR = Manufactured hauling rate per mile, per pound of product on a milk equivalent basis;

QXT_{SX} = Pounds of manufactured product on a milk equivalent basis shipped from supply point S to export facility X;

D_{SX} = Distance in miles from supply point S to export facility X;

XHR = Export hauling rate per mile, per pound of product on a milk equivalent basis;

QS_A = Pounds of raw milk supplied by the representative firm in market area A;

w_i = Mean prices of feed, hired labor, and hauling;

$FNUM_A$ = Number of dairy farms in market area A;

QFD_D = Quantity demanded of fluid milk at consumption center D in pounds;

QMD_D = Quantity demanded of manufactured products at consumption center D in milk equivalent pounds;

QXD_X = Quantity demanded of manufactured products at export facility X in milk equivalent pounds;

$PROD_A$ = Production in pounds of milk for market area A in 1994; and

PF = Production factor.

The math programming model detailed in equations (4-3) through (4-12) is solved using a software package known as the General Algebraic Modeling System (GAMS).[5] Equation (4-3) is the objective function of the NDM. The design of the objective function instructs GAMS to minimize the sum of total marketing costs for all market areas. Total marketing

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[5] The GAMS program used to solve the NDM is presented in Appendix B.

costs is defined as the sum of transportation costs of dairy products from supply areas to the final consumer and producers' costs of production. By minimizing total costs of the U.S. dairy industry, the NDM identifies the cost-minimizing combination of milk producers and interstate flows of milk.

The detailed components of total marketing costs are solved in equations (4-4) and (4-5). The transportation cost for each market area is calculated by equation (4-4). The total transportation cost involves shipments of fluid and manufactured products to domestic consumers as well as manufactured products sold in the export market. The milk equivalent quantity of fluid and manufactured products shipped from a supply point to various consumption centers is an endogenous variable whose value is determined by the model. The distance in miles and hauling rates are exogenous variables.[6] The other component of total marketing costs is cost of production. Equation (4-5) calculates the cost of production for a market area. The parameter estimates and input prices are determined exogenously with the FCRS data. The quantity of milk produced by a market area is the only endogenous variable in the translog cost function. Because the cost function represents the technology on a single farm, the total costs and quantity supplied by the representative farm are multiplied by the number of farms in that market area. The result of this operation yields the total costs and quantity produced by a state, not just the representative farm, equation (4-5).

The optimal solution in the NDM is found subject to constraints. These constraints help simulate a competitive market and are identified in equations (4-6) through (4-12). Equation (4-6) ensures that the total quantity of milk produced by all market areas is equal to

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[6] An in-depth explanation of the data and other exogenous variables can be found in the National Dairy Model's Data Requirements section, page 83.

the milk equivalent demand for all dairy products. The total milk equivalent demand for dairy products in 1994 is composed of domestic commercial disappearances and exports. The sum of these variables represents the milk equivalent consumption of all dairy products in both the domestic and export markets. The quantity of domestic commercial disappearances and exports are exogenous variables whose values are consistent with 1994 data. Equations (4-7) and (4-8) maintain that the shipments of fluid milk and manufactured products from supply points to a consumption center must equal the center's milk equivalent demand for these dairy products. Equation (4-9) ensures that the sum of shipments from supply points to export facilities is equal to the milk equivalent demand for manufactured products at each export facility.

Equation (4-10) reveals the relationships between quantity of milk produced by a market area and quantity of milk shipped from that area's supply point. This constraint forces a market area's production into the domestic and/or export markets. An additional constraint on quantity of milk produced is constraint (4-11). The total milk production from a market area must be less than or equal to the area's 1994 production level multiplied by a production factor. For example, if the production factor is equal to one, a market area can produce up to the region's 1994 production level. Increasing the production factor to 1.1 allows the NDM to determine if the objective function decreases when production in a particular area is allowed to increase up to 10% of the 1994 production level. The production factor is an exogenous variable that is useful when conducting sensitivity analysis. The final constraint, equation (4-12), is a nonnegativity constraint for the value of the unknown decision variables.

Data Requirements

Any study that attempts to compare cost of production across farms requires extremely detailed data. Because of data limitations, there are very few studies that examine the costs advantages in dairy production. In fact, the review of the literature found no publications where cost functions are estimated for dairy farms. The NDM not only addresses technological differences across states, but the spatial dimension of the dairy industry is another component of the model. Given the design of the NDM, the data needed to operationalize the nonlinear programming model are quite extensive.

The specific data requirements of the NDM are associated with dairy production, per capita consumption of dairy products, cost of production estimates, transportation costs of dairy products, and quantity of exports. In order to establish a base run and obtain results that are consistent with yearly marketing activities in a regulated market, a time span is selected that represents a typical year in the dairy industry. For example, years that contain unusual weather patterns, buyout programs, or unseasonable variations in price are not considered a typical year in the dairy industry. The most recent year in which data are available and saw no dramatic changes in dairy policy or the marketing environment is the 1994 calendar year.

Supply Points and Production Levels

The first data category describes the formation of supply points and the 1994 production levels associated with each market area. The NDM has 50 supply points that represent all 48 contiguous states. With the exception of Virginia, each state has one supply point in the NDM. Because the study is primarily interested in the effects of changes in dairy policy on Virginia producers, the state of Virginia is partitioned into three market areas with one supply point in each area. These market areas are consistent with the current regional markets established by the Virginia State Milk Commission. The three market areas in Virginia use the same cost function that is estimated with Virginia 1989 FCRS data indexed up to 1993. By establishing regional market areas in Virginia, the results of the study should be more useful when evaluating the effects on Virginia dairy producers.

The 1994 production levels associated with each market area are obtained from the USDA's *Milk Production, Disposition, Income*. These production levels are represented by the variable $PROD_A$ in equation (4-11) of the NDM. The market areas and their production levels are identified in Table 4-4.

With each market area, a center of milk production is identified. This procedure is necessary in order to incorporate into the NDM the spatial dimension of the dairy industry. Using the 1992 Agricultural Census, the largest milk producing county was identified for each state. Once the largest county is known, a city that is close to the geographical center of the county is recognized as the area's center of milk production. This approach is consistent with the methodology Babb (1990) used in his spatial equilibrium model. Each supply point is linked to all 50 consumption centers by actual distance. By using the market area's geographical center of milk production and not the geographical center of the state, the NDM should result in more accurate transportation costs. Each market area's center of milk production is listed in Table C-1 of Appendix C. Table C-1 also reveals the identification number of each supply point. The identification number is necessary in the programming steps of the NDM.

Consumption Centers and Demand Levels

The NDM has 50 different consumption centers. The location of each consumption center corresponds to the largest population center in the market area. Table C-1 of Appendix C shows the actual location of each area's consumption center. Each consumption center has a fixed level of demand that is representative of the market area's total per capita consumption of

Table 4-4: 1994 Milk Production and Milk Equivalent Demand By State

	Production Levels		Milk Equivalent Demand	
Market area	Million Lbs	Market Share (%)	Million Lbs	Market Share (%)
Alabama	500	0.326	2,462	1.635
Arizona	2,134	1.391	2,234	1.484
Arkansas	753	0.491	1,433	0.952
California	25,019	16.30	18,137	12.04
Colorado	1,563	1.018	2,008	1.333
Connecticut	561	0.346	2,003	1.330
Delaware	142	0.093	406	0.269
Florida	2,623	1.709	4,885	5.237
Georgia	1,595	1.039	3,948	2.622
Idaho	3,754	2.446	614	0.408
Illinois	2,549	1.661	6,967	4.627
Indiana	2,257	1.471	3,379	2.244
Iowa	3,692	2.582	1,692	1.124
Kansas	1,105	0.720	1,510	1.003
Kentucky	2,007	1.301	2,246	1.492
Louisiana	925	0.603	2,572	1.708
Maine	693	0.416	748	0.497
Maryland	1,318	0.859	2,914	1.935
Massachusetts	450	0.293	3,667	2.435
Michigan	5,545	3.613	5,665	3.763
Minnesota	9,342	6.087	2,666	1.771
Mississippi	731	0.476	1,568	1.042
Missouri	2,720	1.772	3,118	2.071
Montana	307	0.200	487	0.323
Nebraska	1,110	0.723	962	0.639
Nevada	413	0.269	732	0.487
New Hampshire	313	0.204	676	0.449
New Jersey	343	0.224	4,711	3.129
New Mexico	3,325	2.167	923	0.613
New York	11,420	7.441	10,964	7.282
North Carolina	1,473	0.959	4,040	2.683
North Dakota	869	0.566	389	0.259
Ohio	4,520	2.945	6,611	4.391
Oklahoma	1,269	0.827	1,917	1.273
Oregon	1,714	1.117	1,732	1.151
Pennsylvania	10,230	6.665	7,241	4.809
Rhode Island	32	0.021	612	0.406
South Carolina	411	0.268	2,125	1.411
South Dakota	1,589	1.035	424	0.282
Tennessee	1,960	1.277	2,972	1.974
Texas	6,225	4.056	10,352	6.876
Utah	1,431	0.932	1,050	0.697
Vermont	2,452	1.598	343	0.228
Southwest VA	89	0.058	1,855	1.232
Eastern VA	250	0.163	1,916	1.272
Western VA	1,585	1.033	370	0.246
Washington	5,203	3.390	2,966	1.970
West Virginia	272	0.177	1,093	0.726
Wisconsin	22,412	14.60	2,981	1.980
Wyoming	89	0.058	276	0.184
Totals	153,470	100%	150,561	100%

dairy products on a milk-equivalent, milkfat basis. The NDM solves for the quantity of raw milk that needs to be produced by each market area in order to satisfy the exogenous level of demand for dairy products at each consumption center.

The consumption centers' milk equivalent demand for dairy products is found by using 1990 census data and 1994 total commercial disappearances of milk and dairy products. Commercial disappearances represent civilian and military purchases of milk and dairy products for domestic and foreign use. In 1994, commercial disappearances totaled 150,561 million pounds of milk. This figure excludes both commercial and subsidized exports. The 1990 census data are used to determine the regional population shares for each market area in the NDM. The domestic commercial disappearance of each market area is then calculated by multiplying the area's population share by the total 1994 U.S. commercial disappearance. The results of these calculations represent a region's milk equivalent (milkfat basis) demand for all dairy products (Table 4-4). The procedures used to determine the exogenous demand levels in the NDM are consistent with those of Cox (1994).

The milk equivalent demand at the consumption centers represents a unique mix of dairy products. Because of the differences in transportation costs, the consumption of milk products in fluid or manufactured form has the potential to impact where milk production is located throughout the country. For example, because fluid milk is relatively bulky and more expensive to transport, Class I milk processors are usually located in areas near population centers. Since the processing of fluid products does not substantially reduce the water content and bulk of raw milk, the farm-to-market assembly of fluid milk products is more cost-efficient if the raw milk is transported in 50,000 pound tankers to plants near the metropolitan areas. As for Class III plants, the manufacturing process for cheese, butter, nonfat dry milk and other storable products allows these facilities to decrease transportation costs by locating near the supply of raw milk and then shipping the final product to consumers.

For the NDM to provide reasonable estimates of a market area's transportation costs, the milk equivalent demand at consumption centers needs to be disaggregated into fluid and manufactured products. In 1994, approximately 60.7% of total milk marketings were used for manufactured dairy products (*Dairy Products Summary* 1995). Based on these data, the NDM assumes that the product mix of total dairy purchases for the average consumer is 39.3% fluid products and 60.7% manufactured products. By disaggregating the consumption center's milk equivalent demand into fluid and manufactured products, the NDM will not only determine where milk is produced, but also what percentage of the market area's production should be shipped as fluid and/or manufactured products . These results can be useful in predicting where processing capacity may be needed as the dairy industry becomes more competitive.

Cost Of Production

Although an extensive discussion of the data needed to estimate the market area's translog cost function, equation (4-5), is provided in previous sections, there are additional data requirements and cost of production issues that need to be discussed. One of the most important cost of production issues is the lack of sufficient data to estimate a firm-level translog cost function for each state. The 1993 and 1989 FCRSs provide enough data to estimate cost functions for only 27 states in the NDM (Tables 4-2). The remaining 21 market areas are assigned one of the 27 cost functions estimated from the FCRS data. The basis for assigning a cost function to a market area is geographic location and similarities in production characteristics. The traditional dairy regions of the USDA are found using similar methodology. Using regional production characteristics provided by Schiek (1991a), each market area is assigned a translog cost function. Table 4-5 indicates the source of the cost function for each state in the NDM that is not represented in the FCRS database.

Once each state is assigned a translog cost function, the cost data needed by the NDM are the mean values of the prices of feed, hired labor, and hauling. These mean values are determined for each state in the 1993 and 1989 FCRS databases. When the parameter estimates and mean values of input prices are incorporated into equation (4-5), the translog cost functions determine total costs of production at different levels of output from the representative farm in each market area.

The final variable needed to calculate a state's total costs is farm numbers. The cost functions in the NDM are representative of a single firm. The farm-level total costs of production calculated from these functions are multiplied by the total number of farms in the state in order to determine the total costs of production at the state level, equation (4-5). The number of farms in each state is determined exogenously using the FCRS data and the state's total production in 1994. The FCRS data provide the mean production level of the respondents in each state. Dividing a state's 1994 total supply by the mean production level in the state results in total number of farms. For states not included in the FCRS database, the farm numbers are calculated using the same procedure except that the mean production level is borrowed from a nearby and similar state that does have costs data (Table 4-5). For those states included in the FCRS database, the total number of farms per state used in the NDM is presented in Table 4-2.

Transportation Costs

Equation (4-4) of the NDM calculates the transportation costs of dairy products for the market areas. The locations of the supply points and the consumption centers have already

Table 4-5: Source of Translog Cost Function For States Not Included In the FCRS Database

Source of Estimated Cost Function	Associated Market areas		
Arizona	New Mexico		
California	Nevada		
Connecticut			
Florida			
Georgia	Alabama	South Carolina	
Idaho	Colorado	Utah	
Iowa			
Kentucky	West Virginia		
Illinois			
Indiana			
Maine			
Massachusetts			
Michigan			
Minnesota			
Missouri			
New York	New Jersey		
New Hampshire			
North Carolina			
Pennsylvania	Rhode Island		
Ohio			
South Dakota	North Dakota Wyoming	Montana	Nebraska
Tennessee	Louisiana	Mississippi	
Texas	Arkansas	Kansas	Oklahoma
Vermont			
Virginia	Delaware	Maryland	
Washington	Oregon		
Wisconsin			

been identified. The final data needed to complete the spatial dimension of the NDM are distance and hauling rates.

Both export facilities and consumption centers are linked to supply points by distance. The actual distance between two points is calculated with AUTOMAP, a popular software package used by organizations like American Automobile Association. When using AUTOMAP to select these distances, one can choose the shortest, quickest, or preferred route. For the current study, the mileage between two points is determined with the shortest route. The mileage charts used in the NDM are shown in Tables C-2 and C-3 of Appendix C. In total, the mileage charts have 2,700 cells.

The final variable needed to calculate transportation costs in the NDM is a hauling rate. The hauling rates in the NDM vary depending on whether the shipment is fluid milk, manufactured products shipped to consumption centers, or manufactured products shipped to export alternatives. For example, shipments of fluid milk from the supply points to the consumption centers are the most expensive types of shipments in the NDM. The hauling rate for these shipments is $0.42/cwt./100 miles (Nubern and Kilmer 1995).

The next type of shipment identified in equation (4-4) is shipments of manufactured products from the supply points to consumption centers. The hauling rate used for these shipments is $0.028/cwt./100 miles. This hauling rate is the milk equivalent of $1.75 per loaded mile of manufactured dairy products. Table D-1 of Appendix D provides a more detailed explanation of how the hauling rate for manufactured dairy products is determined.

The final type of shipment in the NDM is shipments of manufactured products to exporting facilities. The hauling rate assigned to these shipments is $0.027/cwt./100 miles. This hauling rate is also the milk equivalent of $1.75 per loaded mile. An explanation of how this hauling rate is determined is provided in Table D-2 of Appendix D.

Quantity of Exports

The U.S. dairy industry is not currently a major participant in the international dairy market. Current dairy policy provides import restrictions and export subsidies for the U.S. dairy industry. In 1994 a total of 2,858 million pounds of milk equivalent (milkfat basis) dairy products were imported into the U.S. market (*Dairy Market Statistics* 1995). Total imports represented approximately 1.89% of commercial disappearances in 1994. Cheese products accounted for nearly 90% of the dairy imports (Blaney *et al.* 1995). Unsubsidized exports of dairy products also provide a relatively small market for U.S. dairy producers. Commercial exports have averaged 3,000 million pounds since 1988, or about 2% of domestic milk production (Dobson 1995). In 1994, commercial exports totaled 3,072 million milk equivalent pounds.

Although trade in dairy products is relatively small, international and regional trade agreements are expected to increase exports of dairy products. The Uruguay Round of the General Agreements on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA) are two recent trade agreements that have the potential to affect international trade in dairy products. Deregulation of the U.S. dairy industry and the decline in the government support prices also have the potential to make the export market a more profitable alternative for the dairy producers. Given these recent policy changes, the NDM is formulated to predict changes in the U.S. supply of milk resulting from increased exports. Equation (4-6) of the NDM has a variable that represents the milk equivalent demand for U.S. dairy products in the export market. After consulting with Peter Vitaliano of the National Milk Producers Federation, the location of four export facilities were included in the NDM: (1)

Seattle, (2) Los Angeles, (3) New Orleans, and (4) Baltimore. The reason for two facilities on the west coast is the growing export opportunities in the Mexican and Pacific Rim markets. In 1992, dairy exports to Mexico were valued at $160 million, or 22% of the total value of all U.S. dairy exports (Dobson 1995). The North American Free Trade Agreement should assist U.S. dairy producers in expanding export opportunities in the Mexican market. U.S. cheese producers may also benefit from a growing market in the Pacific Rim if companies can meet stringent quality control standards (Dobson 1995).

The total quantity of dairy exports is determined exogenously and is representative of a marketing environment where the U.S. is a net exporter of dairy products. Since the quantity of dairy products exported from each facility is confidential data, the NDM is formulated so that each location exports an equal share of the total U.S. exports. Through sensitivity analysis, the total quantity of exports is varied to determine the impacts on the optimum solution.

CHAPTER 5
ALTERNATIVE SCENARIOS AND RESULTS

The National Dairy Model (NDM) developed in chapter four is a versatile model that can be easily adapted to accommodate alternative marketing scenarios. In this chapter, a number of different marketing situations that could evolve in the dairy industry are formulated into a framework that is consistent with the assumptions and specifications of the NDM. Some alternative marketing scenarios that could provide important information about the future of the dairy industry are (1) models where the hauling rates are varied, (2) alternative scenarios in which the U.S. becomes a major participant in the export market, and (3) situations where the operating environment leads to increasing costs of production. Another alternative scenario involves only the spatial dimension of the NDM. There are two components in the objective function of the NDM, (1) costs of production and (2) transportation costs of dairy products from the supply points to the final consumer. In some cases, examining the results of models that consider only the spatial dimension of the dairy industry allows one to determine if milk is being produced in an area because of production cost advantages or location and transportation advantages.

Regardless of the marketing scenario, the results of the NDM provide a number of variables that can be compared across scenarios. For example, total marketing costs defined in chapter four is one variable that is used to compare and contrast different scenarios. Other variables that are used to analyze the results of alternative scenarios are (1) change in market share, (2) percentage of fluid, manufactured, and export shipments from a supply point, and

(3) shadow prices for quantity supplied by a market area. By comparing the value of these variables across marketing scenarios, information is obtained that can be used to determine the competitiveness of the Virginia dairy producers in a changing operating environment.

Variations Of the National Dairy Model

There are three versions of the NDM that are used to provide information on how different cost of production estimates affect the optimal solution of a marketing scenario. The three variations of the NDM differ only by the way in which total costs of production and output levels are determined in the model. In the sections that follow, a detailed explanation of the differences in the models is presented.

Model A

The first version of the NDM is Model A. Model A determines the optimal solution to the NDM when cost of production per cwt. of milk is fixed at the mean costs per cwt. The mean costs per cwt. for each state in the FCRS database is determined by using the state's translog cost function. After a translog cost function is estimated, total costs at different levels of output can be determined using a spreadsheet. By using the summary statistics from the FCRS data, the average production level of all the respondents in each state is determined. Once the average production level is obtained, the spreadsheet is used to calculate each state's total costs of production at the respondents' mean production level. Dividing this total cost by the average production level results in the average cost of production per cwt. of milk at the mean of the production data. Table 5-1 identifies the cost of production per cwt. of milk that is assigned to each state in Model A. If the states in Table 5-1 are grouped into regions and

Table 5-1: Cost Of Production From Variations Of the National Dairy Model For States Included In the 1989 and 1993 FCRS[1]

	Model A	Model B	Model C
State			
Arizona	10.48	10.59	10.43
California	9.61	9.69	8.42
Connecticut	12.40	12.52	12.30
Florida	13.56	13.70	12.76
Georgia	12.24	12.30	11.58
Idaho	11.56	11.64	11.54
Illinois	9.11	9.19	9.11
Indiana	11.22	11.27	10.84
Iowa	13.33	13.47	12.93
Kentucky	9.72	9.82	9.57
Maine	13.50	13.67	13.02
Massachusetts	16.03	16.16	16.01
Michigan	13.07	13.16	12.76
Minnesota	12.74	12.83	12.69
Missouri	12.30	12.41	11.43
New Hampshire	12.64	12.83	12.14
New York	11.51	11.59	11.30
North Carolina	13.36	13.42	12.55
Ohio	10.28	10.34	9.53
Pennsylvania	11.92	12.05	11.85
South Dakota	11.46	11.60	10.93
Tennessee	12.35	12.36	10.01
Texas	10.92	11.03	10.88
Vermont	12.26	12.34	12.25
Virginia	10.60	10.75	9.97
Washington	12.49	12.62	12.46
Wisconsin	11.02	11.10	10.35

[1] The cost per cwt. for states not included in the FCRS database is the same as the cost per cwt. of the associated state (Table 4-5).

ranked from low to high-cost production areas, the rankings are consistent with the regional rankings from the USDA cost estimates in Table 4-1. For example, both estimates show that states in the Pacific region are the low-cost areas while the Southeast states are the high-cost areas. Based on these patterns, the cost estimates from the translog cost functions are consistent with 1993 data from the USDA.

In order to specify Model A in equation format, minor changes are made to the NDM outlined in equations (4-3) through (4-12). In fact, most of the changes occur in equation (4-5). In the original format of equation (4-5), the total cost of production for a state is determined by using the translog cost function and farm numbers. This specification is used in Model B, which is explained in the next section. In Model A, equation (4-5) of the NDM is revised so that the total cost of milk production for each state is determined as follows:

$$(5\text{-}1) \quad COP_A = QS_A * COPCWT_A$$

where $COPCWT_A$ = Cost of production per cwt. at the mean of the production data;

QS_A = Redefined as total pounds of milk supplied by a market area.

Given the format of equation (5-1), the marginal costs of an additional unit of output from any state is equal to that state's mean cost of production per cwt. The cost equation in Model A assumes that the total cost function is linear and has a slope that is equal to the state's average cost per cwt. at the mean production level. Other changes in the NDM involve removing $FNUM_A$ from equations (4-6), (4-10), and (4-11). With these changes, the NDM becomes a linear mathematical programming model that is solved using GAMS.

Since each additional unit of output from a state is produced at the same cost level, Model A is indirectly holding farm size and output per farm constant. In Figure 5-1, Q_m represents a state's mean production level from a representative farm. At this production level, the average cost per cwt. is COP_m. If a farm is initially producing at Q_m and total supply in a state begins increasing as a result of existing farms getting larger, economic theory predicts that the average cost per cwt. would decline as production levels moved towards Q_{MIN} in Figure 5-1. In Model A, a state can increase output, but each unit of output is charged the same cost of production per cwt. (i.e., COP_m). Because the marginal cost per cwt. of milk remains

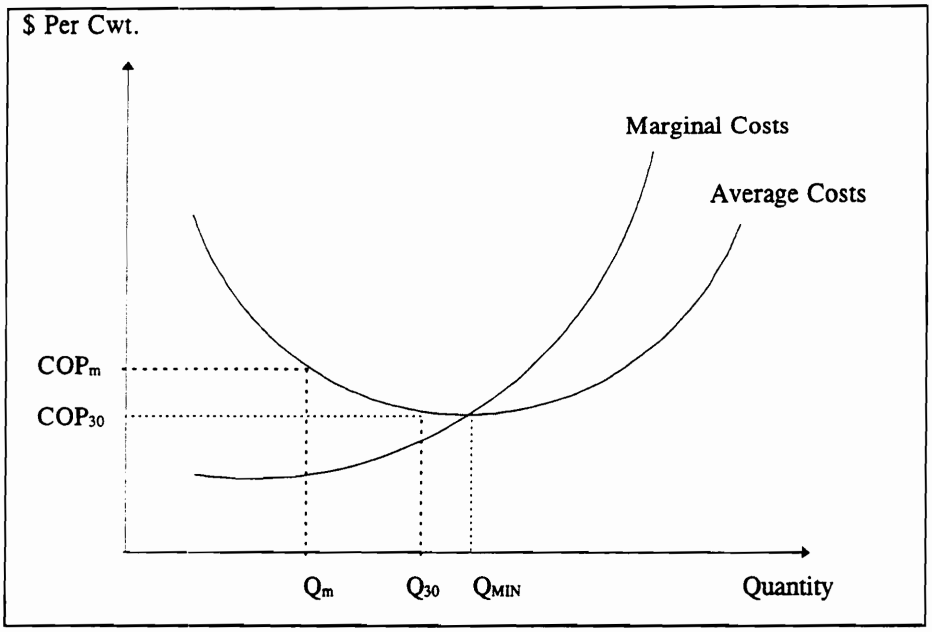

Figure 5-1: Graphical Example Of Cost Estimates From Variations Of the National Dairy Model

constant, increasing production in a state should not be interpreted as the result of existing farms getting larger. Since farm size and marginal cost are constant in Model A, the only source of additional milk production for a state is more farms that have the same production technology. From a theoretical perspective, Model A assumes that the new farms can utilize the same production technology as the state's representative farm, thereby resulting in the same cost curves and average cost per cwt. of milk.

Model B

The second version of the NDM evaluated in the study is Model B. In Model B, total costs and quantity supplied for each state are determined by using the state's translog cost function. Unlike Model A, cost of production per cwt. of milk varies depending on the output level of the state's representative farm. The equation used to calculate total costs of production for a market area in Model B is the same as equation (4-5) of the NDM. In fact, the NDM outlined in chapter four is the equation format of Model B.

The translog cost function specified in equation (4-5) is a firm-level cost function. In equation (4-5), QS_A, or quantity of milk produced by the representative firm, is the only endogenous variable. Total costs of production for a state are determined by multiplying number of farms and total costs of the representative farm. Similarly, total production in a state is found by multiplying quantity produced by the representative firm and number of farms in the state. In each case, QS_A is allowed to vary while farm numbers remain constant.

Since the number of farms remains fixed in Model B, increasing production in a market area should be interpreted as the result of the representative farm getting larger. Figure 5-1 is helpful in explaining this point more clearly. Suppose that the base solution in Model B has a representative firm producing at Q_m with an average cost per cwt. of COP_m. In scenarios where the production factor, equation (4-11), is varied, the representative firm can increase (decrease) production by moving to the right (left) of Q_m. For example, if the production factor is set at 30%, the representative firm in Figure 5-1 can produce at a level that is less than or equal to Q_{30}, which is equivalent to $1.30 * Q_m$. Since Q_m and Q_{30} are on the same cost curve, technology on the farm is unchanged and the only way a firm can produce at Q_{30} is by increasing herd size. When the representative farm's new production level is multiplied by the number of farms, a new production level is also obtained for the state. In contrast to Model A where the farm size remains fixed and changes in output are attributed to more or less farms, Model B holds farm numbers constant and allows output to vary by changing the size of the representative farm.

Because Model B uses the translog cost function to determine production levels in each state, the average cost per cwt. varies as quantity produced by the representative farm changes. In order to compare the cost estimates of Model B with estimates from the other versions of the NDM, the cost per cwt. of milk at the base solution[7] of Model B is provided in Table 5-1. Notice in Table 5-1 that the cost estimates for a state are fairly consistent across Models A and B. Model B was designed so that the production levels in the base solution resulted in per cwt. cost estimates that are close to the cost estimates at the mean of the FCRS production data. The reason that the per cwt. cost estimates are not identical for Models A and B is farm numbers. In order to get the same costs per cwt., the number of farms in Model B needed to be evaluated with three decimal places. The additional iterations needed to solve the nonlinear program for 79.351 farms instead of 79 farms, for example, are beyond the constraints of PC GAMS. For this reason, farm numbers are rounded to the nearest whole number. Although whole farm numbers prevent identical cost estimates in the base solution, all simulations of Model B start at a production level that is consistent with Model A.

Model C

The final version of the NDM is Model C. The purpose of Model C is to predict where milk would be produced if all farms are producing at the minimum of average total costs (ATC). In the long-run, firms in a competitive market maximize total profits by moving towards minimum ATC. In Figure 5-1, the goal of each firm is to move down the average cost curve towards Q_{MIN}. Once a firm is producing at Q_{MIN}, the only way a firm could become more competitive is by changing the technology used by the firm.

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[7] The base solutions have a production factor equal to one, which results in each state producing their 1994 production level. More details about the base solution and alternative scenarios are provided in the following sections.

From a theoretical point of view, Models A and C are solved at different points on the cost curves. For example, the cost estimates in Model A are based on where firms are located on their cost curves at the present time (i.e., Q_m in Figure 5-1). Model C, on the other hand, uses cost estimates from the minimum ATC, which is where all firms would like to operate in the long-run. Model B attempts to capture how the firms would move from Q_m in Model A to Q_{MIN} in Model C.

Although Models A and C are different in theory, these two models are identical from a programming perspective. The only difference between these two models is the cost per cwt. assigned to each unit of milk from a market area. In Model A, the cost per cwt. is determined at the mean of the FCRS production data. Model C, on the other hand, uses the cost per cwt. at the minimum average total costs, which is obtained from spreadsheets and graphs of the translog cost curves. For most of the states in the 1989 and 1993 FCRS databases, Figure 5-1 illustrates the shape of the cost curves for the representative farm. From the spreadsheet that is used to generate the cost curves, the cost per cwt. at the minimum average total costs can be easily identified. For the states in the FCRS database, the minimum average total costs per cwt. used in Model C are listed in Table 5-1.

Chapter four identifies 11 states (Florida, Idaho, Iowa, Maine, Missouri, New Hampshire, Pennsylvania, South Dakota, Texas, Virginia, and Washington) where the average total cost curves are increasing throughout the domain of the production data. Since the cost curves never identify a minimum average total costs, a cost per cwt. in Model C for these 11 states cannot be obtained using the parameter estimates from the original translog cost functions. For these states, an alternative translog cost function is used to identify a cost per cwt. at the minimum ATC. In most cases, a new translog cost function is estimated with regional FCRS data combinations. For example, a cost function that does identify a minimum ATC is estimated for Texas by pooling data from Arizona, California, and Texas. For seven out of 11 states, pooling regional data does result in cost curves that conform to theoretical expectations. In the cases of Maine, New Hampshire, Pennsylvania, and Virginia, pooling regional data does not result in cost functions that identify a minimum ATC. In these instances, a cost function is borrowed from a nearby state. For example, a minimum ATC is identified for Virginia by borrowing North Carolina's translog cost function. The intercept term in North Carolina's cost function is adjusted so that the mean cost per cwt. with the borrowed cost function is the same as Virginia's mean cost per cwt. in Model A. The borrowed cost function is also evaluated with the mean input prices obtained from Virginia FCRS data. The details concerning the alternative cost functions for each of these 11 states are discussed in Appendix E.

Alternative Marketing Scenarios

The three models described in the previous section are used to evaluate the structure of the dairy industry under the guidelines of three different marketing scenarios. The only difference between the three scenarios is hauling rates. Spatial relationships separate competing supply markets. As hauling rates decrease, low-cost producers in the Upper Midwest, Southwest, and Pacific regions become a more competitive source of supplemental milk for handlers located in distant regions. When transportation costs are increasing, the spatial dimension of the dairy industry becomes a formidable trade barrier and interregional competition among alternative supply areas is reduced. Because the spatial dimension of the dairy industry is an important factor, the NDM analyzes the effects of different hauling rates on the location of milk production.

Scenario I is designed to simulate current marketing conditions throughout the dairy industry. The results from this scenario can be thought of as a benchmark to which the results of other marketing scenarios can be compared. In Scenario I, the hauling rates per cwt./per 100 miles for fluid, manufactured, and exported products are \$0.42, \$0.028, and \$0.027, respectively. These hauling rates are consistent with the current hauling rates in the transportation industry.

Scenario II examines the impacts of technological advancements in reverse osmosis. Reverse osmosis is a technology that reduces the transportation costs of fluid milk by removing 50% of the water content in raw milk prior to shipment. If reverse osmosis, or similar technological advancements, can be applied to whole milk, transportation costs of fluid products can be reduced by approximately 50% (Schiek and Babb 1989). Scenario II simulates a marketing environment where the hauling rate of fluid milk is reduced as a result of technologies like reverse osmosis. In this scenario, the fluid hauling rate is reduced to \$0.21 per cwt./per 100 miles. The hauling rates for manufactured and exported products remain unchanged from Scenario I.

The final marketing scenario allows the NDM to determine what states should produce milk when all hauling rates are increased by 25%. A major factor when determining the transportation costs of any commodity is the price of fuel. Fuel prices are seasonal and extremely sensitive to supply conditions. In Scenario III, the hauling rates per cwt./per 100 miles for fluid, manufactured, and exported products are \$0.53, \$0.035, and \$0.034, respectively.

Each marketing scenario is evaluated with two different export levels. In the first set of simulations for each scenario, the quantity of exported dairy products is set at 3% of commercial disappearances, or 4,516 million milk equivalent pounds. The 3% level of exports approximates the U.S. dairy industry's current level of participation in the international dairy market. As the provisions of NAFTA and GATT become effective, trade restrictions will be lowered, and the U.S. dairy producer is expected to play a more important role in the world market. In order to determine the supply impacts of increased exports, the three scenarios also have a set of simulations where the quantity of exported dairy products is increased to 15,056 million milk equivalent pounds, or 10% of commercial disappearances. Because each marketing scenario is evaluated with two different export levels, there are two versions of each scenario. For example, Scenario I-3 should be understood as Scenario I with export levels set at 3% of commercial disappearances. On the other hand, Scenario III-10 represents Scenario III with export levels increased to 10% of commercial disappearances. At this point, there are six different simulations.

All six simulations are evaluated with four different production factors. In the base run for each simulation, the production factor is equal to one. In this case, the optimal solution is found when each state produces the equivalent of its 1994 total production. Each scenario is also evaluated with production increases of 5%, 15%, and 30%. By increasing the production factor, the NDM becomes less constrained and states increase or decrease total production based on location and cost of production advantages. For example, with a production factor of 15% the NDM has a production capacity of 115% of the specified demand level. Although the quantity of total milk production needed from the market areas remains at 150,561 million pounds, the solution to the model is not constrained at the 1994 market shares identified in the results of the base run. Since total domestic disappearances remain constant, the model can increase production in areas only by reducing production by an equal amount in other states.

At this point in the study, there are three scenarios with two versions of each scenario, which results in six different simulations. These six simulations are programmed with four different production factors. Four production factors per simulation results in 24 different simulations. Since each simulation is evaluated with Models A, B, and C, there are a total of 72 simulations that are solved in GAMS.

Results Of Marketing Scenarios

After the different versions of the marketing scenarios are solved in GAMS, there are several types of information that are retrieved from each simulation. For example, the value of the objective function and the shadow price on output levels can be used to compare and contrast alternative scenarios. Another result obtained from the mathematical programming model is a state's percentage change in total production. The results of the base solution for each scenario report the states 1994 share of national milk production. In the remaining simulations where the production factor is varied, the results of the models identify a state's percentage change in total production relative to the base solution.

The output from each simulation also provides information about a market area's percentage of fluid and manufactured shipments. Shipments of dairy products to consumers in the domestic market can be in the form of fluid and/or manufactured products. The difference between the two types of shipments is the hauling rate used in the mathematical programming model. Given a state's total production, the NDM reports what percentage of total production is shipped as fluid and manufactured products.

The final two types of information reported for each scenario deal with exports. In the

NDM, a state can provide manufactured dairy products for both the domestic and international markets. Since manufactured products can also be shipped to the export market, a state can have up to three type of shipments: (1) fluid shipments, (2) manufactured shipments designated for the domestic market, and (3) manufactured shipments designated for the international market. A state's percentage of total production that is shipped to the export market is another type of information retrieved from the GAMS output. If a state does provide milk to the export market, the state's share of total exports is also reported.

In the sections that follow, the results for the alternative scenarios are discussed. Most of the results are presented in table format for each scenario. The results of the base solution for each scenario are examined first. After the findings of the base solution are discussed, the results of the simulations with varying production factors are compared and contrasted for the three marketing scenarios.

Base Runs

The purpose of the base runs are to replicate 1994 production patterns in each scenario. The results from these simulations are a benchmark that is used for comparison with the results from simulations that have varying production factors. The base model in each scenario is programmed so that each state produces the equivalent of its 1994 total production. In the base models, the production factor is equal to one. When the production factor is one, the optimal solution to the NDM is found at the point where each state maintains its 1994 market share. In fact, the base models are constrained so that there is only one feasible optimum solution to the NDM.

Although the base models are designed to have only one solution, the objective value

Table 5-2: Total Marketing Costs Of Base Runs For Alternative Scenarios and Variations Of the National Dairy Model (In Billion $)[1]

Scenario	Model A	Model B	Model C
I-3	18.1	18.2	17.3
II-3	17.9(-1.10%)	18.0(-1.09%)	17.1(-1.15%)
III-3	18.2(0.55%)	18.3(0.55%)	17.4(0.59%)
I-10	19.2	19.4	18.4
II-10	19.1(-0.52%)	19.2(-1.03%)	18.2(-1.08%)
III-10	19.4(1.04%)	19.5(0.52%)	18.5(0.54%)

[1] Values in ( ) are percentage changes from the *TMC* of Scenario I with the same export level.

can be different across variations of the NDM in each scenario. Table 5-2 reports the objective values for Models A, B, and C for each version of a marketing scenario's base run. In both versions of all scenarios, total marketing costs (*TMC*) are minimized in Model C. In fact, Model C always results in the lowest *TMC*, followed by Model A and then Model B. Given the specification of Models A, B, and C, the rankings of each model within a scenario are consistent with expectations. Because Scenario II has a lower fluid hauling rate, the objective value for each model is less than the counterpart in Scenarios I and III. On average, a 50% reduction in the fluid hauling rate decreases the *TMC* by 0.99% when compared to the results of Scenario I. As expected, the 25% increase in all hauling rates (Scenario III) results in objective values that are higher than those in Scenarios I and II. In terms of percentage changes from the *TMC* of Scenario I, a 25% increase in hauling rates results in *TMC* measures that average 0.63% higher. In each case, the simulations with 10% exports have a higher *TMC* than models with 3% exports. The higher *TMC* is the result of 7% more milk being produced and shipped for the export market. Based on these results, one can conclude that the variations of the NDM across scenarios are performing as expected.

The results for the base models of Scenarios I, II, and III are presented in Table 5-3.

Table 5-3: Production Levels, Fluid and Export Shipments By State For Base Runs Of the National Dairy Model[1]

State	% Share Of Total Production	Fluid Shipments (%)		Export Shipments (%)	
		3% Exports	10% Exports	3% Exports	10% Exports
AL	0.33	100.00	100.00		
AZ	1.39	53.78	50.36		
AR	0.49	73.62	68.93		
CA	16.30	28.05	26.27	8.93 (50)	16.89 (30)
CO	1.02	56.55	52.95		
CT	0.35	100.00	100.00		
DE	0.09	100.00	100.00		
FL	1.71	100.00	100.00		
GA	1.04	100.00	100.00		
ID	2.45	6.32	5.92		1.35 (0.3)
IL	1.66	100.00	100.00		
IN	1.47	100.00	100.00		
IA	2.58	16.53	15.48		
KS	0.72	100.00	100.00		
KY	1.30	83.33	61.20		
LA	0.60	100.00	100.00		
ME	0.42	45.32	42.43		
MD	0.86	96.41	90.27		
MA	0.29	100.00	100.00		
MI	3.61	39.53	37.02		
MN	6.09	11.04	10.34	5.17 (11)	37.44 (25)
MS	0.48	92.61	78.66		
MO	1.77	48.12	40.51		29.77 (6)
MT	0.20	61.38	57.47		
NE	0.72	33.53	31.40		
NV	0.27	0.00	0.00		100.00 (3)
NH	0.20	100.00	100.00		
NJ	0.22	100.00	100.00		
NM	2.17	10.75	10.06		
NY	7.44	0.00	0.00		
NC	0.96	100.00	100.00		
ND	0.57	0.00	0.00	73.00 (14)	18.75 (1)
OH	2.95	59.93	55.73		
OK	0.83	100.00	97.84		
OR	1.12	39.11	36.62		6.35 (1)
PA	6.67	87.25	81.15		
RI	0.02	100.00	100.00		
SC	0.27	100.00	100.00		
SD	1.04	19.81	18.55		
TN	1.28	43.98	21.37		
TX	4.06	64.35	60.25		18.94 (8)
UT	0.93	28.39	26.58		73.42 (8)
VT	1.60	51.19	45.87		
SW VA	0.06	100.00	100.00		
E VA	0.16	100.00	100.00		
W VA	1.03	61.70	55.85		
WA	3.39	22.06	20.65	21.48 (25)	47.18 (18)
WV	0.18	100.00	100.00		
WI	14.60	0.00	0.00		
WY	0.06	0.00	0.00		

[1] Values in ( ) represent a state's share of total exports.

Since there are two versions of each scenario, the results of the base runs are compiled according to export levels. Even though the objective values of Models A, B, and C are different, the base runs of these models result in the same combination of total production and types of milk shipments for a particular state. In fact, apart from the *TMC*, the base runs are constrained so that the optimal solution is identical across scenarios with the same export level. The first column in Table 5-3 identifies a state's market share. The share of total production is equal to each state's market share in 1994. Regardless of export levels, a state's share of total production remains the same in the base solution.

Table 5-3 also shows a state's percentage of fluid and export shipments. The percentage of manufactured shipments can therefore be determined by subtracting the state's percentage of fluid and export shipments from a base of 100. A state's percentage of fluid and manufactured shipments are fairly consistent as export levels change. Based on class utilization statistics from the Federal Milk Marketing Orders, the types of shipments from the market areas appear to be consistent with historical data. For example, the results show that production in states like Virginia, North Carolina, Georgia, Florida, South Carolina, Illinois, and Indiana is designated for fluid use. Although market order statistics do not show 100% class one utilization rates in these areas, the statistics do confirm that these areas are historically a high (>60%) class one utilization market (*Federal Milk Marketing Order Statistics* 1995). A comparison of Class II and III utilization rates from federal order statistics also reveals that the NDM model correctly identified market areas where the majority of the production is used in manufactured products (e.g., California, New Mexico, Idaho, Iowa, Michigan, Minnesota, Wisconsin, and New York). Based on these results, the NDM appears to be fairly accurate in simulating marketing conditions throughout the U.S. dairy industry in 1994.

The last column in Table 5-3 identifies the states that have shipments to export facilities. If a state has export shipments, the percentage of total exports produced by that state is shown in parentheses. In simulations that have export levels at 3%, California and Washington account for 75% of total exports. The remaining 25% of exports is shipped from states located in the Upper Midwest. When exports levels are increased to 10%, California, Minnesota, and Washington remain the dominant exporting states with 73% of total exports. The difference with export levels at 10% is the number of states that ship milk to export facilities. At 3% export levels, only four states have export shipments: California, Washington, Minnesota, and North Dakota. With export levels at 10%, six more states begin shipping milk to export locations. Of the six new states, Texas, Utah, and Missouri account for 22% of total exports.

Scenario I-3

Scenario I-3 is evaluated with production factors of 5%, 15% and 30%. The results of these simulations are presented in a format similar to Table 5-3. Unlike the base solution, Models A, B, and C result in different optimal solutions when the production factor is not equal to one. These differences are illustrated in table format for simulations with the same production factor.

5% Production Factor

The results of Scenario I-3 with a production factor of 5% are listed in Table 5-4. The *TMC* in billions for Models A, B, and C is $17.9, $18.0, and $17.1, respectively. When compared to the base runs of Scenario I-3, the percentage change in *TMC* associated with a 5% production increase are -1.10% for Model A, -1.09% for Model B, and -1.15% for Model C.

Table 5-4: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given 1994 Marketing Conditions, 3% Export Level, and 5% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	5.00	5.00	5.00	100.00	100.00	100.00			
AZ	5.00	5.00	5.00	51.22	51.22	51.22			
AR	5.00	5.00	5.00	70.11	70.11	70.11			
CA	5.00	5.00	5.00	26.71	26.71	26.71	8.51(50)	8.50(50)	8.51(50)
CO	5.00	5.00	5.00	53.85	53.85	53.85			
CT	5.00	5.00	5.00	100.00	100.00	100.00			
DE	5.00	5.00	5.00	100.00	100.00	100.00			
FL	5.00	-31.74	5.00	100.00	100.00	100.00			
GA	5.00	5.00	5.00	100.00	100.00	100.00			
ID	5.00	5.00	5.00	6.02	6.02	6.02			
IL	5.00	5.00	5.00	100.00	100.00	100.00			
IN	5.00	5.00	5.00	100.00	100.00	100.00			
IA	-83.47	-62.90	-83.47	100.00	44.55	100.00			
KS	5.00	5.00	5.00	100.00	100.00	100.00			
KY	5.00	5.00	5.00	66.77	66.77	66.77			
LA	5.00	5.00	5.00	100.00	100.00	100.00			
ME	-100.00	-53.01	-26.77	—	96.43	61.88			
MD	5.00	5.00	5.00	91.82	91.82	91.82			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-32.12	5.00	5.00	58.23	37.65	37.65			
MN	5.00	5.00	-16.37	10.52	10.52	13.21	4.48(10)	5.48(12)	5.63(10)
MS	5.00	5.00	5.00	82.17	82.17	82.17			
MO	5.00	5.00	5.00	41.90	41.90	41.90			
MT	5.00	-7.68	5.00	58.46	66.49	58.46			
NE	5.00	-2.48	5.00	31.94	34.38	31.94			
NV	5.00	5.00	5.00	0.00	0.00	0.00			
NH	5.00	-38.07	5.00	100.00	100.00	100.00			
NJ	5.00	5.00	5.00	100.00	100.00	100.00			
NM	5.00	5.00	5.00	10.23	10.23	10.23			
NY	5.00	5.00	5.00	0.00	0.00	0.00			
NC	5.00	5.00	5.00	100.00	100.00	100.00			
ND	5.00	-6.23	5.00	0.00	0.00	0.00	74.3(15)	71.2(13)	74.3(15)
OH	5.00	5.00	5.00	56.79	56.79	56.79			
OK	5.00	5.00	5.00	99.52	99.52	99.52			
OR	5.00	-23.93	0.01	37.24	51.41	39.10			
PA	5.00	-2.15	5.00	82.69	88.73	82.69			
RI	5.00	5.00	5.00	100.00	100.00	100.00			
SC	5.00	5.00	5.00	100.00	100.00	100.00			
SD	5.00	-3.87	5.00	18.87	20.61	18.87			
TN	5.00	5.00	5.00	27.06	73.89	27.06			
TX	5.00	5.00	5.00	61.28	61.28	61.28		0.54(1)	
UT	5.00	5.00	5.00	27.04	27.04	27.04			
VT	5.00	5.00	5.00	76.81	70.79	65.56			
SW VA	5.00	5.00	5.00	100.00	100.00	100.00			
E VA	5.00	5.00	5.00	100.00	100.00	100.00			
W VA	5.00	5.00	5.00	57.32	57.32	57.32			
WA	-13.58	-22.73	-22.11	25.52	28.54	28.32	24.9(25)	27.0(24)	27.6(25)
WV	5.00	5.00	5.00	100.00	100.00	100.00			
WI	5.00	5.00	5.00	0.00	0.00	0.00			
WY	5.00	-7.54	5.00	0.00	0.00	0.00			

With a 5% production factor, most states in Models A, B, and C increase their total production by 5%. Since total demand is fixed in the NDM, increasing production in some states is offset by decreasing production in other states. All three models show a decrease in milk production for Iowa, Maine, Massachusetts, and Washington. Both Iowa and Washington are located near the low-cost producing regions of the country. When the constraints of the NDM are relaxed, production in states like California and Wisconsin is increased at the expense of surrounding states (e.g., Washington and Iowa). A similar explanation is in order for why milk production in Maine and Massachusetts is reduced. The difference is that these states are high-cost producers in their region of the country (Table 5-1).

In general, the results of Models A, B, and C are consistent. When the percentage change in total production varies across models, the reason for the different results can usually be attributed to differences in cost of production. The cost estimates in Table 5-1 can help explain the differences in Models A and C. For example, some states may show decreasing production in Model A, but increasing production in Model C. In these cases, a state's competitive position in the NDM is improved if firms are operating at the minimum average total costs. The results for Michigan in Table 5-4 are explained by the large differences in cost per cwt. in Models A and C. The results for Minnesota help explain the opposite situation. If the cost per cwt. at the minimum average total costs is only a few cents less than the current mean cost per cwt., the optimal solution may show an increase in production for Model A, but a decrease in production for Model C. The end results in both situations are dependent on the relative changes in cost per cwt. from Model A to Model C.

In some instances, the results of Model B are not consistent with those of Models A or C. Because cost per cwt. in Model B is dependent on output levels, the differences in results cannot be explained using Table 5-1. In most cases, the differences can be explained with the shape of the state's average and marginal cost curves. Chapter four identifies states that have marginal and average cost curves that increase throughout the range of the production data. The different results can be attributed, in part, to the unconventional shape of a state's cost curves. For example, Model B decreases production in Montana, Nebraska, New Hampshire, North Dakota, Oregon, Pennsylvania, South Dakota, and Wyoming (Table 5-4). For the same states, Models A and B show an increase in production. For each of the states listed above, the marginal and average cost curves never intersect and are increasing throughout the range of the production data. Apparently, the unusual shape of marginal and average cost curves is a contributing factor that could result in a loss of production for certain states. The shape of the cost curves is only a contributing factor because production also increases in states that have unconventional cost curves (i.e., Texas and Virginia). Based on these observations, the shape of the cost curves and the programming differences in Model B are the most likely source of differences in results when compared with Models A and C.

The percentage of fluid and manufactured shipments are generally consistent across all three models. In fact, the shipments are identical in many cases. Compared to the base solution, there are only minor changes in fluid and manufactured shipments. In most cases, these changes occur when a state's total production is reduced. For example, as production in Iowa, Maine, and Washington is reduced, the percentage of fluid shipments increases. Because fluid products are more expensive to transport, a state experiencing a loss in production will continue to supply fluid milk in the local market while the demand for manufactured products is satisfied with shipments from other low-cost producing states.

On the other hand, increasing production in a state generally results in a smaller percentage of fluid shipments (Table 5-4). The percentage being smaller does not mean that a state is shipping less fluid milk. When a state increases production, if the quantity of milk shipped as fluid products remains unchanged, the percentage of fluid shipments will decrease because of more production in the state. Finally, export shipments across all three models remain virtually unchanged from the base solution.

15% Production Factor

A production factor of 15% gives the NDM more flexibility to increase supply in low-cost states. As expected, the *TMC* for each model is reduced when the production factor is increased. The *TMC* in billions and percentage change from Scenario I-3 are: (1) Model A: $17.7 and -2.21%; (2) Model B: $17.8 and -2.20%; and (3) Model C: $16.8 and -2.89%. Based on the shadow prices of the simulations with a 5% production factor, states that may help decrease the *TMC* by reducing production as the market becomes more competitive are Florida, Iowa, Minnesota, Oregon, and Washington. Table 5-5 shows the results of Scenario I-3 when the production factor is 15%.

In addition to the states that reduced supply with a 5% production factor, all three models indicate that Minnesota and Oregon are not competitive with a production factor of 15%. Again, notice that these two states are located near Wisconsin and California, which have lower costs per cwt. The same interpretation can be applied to results for Michigan in Models A and C. In the case of Florida, Models A and B may ultimately lead to the same conclusion. For example, Model B has already identified Florida as a high-cost producing state. At the same time, Model A increases supply in Florida, but only by 4.63%. Given more flexibility, the NDM may reduce production in Florida in both Models A and B. As far as Virginia is concerned, Models A and C increase production in each region by 15%. Model B

Table 5-5: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given 1994 Marketing Conditions, 3% Export Level, and 15% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	15.00	15.00	15.00	100.00	100.00	100.00			
AZ	15.00	15.00	15.00	46.77	46.77	46.77			
AR	15.00	15.00	15.00	64.02	64.02	64.02			
CA	15.00	15.00	15.00	24.39	24.39	24.39	7.77(50)	11.7(75)	11.7(75)
CO	15.00	-1.66	15.00	49.17	57.70	49.17			
CT	15.00	15.00	15.00	100.00	100.00	100.00			
DE	15.00	9.86	15.00	100.00	100.00	100.00			
FL	4.63	-53.61	15.00	100.00	100.00	100.00			
GA	15.00	15.00	15.00	100.00	100.00	100.00			
ID	15.00	-7.97	15.00	5.50	6.87	5.50			
IL	15.00	15.00	15.00	87.36	87.36	87.36			
IN	15.00	15.00	15.00	100.00	100.00	100.00			
IA	-100.00	-79.86	-83.47	—	82.05	100.00			
KS	15.00	15.00	15.00	100.00	100.00	100.00			
KY	15.00	15.00	15.00	54.02	54.02	42.24			
LA	15.00	15.00	15.00	93.55	93.55	93.55			
ME	-100.00	-59.31	-54.68	—	100.00	100.00			
MD	15.00	2.59	15.00	83.83	93.97	83.83			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-60.47	15.00	-37.01	100.00	34.37	62.75			
MN	-88.96	-22.67	-88.96	100.00	14.28	100.00		9.47(15)	
MS	15.00	15.00	15.00	72.18	72.18	72.18			
MO	15.00	-24.87	15.00	36.77	56.28	36.77			
MT	15.00	-24.24	15.00	53.37	81.02	53.37			
NE	15.00	-19.35	15.00	80.46	41.58	29.16			
NV	15.00	15.00	15.00	0.00	0.00	0.00			
NH	15.00	-47.05	15.00	100.00	100.00	100.00			
NJ	15.00	15.00	15.00	100.00	100.00	100.00			
NM	15.00	15.00	15.00	9.34	9.34	9.34			
NY	15.00	15.00	15.00	0.00	1.25	0.00			
NC	6.12	15.00	15.00	100.00	100.00	100.00			
ND	15.00	-23.15	15.00	0.00	0.00	0.00		64.9(10)	
OH	15.00	15.00	15.00	51.33	51.33	51.33			
OK	15.00	15.00	15.00	86.48	86.48	86.48			
OR	-42.29	-60.24	-60.89	67.76	98.35	100.00			
PA	15.00	-17.17	15.00	74.75	100.00	74.75			
RI	15.00	15.00	15.00	100.00	100.00	100.00			
SC	15.00	15.00	15.00	100.00	100.00	100.00			
SD	15.00	-20.67	15.00	17.23	24.97	17.23			
TN	15.00	15.00	15.00	15.51	77.48	9.71			
TX	15.00	15.00	15.00	55.96	55.96	55.96			
UT	15.00	-7.04	15.00	24.69	30.54	24.69			
VT	15.00	15.00	15.00	68.90	66.57	58.64			
SW VA	15.00	12.47	15.00	100.00	100.00	100.00			
E VA	15.00	15.00	15.00	100.00	100.00	100.00			
W VA	15.00	2.50	15.00	49.70	65.95	49.70			
WA	-22.11	-58.96	-66.88	28.32	53.75	66.59	27.6(25)		
WV	15.00	15.00	15.00	100.00	100.00	100.00			
WI	15.00	15.00	15.00	0.00	0.00	0.00	4.34(25)		4.34(25)
WY	15.00	-24.10	15.00	0.00	0.00	0.00			

also increases production in Virginia market areas, but not as much as Models A and C (Table 5-5). Although there are still inconsistencies where Model B is concerned, the results as a whole from all three models lead to the conclusion that low-cost states continue to expand production in a more competitive market. With the current operating conditions, production costs are more important than transportation costs.

Once again, the fluid and manufactured shipments are generally consistent across models and with the base solution. The pattern of less (more) production, but a higher (lower) percentage of fluid shipments is still apparent in the results (Table 5-5). Most of the changes in shipments occur with exports. With a production factor of 15%, the number of states that ship manufactured products to export locations is reduced. Model A identifies three exporting states: California, Washington, and Wisconsin. The origin of exported products in Model B is California, Minnesota, and North Dakota. Model C exports manufactured products from only California and Wisconsin. According to these results, in a competitive market, the cost of production advantages in California and Wisconsin enable these states to produce and ship export products at a lower costs than states closer to the export facilities.

30% Production Factor

When the NDM is evaluated with a 30% production factor, a number of states are completely removed from milk production (Table 5-6). For example, all three models reduce production in Massachusetts and Minnesota by 100%. Models A and C also decrease supply by 100% in Iowa, Michigan, and North Carolina. Model B leaves some production for use in the fluid market in Iowa and Michigan. Each model decreases production in Florida by at least 47%. In the previous simulations, Model B always reported less production in Florida, opposite the results from Models A and C. At a production factor of 30%, the results of each

Table 5-6: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given 1994 Marketing Conditions, 3% Export Level, and 30% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	30.00	30.00	30.00	100.00	100.00	100.00			
AZ	30.00	30.00	30.00	41.37	41.37	41.37			
AR	30.00	30.00	30.00	100.00	56.63	56.63			
CA	30.00	30.00	30.00	21.58	21.58	21.58	10.3(75)	10.3(75)	10.3(75)
CO	30.00	-11.63	30.00	43.50	63.99	43.50			
CT	30.00	21.36	30.00	100.00	100.00	100.00			
DE	30.00	7.64	30.00	100.00	100.00	100.00			
FL	-90.29	-65.17	-47.20	100.00	100.00	100.00			
GA	30.00	30.00	30.00	100.00	100.00	100.00			
ID	-35.82	-17.78	-93.68	9.85	7.69	100.00			
IL	30.00	30.00	30.00	100.00	67.07	100.00			
IN	30.00	30.00	30.00	100.00	100.00	100.00			
IA	-100.00	-83.47	-100.00	—	100.00	—			
KS	30.00	30.00	30.00	100.00	100.00	100.00			
KY	30.00	30.00	30.00	100.00	44.92	61.14			
LA	7.58	30.00	30.00	100.00	82.76	82.76			
ME	-100.00	-63.62	-100.00	—	100.00	—			
MD	30.00	-0.22	30.00	74.16	100.00	74.16			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-100.00	-60.47	-100.00	—	100.00	—			
MN	-100.00	-100.00	-100.00	—	—	—			
MS	-16.99	30.00	30.00	100.00	63.85	63.85			
MO	-93.67	-44.67	30.00	100.00	76.43	32.53			
MT	30.00	-30.74	30.00	47.22	88.62	47.22			
NE	30.00	-25.70	30.00	71.17	45.13	71.17			
NV	30.00	30.00	30.00	0.00	0.00	0.00			
NH	-100.00	-51.01	30.00	—	100.00	100.00			
NJ	30.00	30.00	30.00	100.00	100.00	100.00			
NM	30.00	30.00	30.00	8.27	8.27	8.27			
NY	30.00	30.00	30.00	0.00	1.72	9.56			
NC	-100.00	30.00	-100.00	—	100.00	—			
ND	30.00	-29.10	30.00	0.00	0.00	0.00			
OH	30.00	30.00	30.00	63.44	44.71	63.44	16.1(21)		
OK	30.00	30.00	30.00	100.00	66.45	66.45			
OR	-60.89	-60.89	-60.89	100.00	100.00	100.00			
PA	30.00	-19.29	30.00	66.61	100.00	66.61			
RI	30.00	8.69	30.00	100.00	100.00	100.00			
SC	30.00	30.00	30.00	100.00	100.00	100.00			
SD	30.00	-26.99	30.00	15.24	27.13	15.24			
TN	30.00	30.00	30.00	100.00	59.96	100.00			
TX	30.00	30.00	30.00	49.50	49.50	49.50			
UT	30.00	-16.88	-71.61	21.84	34.16	100.00			
VT	-14.25	30.00	-88.71	100.00	60.20	100.00			
SW VA	30.00	5.25	30.00	100.00	100.00	100.00			
E VA	30.00	10.51	30.00	100.00	100.00	100.00			
W VA	30.00	-4.49	30.00	46.10	71.94	40.46			
WA	-77.94	-72.38	-77.94	100.00	79.86	100.00			
WV	30.00	30.00	30.00	100.00	100.00	100.00			
WI	30.00	30.00	30.00	3.54	3.54	3.54	0.59(4)	3.84(25)	3.84(25)
WY	30.00	-30.60	30.00	0.00	0.00	0.00			

model lead to the same conclusion regarding the future of the Florida dairy industry in a competitive market. Although not confirmed by all models, other states that appear to be less competitive as more flexibility is added to the NDM are Idaho, Missouri, New Hampshire, Utah, and Vermont. The major dairy states (e.g., California, Wisconsin, Texas, New York, New Mexico, and Arizona) continue to produce at maximum capacity in all three models.

Although Virginia producers remain competitive in Models A and C, Model B decreases supply in the western Virginia production region. The decrease in supply is likely attributable to the irregular shape of Virginia's cost curves. To determine the impact of marginal and average cost curves with unusual shapes, Model B is reprogrammed with the alternative cost functions outlined in Appendix E. Once the 11 states with unconventional cost curves are assigned a new translog cost function, Model B of Scenario I-3 is solved with production factors of 5%, 15%, and 30%. In general, the results for states with alternative cost functions are then more consistent with the results in Models A and C. In the case of Virginia, the results of Model B with the alternative cost functions are identical to those of Models A and C. Instead of decreasing production in Western Virginia by 4.49% (Table 5-6), Model B now shows that production is increased by 30% in all three Virginia market areas. The results by state and a detailed discussion of the impact of marginal and average cost curves that never reach minimum are presented in Appendix E.

As more states decrease production, the percentage of fluid shipments increases (Table 5-6). When compared with the base solution, Model A has five more states that ship 100% of their production as fluid products. The types of shipments across models are relatively consistent, but the differences in absolute terms are greater with a more flexible NDM. California, New Mexico, and Wisconsin are still the dominant sources of manufactured products. In all three models, California produces 75% of total exports. Except for Model A, Wisconsin supplies the remaining 25% of exported dairy products. Finally, *TMC* continues to decline with increasing production factors. The percentage change in *TMC* relative to the base runs of Scenario I-3 for Models A, B, and C are -3.87%, -4.95%, and -4.62%, respectively.

Scenario I-10

The second version of Scenario I has total demand for exported products increased to 10% of commercial disappearances. With the new export level, Scenario I is once again evaluated with production factors of 5%, 15%, and 30%. When the percentage change in total production and percentage of fluid and manufactured shipments are analyzed for Scenario I-10, the changes in the results as the production factor is increased are very similar to the changes in the results of Scenario I-3. For example, with a production factor of 5%, Models A, B, and C show a substantial reduction in output for Iowa, Maine, and Massachusetts. Most of the remaining states increase production by 5%. The only noticeable change in total production occurs in Washington. In the previous 5% simulation, all three models reduced production in Washington. When total exports are increased, Models A and C increase production in Washington by 5% and Model B reduces production by 17%. The increased production in Washington can be attributed to the larger quantity demanded at the Seattle export facility. At a production factor of 30%, all three models reduce supply in Washington by at least 65%, which is consistent with the results of Scenario I-3. The differences in total production for Model B are still present when total exports are increased. As in the previous simulations, fluid and manufactured shipments remain consistent with the base solution and across models. The inverse relationship between percentage change in total production and fluid shipments is still apparent regardless of differences in export levels and production factors. Given the similarities, an evaluation of the results for both versions of Scenario I leads to the same conclusions. Therefore, the percentage change in total production and percentage of fluid and manufactured shipments for Scenario I-10 are not presented in table format.

The usefulness of Scenario I-10 is in predicting which states will benefit from increased export demand for U.S. dairy products. Most of the differences in Scenarios I-3 and I-10 are related to the origin of exported dairy products. Table 5-7 summarizes the results regarding exports shipments in Scenario I-10.

The export results of the NDM in Table 5-7 identify California as the dominant exporting state in competitive market. As the production factor is increased to 30%, California's share of total exports increases from 41% to at least 61%. These results are consistent across all three models. At a production factor of 5%, Minnesota and Washington export a considerable amount of manufactured products. As the market becomes more

Table 5-7: Percentage Of Total Export Shipments By State For Variations Of the NDM Given 1994 Marketing Conditions, 10% Export Level, and 5%, 10%, and 30% Production Increases

	PF = 5%			*PF* = 15%			*PF* = 30%		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
CA	41	41	41	50	57	59	63	68	61
ID		1							
MI					6				
MN	20	25	20		19				
MO		1							
NV	3	2	3						
ND	5		5						
OH				8		10	19		18
OR	1		1						
PA							6		
TX	5	11	5	2	17	11	12	7	14
UT	5	8	5		1				
WA	20	11	20	23		5			
WI				17		15		25	7

competitive, the dairy sectors in California and Wisconsin expand. At a 30% production factor, Minnesota and Washington are not competitive, and the NDM identifies less expensive sources of manufactured products (Table 5-7). The results of all three models indicate that Texas benefits from increased export demand of U.S. dairy products. Even with a production factor of 30%, a substantial amount of export products continues to be shipped from Texas. Compared with the base solution, the number of states that have export shipments decreases as the production factor is increased. These results are consistent with those of Scenario I-3.

If the U.S. dairy industry becomes a major participant in the international market, the results of Scenario I-10 identify several states that could provide manufactured products at a competitive price. Although California and Wisconsin are competitive at any export level, the dairy sector in states like Texas, Pennsylvania, Ohio, and Washington could expand if the U.S. gains more access to overseas markets.

Scenario II

Scenario II attempts to simulate marketing conditions when the fluid hauling rate is reduced by 50%. As in previous scenarios, Scenario II is evaluated with exports levels at 3% and 10% as well as with three production factors. When compared with the formulation of the NDM in Scenario I, the only difference in Scenario II is that an exogenous variable in the model is reduced by 50%. In a mathematical programming framework, changing the value of a constant (e.g., hauling rates) in the NDM does not affect a state's competitiveness on a relative basis. Even though relative differences across states are unchanged, a different hauling rate does influence the spatial dimension of the dairy industry. Because the spatial dimension of the NDM is altered, some changes in the optimum solution are expected as the NDM becomes more flexible.

The results of Scenario II with production factors of 5% and 15% are almost identical to the results of Scenario I with the same production factors and export levels. These results are similar because production increases of 5% and 15% are not sufficient to demonstrate the competitive advantages associated with a lower fluid hauling rate. With a 30% production factor, the added flexibility in the NDM accompanied by a reduced fluid hauling rate does result in some differences when compared to Scenario I. The results of Scenarios II-3 and II-10 with a production factor of 30% are presented in Tables 5-8 and 5-9, respectively.

At export levels of 3% (10%) and a production factor of 30%, the percentage differences in *TMC* when compared to the base runs of Scenario II are Model A: -3.91 (-3.66); Model B: -5.0 (-4.69); and Model C: -4.68 (-4.95). Although the percentage change in total production for all three models at both export levels is relatively consistent with the results in Scenario I, there are some differences in absolute levels. The most noticeable differences from Scenario I and the scenario where the fluid hauling rate is reduced (Scenario II) occur in states like Florida and Vermont. When the fluid hauling rate is reduced, Florida and Vermont suffer a considerable loss in total production at both export levels (Tables 5-8 and 5-9). In Scenario I, Models A and B reduce production in Florida and Vermont to a level where both of these states ship only fluid products. In Scenario II, less expensive sources of fluid milk are now available and milk production in Florida and Vermont continues to decline. In fact, Models A and C in Scenario II remove all milk production from Florida (Tables 5-8 and 5-9). Although these models leave some milk production in Vermont, the output continues to be shipped as fluid products.

In the case of Idaho, all three models at each export level increase production relative

Table 5-8: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given A Reduced Fluid Hauling Rate, 3% Export Level, and 30% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	30.00	30.00	30.00	100.00	100.00	100.00			
AZ	30.00	30.00	30.00	41.37	41.37	41.37			
AR	30.00	30.00	30.00	100.00	56.63	56.63			
CA	30.00	30.00	30.00	21.58	21.58	21.58	10.3(75)	10.3(75)	10.3(75)
CO	30.00	-1.60	30.00	43.50	57.47	43.50			
CT	30.00	10.81	30.00	100.00	100.00	100.00			
DE	30.00	7.39	30.00	100.00	100.00	100.00			
FL	-100.00	-65.43	-100.00	—	100.00	—			
GA	30.00	30.00	30.00	100.00	100.00	100.00			
ID	13.35	-7.91	-91.47	5.58	6.87	74.13			
IL	30.00	30.00	30.00	100.00	100.00	100.00			
IN	30.00	30.00	30.00	100.00	100.00	100.00			
IA	-100.00	-79.73	-100.00	—	81.55	—			
KS	30.00	30.00	30.00	100.00	100.00	100.00			
KY	30.00	30.00	30.00	100.00	44.92	100.00			
LA	7.58	30.00	30.00	100.00	82.76	100.00			
ME	-100.00	-61.61	-100.00	—	100.00	—			
MD	30.00	3.60	30.00	74.16	100.00	74.16			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-100.00	-100.00	-100.00	—	—	—			
MN	-100.00	-100.00	-100.00	—	—	—			
MS	-16.99	30.00	30.00	100.00	63.85	81.08			
MO	-100.00	-27.53	30.00	—	58.34	32.53			
MT	30.00	-24.20	30.00	47.22	80.98	47.22			
NE	30.00	-18.97	30.00	83.10	41.38	71.17			
NV	30.00	30.00	30.00	0.00	0.00	0.00			
NH	-100.00	-49.45	30.00	—	100.00	100.00			
NJ	30.00	30.00	30.00	100.00	100.00	100.00			
NM	30.00	30.00	30.00	8.27	8.27	8.27			
NY	30.00	30.00	30.00	9.56	2.20	10.53			
NC	-100.00	30.00	-100.00	—	100.00	—			
ND	30.00	-22.39	30.00	0.00	0.00	0.00			
OH	30.00	30.00	30.00	63.44	63.44	63.44			
OK	30.00	30.00	30.00	100.00	66.45	66.45			
OR	-60.89	-60.89	-60.89	100.00	100.00	100.00			
PA	30.00	-19.93	30.00	66.61	100.00	66.61			
RI	30.00	-5.80	30.00	100.00	100.00	100.00			
SC	30.00	30.00	30.00	100.00	100.00	100.00			
SD	30.00	-20.21	30.00	15.24	24.83	15.24			
TN	30.00	30.00	30.00	100.00	60.22	100.00			
TX	30.00	30.00	30.00	49.50	49.50	49.50			
UT	30.00	-6.98	29.46	21.84	30.52	21.84			
VT	-72.11	30.00	-94.59	100.00	59.79	100.00			
SW VA	30.00	6.82	30.00	100.00	100.00	100.00			
E VA	30.00	9.80	30.00	100.00	100.00	100.00			
W VA	30.00	2.02	30.00	58.47	67.37	40.46			
WA	-77.94	-60.76	-77.94	100.00	56.22	100.00			
WV	30.00	30.00	30.00	100.00	100.00	100.00			
WI	30.00	30.00	30.00	3.54	3.54	3.54	3.84(25)	3.84(25)	3.84(25)
WY	30.00	-24.07	30.00	0.00	0.00	0.00			

Table 5-9: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given A Reduced Fluid Hauling Rate, 10% Export Level, and 30% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	30.00	30.00	30.00	100.00	100.00	100.00			
AZ	30.00	30.00	30.00	38.74	38.74	38.74			
AR	30.00	30.00	30.00	100.00	53.03	53.03			
CA	30.00	30.00	30.00	20.20	20.20	20.20	31.1(73)	30.6(71)	27.8(65)
CO	30.00	-7.86	30.00	40.73	57.47	40.73			
CT	30.00	3.10	30.00	100.00	100.00	100.00			
DE	30.00	0.20	30.00	100.00	100.00	100.00			
FL	-100.00	-72.73	-100.00	—	100.00	—			
GA	30.00	30.00	30.00	100.00	100.00	100.00			
ID	28.59	-13.77	-88.37	4.60	6.87	50.92			
IL	30.00	30.00	30.00	100.00	100.00	100.00			
IN	30.00	30.00	30.00	100.00	51.62	100.00			
IA	-100.00	-81.35	-100.00	—	82.97	—			
KS	30.00	30.00	30.00	100.00	100.00	100.00			
KY	30.00	30.00	30.00	100.00	40.47	92.79			
LA	0.74	30.00	30.00	100.00	77.49	77.49			
ME	-100.00	-64.27	-100.00	—	100.00	—			
MD	30.00	-3.35	30.00	69.44	100.00	69.44			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-100.00	-62.98	-100.00	—	100.00	—			
MN	-100.00	-100.00	-100.00	—	—	—			
MS	-22.27	30.00	30.00	100.00	59.79	59.79			
MO	-100.00	-32.14	30.00	—	58.35	30.46			
MT	30.00	-29.03	30.00	44.21	80.98	44.21			
NE	30.00	-24.43	30.00	66.64	41.55	66.64			
NV	30.00	30.00	30.00	0.00	0.00	0.00			
NH	-100.00	-52.86	30.00	—	100.00	100.00			
NJ	30.00	30.00	30.00	100.00	100.00	100.00			
NM	30.00	30.00	30.00	7.74	7.74	7.74			
NY	30.00	30.00	30.00	9.82	2.30	9.68			
NC	-100.00	30.00	-100.00	—	92.29	—			
ND	30.00	-27.69	30.00	0.00	0.00	0.00			
OH	30.00	30.00	30.00	52.26	41.48	52.26	40.2(17)		42.0(18)
OK	30.00	30.00	30.00	86.65	56.68	56.68			
OR	-63.38	-63.38	-63.38	100.00	100.00	100.00			
PA	30.00	-25.56	30.00	61.81	100.00	61.81			
RI	30.00	-12.40	30.00	100.00	100.00	100.00			
SC	30.00	30.00	30.00	100.00	100.00	100.00			
SD	30.00	-25.66	30.00	14.27	24.95	14.27			
TN	20.73	30.00	30.00	100.00	56.14	100.00			
TX	30.00	30.00	30.00	46.35	46.35	46.35	4.18(2)	6.35(4)	17.5(10)
UT	30.00	-12.90	30.00	20.45	30.52	20.45			
VT	-79.16	30.00	-94.93	100.00	56.05	100.00			
SW VA	30.00	-0.41	30.00	100.00	100.00	100.00			
E VA	30.00	2.38	30.00	100.00	100.00	100.00			
W VA	30.00	-4.90	30.00	41.60	67.77	35.95			
WA	-79.35	-63.26	-79.35	100.00	56.22	100.00			
WV	30.00	30.00	30.00	100.00	100.00	100.00			
WI	30.00	30.00	30.00	3.32	3.32	3.32	3.87(8)	12.0(25)	3.50(7)
WY	30.00	-28.90	30.00	0.00	0.00	0.00			

to results in Scenario I when the fluid hauling rate is reduced (Tables 5-8 and 5-9). Even though Idaho is located in a low-cost producing region, decreases in the fluid hauling rate allow Idaho to be more competitive with nearby states like California, Washington, and Nevada. With a lower fluid hauling rate, the results for Utah in Model C indicate a similar outcome when compared to Scenario I. As production increases in both Idaho and Utah, the percentage of fluid shipments is slightly reduced.

As far as export shipments are concerned, minor changes occur when the fluid hauling rate is reduced. With export levels at 3%, Wisconsin's share of total exports in Model A increases by 21% as a result of Ohio being completely removed from the export market (Table 5-8). Export shipments for Models B and C in Scenario II-3 are unchanged from Scenario I-3. When export levels are increased to 10% with a reduced fluid hauling rate, California's share of total exports increases in all three models. At the same time, the results of Scenario II-10 compared with those of Scenario I-10 show a decline in export shipments from Utah (Table 5-9). With the exception of Model A, the states that ship export products remain the same across Scenarios I-10 and II-10. The differences occur in the percentage of export shipments from each state (Table 5-9).

Scenario III

Scenario III is the marketing scenario where all hauling rates are increased by 25%. Like Scenario II, the only differences in the NDM when compared to Scenario I involve changes in the hauling rates. Because increasing all hauling rates by 25% does not affect the competitiveness among states on a relative basis, only minor differences are expected between the results of Scenarios I and III. As in Scenario II, the optimum solution at both levels of exports in Scenario III is virtually the same as the outcome in Scenario I when the production factor is 5% or 15%. The differences between scenarios become more evident with a production factor of 30%. For this reason, the only results of Scenario III presented in table format are the simulations with a production factor of 30%.

With the difference being export levels, Tables 5-10 and 5-11 show the effects of increasing the hauling rates by 25%. In order to identify the differences across scenarios, these results are compared with the results of Scenarios I-3 and I-10 with a production factor of 30%. In Scenario III, the percentage change in total production for each state is generally consistent with the results of Scenario I. The major differences between the two scenarios occur in Colorado, Florida, Idaho, New Hampshire, and Vermont. As expected, most of these states also experience considerable changes in total production when the fluid hauling rate is reduced. In contrast to the results in Scenario II, all three models increase production in Florida when the hauling rates are higher (Tables 5-10 and 5-11). In essence, low-cost supply areas are more distant and the Florida market becomes more isolated. The end result is that Florida producers are more competitive if hauling rates increase because of the spatial relationships in the dairy industry. Models A and B indicate similar results for New Hampshire at both export levels.

The states that experience a decrease in supply in some models of Scenario III are Colorado, Idaho, and Vermont (Tables 5-10 and 5-11). As the hauling rates are increased, the NDM identifies alternative sources of milk that can produce and ship dairy products to consumers at a lower cost. As milk production is reduced in Colorado, Idaho, and Vermont, a larger percentage of these states' milk production is shipped as fluid products. Even with these minor changes in the optimal solution, the results of the NDM when the hauling rates are increased by 25% are fairly consistent with results from Scenario I.

Table 5-10: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given A 25% Increase In Hauling Rates, 3% Export Level, and 30% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	30.00	30.00	30.00	100.00	100.00	100.00			
AZ	30.00	30.00	30.00	41.37	41.37	41.37			
AR	30.00	30.00	30.00	100.00	56.63	56.63			
CA	30.00	30.00	30.00	21.58	21.58	21.58	10.3(75)	10.3(75)	10.3(75)
CO	30.00	-13.35	-43.45	43.50	65.26	100.00			
CT	30.00	30.00	30.00	100.00	100.00	100.00			
DE	30.00	8.45	30.00	100.00	100.00	100.00			
FL	-62.73	-59.32	-4.49	100.00	100.00	100.00			
GA	30.00	30.00	30.00	100.00	100.00	100.00			
ID	-50.49	-21.00	-93.68	12.77	8.00	100.00			
IL	30.00	30.00	30.00	100.00	67.07	100.00			
IN	30.00	30.00	30.00	100.00	100.00	100.00			
IA	-100.00	-83.47	-100.00	—	100.00	—			
KS	30.00	30.00	30.00	100.00	100.00	100.00			
KY	30.00	30.00	30.00	100.00	44.92	44.92			
LA	7.58	30.00	30.00	100.00	82.76	82.76			
ME	-100.00	-62.10	-100.00	—	100.00	—			
MD	30.00	-1.44	30.00	74.16	100.00	74.16			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-100.00	-60.47	-100.00	—	100.00	—			
MN	-100.00	-100.00	-100.00	—	—	—			
MS	-16.99	30.00	30.00	100.00	63.85	63.85			
MO	-100.00	-44.38	30.00	—	76.02	32.53			
MT	30.00	-32.42	30.00	47.22	90.83	47.22			
NE	30.00	-26.23	30.00	71.17	45.46	71.17			
NV	30.00	30.00	30.00	0.00	0.00	0.00			
NH	-7.49	-49.48	30.00	100.00	100.00	100.00			
NJ	30.00	30.00	30.00	100.00	100.00	100.00			
NM	30.00	30.00	30.00	8.27	8.27	8.27			
NY	30.00	30.00	30.00	0.00	0.57	9.37			
NC	-100.00	30.00	-100.00	—	96.67	—			
ND	30.00	-30.46	30.00	0.00	0.00	0.00			
OH	30.00	30.00	30.00	63.44	44.71	63.44	18.1(24)		
OK	30.00	30.00	30.00	73.670	66.45	66.45			
OR	-60.89	-60.89	-60.89	100.00	100.00	100.00			
PA	30.00	-17.93	30.00	66.61	100.00	66.61			
RI	30.00	25.01	30.00	100.00	100.00	100.00			
SC	30.00	30.00	30.00	100.00	100.00	100.00			
SD	30.00	-27.83	30.00	15.24	27.45	15.24			
TN	30.00	30.00	30.00	100.00	56.44	72.65			
TX	30.00	30.00	30.00	49.50	49.50	49.50			
UT	30.00	-19.90	-71.61	21.84	35.44	100.00			
VT	-26.06	30.00	-87.57	100.00	59.59	100.00			
SW VA	30.00	9.01	30.00	100.00	100.00	100.00			
E VA	30.00	15.51	30.00	100.00	100.00	100.00			
W VA	30.00	-3.34	30.00	40.46	70.05	40.46			
WA	-77.94	-75.39	-77.94	100.00	89.63	100.00			
WV	30.00	30.00	30.00	100.00	100.00	100.00			
WI	30.00	30.00	30.00	3.54	3.54	3.54	0.19(1)	3.84(25)	3.84(25)
WY	30.00	-32.25	30.00	0.00	0.00	0.00			

Table 5-11: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given A 25% Increase In Hauling Rates, 10% Export Level, and 30% Production Increase

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	Model A	Model B	Model C	Model A	Model B	Model C	Model A	Model B	Model C
AL	30.00	30.00	30.00	100.00	100.00	100.00			
AZ	30.00	30.00	30.00	38.74	38.74	38.74			
AR	30.00	30.00	30.00	100.00	53.03	53.03			
CA	30.00	30.00	30.00	20.20	20.20	20.20	26.0(61)	28.3(66)	23.8(55)
CO	30.00	-11.76	-10.23	40.73	60.00	58.98			
CT	30.00	30.00	30.00	100.00	100.00	100.00			
DE	30.00	2.49	30.00	100.00	100.00	100.00			
FL	-70.14	-55.54	-15.60	100.00	100.00	100.00			
GA	30.00	30.00	30.00	100.00	100.00	100.00			
ID	-35.95	-19.06	-94.08	9.25	7.32	100.00			
IL	30.00	30.00	30.00	100.00	57.16	100.00			
IN	30.00	30.00	30.00	100.00	100.00	100.00			
IA	-100.00	-82.88	-100.00	—	90.39	—			
KS	30.00	30.00	30.00	100.00	100.00	100.00			
KY	30.00	30.00	30.00	86.42	40.47	40.47			
LA	0.74	30.00	30.00	100.00	77.49	77.49			
ME	-100.00	-61.94	-100.00	—	100.00	—			
MD	30.00	-5.10	30.00	69.44	95.13	69.44			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	-100.00	-62.98	-100.00	—	100.00	—			
MN	-100.00	-100.00	-100.00	—	—	—			
MS	-22.27	30.00	30.00	100.00	59.79	59.79			
MO	-100.00	-35.66	30.00	—	61.53	30.46			
MT	30.00	-32.11	30.00	44.21	84.65	44.21			
NE	30.00	-26.42	30.00	66.64	42.67	66.64			
NV	30.00	30.00	30.00	0.00	0.00	0.00			
NH	-13.37	-50.33	30.00	100.00	100.00	100.00			
NJ	30.00	30.00	30.00	100.00	100.00	100.00			
NM	30.00	30.00	30.00	7.74	7.74	7.74			
NY	30.00	30.00	30.00	0.00	0.24	8.95			
NC	-100.00	30.00	-100.00	—	88.74	—			
ND	30.00	-30.46	30.00	0.00	0.00	0.00			
OH	30.00	30.00	30.00	52.26	41.48	52.26	44.2(19)		43.9(18)
OK	30.00	30.00	30.00	56.68	56.68	56.68			
OR	-63.38	-63.38	-63.38	100.00	100.00	100.00			
PA	30.00	-23.18	30.00	61.81	100.00	61.81	6.70(6)		
RI	30.00	26.10	30.00	100.00	100.00	100.00			
SC	30.00	30.00	30.00	100.00	100.00	100.00			
SD	30.00	-27.95	30.00	14.27	25.74	14.27			
TN	30.00	30.00	30.00	100.00	41.11	66.69			
TX	30.00	30.00	30.00	46.35	56.35	46.35	24.8(14)	15.5(9)	33.8(20)
UT	30.00	-18.00	-73.42	20.45	32.42	100.00			
VT	-30.76	30.00	-90.48	100.00	54.96	100.00			
SW VA	30.00	6.53	30.00	100.00	100.00	100.00			
E VA	30.00	12.73	30.00	100.00	100.00	100.00			
W VA	30.00	-5.20	30.00	35.95	65.86	35.95			
WA	-79.35	-68.96	-79.35	100.00	66.55	100.00			
WV	30.00	30.00	30.00	100.00	100.00	100.00			
WI	30.00	30.00	30.00	3.32	3.32	3.32		12.0(25)	3.13(7)
WY	30.00	-31.94	30.00	0.00	0.00	0.00			

The final differences in results between Scenarios I and III involve export shipments. With export levels set at 3% of commercial disappearances, Model A reduces export shipments from Wisconsin and increases shipments from Ohio (Table 5-10). These results are opposite of those found in Scenario II-3. The export shipments in Models B and C remain the same as in Scenario I-3. In simulations with 10% exports, the NDM reduces the percentage of exports supplied by California (Table 5-11). In Models A, B, and C, Texas is the only state that ships more export products when hauling rates are increased.

Virginia Sensitivity Analysis

The results of Models A and C for all three scenarios indicate that Virginia dairy producers are competitive with the producers located in the surrounding states. Regardless of the production factor, hauling rate, or export level, each simulation of the NDM results in Virginia production being increased by the maximum percentage (i.e., 5%, 15%, or 30%). Since Virginia producers are competitive at a cost of $10.60 per cwt., the objective now is to determine how much cost per cwt. can increase before the NDM reduces production in Virginia. The increasing costs of production could be the result of higher feed costs, compliance with environmental regulations, or some other change in marketing conditions that have an effect on production costs. The focus is not to determine how much cost increases from specific feed inputs or certain types of environmental compliance, but to identify a range of cost estimates where Virginia producers remain competitive.

The version of the NDM that is used to conduct sensitivity analysis on Virginia's cost estimate is Model A. Since the cost estimates in Model A are found at the mean of the FCRS production data, these estimates are more representative of the current cost structure throughout the dairy industry. The sensitivity of the optimal solution is found by resolving the NDM with different costs of production for Virginia. As Virginia's cost estimate is varied, the costs per cwt. in the remaining states are the same as those used in Model A (Table 5-1). As in previous scenarios, Model A is once again evaluated with production factors of 5%, 15%, and 30%.

The results of the sensitivity analysis are presented in Table 5-12. With a production factor of 5%, the NDM does not reduce milk production in Virginia until costs increase by 25%, or up to $13.25 per cwt. At a cost estimate of $13.25, the total milk supply in western Virginia is reduced by approximately 40%. Although milk production in southwestern and eastern Virginia increases by 5%, these areas account for only 18% of Virginia's total production. In fact, a 40% decrease in production for western Virginia is the same as a 33% decrease in Virginia's total milk production in 1994. Based on these results, Virginia

Table 5-12: Percentage Change In Virginia's Production Level At Cost Of Production Increases Of 10%, 12.25%, 15%, 20%, 22.5%, and 25%

	% Increase In COP Per Cwt (Costs Per Cwt.)					
	10% ($11.66)	12.25% ($11.92)	15% ($12.19)	20% ($12.72)	22.5% ($12.98)	25% ($13.25)
PF = 5%						
SW VA	5.00	5.00	5.00	5.00	5.00	5.00
E VA	5.00	5.00	5.00	5.00	5.00	5.00
W VA	5.00	5.00	5.00	5.00	5.00	-39.81
PF =15%						
SW VA	15.00	15.00	15.00	15.00	15.00	15.00
E VA	15.00	15.00	15.00	15.00	15.00	15.00
W VA	15.00	15.00	15.00	15.00	-30.75	-61.20
PF =30%						
SW VA	30.00	30.00	30.00	30.00	-100.00	-100.00
E VA	30.00	30.00	30.00	30.00	-100.00	-100.00
W VA	30.00	30.00	-62.04	-100.00	-100.00	-100.00

producers can remain competitive in the short-run with a cost per cwt. up to $12.98 (Table 5-12). Once Virginia producers' costs are increased by 25%, the NDM finds less expensive milk in surrounding states and decreases milk production in Virginia.

When the production factor is increased to 15%, the NDM becomes less constrained by allowing states to increase production up to 115% of 1994 production levels. One can think of a 15% production factor as an intermediate time period between the short-run where a farm has fixed and variable costs and the long-run where all costs are variable. In the intermediate time period where the production factor is 15%, western Virginia experiences a 30.75% decrease in production if costs are increased by 22.5% (Table 5-12). At a cost of $12.72 per cwt., all three production regions in Virginia increase milk supply by 15%. If cost per cwt. are 2.5% higher, the NDM reduces output from Virginia's largest production region. With a less constrained NDM, Virginia producers are no longer competitive with cost of $12.98 per cwt. In a marketing environment where surrounding states are producing milk at a cost less than $12.98 per cwt., Virginia producers remain competitive only if they adopt new technologies that decrease cost per cwt. to $12.72 (Table 5-12).

If a production factor of 15% represents an intermediate time period, then a simulation with a 30% production factor should be interpreted as a long-run situation where production decisions are not constrained by fixed costs. If producers are less constrained and can respond to market signals more quickly, the results of the NDM indicate that Virginia producers are competitive only when cost per cwt. are $11.92 or less (Table 5-12). If costs increase by more than 12.25%, total production in western Virginia is reduced by approximately 62%, which is equivalent to a 51% decrease in Virginia's total 1994 production.

Based on the results of the sensitivity analysis, Virginia producers can remain competitive in the short-run with current operating conditions at costs up to $12.98 per cwt. In the long-run, low-cost producers in other states can respond more quickly to market signals and milk production will decrease in Virginia if cost per cwt. remains at or above $12.98. In fact, the results of the sensitivity analysis indicate that Virginia producers must obtain a cost per cwt. less than or equal to $11.92 if they are going to remain competitive in the long-run.

Because the NDM is a static mathematical programming model, these cost estimates indicate Virginia producers' competitiveness in a deregulated market where technology on farms across other states is held constant. To arrive at the cost estimates of $11.92 and $12.98, Virginia producers' costs are increased while the cost per cwt. for producers in other states is unchanged. In the long-run, Virginia producers can remain competitive as long as relative cost differences with surrounding states do not increase by more than 12.25%. If for some reason Virginia costs increase by more than 12.25% and cost of production in North Carolina, Pennsylvania, and Maryland remains unchanged, Virginia's share of national milk production may decrease. A relative change in cost of production of 12.25% is unusual for the dairy industry. Changes in the costs of labor, feed, hauling, and other inputs affect producers similarly across production regions. One area that does have the potential to increase Virginia producers' relative cost of production is compliance with increased environmental enforcement. Because the majority of Virginia production occurs in environmentally sensitive areas, stringent environmental policies could impact Virginia producers' competitiveness relative to surrounding states.

Spatial Scenario

The spatial scenario is used to determine what states would produce milk if costs of production are assumed to be equal across states. The spatial scenario is simulated with the same marketing conditions outlined in Scenario I. In order to assess the impacts on the solution at different degrees of flexibility, the spatial scenario is evaluated with production factors of 5%, 15%, and 30%. A comparison of the results from both the spatial scenario and Scenario I should provide information about the importance of a state's location advantages versus the costs of production advantages.

The formulation of models in the spatial scenario is the same as the NDM (equations (4-3) through (4-12)), except that equation (4-5) is removed from the NDM and the variable COP_A is omitted from the objective function. Essentially, COP_A is assumed equal to zero across states. The new objective function in the spatial models minimizes transportation costs of dairy products from supply points to consumers. The final difference in the spatial models involves exports. Total export demand for U.S. dairy products is assumed to be zero in the spatial models. After these modifications are made to the NDM, the only variables that influence the optimum solution in the spatial scenario are the costs of transporting fluid and manufactured products to domestic consumers.

Base Run

The purpose of the base run is to replicate 1994 production patterns in a scenario that is concerned only with transportation costs of dairy products. The results of this simulation are a benchmark that can be used for comparison with the results from the other spatial models. Because the base model's production factor is one, total production capacity is 150,561 million pounds, which is the same as the market areas' total milk equivalent demand for dairy products. To satisfy this level of demand, the base model is specified so that each market area produces the equivalent of its 1994 production

The results of the base model show that the *TMC* is $563.45 million, which is substantially less than *TMC* in Scenarios I, II, and III. The reason for the smaller *TMC* is that costs of producing milk are not included in the spatial model. The market share and percentage of fluid and manufactured shipments for each state are listed in Table 5-13. The percentage of total production for each area is the same as the state's 1994 market share. The percentage of fluid and manufactured shipments are generally consistent with the base results of Scenario I-3. The minor differences can be attributed to the fact that the spatial scenario does not have any exports. Even without cost of production, only one combination of production levels across states can result in an optimal solution for the base model. Because of this constraint, the solutions to the base models of Scenario I-3 and the spatial scenario are almost identical.

Results With Varying Production Factors

In these spatial models, the only difference from the base run is that the production factor is increased. By increasing the production factor, a degree of flexibility is allowed into the solution. As in the previous scenarios, the results of the spatial models indicate that as the production factor increases, the *TMC* is steadily reduced: $531.7 million for a 5% production increase, $496.6 million for a 15% production increase, and $469.1 million for a 30% production increase. The percentage change in market share and the percentage of fluid and manufactured shipments for spatial models with varying production factors are presented in Table 5-14.

When the production factor is 5%, the NDM identifies two regions that have a decrease in milk production: (1) California and (2) Washington. The decrease in milk supply relative to

Table 5-13: Production Levels, Fluid and Manufactured Shipments By State For Base Run Of the NDM With Only Transportation Cost

State	Share Of Total Production (%)	Fluid Shipments (%)	Manufactured Shipments (%)
AL	0.33	100.00	0.00
AZ	1.39	55.40	44.60
AR	0.49	75.80	24.20
CA	16.30	28.90	71.10
CO	1.02	58.20	41.80
CT	0.35	100.00	0.00
DE	0.09	100.00	0.00
FL	1.71	100.00	0.00
GA	1.04	100.00	0.00
ID	2.45	6.50	93.50
IL	1.66	100.00	0.00
IN	1.47	100.00	0.00
IA	2.58	17.00	83.00
KS	0.72	100.00	0.00
KY	1.30	93.80	6.20
LA	0.60	100.00	0.00
ME	0.42	46.70	53.30
MD	0.86	99.30	0.70
MA	0.29	100.00	0.00
MI	3.61	40.70	59.30
MN	6.09	11.40	88.60
MS	0.48	99.20	0.80
MO	1.77	52.20	47.80
MT	0.20	63.20	36.80
NE	0.72	34.50	65.50
NV	0.27	0.00	100.00
NH	0.20	100.00	0.00
NJ	0.22	100.00	0.00
NM	2.17	11.10	88.90
NY	7.44	0.00	100.00
NC	0.96	100.00	0.00
ND	0.57	0.00	100.00
OH	2.95	61.90	38.10
OK	0.83	100.00	0.00
OR	1.12	40.30	59.70
PA	6.67	90.10	9.90
RI	0.02	100.00	0.00
SC	0.27	100.00	0.00
SD	1.04	20.40	79.60
TN	1.28	54.60	45.40
TX	4.06	66.30	33.70
UT	0.93	29.20	70.80
VT	1.60	53.70	46.30
SW VA	0.06	100.00	0.00
E VA	0.16	100.00	0.00
W VA	1.03	64.50	35.50
WA	3.39	22.70	77.30
WV	0.18	100.00	0.00
WI	14.60	0.00	100.00
WY	0.06	0.00	100.00

Table 5-14: Production Levels, Fluid and Manufactured Shipments By State For the NDM With Only Transportation Cost and 5%, 15%, and 30% Production Increases

State	% Change In Total Production			Fluid Shipments (%)			Manufactured Shipments (%)		
	PF=5	*PF*=15	*PF*=30	*PF*=5	*PF*=15	*PF*=30	*PF*=5	*PF*=15	*PF*=30
AL	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
AZ	5.00	15.00	30.00	52.80	48.20	42.60	47.20	51.80	57.40
AR	5.00	15.00	30.00	72.20	65.90	58.30	27.80	34.10	41.70
CA	-15.92	-25.65	-26.11	34.40	38.90	39.10	65.60	61.10	60.90
CO	5.00	15.00	30.00	55.50	50.60	44.80	44.50	49.40	55.20
CT	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
DE	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
FL	5.00	15.00	30.00	100.00	100.00	87.20	0.00	0.00	12.80
GA	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
ID	5.00	-69.84	-80.75	6.20	21.60	33.80	93.80	78.40	66.20
IL	5.00	15.00	30.00	100.00	92.60	71.70	0.00	7.40	28.30
IN	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
IA	5.00	15.00	30.00	16.20	14.80	13.10	83.80	85.20	86.90
KS	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
KY	5.00	15.00	30.00	76.70	50.60	34.30	23.30	49.40	65.70
LA	5.00	15.00	30.00	100.00	96.40	85.20	0.00	3.60	14.80
ME	5.00	15.00	30.00	44.50	40.60	35.90	55.50	59.40	64.10
MD	5.00	15.00	30.00	94.60	86.30	76.40	5.40	13.70	23.60
MA	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
MI	5.00	15.00	30.00	38.80	35.40	31.30	61.20	64.60	68.70
MN	5.00	-43.66	-70.91	10.80	20.20	39.10	89.20	79.80	60.90
MS	5.00	15.00	30.00	88.40	74.30	65.80	11.60	25.70	34.20
MO	5.00	15.00	30.00	45.50	37.90	33.50	54.50	62.10	66.50
MT	5.00	15.00	30.00	60.20	55.00	48.60	39.80	45.00	51.40
NE	5.00	15.00	30.00	32.90	30.00	26.60	67.10	70.00	73.40
NV	5.00	10.09	-100.00	0.00	0.00	—	100.00	100.00	—
NH	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
NJ	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
NM	5.00	15.00	30.00	10.50	9.60	8.50	89.50	90.40	91.50
NY	5.00	15.00	30.00	0.00	0.00	0.00	100.00	100.00	100.00
NC	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
ND	5.00	-100.00	-100.00	0.00	—	—	100.00	—	—
OH	5.00	15.00	30.00	58.70	53.00	46.20	41.30	47.00	53.80
OK	5.00	15.00	30.00	100.00	91.70	71.10	0.00	8.30	28.90
OR	5.00	3.01	3.01	38.40	39.10	39.10	61.60	60.90	60.90
PA	5.00	15.00	30.00	85.40	77.30	67.40	14.60	22.70	32.60
RI	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
SC	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
SD	5.00	15.00	3.67	19.40	17.70	19.70	80.60	82.30	80.30
TN	5.00	15.00	30.00	37.40	12.90	0.30	62.80	87.10	99.70
TX	5.00	15.00	30.00	63.10	57.60	51.00	36.90	42.40	49.00
UT	5.00	15.00	4.80	27.90	25.40	27.90	72.10	74.60	72.10
VT	5.00	15.00	30.00	49.60	42.50	33.80	50.40	57.50	66.20
SW VA	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
E VA	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
W VA	5.00	15.00	30.00	60.00	52.10	42.60	40.00	47.90	57.40
WA	-41.89	-41.89	-41.89	39.10	39.10	39.10	60.90	60.90	60.90
WV	5.00	15.00	30.00	100.00	100.00	100.00	0.00	0.00	0.00
WI	5.00	15.00	-22.52	0.00	0.00	0.00	100.00	100.00	100.00
WY	5.00	15.00	30.00	0.00	0.00	0.00	100.00	100.00	100.00

the base level is 15.92% for California and 41.89% for Washington (Table 5-14). Because the shadow prices in the base solution for these two areas are positive and very large (i.e., CA = 13,162 and WA = 14,310), one should not be surprised that supply in these areas is reduced when the NDM becomes less constrained. Except for California and Washington, whose shadow prices are zero in the simulation when the production factor is 5%, the shadow prices for the remaining market areas are negative. For a minimization model, a negative shadow price for a state indicates that the objective function can be reduced as production is increased in that state. To account for the decrease in production from California and Washington, the remaining 48 supply areas increase production by 5%.

With a production factor of 15%, not only do California and Washington show a reduction in market share, but so do Idaho, Minnesota, and North Dakota (Table 5-14). Washington's reduction in market share remains at 41.89%, while California's decrease in market share climbs to 25.65%. The decrease in total production for the other states is (1) Idaho: 69.84%, (2) Minnesota: 43.66%, and (3) North Dakota: 100%. As expected, the shadow prices for these states in the model with a 5% production factor are some of the lowest, negative numbers. Of the remaining states, Nevada and Oregon are the only two areas that do not increase milk supply by 15% (Table 5-14).

The final simulation in the spatial scenario is a model where the production factor is increased to 30%. With a 130% production capacity, a total of seven market areas show a decrease in total production (Table 5-14). In addition to the five areas that decrease supply at a production factor of 15%, the results indicate that Nevada and Wisconsin also relinquish market share as the production factor is increased to 30%. Some of the largest decreases in quantity supplied belong to Idaho (80.75%), Minnesota (70.91%), Nevada (100%), and North

Dakota (100%). The shadow prices from the simulation with a 15% production factor reveal that Nevada had a shadow price of zero while Wisconsin's shadow price of -5.60 is the lowest of all negative shadow prices. With the exception of Oregon, South Dakota, and Utah, the remaining states increase production by 30% (Table 5-14).

The changes in total production from these spatial models reveal a definite pattern in what market areas should reduce or expand milk production when the decision criteria is transportation costs. In each of the models, the *TMC* is minimized by reducing production in market areas that are distant from major consumption centers and that have a small percentage of fluid shipments. In general, these market areas are major production regions located in the Pacific Northwest, West, and Upper Midwest. California, Washington, Idaho, Minnesota, and Wisconsin are five large supply regions that consistently lose production in the spatial scenario. As market share is reduced in these regions, the milk supply is increased in production regions that are east of the Rocky Mountains and near the majority of the U.S. population.

When the results of both the spatial scenario and Scenario I-3 are compared, one can determine if a state's competitive advantage is based on location and/or costs of production. For example, the results of Scenario I-3 indicate that the milk supply in Nevada, California, and Wisconsin increases as the NDM becomes more flexible. In contrast, the spatial scenario reduces milk production in these states. Based on these results, the costs of production advantages in Nevada, California, and Wisconsin clearly outweigh any disadvantages these states might encounter as a result of location. On the other hand, a comparison of the results identifies some states that have location advantages which are overshadowed by high costs of production. Some of these states are Florida, Iowa, Michigan, and North Carolina. In the cases of Idaho, Minnesota, and Washington, the results of both scenarios verify that these states are competitively disadvantaged because of location and/or costs of production. In both the NDM and the spatial model, the Virginia production areas increase production by the maximum allowable percentage. Based on these results, Virginia producers have both cost of production advantages and location advantages.

CHAPTER 6
SUMMARY AND CONCLUSIONS

Summary

As a result of changes in federal and state policy and increasing costs of production, Virginia dairy producers are being subjected to an unstable operating environment. The general objective of this study is to analyze Virginia producers' competitiveness in an industry that is undergoing deregulation, increasing environmental enforcement, and rising costs of production. Assuming that milk handlers operate in a competitive output market, the location of milk production in a deregulated market will be determined primarily by dairy producers' costs of production and the industry's transportation costs of shipping dairy products to the consumer. In this study, the empirical model is developed around these two cost variables. The competitiveness of Virginia dairy producers is examined in a National Dairy Model (NDM) that compares both costs of production across market areas and spatial relationships among producers and consumers. The NDM is a mathematical programming model that minimizes the total costs of producing milk and the assembly costs of shipping dairy products to the final consumer.

A state's total costs of production in the NDM is determined with a translog cost function. The cost functions are estimated with data collected in the 1989 and 1993 dairy versions of the Farm Costs and Returns Survey (FCRS). The supply and demand data in the NDM are annual data for 1994. Transportation costs are determined with current hauling rates and actual mileage between supply and demand points. Once the cost of production and spatial components of the NDM are formulated, the NDM is solved using the General Algebraic Modeling System (GAMS).

The NDM is evaluated under the guidelines of several different scenarios. For example, some alternative marketing scenarios that provide important information about the future of the dairy industry are (1) simulations where the hauling rates are varied, (2) alternative scenarios in which the U.S. becomes a major participant in the export market, and (3) situations where the marketing environment leads to increasing costs of production. Another scenario involves only the spatial dimension of the NDM.

Given the current marketing conditions in the dairy industry, the results of the NDM indicate that Virginia dairy producers are competitive in a marketing environment where the location of milk production is determined by a producer's costs of production and location advantages. Using Virginia's translog cost function, the cost per cwt. at the mean of the FCRS production data is $10.60. The cost estimate applies to Virginia's representative dairy farm where the average herd size is 91 cows and production per cow is 14,160 pounds. With these estimates and the fact that Virginia producers are near large population centers, the results of the NDM show that Virginia dairy farms are competitive with farms in the surrounding states.

Although Virginia producers are competitive at a cost estimate of $10.60 per cwt., sensitivity analysis is conducted to determine how much cost per cwt. can increase before the NDM reduces production in Virginia. Factors that could be responsible for increasing costs of production include new investments needed to comply with environmental regulations and rising costs of feed inputs. Based on the results of the sensitivity analysis, Virginia producers can remain competitive in the short-run at a cost as high as $12.98 per cwt. In the long-run, however, low-cost producers in other states can respond more quickly to market signals and milk production will decrease in Virginia if cost per cwt. remains at $12.98. In fact, the results of the sensitivity analysis indicate that Virginia producers cannot let costs increase above $11.92 per cwt. if they are going to remain competitive in the long-run. These cost estimates are obtained by assuming constant technology on farms in other states. As producers lower costs by adopting new technology, the competitiveness of Virginia dairy producers at different cost per cwt. will need to be reevaluated.

Other areas that benefit from a deregulated market are the low-cost producers in California, Wisconsin, Texas, New Mexico, Pennsylvania, and New York. As the NDM becomes less constrained, these states and many others increase market share as milk supply is reduced in the high-cost producing states. According to the results of the NDM, some states that are not competitive in a deregulated market are Florida, Iowa, Michigan, Minnesota, North Carolina, and Washington. In general, these areas are not competitive due to regional competition from low-cost producers in surrounding states.

In scenarios where the hauling rates are varied, Virginia producers still remain competitive with farms in the surrounding states. In fact, only a few states are affected by changes in hauling rates. For example, when the fluid hauling rate is reduced, Florida and Vermont suffer a considerable loss in total production. With a lower hauling rate, less expensive sources of fluid milk are, in terms of costs, closer to consumers in the Florida and Vermont markets. In the scenario where all hauling rates are increased by 25%, Florida and New Hampshire increase production while the NDM reduces milk supply in Colorado, Idaho, and Vermont.

In the current marketing environment where total exports are 3% of commercial disappearances, the NDM identifies California and Wisconsin as the dominant exporting states.

If the percentage of total exports increases as a result of NAFTA and/or GATT, the NDM then ships a large amount of export products from Minnesota, Texas, and Washington, as well as from California and Wisconsin. Regardless of the simulation, Virginia produced milk is never shipped to the export market.

The spatial scenario determines what states would produce milk if costs of production were assumed to be equal across states. A comparison of the results with other scenarios provides information about the importance of a state's location advantages versus the costs of production advantages. Based on the results of the NDM, costs of production advantages in Nevada, California, and Wisconsin clearly outweigh any disadvantages these states might encounter as a result of location. On the other hand, the location advantages of Florida, Iowa, Michigan, and North Carolina are overshadowed by the relatively high costs of production in these states. In the cases of Idaho, Minnesota, and Washington, the results confirm that these states are competitively disadvantaged because of location and/or costs of production. Virginia producers are competitive because of both location and costs of production.

Conclusions

The results of this study indicate that milk production in a deregulated market will be dominated by low-cost producing states. Some of these states are Arizona, California, New York, Texas, and Wisconsin. Although Virginia is not thought of as a major dairy state with low costs of production, Virginia producers in a deregulated market are competitive with other producers in nearby states. The spatial relationships of the dairy industry create regional market boundaries. Even with a NDM, the results of the model are based on relative costs differences between states in the same region. Although Virginia is competitive with states like

Pennsylvania, Ohio, Kentucky, Tennessee, and North Carolina, Virginia producers would be at a competitive disadvantage if they were in direct competition with producers in California and Wisconsin.

From the results of the NDM, shadow prices can also be used to develop some conclusions regarding how competitive states are on a relative basis. In the mathematical programming model, the shadow prices indicate how much the objective function will decrease if production is increased by one unit for a particular state. Table 6-1 shows the ranking of each state according to shadow prices on quantity of milk produced. The shadow prices are from the simulation where costs per cwt. are set at the mean, exports are 3% of commercial disappearances, and hauling rates are based on 1994 conditions. Of all the simulations in the study, this simulation, Model A of Scenario I-3, is most representative of the current operating environment and cost structure within the U.S. dairy industry.

The ranking of the shadow prices in Table 6-1 indicates the order in which the NDM will increase production if each state is allowed to increase total supply by one additional unit. According to the rankings, the Eastern and Southwestern Virginia markets are the #4 and #5 production areas, respectively, to increase supply when the production factor is increased in the NDM. The Western Virginia region, which is the largest production area in Virginia, is ranked #10. These shadow prices not only indicate that Virginia producers are competitive in a deregulated market, but the rankings also suggest that the Virginia dairy industry is a top 10 state in terms of being able to produce and ship dairy products to consumers at the lowest cost. Other states in the top 10 are California, Illinois, Kentucky, Nevada, Ohio, and West Virginia. As expected, some of the high-cost producing states that are not competitive include Florida, Michigan, Minnesota, North Carolina, Oregon, and Washington.

Table 6-1: Ranking Of Shadow Prices By State Given 1994 Marketing Conditions, 3% Export Level, and 5%, 15%, and 30% Production Increases[1]

State	5% Production Increase	15% Production Increase	30% Production Increase
AL	25	25	23
AZ	15	15	18
AR	19	18	16
CA	7	7	7
CO	32	33	34
CT	26	26	28
DE	9	9	9
FL	43	42	41
GA	24	24	13
ID	35	35	36
IL	1	1	1
IN	18	21	22
IA	48	NP	NP
KS	12	13	17
KY	3	3	2
LA	36	39	38
ME	NP	NP	NP
MD	11	10	11
MA	NP	NP	NP
MI	47	47	NP
MN	44	46	NP
MS	40	41	40
MO	41	40	39
MT	33	32	32
NE	28	28	27
NV	6	6	6
NH	39	38	NP
NJ	21	20	24
NM	14	12	15
NY	23	23	25
NC	42	45	NP
ND	31	29	31
OH	8	8	8
OK	17	17	17
OR	45	43	42
PA	30	31	33
RI	13	14	14
SC	22	22	20
SD	27	27	26
TN	38	37	30
TX	16	16	19
UT	34	34	35
VT	37	36	37
SW VA	5	5	5
E VA	4	4	4
W VA	10	11	10
WA	46	44	43
WV	2	2	3
WI	20	19	21
WY	29	30	29

[1] NP=No Production; Total supply in a state is reduced by 100%. Rankings are from high to low shadow prices

As advancements are made in technologies like reverse osmosis, the market boundaries created by the spatial dimension of the dairy industry begin to expand. As these boundaries expand, Virginia producers may experience increased competition from low-cost producers in the Upper Midwest, Southern Plains, or Pacific regions. In a marketing environment of increased competition, the results of the NDM indicate that Virginia producers can remain competitive in the long-run if cost per cwt. are below \$11.92. If Virginia producers' cost of production increases by more than 12.25% relative to surrounding states, Virginia's total milk production in a deregulated market may decrease.

The results of the study also lead to some conclusions about the effectiveness of dairy programs in achieving a competitive equilibrium. The objective function of the NDM is to minimize Total Marketing Cost (*TMC),* which is defined as the sum of each state's cost of production and transportation cost from shipping dairy products to the final consumer. Because the base runs of the NDM are designed to replicate 1994 production levels, the objective values from these simulations can be interpreted as the *TMC* in a regulated dairy industry. As the production factor is increased and the NDM becomes more flexible, the *TMC* is representative of the cost of producing and shipping dairy products in a competitive market that is not constrained by federal and state policies. Table 6-2 compares the *TMC* from Model A given 1994 hauling rates, 3% exports, and 5%, 15%, and 30% production factors (i.e., Scenario I-3). The reason for comparing *TMC* from Model A of Scenario I-3 and not other variations of the NDM is that this simulation reflects the current operating environment and cost structure on farms throughout the U.S. dairy industry by using the mean cost per cwt.

With the geographic distribution of milk production in 1994, the NDM returns a *TMC* of \$18.1 billion, or \$12.02 per cwt. of milk produced in 1994. The \$12.02 per cwt. represents

Table 6-2: Comparative Analysis Of Total Marketing Cost From the NDM Given 1994 Marketing Conditions, 3% Export, and 5%, 15%, and 30% Production Increases[1]

	Base Run	5% Production Increase	15% Production Increase	30% Production Increase
Actual Value In Billions of $	$18.1 ($12.02)	$17.9 ($11.89)	$17.7 $(11.76)	$17.4 ($11.56)
Difference From Base Run In Millions of $		$200 ($0.13)	$400 ($0.26)	$700 ($0.46)
Percentage Change Relative to Base Run		-1.10%	-2.21%	-3.87%

[1] **Values in ( ) are dollars per cwt. of 1994 national milk production.**

the cost of producing and shipping milk to consumers in a regulated dairy industry. As a competitive market is simulated with the NDM, the *TMC* is reduced up to 3.87%, or $700 million dollars ($0.46 per cwt.). The $700 million dollar decrease in *TMC* should be interpreted as the annual costs of a regulated dairy industry. If these costs are passed along to consumers, the prices of a gallon of whole milk and a pound of cheddar cheese could be as much as $0.04 and $0.05 higher, respectively. Based on domestic per capita consumption of fluid and manufactured dairy products in 1994 (i.e., 371 pounds of milk equivalent manufactured products and 238 pounds of fluid products), the annual cost of dairy regulation could be $2.80 per person, or $11.20 for a family of four.

Based on the results in Table 6-2, dairy policies appear to have been fairly effective in achieving a cost-efficient distribution of milk production, a "solution" not markedly different from what would be expected in a competitive market. In the most flexible version of the NDM, the *TMC* is reduced by only 3.87%, or $700 million, from the base solution. From a budget perspective, dairy programs have cost the consumers about $2.80 per person per year. Even though dairy programs may have been reasonably successful at approximating a competitive equilibrium in the dairy market, the future of Federal Milk Marketing Programs and price supports may depend on whether consumers and policy makers view $700 million as a significant amount of money. In the meantime, Virginia has a viable dairy industry that can compete in a less regulated market.

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APPENDIX A
SAS OUTPUT AND SAMPLE PROGRAM

The first section of Appendix A includes the SAS output from the translog cost models. Because the study uses both 1993 and 1989 data, there are two sections with detailed results from the econometric model. The final section of Appendix A includes the SAS program that is used to estimate translog cost functions with the FCRS data.

Parameter Estimates From 1993 Data

```
                       1993 PRODUCTION COSTS OF DAIRY OPERATIONS,
                                BY CASH COST GROUP, 1993

                   NASS AND PCCARP STATISTICS FOR STRATIFIED RANDOM SAMPLES

                       ******* VARIANCE, CVS, AND DEFF OF MEANS *******

                        T          N          SW    NSTRAT       NSEG          K
                       695       1016     105230        67        695         38

                                                                DF
                                 DEGREES OF FREEDOM=           628


                                  REGRESSION COEFFICIENT ESTIMATES
                                     DEPENDENT VARIABLE=LHS

              L                      BWLS           SEBWLS          TSTATS            PROB1

Translog Parameter Estimates
              INTERCEPT      -0.51980223       5.0334866  -0.1032688221         0.4588913
              B1T            -0.32568250       0.9337119  -0.3488040782         0.3636767
              B2T             0.85434133       0.5328431   1.6033638718         0.0546786
              B1YT            0.10057499       0.0645084   1.5591002896         0.0597382
              B2YT            0.02077324       0.0355395   0.5845116031         0.2795430
              B11T            0.02661351       0.1128624   0.2358048774         0.4068305
              B12T            0.08524890       0.0693288   1.2296314174         0.1096478
              B22T            0.06567688       0.0403746   1.6266899562         0.0521523
              LOUTPUT         1.15679856       0.6480467   1.7850543841         0.0373675
              BYYT            0.03201100       0.0531307   0.6024950375         0.2735311

Intercept Dummy Variables
              PA             -1.49346828       1.5555618  -0.9600828773         0.1686915
              VT             -0.35427892       1.4280113  -0.2480925297         0.4020720
              OH              0.20202090       2.5661311   0.0787258694         0.4686379
              GA              1.99400020       1.7917624   1.1128709025         0.1330948
              FL             -0.49838573       2.1855150  -0.2280404074         0.4098445
              MN             -0.47127027       0.7770636  -0.6064758022         0.2722090
              WI              0.31681714       1.1553678   0.2742132258         0.3920055
              MI             -1.05239852       0.9587748  -1.0976493685         0.1363892
```

```
                     MO            -0.73855566       1.5937797  -0.4633988331          0.3216195
                     IA            -2.22904059       1.1157240  -1.9978422144          0.0230823
                     TX            -0.58589493       1.8375292  -0.3188493128          0.3749734
                     AZ             0.77308392       2.7185611   0.2843724644          0.3881093
                     CA             1.13910629       1.4837263   0.7677334527          0.2214671
                     WA            -1.75510308       1.4740461  -1.1906704305          0.1171164

 Slope Dummy Variables
                     PAS            0.10610963       0.1125624   0.9426742584          0.1731050
                     VTS            0.02247565       0.1028229   0.2185861083          0.4135217
                     OHS           -0.02703543       0.1893190  -0.1428035587          0.4432456
                     GAS           -0.15410552       0.1244107  -1.2386840124          0.1079627
                     FLS            0.01207567       0.1505928   0.0801876007          0.4680568
                     MNS            0.04421044       0.0568709   0.7773830199          0.2186128
                     WIS           -0.00566055       0.0845603  -0.0669409373          0.4733250
                     MIS            0.06533132       0.0698033   0.9359341674          0.1748334
                     MOS            0.03560277       0.1180026   0.3017117695          0.3814858
                     IAS            0.16152038       0.0819062   1.9720176755          0.0245230
                     TXS            0.01753138       0.1273660   0.1376457166          0.4452823
                     AZS           -0.06653420       0.1803191  -0.3689803693          0.3561334
                     CAS           -0.08675632       0.1036494  -0.8370173466          0.2014506
                     WAS            0.09303490       0.1020948   0.9112601539          0.1812540

                            F-TEST FOR ALL MODEL PARAMETERS (EXCEPT INTERCEPT) =0

                                        F       DF1        DF2            PROB
                               237.50208         37        628  0.000000000000

                                                                 SV2
                                       RESIDUAL MEAN SQUARED= 0.1164904
                                                                  R2
                                     ESTIMATED R-SQUARED=    0.857890091
```

Parameter Estimates From 1989 Data

```
                                      1989 PRODUCTION COSTS OF DAIRY OPERATIONS,
                                          BY CASH COST GROUP, 1993

                           NASS AND PCCARP STATISTICS FOR STRATIFIED RANDOM SAMPLES

                               ******* VARIANCE, CVS, AND DEFF OF MEANS *******


                                  T          N        SW    NSTRAT       NSEG          K
                                307        499 14011.639        42        307         32


                                                                     DF
                                       DEGREES OF FREEDOM=          265


                                                 REGRESSION COEFFICIENT ESTIMATES
                                              DEPENDENT VARIABLE=LHS

                     L                   BWLS           SEBWLS          TSTATS           PROB1

 Translog Parameter Estimates
                    INTERCEPT    -8.48198407        6.8879333  -1.2314265763          0.1096275
                    B1T          -2.80393028        0.6003363  -4.6705993796          0.0000024
                    B2T          -0.17629242        0.8877673  -0.1985795454          0.4213720
                    B1YT          0.11752296        0.0457904   2.5665411015          0.0054109
                    B2YT          0.03399111        0.0493642   0.6885782837          0.2458455
                    B11T         -0.14848739        0.1249647  -1.1882346872          0.1179024
                    B12T         -0.05852573        0.0550339  -1.0634495290          0.1442731
                    B22T          0.06023388        0.0436216   1.3808276706          0.0842477
                    LOUTPUT       0.43538716        0.7334698   0.5935992771          0.2766432
                    BYYT          0.11232891        0.0508845   2.2075252297          0.0140672

 Intercept Dummy Variables
```

```
                    CT             1.35671122       2.2565123   0.6012425648         0.2740962
                    ID             2.20217544       2.1948753   1.0033260083         0.1583094
                    IL             0.50010203       2.0710461   0.2414731496         0.4046876
                    IN             2.17178209       1.7767052   1.2223648811         0.1113279
                    KY             0.00907967       1.8595714   0.0048826681         0.4980539
                    ME            -0.73274868       1.7424847  -0.4205194465         0.3372234
                    MA             1.41740568       2.6993993   0.5250818937         0.2999826
                    NH            -1.66112671       1.7509799  -0.9486840283         0.1718228
                    NC             4.53887748       1.5742929   2.8831213433         0.0021303
                    SD            -1.01016156       1.9470633  -0.5188129107         0.3021621
                    TN             4.90203415       1.6810783   2.9160059021         0.0019244

Slope Dummy Variables
                    CTS           -0.09576198       0.1590411  -0.6021208050         0.2738043
                    IDS           -0.15221513       0.1534255  -0.9921112924         0.1610241
                    ILS           -0.04303192       0.1468972  -0.2929389438         0.3848990
                    INS           -0.16393391       0.1260232  -1.3008229883         0.0972245
                    KYS           -0.00324840       0.1332916  -0.0243706567         0.4902876
                    MES            0.06430462       0.1246955   0.5156929804         0.3032494
                    MAS           -0.08062715       0.1918522  -0.4202565222         0.3373193
                    NHS            0.12531828       0.1255286   0.9983243626         0.1595164
                    NCS           -0.30659160       0.1109022  -2.7645228249         0.0030504
                    SDS            0.08050832       0.1395620   0.5768642435         0.2822604
                    TNS           -0.34687889       0.1201566  -2.8868893888         0.0021057

                              F-TEST FOR ALL MODEL PARAMETERS (EXCEPT INTERCEPT) =0

                                             F        DF1        DF2            PROB
                                      200.4162         31        265  0.000000000000


                                          RESIDUAL MEAN SQUARED= 0.0757752


                                                                              R2
                                           ESTIMATED R-SQUARED=     0.920918376
```

Sample SAS Program

```
OPTIONS OBS=MAX;
LIBNAME DAIRY93 'X:\DAIRY\1993DATA';


*****************************************************************;
*   PROGRAM TO GENERATE PER CWT OF MILK SOLD PRODUCTION COSTS   *;
*           FOR FARMS DIVIDED ACCODING TO A BY VARIABLE.         *;
*                                                                *;
*                        DSN = COST.SAS                          *;
*****************************************************************;
%LET BYVAR    = CCGROUP;              /*  CONTROL STATEMENTS   */
%LET BYLAB    = CASH COST GROUP;      /*  FOR TYPE OF ANALYSIS */
*****************************************************************;
%LET CLASOLD  = SUMSTATE REG;
%LET ANALOLD  = COWS CWT_SOLD GROSSR MILK_TR CATTLE OTHINC
                COSTCONC COSTBYPD COSTLQWH COSTHAYS COSTSILG
                COSTPAST COSTVETM COSTAI COSTDHIA COSTHAUL
                COSTMKT COSTBEDL COSTASMT COSTSERV COSTFUEL
                WFREPA COSTPDL COSTOVER COSTTXIN COSTINT
                COSTUPDL CAPREPL NLCAP CLAND OPCAP P527 COWS COSTPDL;
%LET CLASVARS = &CLASOLD CCGROUP VCGROUP NUMBER AREA;
%LET ANALVARS = &ANALOLD KOUNT COSTFEED COSTVAR COSTFIX COSTCASH
                NCASH COSTECON NECON CWT_SOL1;
%LET WGHT     = EF_V2;
%LET FILE1    = DAIRY93.MILKALL;       /*  FARM-LEVEL INPUT FILE */
```

```
%LET FILE2    = DAIRY93.MILK2;
%LET FILE3    = DAIRY93.MILK3;

TITLE1 " ";
TITLE2 "PRODUCTION COSTS OF DAIRY OPERATIONS,";
TITLE3 "BY &BYLAB, 1993";
*****************************************************************;
*********  COLLECT INFORMATION FROM FARM-LEVEL DATA FILES;
*****************************************************************;
DATA A;
  SET &FILE1
  (KEEP = Q_ID &CLASOLD &ANALOLD &WGHT P122 P526 STATE
          STRATAY  EF_V2 NIJ_V2 MPOPCNT MFRAME ID);

DATA B;
   SET &FILE2
   (KEEP = Q_ID LBSFEED);

DATA C;
   SET &FILE3
   (KEEP =Q_ID PTWAGE FTWAGE);

PROC SORT DATA =A; BY Q_ID;
PROC SORT DATA =B; BY Q_ID;
PROC SORT DATA =C; BY Q_ID;

DATA FILEDAT;
MERGE A(IN=INA) B(IN=INB) C(IN=INC); BY Q_ID;
IF INA;

IF P526>0 AND P122>0 THEN CMHAUL = (P526/100)*P122;
IF P527 > 0 THEN CMHAUL = P527;
  COSTFEED = SUM(COSTCONC,COSTBYPD,COSTLQWH,COSTHAYS,COSTSILG,
                 COSTPAST);

IF CMHAUL<=0 THEN DELETE;
IF COSTFEED<=0 THEN DELETE;
IF FTWAGE<=0 THEN DELETE;

  COSTVAR  = SUM(COSTFEED,COSTVETM,COSTAI,COSTDHIA,COSTHAUL,
                 COSTMKT,COSTBEDL,COSTASMT,COSTSERV,COSTFUEL,
                 WFREPA,COSTPDL);
  COSTFIX  = SUM(COSTOVER,COSTTXIN,COSTINT);
  COSTCASH = SUM(COSTVAR,COSTFIX);
  COSTECON = SUM(COSTVAR,COSTOVER,COSTTXIN,CAPREPL,OPCAP,NLCAP,
                 CLAND,COSTUPDL);
  NCASH    = (GROSSR - COSTCASH);

LBS_SOLD    = CWT_SOLD*100;
PHAUL       = CMHAUL/LBS_SOLD;
PFEED       = COSTFEED/LBSFEED;
PRODCOW     = LBS_SOLD/COWS;
FCPP        = COSTFEED/LBS_SOLD;
LCPP        = COSTPDL/LBS_SOLD;


*** VARIABLES NEEDED IN THE TRANSLOG ***;
LOUTPUT = LOG(LBS_SOLD) ;
LTCOSTS = LOG(COSTCASH);
LPFEED = LOG(PFEED);
LPHAUL = LOG(PHAUL);
LPLABOR = LOG(FTWAGE);
```

```
B1T = LPFEED-LPLABOR;
B2T = LPHAUL-LPLABOR;
B1YT = LOUTPUT*B1T;
B2YT = LOUTPUT*B2T;

SQLPFEED = LPFEED**2;
SQLPLABR = LPLABOR**2;
SQLPHAUL = LPHAUL**2;
SQLOUTPT = LOUTPUT**2;

LPFLPL = LPFEED*LPLABOR;
LPFLPH = LPFEED*LPHAUL;
LPHLPL = LPHAUL*LPLABOR;

B11T   = SQLPFEED/2 - LPFLPL + SQLPLABR/2 ;
B12T   = LPFLPH - LPFLPL - LPHLPL + SQLPLABR ;
B22T   = SQLPHAUL/2 - LPHLPL + SQLPLABR/2 ;
BYYT   = SQLOUTPT*.5;


SHFEED = COSTFEED/COSTCASH;
SHHAUL = CMHAUL/COSTCASH;

LHS = LTCOSTS - LPLABOR;

Z1 = SQLPFEED/2 - LPFLPL + SQLPLABR/2;
Z2 = LPFLPH - LPFLPL - LPHLPL + SQLPLABR;
Z3 = SQLPHAUL/2 - LPHLPL + SQLPLABR/2;

*** INTERCEPT DUMMIES ***;
*** NEW YORK WITH 88 OBS IS THE BASE ***;
PA=0; IF SUMSTATE = 42 THEN PA=1;
VT=0; IF SUMSTATE = 50 THEN VT=1;
OH=0; IF SUMSTATE = 39 THEN OH=1;
GA=0; IF SUMSTATE = 13 THEN GA=1;
FL=0; IF SUMSTATE = 12 THEN FL=1;
MN=0; IF SUMSTATE = 27 THEN MN=1;
WI=0; IF SUMSTATE = 55 THEN WI=1;
MI=0; IF SUMSTATE = 26 THEN MI=1;
MO=0; IF SUMSTATE = 29 THEN MO=1;
IA=0; IF SUMSTATE = 19 THEN IA=1;
TX=0; IF SUMSTATE = 48 THEN TX=1;
AZ=0; IF SUMSTATE = 4  THEN AZ=1;
CA=0; IF SUMSTATE = 6  THEN CA=1;
WA=0; IF SUMSTATE = 53 THEN WA=1;


*** SLOPE DUMMIES *** ;
*** NEW YORK WITH 88 OBS IS THE BASE ***;
PAS = LOUTPUT*PA ;
VTS = LOUTPUT*VT ;
OHS = LOUTPUT*OH ;
GAS = LOUTPUT*GA ;
FLS = LOUTPUT*FL ;
MNS = LOUTPUT*MN ;
WIS = LOUTPUT*WI ;
MIS = LOUTPUT*MI ;
MOS = LOUTPUT*MO ;
IAS = LOUTPUT*IA ;
TXS = LOUTPUT*TX ;
AZS = LOUTPUT*AZ ;
CAS = LOUTPUT*CA ;
WAS = LOUTPUT*WA ;
```

```
DATA STATE;
  SET FILEDAT;

PROC SORT;
BY SUMSTATE;

PROC MEANS N;
WEIGHT EF_V2;
VAR COWS COSTVAR COSTCASH COSTECON LBS_SOLD PHAUL
PFEED FTWAGE PTWAGE PRODCOW LPFEED LPHAUL LPLABOR;
BY SUMSTATE;

*******************************************************************
  PCCARP-TYPE REGRESSION FOR ALL VERSIONS, BOB DUBMAN, SEP 1994
    DO NOT COPY -- SEE BOB DUBMAN FOR THE LATEST EDITION
*******************************************************************;
***** DEFINE THESE VARIABLES ******;
%LET DATA1 = STATE ;
%LET DEPV = LHS;
%LET VARS= B1T B2T B1YT B2YT B11T B12T B22T LOUTPUT BYYT
           PA VT OH GA FL MN WI MI MO IA TX AZ CA WA
           PAS VTS OHS GAS FLS MNS WIS MIS MOS IAS TXS AZS CAS WAS;

          *VERSION>>   *ALL86-93   COPV1    COPV3;
%LET STRATA   = STRATAY ; *STRATA   STRATV1  STRATV3;
%LET EF_VALL = EF_V2   ; *EF_VALL  EF_V1    EF_V3;
%LET NIJ_VALL= NIJ_V2  ; *NIJ_VALL NIJ_V1   NIJ_V3;
%LET POPCNT   = MPOPCNT ; *POPCNT   POP_V1   POP_V3;
%LET FRAME    = MFRAME  ; *FRAME    FRAME    FRAME;
%LET SEGMENT  = ID      ; *SEGMENT  SEGMENT  SEGMENT;

PROC SORT DATA=&DATA1; BY STATE &STRATA &SEGMENT;
DATA &DATA1;SET &DATA1;BY STATE &STRATA &SEGMENT;
M=FIRST.&STRATA+FIRST.&SEGMENT;
PROC IML;USE &DATA1;
  READ ALL VAR{&DEPV} INTO Y;
  READ ALL VAR{&VARS} INTO X;L={&DEPV INTERCEPT &VARS}`;
  READ ALL VAR{&EF_VALL} INTO W;
  READ ALL VAR{&NIJ_VALL} INTO NIJ;
  READ ALL VAR{&FRAME &POPCNT} INTO H;
  READ ALL VAR{M} INTO M;
T=NROW(X);X=Y||J(T,1)||X;K=NCOL(X);SUM1=X`*W;SW=SUM(W);
MEANS=SUM1/SW;NSTRAT=SUM(M>1);NSEG=SUM(M>0);
H=((1-(H(|,1|)=1)#NIJ/H(|,2|))#(1/(NIJ-1)))(|LOC(M>1),|);
NIJ=NIJ(|LOC(M>1),|);N=SUM(NIJ);NSWOS=SUM(NIJ=1);
X1=CUSUM(M>0);X2=CUSUM(M>1);X3=CUSUM(M(|LOC(M),|)>1);
Z=X-REPEAT(MEANS`,T,1);WVAR=(N/(N-1)#W/SW#Z)`*Z;
 WVAR1=VECDIAG(WVAR); *SRS VARIANCES;

START V;V=J(K);US=J(NSTRAT,K,0);UT=J(NSEG,K,0);U=W#U;
DO I=1 TO T;US(|X2(|I,|),|)=US(|X2(|I,|),|)+U(|I,|);
  UT(|X1(|I,|),|)=UT(|X1(|I,|),|)+U(|I,|);END;
DO R=1 TO K;U=J(NSTRAT,K,0);DO I= 1 TO NSEG;
  U(|X3(|I,|),|)=U(|X3(|I,|),|)+UT(|I,R|)#UT(|I,|);END;
V(|R,|)=CHOOSE(REPEAT(NIJ>1,1,K),H#(NIJ#U-US(|,R|)#US),
   US(|,R|)#US)(|+,|);END;V1=VECDIAG(V);SE=SQRT(V1);FINISH;

Print "NASS AND PCCARP STATISTICS FOR STRATIFIED RANDOM SAMPLES",,
  "******* VARIANCE, CVS, AND DEFF OF MEANS *******";
U=Z/SW;RUN V;CV=100*SE/ABS(MEANS);
DEFF=V1/WVAR1*N/(1-(N+1)/SW);*KISH'S DESIGN EFFECT;
*PRINT L MEANS(|F=18.8|) V1(|F=20.1|) SE(|F=9.1|) CV(|F=10.6|)
```

```
 DEFF(|F=6.2|),"VARIANCE-COVARIANCE MATRIX OF MEANS",V(|R=L C=L|),

  "******* VARIANCE, CVS, AND DEFF OF TOTALS *******";
U=X;RUN V;CV=100*SE/ABS(SUM1);
DEFF=V1/WVAR1*N/(1-(N+1)/SW)/SW##2;*KISH'S DESIGN EFFECT;
*PRINT L SUM1(|F=18.8|) V1(|F=20.1|) SE(|F=9.1|) CV(|F=10.6|)
  DEFF(|F=6.2|),"VARIANCE-COVARIANCE MATRIX OF TOTALS",V(|R=L C=L|),,

  "******* REGRESSION ANALYSIS *******";
X=X(|,2:K|);K=K-1;Z=SQRT(W)#X;BWLS=SOLVE(Z`*Z,Z`*(Y#SQRT(W)));
V=Y-X*BWLS;SV2=N/(N-K)*((V##2)`*W)/SW;
R2=1-(N-K)/(N-1)*SV2/WVAR1(|1,|);
U=X#V;RUN V;COVB=SOLVE(Z`*Z,(N-1)/(N-K)*V*INV(Z`*Z));
SEBWLS=SQRT(VECDIAG(COVB));TSTATS=BWLS/SEBWLS;
DF=NSEG-NSTRAT;PROB1=1-PROBT(ABS(TSTATS),DF);
F=(BWLS(|2:K,|)`*INV(COVB(|2:K,2:K|))*BWLS(|2:K,|))/(K-1);
DF1=K-1;DF2=DF;PROB=1-PROBF(F,DF1,DF2);
PRINT T N SW NSTRAT NSEG K," DEGREES OF FREEDOM= " DF,
  "NUMBER OF STRATA WITH ONE SEGMENT= "NSWOS,
  L MEANS(|F=14.4|) WVAR1(|F=14.4|),/*"SRS VARIANCE-"
  "COVARIANCE MATRIX OF REGRESSION VARIABLES",WVAR(|R=L C=L|)*/;
  L=L(|2:K+1,|);PRINT "REGRESSION COEFFICIENT ESTIMATES",
  "DEPENDENT VARIABLE=&DEPV",L BWLS(|F=15.8|) SEBWLS(|F=15.7|)
  TSTATS(|F=14.10|) PROB1(|F=15.7|),/*COVB(|F=12.6 R=L C=L|)*/,
  "F-TEST FOR ALL MODEL PARAMETERS (EXCEPT INTERCEPT) =0",
  F DF1 DF2 PROB (|F=15.12|),"RESIDUAL MEAN SQUARED=" SV2,
  "ESTIMATED R-SQUARED=  "R2(|F=12.9|);

RUN;
QUIT;
```

APPENDIX B
GAMS PROGRAM OF NATIONAL DAIRY MODEL

The GAMS program in this section is for Model B of the National Dairy Model. Model B is a nonlinear math programming model that uses the translog cost function to determine the total costs of production for a marketing area. Model A and C are formulated in GAMS with a similar program.

GAMS Program

```
SETS

DS      domestic production areas                   / 1 * 50 /

DD      domestic consumption areas                  / 1 * 50 /

XP      export areas                                / LA, NO, BA, SE /  ;

PARAMETER BASESPLY(DS) adjusted domestic US supply for 1994 in million pounds

/ 1     490.52
2       2093.55
3       738.73
4       24544.77
5       1533.37
6       520.93
7       139.31
8       2573.28
9       1564.77
10      3682.84
11      2500.68
12      2214.22
13      3886.90
14      1084.05
15      1968.96
16      907.47
17      626.89
18      1293.02
19      441.47
20      5439.9
21      9164.92
22      717.14
23      2668.44
24      301.18
25      1088.96
26      405.17
```

```
27       307.07
28       336.5
29       3261.98
30       11203.54
31       1445.08
32       852.53
33       4434.32
34       1244.95
35       1681.51
36       10036.09
37       31.00
38       403.21
39       1558.88
40       1922.85
41       6107.01
42       1403.88
43       2405.52
44       87.77
45       245.00
46       1554.76
47       5104.38
48       266.84
49       21987.18
50       87.71 /

BASEDEMD(DD) domestic disappearances for 1994 in million pounds

/ 1      2462.46
2        2233.70
3        1432.61
4        18136.69
5        2007.71
6        2003.27
7        405.98
8        7884.78
9        3948.03
10       613.54
11       6966.17
12       3378.78
13       1692.24
14       1509.91
15       2245.94
16       2571.78
17       748.34
18       2913.98
19       3666.60
20       5664.85
21       2666.32
22       1568.20
23       3118.50
24       486.98
25       961.92
26       732.43
27       676.01
28       4711.02
29       923.33
30       10963.95
31       4039.70
32       389.30
33       6610.57
34       1917.02
35       1732.20
36       7241.05
```

```
37      611.54
38      2124.91
39      424.17
40      2972.31
41      10352.11
42      1049.96
43      342.96
44      1855.21
45      1915.56
46      369.86
47      2965.91
48      1093.00
49      2981.21
50      276.43   /

FARMNUM(DS) farm numbers

/ 1     189
2       72
3       280
4       2468
5       827
6       370
7       100
8       210
9       603
10      1987
11      3143
12      3196
13      5114
14      410
15      3492
16      1015
17      827
18      931
19      589
20      5221
21      12229
22      803
23      4393
24      450
25      1627
26      41
27      294
28      327
29      113
30      10878
31      874
32      1274
33      6530
34      471
35      898
36      12191
37      38
38      155
39      2329
40      2152
41      2311
42      758
43      2285
44      63
45      177
46      1119
```

```
47      2727
48      473
49      25227
50      131 /

DATALB(DS) lower range of data in pounds

/ 1     167000
2       4100000
3       318100
4       390600
5       548625
6       570000
7       195200
8       547500
9       167000
10      548625
11      110200
12      66061
13      205900
14      117800
15      97281
16      197923
17      345000
18      90000
19      405978
20      114200
21      177000
22      197923
23      117800
24      189000
25      189000
26      390600
27      245402
28      146000
29      4100000
30      146000
31      200000
32      189000
33      83600
34      117800
35      316200
36      195000
37      195000
38      167000
39      189000
40      197923
41      318100
42      548625
43      195200
44      90000
45      90000
46      90000
47      316200
48      97281
49      136400
50      189000  /

DATAUB(DS) upper range of data in pounds

/ 1     18733300
2       106776500
3       20040100
```

```
4        39605600
5        14800000
6        3000000
7        7026800
8        154272300
9        18733300
10       14800000
11       4796484
12       4600000
13       3701100
14       3326100
15       5342000
16       6360000
17       3021270
18       6000000
19       2501544
20       5364800
21       10400000
22       6360000
23       3326100
24       4404374
25       4404374
26       39605600
27       2000000
28       13000000
29       106776500
30       13000000
31       8400000
32       4404374
33       2466700
34       3326100
35       24000000
36       4014300
37       4014300
38       18733300
39       4404374
40       6360000
41       20040100
42       14800000
43       7026800
44       6000000
45       6000000
46       6000000
47       24000000
48       5342000
49       20833000
50       4404374  /     ;

SCALARS FLSHARE share of US milk marketings used for fluid products / .391 /
PF production factor used to manipulate supply levels / 1.03 /
DF demand factor used to manipulate demand levels / 1 / ;

PARAMETER PASUPPLY(DS)  scaled supply at each production area in pounds;
PASUPPLY(DS) = BASESPLY(DS)*PF*1000000 ;

PARAMETER CONSUMP(DD)  scaled demand levels at each consumption area in pounds;
CONSUMP(DD) = BASEDEMD(DD)*DF*1000000 ;

PARAMETER  FLDEMAND(DD)  fluid demand at individual consumption areas;
FLDEMAND(DD) = CONSUMP(DD)*FLSHARE ;

PARAMETER  MFGDEMAND(DD)  mfg demand at individual consumption areas ;
MFGDEMAND(DD) = CONSUMP(DD)*(1-FLSHARE) ;
```

```
PARAMETER TMEDEMAND(DD) total milk equivalent demand at a consumption area in
pounds;
TMEDEMAND(DD) = FLDEMAND(DD) + MFGDEMAND(DD) ;

PARAMETER OTSUPPLY  total original supply in million pounds;
OTSUPPLY = SUM(DS, BASESPLY(DS));

PARAMETER OSHARE(DS)  original 1994 market share for production area;
OSHARE(DS) = BASESPLY(DS) / OTSUPPLY;

PARAMETER XPORTD(XP)  milk equivalent demand at each export alternative

/ LA    1129200000
  NO    1129200000
  BA    1129200000
  SE    1129200000  / ;

TABLE T(DS,DD) distance from production areas to consumption centers

* The distance tables are presented in Appendix C.


TABLE XD(DS,XP) distance to export facilities

* The distance tables are presented in Appendix C.


SCALARS FHR  fluid transportation cost per mile per pound of milk / .000042 /
MHR  mfg transportation costs per mile per pound of milk /.0000028 /
EHR  export transportation costs per mile per pound of milk / .0000027 / ;

PARAMETER FLFTM(DS,DD)  trans cost of fluid milk from a production to
consumption areas ;
FLFTM(DS,DD) = FHR*T(DS,DD) ;

PARAMETER MFGFTM(DS,DD)  trans cost of mfg milk from a production to consumption
areas ;
MFGFTM(DS,DD) = MHR*T(DS,DD) ;

PARAMETER EXPFTM(DS,XP)  trans cost of mfg milk from production area to export
source ;
EXPFTM(DS,XP) = EHR*XD(DS,XP);

PARAMETER LPFEED(DS) mean value of the ln of feed prices

/ 1    -2.9859
.
.
50     -3.592 /

LPHAUL(DS) mean value of the ln of hauling prices

/ 1    -5.0471
.
.
50     -5.4667 /

LPLABOR(DS) mean value of the log of labor prices

/ 1    1.6197
.
.
```

```
50      1.8034 /

BOT(DS) estimate of parameter value BO

/ 1     1.4742
.
.
50      -9.3057 /

B1T(DS) estimate of parameter value B1

/ 1     -.3256
.
.
50      -2.8039 /

B2T(DS) estimate of parameter value B2

/ 1     .8543
.
.
50      -.1762 /


B1YT(DS) estimate of parameter value B1Y

/ 1     .1005
.
.
50      .1175 /

B2YT(DS) estimate of parameter value B2Y

/ 1     .0207
.
.
50      .0339 /


B11T(DS) estimate of parameter value B11

/ 1     .0266
.
.
50      -.1484 /

B12T(DS) estimate of parameter value B12

/ 1     .0852
.
.
50    -.0585 /

B22T(DS) estimate of parameter value B22

/ 1     .0656
.
.
50      .0602 /

BYT(DS) estimate of parameter value BY

/ 1   1.0026
```

```
.
.
50    .5158  /

BYYT(DS) estimate of parameter value BYYT

/ 1    .032
.
.
50     .1123 /;

PARAMETER B3T(DS) estimated parameter value of B3;
    B3T(DS) = 1 - B1T(DS) - B2T(DS);
PARAMETER B3YT(DS) estimated parameter value of B3Y;
    B3YT(DS) = (- B1YT(DS) - B2YT(DS));
PARAMETER B23T(DS) estimated parameter value of B23;
    B23T(DS) =  (- B22T(DS) - B12T(DS));
PARAMETER B13T(DS) estimated parameter value of B13;
    B13T(DS) = (- B11T(DS) - B12T(DS));
PARAMETER B33T(DS) estimated parameter value of B33;
   B33T(DS) =  (- B23T(DS) - B13T(DS));

PARAMETER LPFEEDS(DS) ln of feed prices squared;
   LPFEEDS(DS) = LPFEED(DS)*LPFEED(DS) ;
PARAMETER LPHAULS(DS) ln of haul prices squared;
   LPHAULS(DS) = LPHAUL(DS)*LPHAUL(DS) ;
PARAMETER LPLABORS(DS) ln of labor prices squared;
   LPLABORS(DS) = LPLABOR(DS)*LPLABOR(DS) ;

VARIABLES
QFT(DS,DD)    quantity of fluid milk shipped from a production area to a
       consumption center
QMT(DS,DD)    quantity of mfg milk shipped from a production area to a
              consumption center
QXT(DS,XP)    quantity of mfg milk shipped from a production area to a export
              alternative
QS(DS)        total quantity of production at a supply area
TCHAUL        total transportation costs involved in milk assembly
PATCST(DS)    production area's total transportation cost
MIN           defines the minimum transportation cost objective function ;

POSITIVE VARIABLES QFT, QMT, QS, QXT ;
QS.L(DS) = PASUPPLY(DS)/FARMNUM(DS);
QS.LO(DS) = 1;
QS.UP(DS) = PASUPPLY(DS)/FARMNUM(DS);

EQUATIONS
SPLYCST(DS)        constrains the supply from a production area
SUPPLY(DS)         identifies the types of shipments from a production area
FLMILK             constrains shipments of fluid milk
MFGMILK            constrains shipments of mfg products
EXPMILK            constrains shipments of export products
EQUIL              balances the supply of milk with demand
PACOSTS(DS)        calculates production area's total transportation costs
MKTCOST            identifies the objective function
FL(DD)             identifies fluid demand at each consumption area
MFG(DD)            identifies mfg demand at each consumption area
EXPD(XP)           identifies mfg demand at each export area  ;

SPLYCST(DS)..   QS(DS) =L= PASUPPLY(DS)/FARMNUM(DS) ;

SUPPLY(DS)..    SUM(DD, QFT(DS,DD) + QMT(DS,DD)) + SUM(XP, QXT(DS,XP)) =E=
                QS(DS) ;
```

```
MFGMILK..        SUM((DS,DD), QMT(DS,DD)*FARMNUM(DS)) =E= SUM(DD,
                 MFGDEMAND(DD));

FLMILK..         SUM((DS,DD), QFT(DS,DD)*FARMNUM(DS)) =E= SUM(DD,
                 FLDEMAND(DD));

EXPMILK..        SUM((DS,XP), QXT(DS,XP)*FARMNUM(DS)) =E= SUM(XP, XPORTD(XP));

FL(DD)..         SUM(DS, QFT(DS,DD)*FARMNUM(DS)) =E= FLDEMAND(DD);

MFG(DD)..        SUM(DS, QMT(DS,DD)*FARMNUM(DS)) =E= MFGDEMAND(DD);

EXPD(XP)..       SUM(DS, QXT(DS,XP)*FARMNUM(DS)) =E= XPORTD(XP);

EQUIL..          SUM(DS, QS(DS)*FARMNUM(DS)) =E= SUM(DD, TMEDEMAND(DD)) +
                 SUM(XP,XPORTD(XP));

PACOSTS(DS)..    SUM(DD, FARMNUM(DS)*QFT(DS,DD)*FLFTM(DS,DD) +
                 QMT(DS,DD)*MFGFTM(DS,DD)*FARMNUM(DS))
                 + SUM(XP, QXT(DS,XP)*EXPFTM(DS,XP)*FARMNUM(DS)) =E=
                 PATCST(DS);


MKTCOST..  SUM(DS, PATCST(DS) + FARMNUM(DS)*EXP(BOT(DS) + B1T(DS)*LPFEED(DS)

                 + B2T(DS)*LPHAUL(DS)

                 + B3T(DS)*LPLABOR(DS) + LOG(QS(DS))*(B1YT(DS)*LPFEED(DS) +

                 B2YT(DS)*LPHAUL(DS) + B3YT(DS)*LPLABOR(DS)) +

                .5*B11T(DS)*LPFEEDS(DS) + .5*B22T(DS)*LPHAULS(DS) +

                 B12T(DS)*LPFEED(DS)*LPHAUL(DS) +

                 B23T(DS)*LPHAUL(DS)*LPLABOR(DS) +

                 B13T(DS)*LPFEED(DS)*LPLABOR(DS) +

                 .5*B33T(DS)*LPLABORS(DS) + BYT(DS)*LOG(QS(DS)) +

                 .5*BYYT(DS)*LOG(QS(DS))*LOG(QS(DS)))) =E= MIN ;

MODEL MILK /ALL/ ;

SOLVE MILK USING NLP MINIMIZING MIN;

PARAMETER LNTC(DS) natural log of total costs ;
LNTC(DS) = BOT(DS) + B1T(DS)*LPFEED(DS) + B2T(DS)*LPHAUL(DS)

            + B3T(DS)*LPLABOR(DS) + LOG(QS.L(DS))*(B1YT(DS)*LPFEED(DS) +

            B2YT(DS)*LPHAUL(DS) + B3YT(DS)*LPLABOR(DS))  +

            .5*B11T(DS)*LPFEEDS(DS) + .5*B22T(DS)*LPHAULS(DS) +

            B12T(DS)*LPFEED(DS)*LPHAUL(DS) +

            B23T(DS)*LPHAUL(DS)*LPLABOR(DS) +

            B13T(DS)*LPFEED(DS)*LPLABOR(DS) +
```

```
            .5*B33T(DS)*LPLABORS(DS) + BYT(DS)*LOG(QS.L(DS)) +

            .5*BYYT(DS)*LOG(QS.l(DS))*LOG(QS.l(DS)) ;

PARAMETER EXPTC(DS) exponential of total cost ;
EXPTC(DS) = EXP(LNTC(DS));

PARAMETER COPCWT(DS) cost of production per cwt;
COPCWT(DS) = EXPTC(DS)/QS.L(DS)*100;

PARAMETER TTCSTS total transportation costs;
TTCSTS = SUM(DS, PATCST.L(DS));

PARAMETER TPCSTS total production costs;
TPCSTS = SUM(DS, EXPTC(DS)*FARMNUM(DS));

PARAMETER TMSUPPLY  total market supply;
TMSUPPLY = SUM(DS, QS.L(DS)*FARMNUM(DS));

PARAMETER TMDEMAND  total market demand;
TMDEMAND = SUM(DD, TMEDEMAND(DD))+ SUM(XP, XPORTD(XP));

PARAMETER TXDEMAND  total export demand;
TXDEMAND = SUM(XP, XPORTD(XP));

PARAMETER TOTMFG  total mfg milk supplied;
TOTMFG = SUM((DS,DD), QMT.L(DS,DD)*FARMNUM(DS));

PARAMETER TOTFL  total fl milk supplied;
TOTFL = SUM((DS,DD), QFT.L(DS,DD)*FARMNUM(DS));

PARAMETER NSHARE(DS) new market share;
NSHARE(DS) = QS.L(DS)*FARMNUM(DS) / TMSUPPLY ;

PARAMETER DIF(DS) difference in market shares;
DIF(DS) = NSHARE(DS) - OSHARE(DS);

PARAMETER SMFG(DS)  share of mfg milk shipped from farm;
SMFG(DS) = SUM(DD, QMT.L(DS,DD) / QS.L(DS)) ;

PARAMETER SFL(DS)  share of fluid milk shipped from farm;
SFL(DS) = SUM(DD, QFT.L(DS,DD) / QS.L(DS)) ;

PARAMETER SXP(DS)  share of export milk shipped from farm;
SXP(DS) = SUM(XP, QXT.L(DS,XP) / QS.L(DS)) ;

PARAMETER RANGELB(DS) lower bound of data;
RANGELB(DS) = QS.L(DS) - DATALB(DS);

PARAMETER RANGEUB(DS) upper bound of data;
RANGEUB(DS) = DATAUB(DS) - QS.L(DS) ;

PARAMETER PERCTEXP(DS) percentage of total exports supplied by production area;
PERCTEXP(DS) = SUM(XP, QXT.L(DS,XP)*FARMNUM(DS) / TXDEMAND) ;

PARAMETER PERCTDIF(DS) percentage change in market share;
PERCTDIF(DS) = (NSHARE(DS) - OSHARE(DS))/OSHARE(DS) ;

OPTION DECIMALS = 4;

DISPLAY TMDEMAND
DISPLAY TMSUPPLY;
DISPLAY TXDEMAND;
```

```
DISPLAY TOTMFG;
DISPLAY TOTFL;
DISPLAY NSHARE;
DISPLAY OSHARE;
DISPLAY DIF;
DISPLAY PERCTDIF;
DISPLAY SMFG;
DISPLAY SFL;
DISPLAY SXP;
DISPLAY PERCTEXP;
DISPLAY QXT.L;
DISPLAY COPCWT;
DISPLAY LNTC;
DISPLAY EXPTC;
DISPLAY RANGELB;
DISPLAY RANGEUB;
DISPLAY QMT.L;
DISPLAY QFT.L;
DISPLAY TTCSTS;
DISPLAY TPCSTS;
```

APPENDIX C
IDENTIFICATION AND DISTANCE TABLES

Identification Tables

Supply and Demand Points

The information presented in Table C-1 identifies the (1) state, (2) identification number in the NDM, (3) the geographic center of milk production in each state, and (4) the consumption center in each state. This information remains consistent across all scenarios in this study.

Table C-1: Identification Of National Dairy Model's Supply and Demand Points By State

Supply Area	Identification Number	Geographic Center Of Milk Production	Processing and Consumption Center
Alabama	1	Huntsville	Birmingham
Arizona	2	Phoenix	Phoenix
Arkansas	3	Fayetteville	Little Rock
California	4	Modesto	Los Angeles
Colorado	5	Fort Collins	Denver
Connecticut	6	Torrington	Bridgeport
Delaware	7	Dover	Wilmington
Florida	8	Basinger	Jacksonville
Georgia	9	Macon	Atlanta
Idaho	10	Pocatello	Boise
Illinois	11	Freeport	Chicago
Indiana	12	Elkhart	Indianapolis
Iowa	13	Waterloo	Des Moines
Kansas	14	Topeka	Wichita
Kentucky	15	Glasgow	Louisville

Louisiana	16	Ponchatoula	New Orleans
Maine	17	Bangor	Portland
Maryland	18	Frederick	Baltimore
Massachusetts	19	Worcester	Boston
Michigan	20	Lansing	Detroit
Minnesota	21	St Cloud	Minneapolis
Mississippi	22	McComb	Jackson
Missouri	23	Springfield	Kansas City
Montana	24	Bozeman	Billings
Nebraska	25	Norfolk	Omaha
Nevada	26	Reno	Las Vegas
New Hampshire	27	Littleton	Manchester
New Jersey	28	Washington	Newark
New Mexico	29	Clovis	Albuquerque
New York	30	Oneida	New York City
North Carolina	31	Statesville	Charlotte
North Dakota	32	Bismark	Fargo
Ohio	33	Wooster	Columbus
Oklahoma	34	Muskogee	Oklahoma City
Oregon	35	Portland	Portland
Pennsylvania	36	Lancaster	Philiadelphia
Rhode Island	37	Providence	Providence
South Carolina	38	Newberry	Columbia
South Dakota	39	Watertown	Sioux Falls
Tennessee	40	Johnson City	Memphis
Texas	41	Dallas	Houston
Utah	42	Salt Lake City	Salt Lake City
Vermont	43	Burlington	Burlington
Virginia			
(a) Southwest	44	Rocky Mount	Roanoke
(b) Eastern	45	Petersburg	Virginia Beach
(c) Western	46	Harrisonburg	Washington, D.C.
Washington	47	Bellingham	Seattle
West Virginia	48	Morgantown	Charleston
Wisconsin	49	Eau Clarie	Milwaukee
Wyoming	50	Rock Springs	Cheyenne

Distance Tables

The spatial dimension of the NDM requires that each supply point be connected to all consumption centers and export facilities by the actual distance. The distance between two points is found with a software package known as AUTOMAP. The distance matrix for supply points and consumption centers has 50 rows and columns, which gives a total of 2500 cells. The distance chart for supply points and export alternatives has 50 rows and four columns, for a total of 200 cells. The mileage used in the NDM is illustrated in Tables C-3 and C-4.

Table C-2: Mileage Chart For Supply and Demand Points In the National Dairy Model

	1	2	3	4	5	6	7	8	9	10
1	103	1692	356	2019	1272	990	810	544	197	2041
2	1716	0	1342	372	832	2538	2389	2052	1859	961
3	560	1235	175	1562	821	1360	1211	1014	705	1634
4	2296	707	1911	331	1150	2975	2875	2705	2441	647
5	1411	890	1043	1062	64	1848	1749	1813	1463	751
6	1065	2569	1326	2889	1888	53	235	1051	987	2575
7	841	2414	1102	2741	1744	234	50	810	738	2504
8	657	2255	1047	2627	1956	1265	1077	256	552	2726
9	227	1939	615	2278	1486	997	786	244	82	2256
10	1896	836	1568	852	590	2326	2227	2297	1948	234
11	744	1741	677	1940	939	998	898	1146	796	1626
12	639	1886	729	2097	1096	761	662	1023	675	1782
13	863	1594	691	1793	792	1162	1062	1264	915	1478
14	813	1223	463	1543	539	1329	1180	1215	865	1349
15	283	1771	436	2099	1169	887	725	662	312	1939
16	365	1490	388	1862	1364	1393	1213	569	489	2174
17	1411	2915	1672	3208	2207	389	581	1398	1332	2894
18	732	2275	992	2602	1605	320	121	748	653	2365
19	1141	2645	1402	2965	1964	119	311	1128	1063	2651
20	724	1994	837	2205	1204	743	643	1082	752	1890
21	1137	1715	896	1887	886	1361	1262	1538	1189	1379
22	314	1537	333	1909	1316	1341	1161	586	457	2127
23	550	1305	224	1632	778	1236	1087	1046	697	1557
24	1930	1095	1588	1112	699	2277	2178	2331	1982	464
25	1055	1353	713	1525	525	1425	1326	1456	1107	1211
26	2339	749	1903	513	1033	2770	2670	2741	2391	442
27	1283	2736	1543	3025	2024	260	453	1270	1204	2711
28	940	2482	1200	2809	1812	176	96	889	838	2547
29	1085	691	700	1018	465	1896	1747	1465	1230	1191
30	1066	2442	1243	2731	1730	264	299	1103	987	2417

31	426	2063	727	2390	1541	675	494	425	280	2310
32	1494	1542	1202	1613	713	1719	1619	1896	1546	1016
33	684	2030	831	2357	1360	523	424	854	674	2048
34	609	1152	224	1479	760	1427	1278	1063	754	1570
35	2547	1333	2220	963	1241	2978	2878	2949	2599	430
36	830	2338	1090	2665	1668	226	54	822	751	2400
37	1151	2657	1411	2977	1976	122	309	1131	1072	2662
38	352	2073	737	2400	1551	807	604	331	206	2320
39	1216	1567	874	1696	738	1504	1404	1617	1268	1259
40	364	1960	624	2287	1410	687	507	505	263	2180
41	648	1068	319	1440	825	1612	1432	1007	791	1635
42	1824	673	1497	689	518	2254	2155	2226	1876	339
43	1222	2657	1459	2946	1945	269	418	1240	1143	2632
44	535	2131	795	2458	1551	553	373	533	405	2320
45	652	2277	942	2604	1677	432	243	577	506	2447
46	614	2209	874	2537	1573	420	240	679	535	2342
47	2680	1570	2353	1224	1374	3024	2925	3082	2732	563
48	669	2131	876	2458	1461	446	284	754	609	2206
49	978	1800	911	1999	998	1203	1103	1380	1030	1533
50	1644	828	1317	844	338	2075	1975	2046	1696	477

	11	12	13	14	15	16	17	18	19	20
1	574	391	785	813	277	445	1241	737	1143	640
2	1805	1754	1474	1079	1773	1522	2786	2322	2687	2059
3	627	576	446	301	595	613	1608	1144	1509	881
4	2123	2257	1782	1648	2303	2229	3189	2835	3116	2378
5	997	1130	655	582	1169	1458	2062	1708	1989	1251
6	899	814	1515	1494	847	1411	233	303	135	679
7	829	660	1144	1340	665	1187	494	91	395	636
8	1255	1072	1469	1552	958	755	1526	1005	1427	1274
9	785	602	999	1082	488	521	1249	714	1151	804
10	1475	1608	1133	1107	1654	1983	2540	2186	2468	1729
11	122	307	266	662	419	994	1211	858	1139	401
12	107	163	423	791	269	982	1001	622	903	180
13	284	444	119	515	554	1035	1375	1022	1303	565
14	575	546	261	153	571	901	1577	1113	1479	829
15	392	209	679	765	95	626	1139	652	1040	458
16	878	811	983	843	708	51	1644	1140	1546	1071
17	1218	1160	1534	1840	1193	1757	131	650	241	942
18	689	520	1005	1201	542	1078	571	48	473	497
19	975	890	1291	1570	923	1487	142	381	45	724
20	215	253	531	899	354	1066	875	603	814	89
21	485	671	312	708	782	1312	1575	1222	1503	764
22	823	756	928	796	653	110	1593	1089	1494	1016
23	504	453	360	272	472	662	1484	1020	1385	757
24	1401	1551	1100	1175	1661	2027	2491	2137	2418	1680
25	573	707	232	346	813	1152	1639	1285	1566	828
26	1918	2052	1577	1550	2097	2202	2983	2630	2911	2173
27	1036	982	1351	1662	1018	1628	122	522	153	760
28	871	728	1187	1408	756	1285	436	162	338	678

29	1164	1113	917	491	1132	969	2144	1680	2046	1417
30	741	688	1057	1368	724	1412	349	354	288	465
31	718	536	1006	1136	449	753	926	422	828	607
32	843	1028	670	827	1140	1640	1933	1579	1860	1122
33	372	275	688	955	311	1027	763	362	664	184
34	695	644	473	240	663	662	1675	1211	1577	948
35	2126	2260	1785	1759	2306	2635	3192	2838	3119	2381
36	725	584	1040	1264	612	1176	477	73	379	532
37	987	902	1303	1582	933	1496	159	383	48	764
38	761	573	1043	1147	459	676	1058	531	960	728
39	627	813	386	575	924	1313	1717	1364	1645	907
40	602	414	884	1006	300	710	939	434	840	569
41	940	904	718	369	836	511	1863	1359	1765	1199
42	1403	1536	1062	1035	1582	1802	2468	2115	2396	1657
43	956	903	1272	1583	939	1568	211	493	216	680
44	689	507	977	1147	441	881	805	300	706	578
45	815	634	1104	1273	567	979	692	171	593	627
46	674	500	969	1168	463	959	672	168	574	485
47	2148	2298	1847	1891	2408	2767	3238	2884	3165	2427
48	542	377	846	1057	384	1015	697	211	599	349
49	326	512	325	721	623	1227	1416	1063	1344	605
50	1223	1357	882	855	1402	1732	2288	1935	2216	1478

	21	22	23	24	25	26	27	28	29	30
1	989	342	669	1708	856	1807	1165	909	1229	916
2	1718	1475	1280	1205	1372	302	2709	2457	463	2464
3	689	446	258	1301	448	1350	1531	1279	773	1286
4	1985	2106	1793	1149	16553	511	3107	2904	1032	2912
5	899	1315	665	501	526	792	1981	1777	510	1786
6	1316	1307	1296	2158	1348	2618	157	114	2106	107
7	1246	1083	1141	2087	1277	2478	418	164	1951	170
8	1673	807	1353	2392	1540	2454	1449	1195	1876	1201
9	1203	468	883	1922	1070	2065	1173	917	1488	924
10	1214	1840	1144	373	1004	582	2459	2255	810	2264
11	336	807	461	1115	399	1669	1130	927	1278	935
12	524	820	592	1366	556	1826	897	690	1424	699
13	209	848	313	966	252	1522	1294	1090	1131	1099
14	505	742	67	1030	178	1272	1501	1248	761	1255
15	809	493	566	1605	753	1886	1062	806	1309	813
16	1193	136	792	1834	982	1720	1568	1312	1143	1319
17	1635	1653	1641	2332	1667	2937	233	462	2452	453
18	1106	974	1002	1948	1138	2338	495	239	1812	246
19	1392	1383	1371	2234	1424	2694	66	192	2182	183
20	632	928	700	1473	664	1934	794	671	1532	680
21	69	1126	507	779	392	1617	1494	1290	1271	1299
22	1138	81	737	1779	927	1713	1517	1260	1135	1268
23	604	503	181	1223	371	1420	1408	1155	842	1162
24	984	1868	1178	142	996	841	2409	2206	1069	2214
25	364	993	302	740	119	1255	1557	1354	902	1362
26	1780	2098	1588	944	1448	447	2902	2698	1024	2707

27	1390	1524	1463	2150	1484	2755	104	333	2274	324
28	1288	1181	1209	2130	1320	2546	360	106	2020	112
29	1161	865	723	1022	786	806	2068	1815	228	1822
30	1158	1308	1169	2000	1190	2460	268	266	1980	274
31	1135	667	938	1941	1125	2177	850	594	1600	601
32	426	1483	792	416	609	1343	1851	1648	1159	1656
33	789	888	756	1631	821	2091	687	452	1567	460
34	717	495	278	1271	460	1267	1599	1346	689	1353
35	1737	2491	1796	895	1656	1002	3110	2907	1411	2915
36	1142	1072	1065	1983	1173	2401	401	145	1875	152
37	1404	1393	1383	2246	1436	2706	103	194	2194	186
38	1178	593	948	1987	1135	2187	982	726	1610	733
39	210	1154	465	659	282	1425	1636	1433	1131	1441
40	1019	606	807	1819	994	2075	862	606	1497	613
41	962	407	523	1400	692	1243	1787	1531	667	1538
42	1264	1698	1073	533	932	418	2387	2183	646	2192
43	1373	1464	1384	2078	1405	2676	166	316	2195	314
44	1106	777	948	1912	1110	2246	728	472	1668	479
45	1232	893	1074	2038	1237	2392	615	361	1815	368
46	1091	855	969	1932	1102	2306	596	340	1747	347
47	1731	2624	1929	890	1743	1218	3157	2953	1543	2961
48	959	911	858	1801	979	2194	621	365	1668	372
49	92	1041	520	933	458	1729	1335	1131	1338	1140
50	1085	1588	893	411	753	574	2207	2004	674	2012

	31	32	33	34	35	36	37	38	39	40
1	417	1221	490	686	2467	840	1110	409	1036	221
2	2074	1713	1930	1006	1333	2411	2657	2071	1483	1471
3	908	870	752	229	2060	1232	1478	917	629	304
4	2644	1759	2428	1575	660	2896	3085	2654	1750	2040
5	1612	851	1302	744	1177	1770	1959	1648	656	1173
6	749	1548	642	1565	3001	207	104	841	1480	1190
7	500	1478	484	1431	2930	75	355	580	1410	966
8	642	1905	1076	1377	3152	1107	1387	547	1721	913
9	287	1435	654	945	2682	816	1117	197	1251	481
10	2097	982	1780	1270	660	2248	2437	2132	1030	1625
11	884	569	477	822	2052	919	1108	920	446	598
12	672	756	232	883	2208	683	872	737	688	611
13	1015	442	615	674	1860	1083	1272	1050	296	639
14	1014	599	722	313	1775	1202	1448	1050	359	533
15	394	1042	308	766	2365	760	1007	429	934	301
16	731	1403	921	680	2600	1242	1513	696	1163	347
17	1095	1722	987	1911	3320	553	286	1187	1799	1536
18	416	1339	344	1271	2791	151	439	508	1271	857
19	825	1624	717	1641	3076	283	45	917	1556	1266
20	686	864	249	991	2316	864	825	778	796	719
21	1248	170	840	868	1674	1283	1472	1284	232	917
22	697	1348	866	673	2553	1191	1461	669	1108	292
23	846	792	629	301	1983	1109	1355	881	552	294
24	2131	752	1723	1338	753	2198	2388	2166	820	1659

25	1255	377	878	509	1637	1346	1535	1291	149	784
26	2540	1554	2223	1568	555	2691	2880	2576	1544	2033
27	967	1540	809	1733	3137	425	204	1058	1617	1408
28	599	1520	552	1478	2973	73	298	660	1452	1065
29	1433	1158	1289	364	1617	1769	2015	1443	930	829
30	750	1391	515	1438	2843	280	299	842	1322	1108
31	43	1367	397	1057	2736	524	794	135	1271	592
32	1605	194	1198	990	1311	1640	1829	1641	433	1274
33	472	1022	102	1026	2474	445	634	564	953	696
34	956	881	820	146	1996	1300	1546	966	641	353
35	2748	1505	2431	1921	0	2899	3088	2784	1572	2276
36	514	1374	407	1334	2826	72	346	606	1306	955
37	835	1636	728	1653	3088	281	0	927	1568	1276
38	96	1410	529	1067	2746	633	927	45	1315	602
39	1417	147	983	737	1553	1425	1614	1452	106	945
40	149	1251	351	954	2606	537	807	219	1150	489
41	1032	1114	1049	205	2061	1462	1732	1003	873	456
42	2025	1142	1708	1131	765	2176	2365	2061	1029	1553
43	906	1468	730	1654	3058	390	256	998	1538	1323
44	164	1338	368	1125	2746	403	673	260	1243	660
45	267	1465	466	1271	2873	273	553	348	1369	806
46	297	1323	324	1204	2768	270	540	389	1235	739
47	2881	1499	2470	2054	260	2945	3135	2917	1567	2409
48	372	1191	200	1127	2632	319	566	464	1111	741
49	1089	324	682	881	1828	1124	1313	1125	333	832
50	1845	963	1528	1018	903	1996	2185	1881	850	1373

	41	42	43	44	45	46	47	48	49	50
1	773	1744	1181	475	754	700	2519	488	668	1310
2	1173	673	2656	2112	2391	2337	1439	2015	1852	930
3	546	1337	1479	945	1224	1140	2112	810	715	903
4	1879	726	3055	2681	2951	2832	833	2544	2159	1155
5	1189	453	1928	1586	1818	1705	1229	1411	1033	45
6	1739	2277	219	564	472	343	2966	618	993	1843
7	1515	2207	465	340	202	102	2896	424	922	1773
8	1082	2428	1497	814	893	969	3204	907	1349	1994
9	849	1958	1189	467	601	678	2734	551	879	1524
10	1715	164	2406	2071	2303	2183	712	1895	1511	506
11	1132	1328	1078	787	1019	855	1924	611	119	894
12	1185	1485	844	579	820	618	2174	404	200	1051
13	1078	1181	1242	923	1155	1019	1774	747	268	747
14	758	1051	1448	988	1220	1110	1827	813	638	611
15	892	1641	1038	419	698	629	2417	305	486	1207
16	317	1767	1584	878	1077	1103	2652	928	971	1460
17	2085	2596	287	910	820	690	3141	964	1312	2162
18	1405	2068	511	230	246	45	2757	301	783	1633
19	1815	2353	213	640	550	420	3042	694	1068	1919
20	1293	1593	742	593	801	599	2282	418	308	1159
21	1272	1212	1344	1150	1382	1218	1588	974	405	835
22	368	1759	1533	826	1043	1052	2605	876	916	1381

23	680	1259	1354	889	1121	1017	2035	713	592	825
24	1783	423	2220	2030	2262	2134	667	1855	1321	600
25	954	914	1505	1186	1418	1282	1548	1010	609	480
26	1922	520	2850	2514	2746	2626	728	2338	1954	950
27	1956	2414	91	781	691	561	2958	836	1129	1980
28	1613	2249	420	438	274	201	2938	509	965	1815
29	648	852	2015	1470	1749	1696	1669	1373	1252	567
30	1700	2119	214	565	549	392	2808	573	835	1685
31	1081	2013	866	144	329	385	2788	228	811	1579
32	1435	948	1662	1508	1740	1576	1225	1332	763	614
33	1287	1751	641	379	534	359	2440	204	466	1316
34	494	1273	1546	994	1273	1220	2048	904	783	857
35	2366	765	3058	2722	2954	2835	173	2547	2074	1158
36	1503	2103	420	329	299	113	2792	383	818	1669
37	1824	2365	258	649	552	422	3054	704	1080	1931
38	1004	2023	998	276	448	496	2798	361	854	1589
39	1182	1031	1584	1292	1524	1361	1467	1117	548	661
40	1037	1882	878	172	426	398	2628	222	696	1448
41	241	1290	1778	1097	1376	1323	2113	1052	1028	921
42	1500	0	2335	1999	2231	2111	817	1823	1439	434
43	1895	2335	0	721	667	532	2886	775	1050	1900
44	1208	2023	744	24	264	264	2721	200	783	1589
45	1306	2149	663	168	100	135	2847	326	909	1715
46	1287	2045	612	112	227	131	2741	221	767	1610
47	2499	897	2967	2778	3010	2881	89	2602	2068	1291
48	1343	1908	637	244	370	207	2609	143	636	1474
49	1285	1388	1283	991	1223	1059	1742	816	247	953
50	1463	180	2155	1819	2051	1932	955	1643	1259	255

Table C-3: Mileage Chart For Supply Points and Export Facilities In the National Dairy Model

	Las Angeles	New Orleans	Baltimore	Seattle
1	2019	445	737	2519
2	372	1522	2322	1439
3	1562	613	1144	2112
4	331	2229	2835	833
5	1062	1458	1708	1229
6	2889	1411	303	2966
7	2741	1187	91	2896
8	2627	755	1005	3204
9	2278	521	714	2734
10	852	1983	2186	712
11	1940	994	858	1924
12	2097	982	622	2174

13	1793	1035	1022	1774
14	1543	901	1113	1827
15	2099	626	652	2417
16	1862	51	1140	2652
17	3208	1757	650	3141
18	2602	1078	48	2757
19	2965	1487	381	3042
20	2205	1066	603	2282
21	1887	1312	1222	1588
22	1909	110	1089	2605
23	1632	662	1020	2035
24	1112	2027	2137	667
25	1525	1152	1285	1548
26	513	2202	2630	728
27	3025	1628	522	2958
28	2809	1285	162	2938
29	1018	969	1680	1669
30	2731	1412	354	2808
31	2390	753	422	2788
32	1613	1640	1579	1225
33	2357	1027	362	2440
34	1479	662	1211	2048
35	963	2635	2838	173
36	2665	1176	73	2792
37	2977	1496	383	3054
38	2400	676	531	2798
39	1696	1313	1364	1467
40	2287	710	434	2628
41	1440	511	1359	2113
42	689	1802	2115	817
43	2946	1568	493	2886
44	2458	881	300	2721
45	2604	979	171	2847
46	2537	959	168	2741
47	1224	2767	2884	89
48	2458	1015	211	2609
49	1999	1227	1063	1742
50	844	1732	1935	955

APPENDIX D
HAULING RATES

Manufactured Products To Consumption Centers

The hauling rate for shipments of manufactured products to consumption centers is $0.028/cwt./100 miles. This figure is the milk equivalent of $1.75 per loaded mile of manufactured products. Based on 1994 production statistics, 68.6% of all milk marketings was used in the production of butter (17.9%), cheese (44.8%), and nonfat dry milk (5.9%) (*Dairy Products Summary* 1995). Using these statistics, the researchers assume that the average 50,000 pound truck load of manufactured dairy products consists of 32,650 pounds of cheese, 13,050 pounds of butter, and 4,300 pounds of nonfat dry milk. Table D-1 shows how a milk equivalent hauling rate is determined from the $1.75 per loaded mile.

Table D-1: Procedures Used When Calculating A Manufactured Hauling Rate

Product	Loaded Pounds	X	Whole Milk Conversion Factor	=	Milk Equivalent Pounds
Cheese	32,650		10.1		329,765
NFDM	4,300		7.4		31,820
Butter	13,050		21		274,050
					635,635

* Hauling Rate Per Milk Equivalent Pound of Fluid Milk:
$1.75 loaded mile / 635,635 pounds of fluid milk = $0.000002753 ≈ $0.028/cwt./100 miles

Manufactured Products To Export Alternatives

The hauling rate for shipments of manufactured products designated for export markets is determined using the same procedures described above. The only difference is that the product mix for the average truck load of manufactured dairy products is based on 1994 exports. Although cheese, butter, and nonfat dry milk are still the primary commodities, butter and nonfat dry milk play a more important role in the export market than cheese. Preliminary 1994 data show that exports of cheese, butter, and nonfat dry milk totaled approximately 221,447 tons (USDA FAS 1994). Butter accounted for 40% of this total, exports of cheese was 6.7%, and the majority of these exports was nonfat dry milk (53.3%). Table D-2 illustrates how a hauling rate for manufactured products designated for export markets is determined.

Table D-2: Procedures Used When Calculating A Export Hauling Rate

Product	Loaded Pounds	X	Whole Milk Conversion Factor	=	Milk Equivalent Pounds
Cheese	3,350 (6.7%)		10.1		33,835
NFDM	26,650 (53.3%)		7.4		197,210 _
Butter	20,000 (40%)		21		420,000
	50,000				651,045

* Hauling Rate Per Milk Equivalent Pound of Fluid Milk:
$1.75 loaded mile / 651,045 pounds of fluid milk = $0.000002688 ≈ $0.027/cwt./100 miles

APPENDIX E
ALTERNATIVE COST FUNCTIONS

A very important component of the NDM is each state's cost of production estimate. These estimates are found with the translog cost function estimated from the FCRS data. In Model C, the NDM is evaluated with cost estimates that are obtained from each state's minimum average total costs (ATC). As discussed in chapter four, the average and marginal cost curves for eleven states increase throughout the range of the data and never reach a minimum point. Since the curves never identify a minimum average total costs, a cost per cwt. for eleven states in Model C cannot be obtained using these costs curves.

For those eleven states where the marginal and average cost curves are steadily increasing, an alternative translog cost function is used to identify a cost per cwt. at the minimum ATC. In some cases, a cost function is borrowed from a nearby state. In other instances, a new translog cost function is estimated with different FCRS data combinations. The details for each of these eleven states are discussed below.

Florida:	A new translog cost function is estimated for Florida. Firm-level data from Georgia and Florida are combined to form a regional data set. As in the previous estimation process, the cost model has slope and intercept dummies.
Idaho:	A new translog cost function is estimated for Idaho. Firm-level data from Illinois, Indiana, Idaho, and South Dakota are combined to form a data set with sufficient degrees of freedom to estimate a translog cost function. As in the previous estimation process, the cost model has slope and intercept dummies.
Iowa:	A new translog cost function is estimated for Iowa. Firm-level data from Iowa and Missouri are combined to form a regional data set. As in the revious estimation process, the cost model has slope and intercept dummies.

Maine: A minimum ATC is identified for Maine by borrowing Vermont's translog cost function. The intercept term in Vermont's cost function is adjusted so that the mean cost per cwt. is the same as Maine's mean cost per cwt. in Model A. The cost function is also evaluated with the mean input prices obtained from Maine FCRS data.

Missouri: A new translog cost function is estimated for Missouri. Firm-level data from Iowa and Missouri are combined to form a regional data set. As in the revious estimation process, the cost model has slope and intercept dummies.

New Hampshire: A minimum ATC is identified for New Hampshire by borrowing Vermont's translog cost function. The intercept term in Vermont's cost function is adjusted so that the mean cost per cwt. is the same as New Hampshire's mean cost per cwt. in Model A. The cost function is also evaluated with the mean input prices obtained from New Hampshire FCRS data.

Pennsylvania: A minimum ATC is identified for Pennsylvania by borrowing New York's translog cost function. The intercept term in New York's cost function is adjusted so that the mean cost per cwt. is the same as Pennsylvania's mean cost per cwt. in Model A. The cost function is also evaluated with the mean input prices obtained from Pennsylvania FCRS data. Attempts to estimate a new cost function for Pennsylvania using regional data (i.e., PA, NY, and VT) were unsuccessful.

South Dakota: A new translog cost function is estimated for South Dakota. Firm-level data from Illinois, Indiana, Idaho, and South Dakota are combined to form a data set with sufficient degrees of freedom to estimate a translog cost function. As in the previous estimation process, the cost model has slope and intercept dummies.

Texas: A new translog cost function is estimated for Texas. Firm-level data from California, Texas, and Arizona are combined to form a regional data set. As in the previous estimation process, the cost model has slope and intercept dummies.

Virginia: A minimum ATC is identified for Virginia by borrowing North Carolina's translog cost function. The intercept term in North Carolina's cost function is adjusted so that the mean cost per cwt. is the same as Virginia's mean cost per cwt. in Model A. The cost function is also evaluated with the mean input prices obtained from Virginia FCRS data. Attempts to estimate a new cost function for Virginia using regional data (i.e., VA and KY) were unsuccessful.

Washington: A new translog cost function is estimated for Washington. Firm-level data from California, Arizona, and Washington are combined to form a regional data set. As in the previous estimation process, the cost model has slope and intercept dummies.

The primary reason for an alternative cost function for these eleven states is to identify a minimum ATC per cwt. for use in Model C. These cost functions can also be used to determine the stability of Model B's optimal solution. The alternative cost functions described above are programmed into Model B of the NDM. The old cost functions are replaced for these eleven states and any states that are associated with these marketing areas. For Scenario I-3, Model B with the alternative cost functions is solved once again with production factors of 5%, 15%, and 30%. The results from these simulations are presented in Table E-1.

A comparison of the results in Table E-1 with the results of Model B (Scenario I-3) in chapter five illustrates the impact of cost functions that do not have the correct theoretical shape. In the cases of Florida, Iowa, South Dakota, Texas, and Washington, the new cost functions do not make a difference in the states' competitiveness. The NDM continues to decrease production in Florida, Iowa, South Dakota, and Washington. Although the actual percentage change in production is not the same as the results in Model B of chapter five, the results are generally consistent in direction of change and magnitude. The results for Texas with a new cost function are identical to those results in chapter five. Idaho, New Hampshire, Pennsylvania, and Virginia benefit from a new cost function. In general, the results for these states with a new cost function are more consistent with results in Models A and C.

The results in Table E-1 do not lead to any definite conclusions about the effects of average and marginal cost curves that are always increasing. In some cases, states are more competitive with the new cost curves. On the other hand, the NDM continues the same production pattern for Florida, Iowa, South Dakota, Texas, and Washington. Although the new cost curves have an effect on the optimal solution, the results do not change the conclusions of the study.

Table E-1: Production Levels, Fluid and Export Shipments By State For the NDM Given Alternative Cost Functions, 1994 Marketing Conditions, 3% Export Level, and 5%, 15%, and 30% Production Increases

	% Change In Total Production			Fluid Shipments (%)			Export Shipments (%)		
State	*PF*=5%	*PF*=15%	*PF*=30%	*PF*=5%	*PF*=15%	*PF*=30%	*PF*=5%	*PF*=15%	*PF*=30%
AL	5.00	15.00	30.00	100.00	100.00	100.00			
AZ	5.00	15.00	30.00	51.22	46.77	41.37			
AR	5.00	15.00	30.00	70.11	64.02	56.63			
CA	5.00	15.00	30.00	26.71	24.39	21.58	8.37(49)	10.5(67)	10.3(75)
CO	5.00	15.00	16.13	53.85	49.17	48.69			
CT	5.00	15.00	-13.26	100.00	100.00	100.00			
DE	5.00	15.00	30.00	100.00	100.00	100.00			
FL	-43.77	-47.68	-65.17	100.00	100.00	100.00			
GA	5.00	15.00	30.00	100.00	100.00	100.00			
ID	5.00	15.00	6.72	6.02	5.50	5.93			
IL	5.00	15.00	30.00	100.00	87.36	100.00			
IN	5.00	15.00	30.00	100.00	100.00	100.00			
IA	-37.72	-39.78	-50.52	26.54	27.44	33.40			
KS	5.00	15.00	30.00	100.00	100.00	100.00			
KY	5.00	15.00	30.00	66.77	54.02	44.92			
LA	5.00	15.00	30.00	100.00	93.55	82.76			
ME	5.00	-100.00	-100.00	43.16	100.00	---			
MD	5.00	15.00	30.00	91.82	83.83	74.16			
MA	-100.00	-100.00	-100.00	—	—	—			
MI	5.00	-5.17	-100.00	37.65	41.69	—			
MN	-3.08	-100.00	-100.00	11.39	—	—	6.47(13)		
MS	5.00	15.00	30.00	82.17	72.18	63.85			
MO	-31.57	-33.42	-43.20	64.29	63.51	74.44			
MT	-13.19	-17.69	-38.62	70.71	74.57	100.00			
NE	-8.24	-12.32	-35.47	36.55	38.24	51.97			
NV	5.00	15.00	30.00	0.00	0.00	0.00			
NH	5.00	15.00	30.00	100.00	100.00	100.00			
NJ	5.00	15.00	30.00	100.00	100.00	100.00			
NM	5.00	15.00	30.00	10.23	9.34	8.27			
NY	5.00	15.00	30.00	0.00	0.00	1.70			
NC	5.00	15.00	30.00	100.00	100.00	100.00			
ND	-11.81	-14.99	-38.02	0.00	0.00	0.00	69.4(12)		
OH	5.00	15.00	30.00	56.79	51.33	63.44			
OK	5.00	15.00	30.00	99.52	86.48	66.45			
OR	-22.59	-38.70	-60.89	50.52	63.79	100.00			
PA	5.00	15.00	-15.03	82.69	74.75	100.00			
RI	5.00	15.00	-100.00	100.00	100.00	—			
SC	5.00	15.00	30.00	100.00	100.00	100.00			
SD	-9.57	-13.27	-36.39	21.90	22.84	31.14			
TN	5.00	15.00	30.00	89.22	70.57	59.96			
TX	5.00	15.00	30.00	61.28	55.96	49.50	0.54(1)		
UT	5.00	15.00	8.09	27.04	24.69	26.27			
VT	5.00	15.00	-30.84	65.56	68.90	100.00			
SW VA	5.00	15.00	30.00	100.00	100.00	100.00			
E VA	5.00	15.00	30.00	100.00	100.00	100.00			
W VA	5.00	15.00	30.00	57.32	49.70	49.42			
WA	-22.11	-37.13	-77.94	28.54	35.08	100.00	27.6(25)	10.3(8)	
WV	5.00	15.00	30.00	100.00	100.00	100.00			
WI	5.00	15.00	30.00	0.00	4.00	3.54		4.34(25)	3.84(25)
WY	-13.06	-17.55	-40.43	0.00	0.00	0.00			

VITA

Christopher Allan Nubern, the son of Rodney and Shelvy Nubern, was born on January 18, 1969, in Savannah, Georgia. He lived in Statesboro, Georgia for the majority of his life. In 1987, he enrolled at Georgia Southern University where he majored in economics with an emphasis in agribusiness. In 1991, he graduated from Georgia Southern at the top of his class with a Bachelor of Science degree. At the completion of his bachelor degree, he married Natalie Jenkins, also of Statesboro, Georgia.

He enrolled at the University of Florida in August of 1991 to pursue the degree of Master of Science in the Food and Resource Economics Department. This degree was completed in August of 1993. At that time, Chris and Natalie moved to Blacksburg, Virginia. While in Blacksburg, Chris started working on his Ph.D. in the Agricultural and Applied Economics Department at Virginia Tech. He completed his doctorate in September of 1996.