THE EFFECTS OF THE FEDERAL PROGRAMS ON THE U.S. DAIRY INDUSTRY

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Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Agricultural Economics

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March, 1988

Blacksburg, Virginia

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(ABSTRACT)

Milk surplus in the U.S. dairy industry has been increasing substantially since the beginning of the 1980s. In order to analyze the surplus production situation, an interregional dairy trade model based on a spatial equilibrium framework was developed. The model included disaggregate manufactured milk markets and utilized separable programming as the solution technique.

The objective of the interregional dairy trade model was to maximize the sum of producers' and consumers' surplus subject to the various institutional constraints incorporating unregulated and regulated market situations. Under the regulated market situation, the institutional constraints were based on the federal milk marketing order and dairy price support programs. Utilizing the interregional dairy trade model, a comparison of simulated market results and net economic effects between unregulated and regulated markets was drawn first. Results of the simulations for market results and welfare effects under pricing policy options with regard to changes in the support and purchase prices were also analyzed. Finally, a comparison of the results of simulations for simultaneous market clearing situations in butter and nonfat dry milk markets with no government purchases of these commodities under the 1982 market situation and an increasing quota sytem was considered.

It was found that without considering the supply effect induced by price stabilizing regulations, the competitive manufactured milk market price would be lower than the 1982 support price level. The butter and nonfat dry milk markets would move toward a market clearing situation if the support price level was decreased by $1.00 per cwt for butter and by $2.00 per cwt for nonfat dry milk when

cross price elasticity effects were included. Due to cross price elasticity effects, the butter market would clear at a higher price level (in terms of the support price) than the nonfat dry milk market. Simulations of simultaneous market clearing situations suggested that the 1982 butter price would be lower and the nonfat dry milk price would be higher than market clearing prices. Increases in import quotas would drop butter and cheese market clearing prices and raise the nonfat dry milk price relative to the actual 1982 case.

Acknowledgements

The author expresses his gratitude to his committee members David Orden, Darrell Bosch, Warren Preston, and especially to his former chairman Howard McDowell and chairman Daniel Taylor for their contribution to this research effort. The author especially thanks Dr. Howard McDowell for allowing the author to use the data set established for a USDA project and to modify FORTRAN matrix generating program for the analysis. The author also thanks Drs. Daniel Taylor and David Orden for their continuous encouragement, valuable comments and corrections. Being a foreign student, it would have been impossible for the author to adequately express his thoughts and knowledge without their guidance and help.

The author also thanks for typing this dissertation. The author expresses his thanks to his family whose support was unfailing and deeply appreciated. The author also owes a deep gratitude to his long-time mentors, , , and at Sogang University, Korea, and at the Illinois State University.

Last, and most importantly, a heartfelt thank you goes to the author's wife, , whose devotion and love has been a constant source of inspiration throughout.

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CHAPTER I

INTRODUCTION

I.1. Introduction

The United States (U.S.) dairy industry in the 1980s faces several problems associated with a new economic and technological environment. Today's technology provides high productivity per cow, efficient long distance fluid milk transportation, and an efficient communication and information system. The economic environment is dominated by long established government dairy programs. The U.S. dairy industry has been directly affected by two major federal dairy programs: the federal marketing order program in the fluid milk market, and the price support program in the manufactured milk product market. The market power of today's processors is weakened and widely dispersed over a greater number of processors than the oligopolistic or monopolistic structure of the 1930s. Dairy producers have been encouraged by law to act together in order to gain bargaining power against processors.

The current U.S. support price level in the domestic manufactured milk market exceeds the world milk market price. The blend price for Grade A milk in the federal milk marketing order system is directly affected by the level of manufactured milk price support. The two price system of the federal order program allows the average revenue and the marginal revenue of producers to differ. This has led to overproduction of Grade A milk at the aggregate level, and thus society bears the cost of this resource misallocation. High levels of regulated manufactured and fluid milk prices contribute to excess supplies in the manufactured market resulting in increased net market removals and expenditures under the support program.

The overproduction problem of the U.S. dairy industry in the late 1970s and early 1980s can not be attributed solely to the high market prices maintained by federal programs. Highly developed technologies are available to today's dairy producers. The effect of biotechnology and other developments has genetically increased the milk production potential of cows and improved animal nutritional efficiency. Improved farm management systems enhance the profitability of the new technology. The long-run effect of these technologies on the dairy industry has been an outward shift in the dairy supply curve. An improved economic environment for dairy producers has been provided by dairy programs which have reduced price variations, increased expected prices in the dairy market and, provided an unlimited demand. This environment has led dairy producers to increase their output levels in the short run because of reduced risk involving operating costs and to overinvest in long-run capital from society's view point.

Another issue is that the nonfat dry milk market has been far more protected by dairy programs since 1980. Increasing government purchases of nonfat dry milk at a high domestic price has resulted in increasing casein imports. The amount of casein imports in the 1980s reached almost a half of the amount of nonfat dry milk purchased by the government.

It is possible that the dairy industry will be less regulated in the near future. Excessive spending on surplus dairy products has resulted in political pressures to alter the level of support, and possibly to change the regulatory environment. A free market may be used as a benchmark for comparison purposes. Whether a free market would provide politically feasible quantities, consumer prices and producer incomes remains to be seen.

Many dairy economists have estimated welfare effects and/or administration costs of these government dairy programs employing consumer and producer surplus and other program cost measures (Ippolito and Masson; Dahlgran, 1980; and McDowell, 1982). They have claimed that the welfare impacts of the dairy programs are not favorable to a continuation of the regulated dairy market. Hence, in a limited sense, the economic problem of the government's dairy pricing programs is to determine at what level and by what method milk prices should be set. One objective, consistent with pure competition, is to optimize net social surplus of the participating economic agents including producers, consumers, and processors of dairy products as well as taxpayers who ultimately bear the burden of the programs.

This study will analyze the effects of the dairy programs on the market results, producer and consumer surpluses, on a regional and national basis, and direct price support program costs on a national basis, using a model that explicitly considers the national market for manufactured milk products and the fluid milk markets on an interregional trade basis. Milk supply and fluid demand markets will be divided into nine regions while butter, nonfat dry milk, and cheese markets will be treated as a national market. Market results and welfare effects on regional Grade A and B milk supply, fluid demand, and national manufactured product demand will be analyzed based on several policy options. Policy options will be implemented in terms of changes in the support and purchase prices under the dairy support program, and increases in import quotas of dairy products.

I.2. Objectives of This Study

The purpose of this study is to estimate the impacts of existing and potential federal milk market regulatory programs and import quotas on national and regional prices and quantities, geographical price patterns, transportation patterns and income distribution by region and among producers and consumers. An economic model with disaggregate manufactured milk product markets will be developed for estimating values of the above mentioned economic variables under regulatory programs.

I.2.1. Contribution to the Literature

The economic effects of regulating the U.S. dairy industry on the differentials among regional prices, quantities and income distribution have been analyzed in several studies. Studies by Blakley and Riley, and Riley and Blakley were concerned with Grade A and fluid milk markets only. The markets were divided into six regions. They found that the establishment of uniform Class I price (flat differentials) at $7.36 per cwt[1] would have reduced producer surplus in the Grade A milk market by $18.6 million and enhanced consumer surplus in this market by $21.6 million resulting in net social benefit of $3.0 million in 1973.

[1] Cwt. is equivalent to hundredweight in milk equivalents terms.

Similar analyses of the impact of the federal marketing order program in more disaggregated regions have been conducted by Babb et al. (1977) and Hallberg et al. To create a policy simulation model for forty-five federal marketing orders, Babb et al. developed a cost minimizing objective function to simulate the actual market situation utilizing a traditional linear programming method. The objective of the study by Babb et al. was to provide the theoretical and empirical basis of the model and to suggest potential applications.

Hallberg et al. extended the work of Riley and Blakley by disaggregating the U.S. dairy market into twenty-eight producing regions and thirty-nine consuming regions. They maximized the social net payoff function subject to market price equilibrium constraints. An initial blend price was estimated by using a current Class I utilization ratio, and iterated upon until the blend price alignment was stabilized at equilibrium. They also constrained regional market equilibrium prices such that their only difference was transportation costs. They found that the U.S. dairy industry in 1975 should be based on three basing points (Northeast, Southeast, and Upper Midwest) instead of a single basing point (Upper Midwest: Eau Clair, Wisconsin) based on distributional impacts among various participants in the dairy industry.[2] They also found that high levels of current Class I differentials cause an overproduction of Grade A milk and place fluid consumers in a disadvantageous position while benefiting Grade A producers.[3] According to Hallberg et al., consumers in the Corn Belt, Lake States, Northeast, South Atlantic, and South Central regions would lose while producers in the South Atlantic, South Central, and Corn Belt regions would gain if Class I differentials were increased.

McDowell (1982) furthered the analysis of Babb et al. and Hallberg et al. by using a nonlinear blend price constraint with a net social payoff objective function. His study included the

[2] Under the current federal marketing order program, the minimum Class I price for fluid milk is set by an order in terms of the manufacturing milk price, transportation cost of fluid milk, and other additional costs. The transportation cost of fluid milk is determined by the distance from the base point, Eau Claire, Wisconsin, to the specific consumption point assuming that the Upper Midwest is the major surplus area of Grade A milk supply.

[3] Class I differentials are set by an order to reflect the transportation cost and other additional costs of providing Grade A milk for fluid purposes. Detailed discussion of this calculation follows in the next chapter.

manufactured demand and the Grade B supply sectors in an interregional dairy model. His overall conclusion was similar to Blakley and Riley, and Hallberg et al.

As Christ pointed out, previous studies have not reflected the real production behaviour of Grade A milk producers under government regulations. He argued that the natural result of producers' shipments to more attractive markets will not be a structure of fluid or manufactured milk prices, but of blend prices that reflect differences in transportation costs from supply areas to demand areas.

This study will contribute to the literature in three ways. First, extending the work of McDowell (1982; 1986c), an interregional dairy model with disaggregate manufactured milk product markets, which has not been considered in earlier studies, will be specified. In so doing, the study will be able to analyze the effects of changes in purchase prices for disaggregate milk products and changes in import quotas on the market results. Second, the interregional dairy trade model under current federal programs in this study will reflect the producers' shipments of Grade A milk based on regional blend prices. Milk shipments in the previous models were based either on fluid prices or not allowed. Third, cross-price elasticity effects among manufactured milk products will be considered. The scope of this study includes the Grade A and the Grade B milk supplies, and the fluid and the manufactured milk demands. The manufactured milk demand is disaggregated into three major products: butter, nonfat dry milk, and cheese. The U.S. dairy markets are divided into nine regions.

I.2.2. Contribution to Policy Analysis

This study will empirical methods to assist dairy policy decision makers. Results drawn from the simulations for the competitive market and regulated markets under several policy options will aid in the evaluation of policy alternatives providing estimated equilibrium prices and quantities, and welfare impacts.

I.2.3. Modeling Procedure

The study will extend an interregional dairy trade model developed by McDowell (1982;

1986c) based on a partial equilibrium framework which maximizes consumer and producer surplus in the dairy industry. A partial equilibrium model of the U.S. dairy industry, developed as an interregional trade model, consisting of demand for fluid and manufactured milk products, and Grade A and Grade B milk supply will be developed. The interrelationships among disaggregated manufactured milk products, butter, nonfat dry milk, and cheese, and with the fluid milk market and the supply of Grade A and Grade B milk will be evaluated. The effects of the price support programs and import quotas on each manufactured milk product market will be considered. As a result, it will be possible to address current problems (for example over-protection of the nonfat dry milk market relative to markets for other products) that have not been considered in previous studies. The interregional trade model will provide market equilibrium prices and quantities in each region and optimal trade flows among regions. The model will also provide estimations of producer and consumer surpluses by region.

Simulations of an interregional trade model utilizing separable programming will be conducted to evaluate the effects of potential changes in federal milk policy. The results from the simulations under various policy options will provide estimates of equilibrium prices and quantities, trade flows, income distribution and direct program costs.

Policy options to be considered first are changes in raw milk support price levels. Pricing policy options of changing the support price levels will be a stepwise reduction from $12.60 per cwt to $9.60 per cwt by $1.00 per cwt decrements combined with split ratios for allocating the price decrease between butter and nonfat dry milk of 0 to 1.0 (Option 1), 0.5 to 0.5 (Option 2), and 0.16 to 0.84 (Option 3). These options will be applied to dairy markets under the 1982 federal milk marketing order system (1982 system) and under the 1985 federal milk marketing order system representing a new Class I differential system established by dairy provisions of the 1985 Farm Bill (1985 Farm Bill system).[4] The purpose of the stepwise decrease in the support and purchase price levels associated with the three options of splitting a $1.00 decrease in the support price between butter and nonfat dry milk is to induce the dairy industry to move toward a market clearing

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[4] For a detailed discussion, see the section 2.2 in Chapter II.

situation. This study will also simulate the market clearing situation with a zero level of CCC purchases of nonfat dry milk and butter under the 1982 federal dairy programs and quota system, and under the option that quota levels are increased by ten percent of the 1982 commercial demands for butter, nonfat dry milk, and cheese.

In the analysis, the regulatory institutions are reflected in constraints upon the objective function of the model. Changes in policy parameters such as support price levels, Class I differentials, or quotas result in changes in constraint parameters faced by the industry. Therefore, changes in policy in the dairy industry will be modeled by changing the parameters of the constraints.

I.3. Structure of This Dissertation

In order to analyze the effects of regulatory policies, these policies need to be understood. Chapter II describes dairy programs and discusses the effects of two major federal programs, the federal marketing order and price support programs, with a graphical analysis. A description of recent dairy market performance through 1985 follows. Then, recent literature concerning dairy market structure is reviewed.

Chapter III contains the economic implications of the U.S. interregional trade model with disaggregation among manufactured milk products. Market demand and supply functions, supply aggregation conditions, classified and blend prices, and prices for manufactured dairy products are discussed in the context of an interregional dairy trade model. At the end of Chapter III, a mathematical comparative static analysis of the effects of changes in the support and purchase prices, and import quotas on the dairy market is presented.

Chapter IV conveys the structure of the empirical analysis of this study. This chapter introduces the spatial equilibrium framework of an interregional dairy trade model maximizing the total area of consumer and producer surplus subject to the institutional constraints. Utilizing the separable linear programming technique, the means of solving the problem, linear programming specifications of the model and economic implications of the optimal conditions are also presented in this chapter.

In Chapter V, simulation results concerning unregulated and current markets are first presented. Treating the unregulated market equilibrium as a norm, comparisons are drawn between unregulated and regulated markets in terms of changes in national and regional prices, quantities, and welfare gains and losses. Then simulation results concerning regulated markets with various policy options are also presented. Effects of changes in the CCC support and purchase prices, and import quotas, on national and regional prices, quantities, producer and consumer surplus, and direct program costs are evaluated. The final chapter, Chapter VI, includes a summary, conclusions, and limitations of the study.

A theoretical review of consumer and producer's surplus, and an application of the review to the dairy industry is discussed in Appendix A. In Appendix B, full specification of the mathematical problem of the interregional dairy trade model and economic implications of the Kuhn-Tucker optimality conditions are presented. Development of the model parameters including regional supply and demand functions and data collection is described in Appendix C. Simulated market results under various pricing policy options are displayed in Appendix D. Finally, matrix generating FORTRAN program, input and output (MPS input) files for the 1982 system simulation are displayed in Appendix E.

CHAPTER II

CURRENT GOVERNMENT DAIRY REGULATORY PROGRAMS AND MARKET INSTITUTIONS

II.1. Introduction

The U.S. dairy industry is affected by many federal government regulations and policies. In the broad sense, monetary and macro-economic policies, including international trade policies, also have a significant influence on the dairy industry. In this chapter, however, the focus is only on the principal policies that directly affect the dairy industry. Other policies that may affect the dairy sector are beyond the scope of the discussion.

The chapter begins with a description of the dairy price support program and the federal milk marketing order program. The dairy market under the price suppport and marketing order is then graphically illustrated within the context of an average regional fluid market and an aggregated national manufactured milk market. In order to link the discussion of the dairy industry under current government programs to the following modeling chapters, several aspects of recent national and regional market performance are reviewed. This is followed by a discussion about processing raw milk into butter, nonfat dry milk, and cheese, and of calculation of CCC purchase prices for these products. Selected literature concerning the dairy market structure is reviewed at the end of the chapter.

II.2. Major Dairy Programs

II.2.1. Dairy Price Support Program

The dairy price support program is authorized by the Agricultural Act of 1949 and administered by the Commodity Credit Corporation (CCC). The CCC stands ready to purchase butter, nonfat dry milk, and cheese in the manufactured milk market mainly to support farm level milk prices at announced levels. The support program has three major objectives: (1) to assure an adequate supply of milk to consumers, (2) to reflect changes in the cost of production and, (3) to assure a level of farm income to maintain productive capacity sufficient to meet future needs (USDA, ASCS, Commodity Fact Sheet, March 1986; p. 1).

The Secretary of Agriculture is directed by law to establish a support price for manufactured milk products only and to seek to achieve the specified national average milk price (usually in milk equivalents) by offering to purchase surplus cheddar cheese, butter, and nonfat dry milk at announced prices.[5] Since the CCC purchases the final manufactured products in the market at the support price level, the prices actually paid by milk processors to dairy producers are not directly regulated by the program.[6]

The effects of the price support program became prominent in the 1980s. Prior to 1980, the net expenditure on the dairy support and related programs peaked at about $721 million during the 1976-1977 marketing year, with a net market removal of approximately 7 billion pounds in milk equivalents (m.e.) as shown in table II-1. The percentage of the net removal to total milk production ranged from 0.6 percent (1973-74) to 6.0 percent (1970-71). Since 1980, the net removal and the net expenditure of the price support program has expanded dramatically. Net removals reached 13 billion pounds (m.e.) during the 1980-1981 marketing year through an expenditure of approximately $2 billion to purchase 9.8 percent of the total milk produced. The CCC purchased more than ten percent of the total milk produced during 1981-1983 (table II-1). During the 1981-1982 marketing year, the net expenditure was $2.28 billion followed by $2.72 billion during 1982-1983. Provisions to reduce the support prices established by two recent laws, the Dairy Production Stabilization Act of 1983 and the dairy title of the Food Security Act of 1985, are expected to play a major role in reducing CCC purchase levels, and reducing the government

[5] These prices will be called purchase prices in this study. Since manufactured milk products are processed from the raw milk, prices for these products can be expressed in terms of their own units or milk equivalents.

[6] The national average of support price level, however, is indirectly associated with the minimum prices of the federal milk-marketing order program. See the next section for a detailed explanation.

Table II.1. Average Support Price, Total Milk Production, Market Removals, and Net Government Purchase Expenditures, 1970-1985

Year	Average Support Price ($/cwt)	Total Production (bil lbs)	Market Removals (bil lbs)	Net Purchase Expenditures ($ mil)
1970-71	4.66	117.4	7.1	383.5
1971-72	4.93	119.4	6.6	385.1
1972-73[a]	5.11	119.1	4.9	158.2
1973-74	5.45	114.9	0.7	26.7
1974-75	6.91	115.6	2.4	475.7
1975-76	7.48	116.4	0.9	176.8
1976-77[b]	8.63	122.2	6.9	720.8
1977-78	9.22	121.7	3.2	444.9
1978-79	10.32	122.5	1.1	246.7
1979-80	11.93	127.3	8.2	1262.4
1980-81	13.10	131.7	12.7	1990.7
1981-82	13.10	135.0	13.8	2282.4
1982-83	13.10	139.0	16.6	2716.0
1983-84	12.68	136.1	10.3	1982.6
1984-85	12.23	140.5	11.5	1819.7

[a] From 1972-73 forward, the program provided for mid-year adjustment. Figures are simple averages for years.

[b] From 1976, the marketing year began in October 1 instead of April 1.

Source: USDA, ASCS. Commodity Fact Sheet. April 1986, Tables 1 and 9.

expenditure. Decreased average support prices and net expenditures during 1983-1985 reflected the desired role of the government in the dairy market, that of less involvement.

On December 25, 1985, the Food Security Act of 1985 (1985 Farm Bill) was signed. It consisted of a compromise of conflicting interests among dairy, other agricultural and non-agricultural interest groups. In the dairy title of the 1985 Farm Bill, provisions to adjust the support prices were established along with other provisions.[7] The bill required that the support price be $11.60 per cwt by the end of 1986 and that the support price be reduced to $11.10 per cwt by October 1, 1987. Then the support price may be adjusted up or down by $0.50 annually in the 1988, 1989 and 1990 calendar years. If the projected annual government purchases exceed 5 billion pounds in calendar year 1988, 1989, or 1990, the bill requires the Secretary of Agriculture to lower the support price by $0.50. If the projected purchases, however, are less than 2.5 billion pounds during the same period calendar years, the Secretary may increase the price by $0.50.

II.2.2. Federal Milk Marketing Order Program

The current federal milk marketing order program has its roots in the Agricultural Adjustment Act of 1933, and is authorized by the Agricultural Marketing Agreement Act of 1937, as amended. The federal marketing order program was established by these laws in order to help milk producers equalize bargaining power with processors and to reduce the inherent instability in the milk market which existed prior to 1930. The federal order program is administered by the Agricultural Marketing Service, and each order employs a market administrator appointed by the Secretary of Agriculture.

The federal order program is primarily a stabilizing tool for fluid milk markets and, hence, is applied to milk produced under more stringent sanitary conditions for sale in fluid use. The federal order, however, regulates milk handlers, who are defined as persons who handle Grade A milk from dairy producers for distribution in the marketing area. The regulated milk handlers under the order must pay at least the minimum prices for specific uses of purchased Grade A milk. However, the

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[7] Other provisions included the establishment of the Milk Termination Program and changes in the minimum Class I differentials in Eastern and Midwestern orders in the federal milk marketing order program. See McDowell (1986a) for a detailed explanation.

order does not regulate from whom, among regulated Grade A milk producers, the handlers shall buy, or to whom or for what prices they may sell the milk.

Babb et al. (1983; p. 165) summarized the objectives of the federal program which have been used to administer the order program as follows:

1. Promote "orderly marketing" in fluid milk markets.

2. Stabilize milk prices and improve the income situation of dairy farmers.

3. Supervise the terms of trade in milk markets in such a manner as to achieve more equality of bargaining between producers and milk processors.

4. Assure consumers of "adequate supplies" of good-quality milk at reasonable prices.

Buxton (1979; pp.4-5) defines the terms of "orderly marketing" and "adequate supply" as follows:

> The term "orderly marketing" is usually associated with stabilizing fluid milk prices, providing secure and dependable markets for individual Grade A dairy producers providing milk primarily for the fluid market, and promoting constructive competition by improving the balance of market power between farmers and handlers. "Adequate supply" is usually associated with maintaining a reserve of Grade A milk on a seasonal, weekly, and daily basis that can be drawn from when the Grade A milk supply is tight relative to fluid demand. Such a reserve would eliminate unusually high prices and possible shortage.

To carry out these objectives, federal milk marketing orders undertake four principal activities: classifying, pricing, auditing, and pooling. Under all marketing orders, milk is classified based on its use and a handler must pay a specific price for the milk which varies with the use the handlers make of the milk. Class I milk is the Grade A milk used to produce fluid milk products such as whole milk, low-fat milk, chocolate milk, butter milk, etc. Class II milk is Grade A milk used to produce "soft" manufactured products, generally including fluid cream, ice cream, cottage cheese, and yogurt. Class III milk is Grade A milk used to produce "hard" manufactured products. Cheddar cheese, butter, nonfat dry milk, and canned milk are included in Class III milk.[8]

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[8] As of 1984, 38 out of 45 orders use a three-class system and the remaining 7 orders use a two-class system where all Grade A milk used in manufacturing is Class II, and priced accordingly (USDA, 1984a). Due to the complexity of calculating Class II and Class III prices, all Grade A milk used in manufacturing will be classified as Class II milk in this analysis.

The Minnesota-Wisconsin (M-W) manufacturing price[9] is used as a basic formula price by all orders. The minimum Class III price in the three-class system orders and the minimum Class II price in the five orders with the two-class system are equivalent to the M-W price. The minimum Class II price in forty orders (including two orders with two-class system) is calculated by adding a small differential to the M-W price. The differential ranges from 5 to 25 cents per cwt, and averages around 10 or 15 cents per cwt (USDA, AMS, 1984a; pp. 93-5).

The minimum Class I price is the M-W price plus a Class I differential. Four factors are considered to establish the Class I differentials: (1) additional costs incurred for sanitary requirements, (2) transportation costs, (3) additional costs of producing milk in a given supply area, and (4) supply and demand conditions for milk, including the cost of alternative supplies (USDA, AMS, 1981; p. 25). Generally 90 cents per cwt was paid for Class I milk in consideration of factors (1), (3) and (4). The transportation cost is reflected by a pricing surface that approximates an increase of 15 cents per cwt per hundred miles from Eau Clair, Wisconsin. This is consistent with the assumption that the Upper Midwest was the major surplus area of Grade A milk supply.

Under the 1985 Farm Bill, minimum Class I differentials were increased in 35 federal marketing orders temporarily for two years effective May 1, 1986. Class I differentials in the South Atlantic, East South Central and West South Central regions will be increased relatively more than other regions (table II-2). Class I differentials will be increased more than $.90 per cwt in the Tampa Bay and Southeastern Florida orders in the South Atlantic region, and in the Texas and New Orleans-Mississippi orders in the West South Central region. After the temporary two-year period, the differentials will be subject to modification through the normal hearing procedure (McDowell, 1986a; p. 5).[10]

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[9] The M-W price is calculated by surveying on a monthly basis 110 cheese, butter and nonfat dry milk manufacturing plants in Minnesota and Wisconsin to determine the average price they paid producers for manufacturing milk. The prices paid by these plants are unregulated and are believed to be competitively determined and representative of supply and demand conditions for milk used in manufacturing (Babb et al., 1983; p. 166).

[10] The Class I differential, especially transportation cost, is generally less systematic in orders West of the Rocky Mountains. Furthermore the California milk market is regulated by the state.

Table II.2. New Minimum Class I Differentials in 35 Federal Orders (1985 Farm Bill)

Marketing Orders	New Differential	Increase
	-- dollars per hundredweight --	
North Atlantic		
New England	3.24	.24
New York-New Jersey	3.14	.30
Middle Atlantic	3.03	.25
South Atlantic		
Georgia	3.08	.78
Alabama-W. Florida	3.08	.78
Upper Florida	3.58	.73
Tampa Bay	3.88	.93
Southeastern Florida	4.18	1.03
East North Central		
Southern Michigan	1.75	.15
Eastern Ohio-W. Penn.	1.95	.10
Ohio Valley	2.04	.34
Indiana	2.00	.47
Chicago Regional	1.40	.14
Central Illiois	1.61	.22
Southern Illiois	1.92	.39
Louis.-Lex.-Evans.	2.11	.41
West North Central		
Upper Midwest	1.20	.08
Eastern South Dakota	1.50	.10
Blackhills	2.05	.10
Iowa	1.55	.15
Nebrska-W. Iowa	1.75	.15
Greater Kansas City	1.92	.18
East South Central		
Tennessee Valley	2.77	.83
Nashiville	2.52	.67
Paducah	2.39	.69
Memphis	2.77	.83
West South Central		
Central Arkansas	2.77	.83
Forth Smith	2.77	.82
Southwest Plains	2.77	.79
Texas Panhandle	2.49	.24
Lubbock-Plainview	2.49	.07
Texas	3.28	.96
Grater Lousiana	3.28	.81
New Orleans-Miss.	3.85	1.00
Mountain		
Eastern Colorado	2.73	.43

Source: McDowell, 1986a

Under the order system, each handler is required to report purchasing information about volumes, prices, and sources and processing information about usage and classification on the monthly basis to the local order authority. Handler's reports can be corrected based on audits.

Under all orders, dairy producers are paid a weighted average price. The weighted average price is often called blend price or uniform price. Under the pooling system, each handler pays the specific price for milk used in each classification into a pool.[11] The blend price is calculated by dividing the total payments for all classified milk used by the total quantity of milk purchased. Under a two-class system order, for instance, the blend price is formulated in the following way.

$$Blend\ Price\ (\tilde{Pb}) = \frac{(\mathrm{PI} \times \mathrm{XI}) + (\mathrm{PII} \times \mathrm{XII})}{XA} \qquad (II-1)$$

where PI is the minimum Class I price of Grade A milk; PII is the minimum Class II price of Grade A milk; XI is the total quantity of Grade A milk classified into Class I milk; XII is the total quantity of Grade A milk classified into Class II milk; XA is the total quantity of Grade A milk used in all classes of milk, the sum of XI and XII.

Processors with a greater portion of Class I milk use than the order market average pay into a settlement fund of the pool and those with a lesser portion withdraw an equal amount of money from the pool. In this way, milk producers may be ensured that they are paid the same price for milk even though an individual's milk may be used at variance to the marketwide average.

As of 1985, there were 44 federal milk order marketing areas as shown in table II-3. During that year, 116,750 dairy producers delivered approximately 98 million pounds of milk to handlers regulated under the 44 federal milk orders. Almost 80 percent of all Grade A milk was under federal order regulation. This was equivalent to 70 per cent of all the milk marketed in the United States. Producer deliveries used in Class I milk amounted to 42.2 billion pounds. Equivalently the Class

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[11] There are two types of pools, market-wide and individual-handler. With individual-handler pooling, a blend price is computed for each pool handler, based on that handler's utilization and classified prices. With this system, each handler pays his dairy producers the full amount of the obligation computed for that handler. Consequently, producers shipping to different handlers receive different blend prices. The market-wide system is introduced in the text. Currently, three of the orders provide for individual-handler pooling rather than market-wide pooling.

Table II.3. Measures of Growth in Federal Milk Order Markets, 1947-1985

Year	Number of markets 1/	Population of Federal milk marketing areas 2/	Number of handlers 1/	Number of producers 3/	Producer deliveries	Producer deliveries used in Class I	Percentage of producer deliveries used in Class I	Prices at 3.5% butterfat content 4/: Class I	Prices at 3.5% butterfat content 4/: Blend	Receipts as percentage of milk sold to plants and dealers: Fluid grade	Receipts as percentage of milk sold to plants and dealers: All milk	Daily deliveries per producer	Gross value at blend price adjusted for butterfat content: Per producer	Gross value at blend price adjusted for butterfat content: All producers
	Number	1,000	Number	Number	Million pounds	Million pounds	Percent	Dol. per 100 lb.	Dol. per 100 lb.	Percent	Percent	Pounds	Dollars	1,000 dol.
1947	29	*	991	135,830	14,980	9,808	65.5	4.65	4.34	*	21	302	5,024	682,407
1950	39	*	1,101	156,584	18,660	11,000	58.9	4.51	3.93	41	25	326	4,914	769,442
1955	63	46,963	1,483	188,611	28,948	18,032	62.3	4.67	4.08	51	32	420	6,510	1,227,815
1956	68	48,575	1,486	183,830	31,380	19,615	62.5	4.90	4.24	51	33	466	7,534	1,384,995
1957	68	57,297	1,889	182,551	33,455	21,339	63.8	4.87	4.51	53	34	502	8,147	1,487,153
1958	74	60,717	1,962	186,155	36,356	23,309	64.1	4.72	4.40	56	36	535	8,500	1,582,310
1959	77	67,720	2,197	187,576	40,149	26,250	65.4	4.79	4.43	60	40	586	9,466	1,775,583
1960	80	88,818	2,259	189,816	44,812	28,758	64.2	4.88	4.47	64	43	648	10,482	1,989,615
1961	81	93,727	2,314	192,947	48,803	29,859	61.2	4.91	4.45	67	45	704	11,131	2,147,656
1962	83	97,353	2,258	186,468	51,648	31,606	61.2	4.80	4.14	70	47	761	11,854	2,210,330
1963	82	100,083	2,144	176,477	52,860	32,964	62.4	4.78	4.15	70	48	821	12,814	2,261,437
1964	77	99,333	2,010	167,503	54,447	33,965	62.4	4.87	4.23	70	48	888	14,174	2,374,137
1965	73	102,351	1,891	158,077	54,444	34,561	63.5	4.93	4.31	70	48	944	15,300	2,418,526
1966	71	98,307	1,724	145,964	53,012	34,805	65.7	5.55	4.95	70	48	994	18,526	2,630,908
1967	74	103,566	1,650	140,657	53,761	34,412	64.0	5.85	5.17	71	49	1,056	20,321	2,858,351
1968	67	117,013	1,637	141,623	56,444	36,490	64.6	6.23	5.53	74	52	1,089	22,561	3,195,087
1969	67	122,319	1,628	144,275	61,026	39,219	64.3	6.50	5.74	77	56	1,164	24,892	3,591,293
1970	62	125,721	1,588	143,411	65,104	40,063	61.5	6.74	5.95	79	59	1,244	27,636	3,963,311
1971	62	142,934	1,529	141,347	67,872	40,268	59.3	6.90	6.08	80	60	1,316	29,893	4,225,340
1972	62	142,934	1,487	136,881	68,719	40,938	59.6	7.10	6.31	78	60	1,372	32,439	4,440,288
1973	61	141,472	1,355	131,565	66,229	40,519	61.2	8.03	7.31	78	60	1,386	37,461	4,928,514
1974	61	141,546	1,312	126,805	67,778	39,293	58.0	9.35	8.36	78	61	1,464	45,376	5,753,852
1975	56	144,467	1,315	123,855	69,249	40,106	57.9	9.36	8.64	78	63	1,532	49,233	6,097,768
1976	50	149,493	1,305	122,675	74,586	40,985	54.9	10.70	9.75	79	65	1,661	60,277	7,394,486
1977	47	150,093	1,260	122,755	77,947	41,125	52.8	10.59	9.69	80	66	1,740	62,692	7,695,764
1978	47	150,131	1,189	119,326	78,091	41,143	52.7	11.40	10.57	80	67	1,793	70,528	8,415,787
1979	47	150,131	1,127	116,447	79,436	41,011	51.6	12.88	11.97	80	67	1,870	83,262	9,695,637
1980	47	164,908	1,091	117,490	83,998	41,034	48.9	13.77	12.86	80	67	1,954	93,685	11,007,001
1981	48	165,459	1,058	119,323	87,989	40,746	46.3	14.69	13.63	80	68	2,021	102,354	12,213,199
1982	49	169,770	1,010	120,743	91,611	40,807	44.5	14.63	13.53	81	69	2,079	104,573	12,626,510
1983	46	170,882	958	121,052	95,757	41,091	42.9	14.69	13.53	82	70	2,168	109,142	13,211,805
1984	45	171,044	912	119,033	91,676	41,517	45.3	14.41	13.33	81	70	2,104	104,935	12,490,729
1985	44	168,565	884	116,750	97,764	42,201	43.2	13.88	12.61	80	70	2,294	107,886	12,595,737

* Data not available.
1/ End of year. (Date on which pricing provisions became effective.)
2/ End of year. 1955-59, 1960-70, 1971-79, 1980 -1985 according to 1950, 1960, 1970, and 1980 U.S. census, respectively.
3/ Average for year.
4/ Prices are simple averages for 1947-61 and weighted averages for 1962-84.

Source: USDA, AMS, Federal Milk Order Market Statistics, July 1986; p. 16.

I utilization rate (percentage of producer deliveries used in Class I milk) was 43.2 percent (table II-3).

Measures of the growth in federal milk order markets during 1947-1985 are listed in table II-3. As indicated in this table, the federal marketing order has been changing in its structure in three aspects over the period. The average size of the federal order has expanded more than four times in terms of the average volume of producer deliveries and the average population of the federal milk marketing area. Numbers of handlers and producers have significantly declined since 1961, by 62 percent and 40 percent respectively. Over the same period, producer deliveries doubled from 49 billion pounds to 98 billion pounds. And, finally, the Class I utilization rate has dropped from 61 percent to 43 percent. This is because of increasing Grade A milk production as a percentage of total milk produced and declining fluid milk consumption.

II.2.3. Effects of Federal Dairy Programs

As shown in figure II-1, Grade A milk may be used in fluid milk or manufactured milk while Grade B milk is used in manufactured milk only. The federal milk marketing order program affects Grade A milk market. The dairy price support program and import quotas affect manufactured milk market. The two major federal programs affect classified prices, M-W price, and blend price in the interrelated fluid and manufactured dairy markets as shown in figure II-2. An average regional fluid market is illustrated in panel (a) and an aggregated national manufactured market in panel (b).

Definitions of notation in figure II-2 are as follows: SA, the aggregated Grade A milk supply curve of a region; XI, the aggregated Grade A milk supply in fluid use (Class I milk) in the region; XII, the aggregated Grade A milk supply in manufactured use (Class II milk) in the region; $\sum SB$, the aggregated national Grade B milk supply curve; $\sum XII$, the national aggregated quantity of Class II milk supplied; YF, the regional fluid milk demand curve; AR, the blend price curve based on the formula for pooling in the region; YM, the national manufactured milk product demand curve; Ym, the quantity of commercial demand for manufactured milk; Qg, the quantity of manufactured milk purchased by the government under the support price program; $\sum XB$, the total

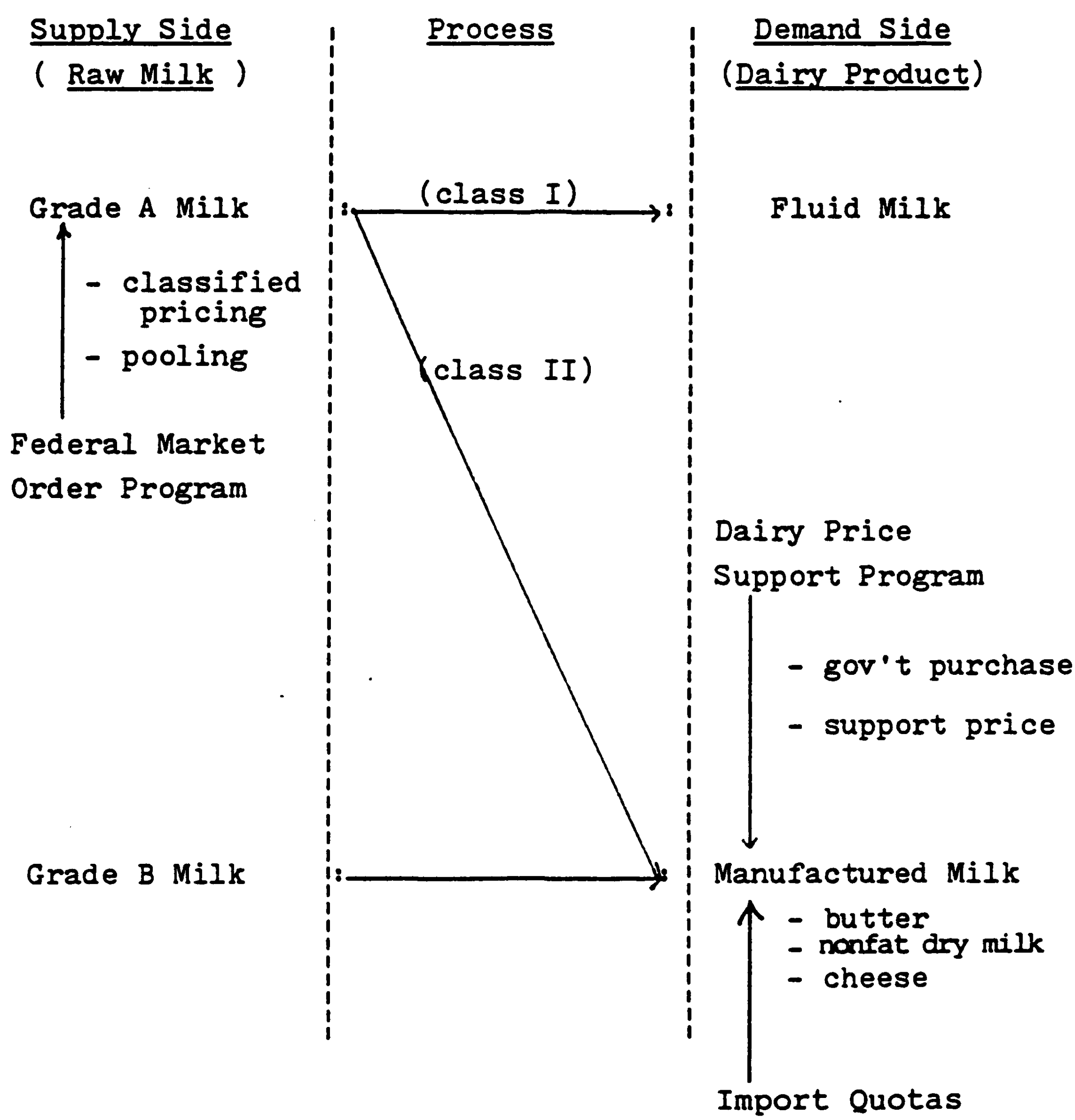
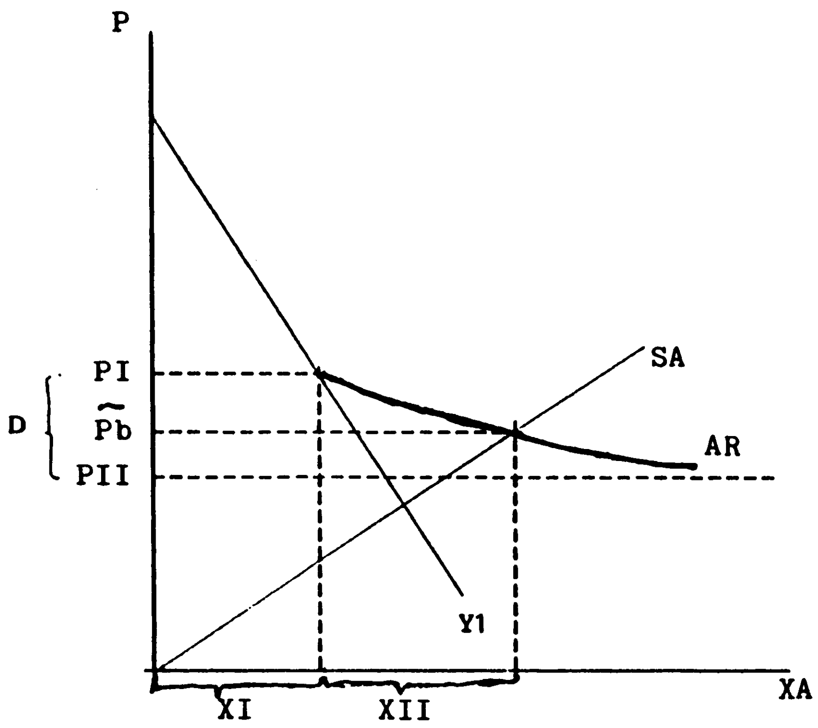
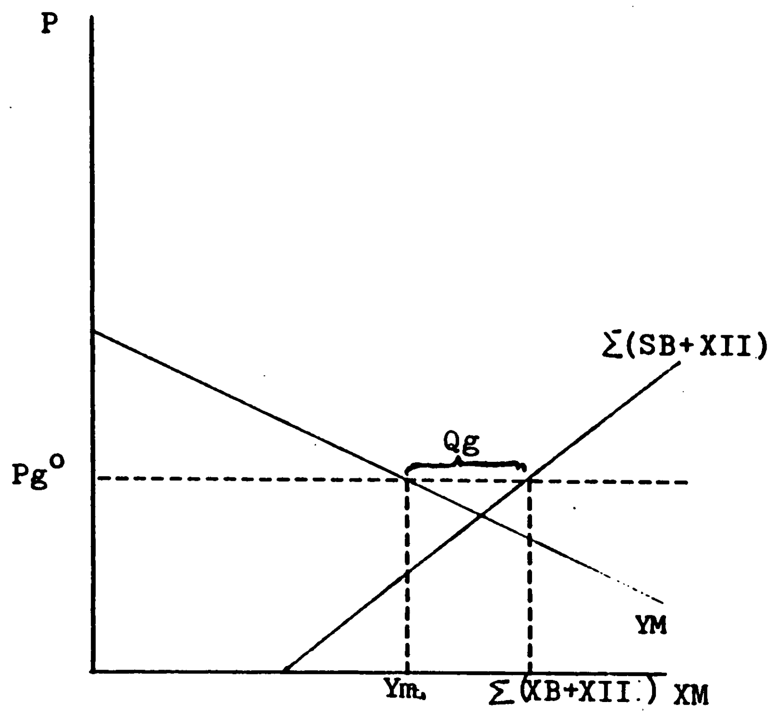


Figure II.1. Product Flows in the Dairy Industry



(a) Regional Grade A supply and fluid demand under federal programs



(b) National manufactured dairy market

Figure II.2. U.S. Dairy Market: Minimum Class Prices, Support Price and Blend Price (McDowell, 1982, p. 18) quantity of Grade B milk supplied; PI, the minimum Class I price; PII, the minimum Class II price; $\tilde{P}b$, the expected blend price defined in equation (II-1); Pg^o , the government support price level; and D, the minimum Class I differential. The demand and supply curves are at the farm level. All prices are then converted into one measurement unit of milk equivalents.

The CCC intervenes in the market by purchasing Qg in the national manufactured milk market at its announced support price level, Pg^o . Hence the manufactured market is cleared at the support price level, Pg^o. The total quantity demanded for the manufactured milk by the private sector, Ym, and the government sector, Qg, is equal to the total quantity supplied by the Grade B milk producers, $\sum XB$, and Grade A milk producers, $\sum XII$, throughout the nation. Since the M-W manufactured dairy market is an important part of the national manufactured dairy market, the M-W price is closely related to the CCC support price level, Pg^o .

Since the Class II minimum price, PII, is equivalent to the M-W price for all practical purposes, the PII in figure II-2(a) is at the same level as Pm^o in figure II-2(b). The Class I minimum price, PI, is equal to PII plus the Class I differential, D. The Class I minimum price, set by the federal order, has two important economic implications. Since PI is the mimimum price, it limits fluid consumers to no more than XI along the demand function. Increased consumption will not take place unless the support price level and/or the Class I differential are reduced. The dairy producers produce XI + XII amount of total Grade A milk under the assumption that they will be paid the blend price, $\tilde{P}b$, calculated by the pooling formula. If there is no interregional trade of fluid milk, then some of the Grade A milk produced, XI or Class I milk, is used for fluid milk and the remaining Grade A milk, XII or Class II milk, is processed into manufactured dairy products.

Given that the number of dairy producers in an order area is relatively large,[12] it can reasonably be assumed that the individual farmer is a price taker rather than a price controller. Since the producer cooperatives cannot control individual producers's production levels (Manchester, 1983; p. 247) and the blend price is directly related to the aggregated production level

[12] The average number of producers in a market order in 1985 was 2,464.

of Grade A milk, the blend price may be assumed to be competitively determined within the federal order institutional arrangements. Provided with various market services and information by cooperatives, the individual producers face a near perfectly competitive market situation.[13]

Given that individual dairy producers are price takers, they simply consider the blend price level, $\tilde{P}b$, as a marginal revenue (MR) and optimize their profits where the marginal revenue (MR), or the blend price level, matches the marginal cost (MC) of milk production. The long-run equilibrium condition for the individual farmer with zero excess profits is shown in figure II-3(a). Figure II-3(b) is a replica of figure II-2(a). The two-price system under current dairy programs has somewhat distorted the industry by signaling an inefficient price, for society as a whole, to dairy producers. Suppose figure II-3(b) represents an average regional fluid milk demand and Grade A milk supply market. Under the classified pricing regime, Class II Grade A milk is sold at PII in the market. However since the marginal cost of producing Grade A milk is increasing, the marginal cost to society exceeds the marginal revenue of society when the total Grade A milk production level is beyond point "a" in figure II-3(b).

Given that there are no controls over production decisions, the individual producer considers $\tilde{P}b$ as the marginal revenue and tries to maximize his profit producing "xa" where $\tilde{P}b$ = MR = MC (figure II-3(a)). However the marginal revenue of the individual producer is the average revenue, not the marginal revenue, of the society. Nevertheless, the aggregated Grade A milk is produced where the marginal cost is equal to $\tilde{P}b$. Since the marginal revenue of society is still at PII, due to the classified pricing system, the triangle "abc" is the net social cost which results in resource misallocation and inefficiency in the economy (Kessel, p. 59).

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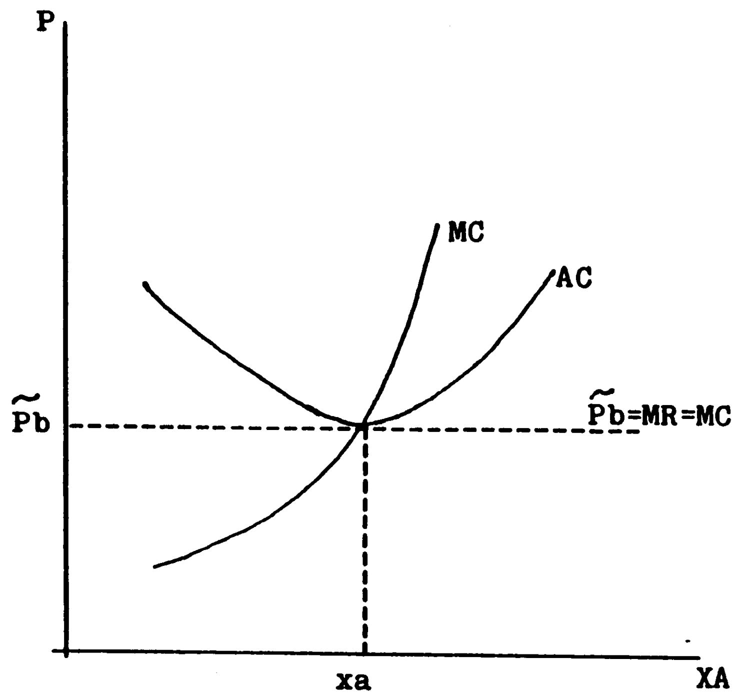
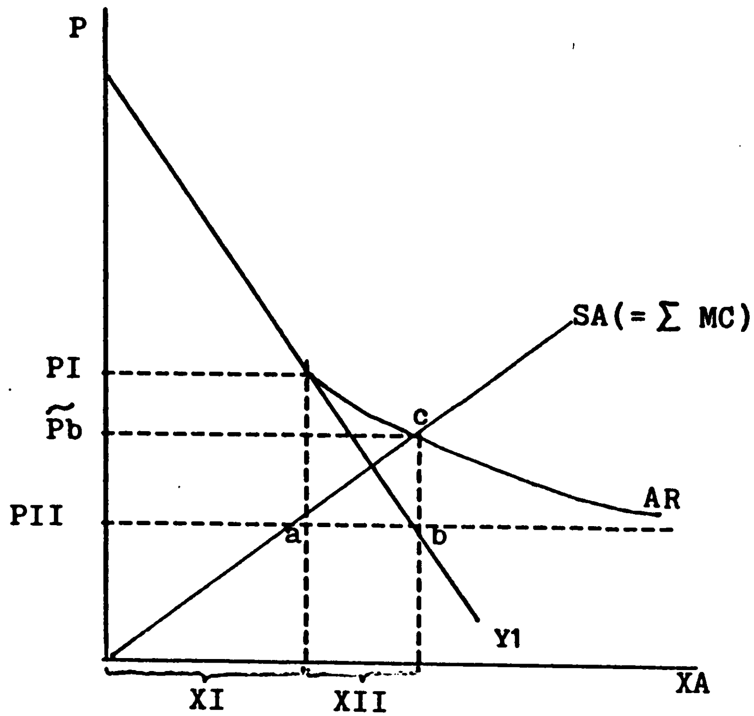
[13] Perfect competition requires four principal assumptions: homogenous commodity; numerous economic agencies; full information; and free entry and exit in the long run (Henderson and Quandt, pp. 104-5).



(a) Long-run equilibrium condition for individual dairy producer in the near perfect competition



(b) Regional Grade A supply and fluid demand under federal programs

Figure II.3. Long-Run Equilibrium of the Grade A Milk Production

II.3. Recent Market Performance

II.3.1. Raw Milk Market

Prices and quantities generated by the U.S. dairy industry for the last two decades are shown in table II-4.[14] Total milk production in the U.S. varied from 115 billion pounds (1975) to 144 billion pounds (1985). Milk production has steadily increased since 1975. The consumption pattern shows some interesting trends: fluid milk use fell from 1965 through 1983 and then increased in 1984 and 1985. Manufactured milk use has increased by about 40 percent over the period. This increase in manufactured milk use is attributed to both an increase in the commercial use (60 percent) and an increase in CCC purchases (40 percent). Milk prices reached a peak in 1983 and declined after that time. These trends imply that the supply of milk has gradually shifted outward in the first half of the 1980s.

The outward shift of milk supply is partially explained by the increasing milk productivity per cow. During the past two decades, total milk production increased 20 billion pounds while total cow numbers declined from 15 million to 11 million. This implies an increase of milk productivity per cow of about 60 percent over the period.

In table II-5, the annual average Grade A (Class I and blend) and Grade B (manufactured) milk prices during the period 1965-1985 are shown. Major trends are an increase in the difference between the Class I and Grade B milk prices, and a decrease in the difference between the blend and Grade B milk prices. In absolute terms the Class I differential (column iv) increased from \$1.89 per cwt in 1965 to \$2.83 per cwt in 1985. However, the ratio of the difference to the Grade B price (column (iv)/(iii)) declined from .57 in 1965 to .24 in 1985. The difference in the blend price and the Grade B price (column vi) was reduced from \$1.29 to \$1.16 per cwt over the period. The ratio of the difference to the Grade B price (column (vi)/(iii)) dropped from .39 to .10 over the period.

The declining trend of the relative Class I differential (column v) was drastic during the period of 1965-1980 while it has stabilized since 1980. This implies that supply variations decreased

[14] The discussion in this section draws largely on McDowell (1982; pp. 34-41).

Table II.4. Dairy Production, Consumption, Factors, and Prices, 1965-1985

	1965	1975	1980	1983	1984	1985
Production and Consumption (bil. lbs. m.e.)						
Production	124.2	115.4	126.5	139.7	135.4	143.7
Farm Use	6.0	3.1	2.3	2.4	3.0	2.5
Marketings	118.2	112.3	124.2	137.3	132.4	141.2
Fluid Products	55.4	51.1	50.9	49.7	50.6	52.0
Mfd. Products						
Commercial	57.1	59.2	64.5	70.8	73.2	76.0
CCC Purchase	5.7	2.0	8.8	16.8	8.6	13.2
Production Factors						
Cow Numbers (1000)	14,953	11,140	10,779	11,098	10,840	11,025
Production per Cow (lbs/year)	8,305	10,352	11,875	12,585	12,495	13,031
Milk/Feed Price Ratio[a]	1.18	1.31	1.48	1.45	1.41	1.51
Prices ($/cwt)[b]						
Support	3.71	7.24	12.33	13.06	12.60	11.73
Mfd. Milk	3.34	7.63	12.00	12.63	12.47	11.72
Blend (Grade A)	4.63	9.02	13.20	13.72	13.58	12.88

[a] Pounds of 16% ration equal in value to one pound of milk.
[b] Prices at national average milk fat test.

Sources: USDA, ERS, Dairy Outlook and Situation, 1982, 1985 and 1986.

Table II.5. National Average Prices and Class I Utilization Rate, 1965-1985

Year	Average Prices[a]			Class I Differential[a]		Blend Differential[a]		Class I Utilization (%)	Ratio of Grade A Milk to all Milk Marketed (%)
	Class I (i)	Blend (ii)	Grade B (iii)	(i-iii) (iv)	Ratio (iv/iii) (v)	(ii-iii) (vi)	Ratio (vi/iii) (vii)	(viii)	(ix)
1965	5.23	4.63	3.34	1.89	.57	1.29	.39	63.4	69
1970	7.09	6.05	4.70	2.39	.51	1.35	.29	61.5	74
1975	9.81	9.02	7.63	2.18	.29	1.39	.18	57.9	80
1980	14.44	13.20	12.00	2.44	.20	1.20	.10	48.9	85
1982	15.34	13.73	12.66	2.68	.21	1.07	.09	44.5	85
1983	15.40	13.72	12.63	2.77	.22	1.09	.09	42.9	86
1984	15.11	13.58	12.47	2.64	.21	1.11	.09	45.3	86
1985	14.55	12.88	11.72	2.83	.24	1.16	.10	43.2	86

[a] $ per hundredweight

Source: USDA, ERS, Dairy Outlook and Situation, 1982, 1985 and 1986.

gradually from 1965 until 1980 and stabilized after that. Another important trend is that the support price level has stabilized from 1980 until 1983 and it has fallen after 1983 (table II-1). The fact that the difference between the blend price and the Grade B price has steadily deteriorated may be viewed partially as a result of the rational behavior of profit maximizing dairy producers. If the difference between the blend price and the Grade B price was greater than the additional cost of meeting the sanitary conditions for the Grade A milk production over time, then Grade B milk producers would be expected to convert to Grade A milk producers. This would lower Class I utilization ratios and create a higher percentage of the Grade A milk production to all milk marketed. This behavior is reflected in the last two columns in table II-6. The Class I utilization rate was 63.4 percent in 1965. Since 1965, the rate has declined to 42.9 percent in 1983. This means that since 1980 more than half of the fluid eligible (Grade A) milk has been transferred to and marketed in the manufactured milk market. The domiance of the Grade A milk is represented by high percentages of the Grade A milk to all milk marketed, which has been over 85 percent since 1980.

Regional production trends during 1970-1985 are shown in table II-6. In only two regions, the Pacific and Mountains, did production increase over all periods. Two other regions, the Delta and Northern Plains, showed decreases over all periods. The decrease over the last period in these regions was 0.5 and 6.7 percent, respectively. From 1980 to 1985, all regions but the two above plus the Appalachian and Southeast regions showed increases in production.

The average price information for these regions is shown in table II-7. Over-time regional prices tend to diverge less from the national average. This is illustrated by examining regional prices as proportions of the national average price. In 1970, the range of these proportions was from .84 in the Northern Plains to 1.27 in the Southeast. In 1985, the distribution of these proportions was closer to 1.0. The lowest rate was .95 in the Northern Plains and the highest was 1.22 in the Southeast. This means that the regional average price surface across the nation has become much flatter. Two reasons for this trend are decreasing fluid utilization of the Grade A milk and decreasing Class I differentials relative to the manufactured milk prices over time, both driving the average price towards the manufactured milk price.

Table II.6. Milk Production and Proportional Changes by Region, 1970-1985

Region	Production (mil. lbs)				Proportional Changes		
	1970	1975	1980	1985	70-75	75-80	80-85
Northeast	24,224	23,515	26,139	28,733	-.029	+.112	+.099
Lake	32,673	32,257	36,885	41,520	-.013	+.143	+.126
Corn Belt	17,334	15,642	15,994	17,096	-.098	+.023	+.069
Northern Plains	5,904	5,309	5,253	5,603	-.101	-.010	-.067
Appalachian	8,202	7,946	8,415	8,620	-.031	+.059	-.024
Southeast	4,151	4,353	4,546	4,454	+.049	+.044	-.020
Delta	2,823	2,637	2,574	2,586	-.066	-.024	-.005
Southern Plains	4,315	4,286	4,735	5,172	-.011	+.109	+.092
Mountains	4,662	5,081	6,131	7,902	+.090	+.207	+.289
Pacific	12,518	14,165	17,688	22,286	+.140	+.249	+.259
U.S.	116,962	115,334	128,525	143,667	-.014	+.114	+.118

Sources: USDA, SRS, Milk Production, Disposition, and Income, Various Years.

Table II.7. Cash Receipts[a] and Average Prices[b] by Region, 1970-1985

Region	1970	1975	1980	1985	Proportion of National Averages 1970	1975	1980	1985
Northeast	1516.7	2053.7	3338.2	3718.1				
	6.26	8.73	12.77	12.94	1.12	1.04	1.01	1.03
Lake	1619.3	2543.2	4574.8	5005.6				
	4.96	7.88	12.40	12.06	.89	.94	.98	.96
Corn Belt	918.4	1280.2	2015.1	2106.0				
	5.30	8.18	12.60	12.32	.95	.98	1.00	.98
Northern Plains	277.7	393.8	640.8	668.9				
	4.70	7.42	12.20	11.94	.84	.89	.97	.95
Appalachian	458.6	684.4	1079.2	1126.3				
	5.59	8.61	12.82	13.07	1.00	1.03	1.01	1.04
Southeast	295.0	447.0	661.2	685.1				
	7.11	10.27	14.54	15.38	1.27	1.23	1.15	1.22
Southern Plains	278.4	382.5	636.9	701.1				
	6.45	8.96	13.45	13.56	1.16	1.07	1.06	1.07
Delta	172.4	240.1	341.9	358.6				
	6.11	9.11	13.28	13.87	1.09	1.09	1.05	1.10
Mountains	262.1	410.3	746.9	996.4				
	5.62	8.08	12.18	12.61	1.01	.96	.96	1.00
Pacific	711.2	1205.9	2187.0	2736.4				
	5.68	8.51	12.36	12.29	1.02	1.02	.98	.97
U.S.	6525.2	9664.3	16251.0	18135.2				
	5.58	8.38	12.64	12.62	1.00	1.00	1.00	1.00

a Cash receipts are figures at the top of each row of the region ($ mil.).

b Average prices are figures at the bottom of each row of the region ($ per hundred weight).

Sources: USDA, ERS, Dairy Outlook and Situation, 1974, 1981 and 1986.

The use of federally regulated Grade A milk in fluid products changed from 61.2 percent in 1973 to 43.2 percent in 1985 for all marketing orders (table II-8). On a regional basis, the Class I utilization rate decreased over time in all regions except the New Orleans-Mississippi and Nashville orders. The largest decrease was 29.1 percent in the Iowa order. The largest increase was 16.3 percent in the Nashville order. Given fixed or decreasing minimum fluid prices, increased Grade A milk moving into manufacturted use results in the blend price approaching the manufactured milk price.

II.3.2. Manufactured Milk Markets

In this section, product flows of processed dairy products and the relationships among the support price and purchase prices are described first. A discussion of the recent market performance of the manufactured milk products follows.

II.3.2.1. Processed Manufactured Milk Products

The manufactured milk market may be divided into three major product markets: butter, cheese, and nonfat dry milk. Butter is produced either in butter-powder or cheese plants. In a butter-powder plant, butter is manufactured as a joint product with nonfat dry milk. In a cheese plant, butter is made from whey cream which is a by-product of the cheese. Since whey butter is a by-product, net milk equivalent butter statistics do not usually include this amount. Butter produced in the cheese plant is therefore not considered in this study.

A simplified product flow in a cheese plant is illustrated in figure II-4. Both Grade A and Grade B milk may be received at the cheese processing plant. Some milk may be shipped to other plants, with the remaining milk going into the manufacturing process. Some cheese plants also receive condensed skim milk to mix with raw milk, which raises the solid content of the milk. The by-product of cheese making is whey. Some plants simply dump the whey. Other plants pasteurize the whey, then dry it into whey powder and package it. Still others condense the whey and ship it out of the plant for further processing. Whey fat may be separated and shipped out or churned into whey butter (Ling, p. 3).

Table II.8. Class I Utilization for Selected Federal Milk Marketing Orders, East of the Rockies, 1973 and 1985

Market	Class I Utilization(%) 1973	1985	Change 73 - 85
New England[a]	66.6	51.7	-14.9
New York-New Jersey	53.4	39.9	-13.5
Mid Atlantic	64.5	46.0	-18.5
Upper Florida	96.3	86.9	- 9.4
Georgia	89.5	81.0	- 8.5
Tennessee Valley[a]	81.7	73.0	- 8.7
Tampa Bay	93.5	88.1	- 5.4
S.E. Florida	93.2	88.6	- 4.6
Chicago Regional	42.0	19.4	-22.6
Ohio Valley	67.4	53.8	-13.6
E. Ohio-W. Pennsylvania	66.3	52.6	-13.7
S. Michigan[a]	65.5	41.7	-23.8
Louisville-Lexington-Evansville	72.9	63.3	- 9.6
Central Illinois	59.4	56.5	- 2.9
St. Louis-Ozarks	65.3	52.8	-12.4
Greater Kansas City	58.0	48.9	- 9.1
Upper Midwest	38.6	13.5	-25.1
Iowa[a]	58.6	29.5	-29.1
New Orleans-Miss.[a]	62.9	69.8	+ 6.9
Greater Louisiana[a]	85.4	81.7	- 3.7
Memphis	80.3	73.7	- 6.6
Nashville	73.8	90.1	+16.3
Paducah	88.8	76.9	-11.9
Oklahoma Metro	69.8	49.9	-19.9
Cent. Ark.-Ft. Smith[b]	87.5	80.5	- 7.0
Lubbock-Plainview	92.3	90.3	- 2.0
Texas[a]	75.2	67.7	- 7.5
Texas Panhandle	85.8	72.6	-13.2
E. Colorado	74.5	64.3	-10.2
All Marketing Orders	61.2	43.2	-18.0

[a] Markets are defined differently in 1973 and 1985. Utilization rates are calculated using similar marketing area definitions.

[b] Combined markets.

Sources: USDA, AMS, Federal Milk Order Market Statistics, 1975 and 1986.

Simplified product flow in a cheese plant

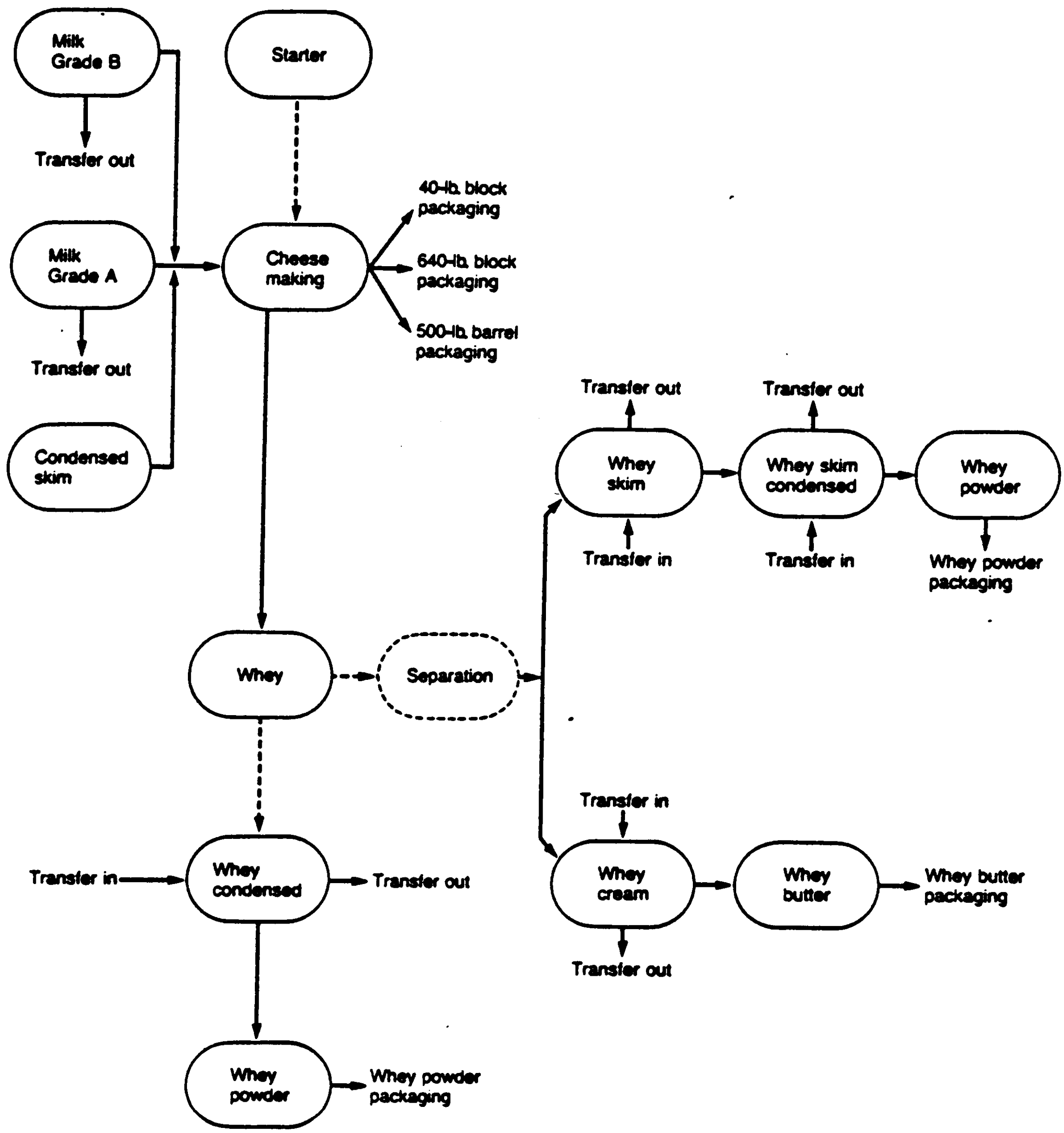


Figure II.4. Simplified Product Flow in a Cheese Plant (Ling, 1983; P. 2)

A simplified product flow in a butter-powder (nonfat dry milk) plant is illustrated in figure II-5. Milk receiving and shipping operations in the plant are the same as in a cheese plant. Milk is then moved into the first step in the manufacturing process, that of being separated into skim milk and cream. A plant also may ship and receive some skim milk and cream from other plants. Skim milk is condensed and sent through the dryer to be made into powder. The powder may be packaged in bags to be sold to the CCC or in commercial sale units. Cream is churned into butter. Butter may be bulk-packaged in containers to be sold to the CCC or in commercial cardboard boxes. Buttermilk, the residue from butter churning, may be put through a condenser and dryer for buttermilk powder and sold commercially (Ling, p. 4).

II.3.2.2. Relationship Among the Support Price and Purchase Prices

Calculation of CCC purchase prices for butter, nonfat dry milk, and cheese is illustrated in table II-9. In 1982, the farm-level support price was $12.60 per cwt milk equivalent. The CCC manufacturing allowance for converting 100 pounds of whole milk into cheese and whey was $1.37 per cwt. Hence the value of the cheese and whey per hundred pounds of milk was $13.97 per cwt with a farm-level support price of $12.60. The value of whey was $.37 and the value of cheese per hundred pounds of milk was $13.97 less $.37 per cwt. Since the conversion ratio for cheese is 10.1, the cheese purchase price is calculated by dividing $13.60 by 10.1. This was $1.3465 per pound of cheese at the plant level.

As illustrated in figure II-4, butter and nonfat dry milk are jointly processed from raw milk. An increase or decrease in support price is split arbitrarily between butter and nonfat dry milk.[15] Conversion ratios for butter and nonfat dry milk are 4.48 pounds and 8.13 pounds respectively per hundred pounds of raw milk. The CCC manufacturing allowance for converting hundred pounds of whole milk into butter and nonfat dry milk was $1.22 per cwt. Hence the value of butter and nonfat dry milk made from hundred pounds of raw milk was $13.82 per cwt. This value was the sum of $6.45 for butter and $7.37 for nonfat dry milk. The CCC purchase prices for butter and

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[15] See footnote 2 in table 3, USDA, ASCS, Commodity Fact Sheet , April 1984.

Simplified product flow in a butter/powder plant

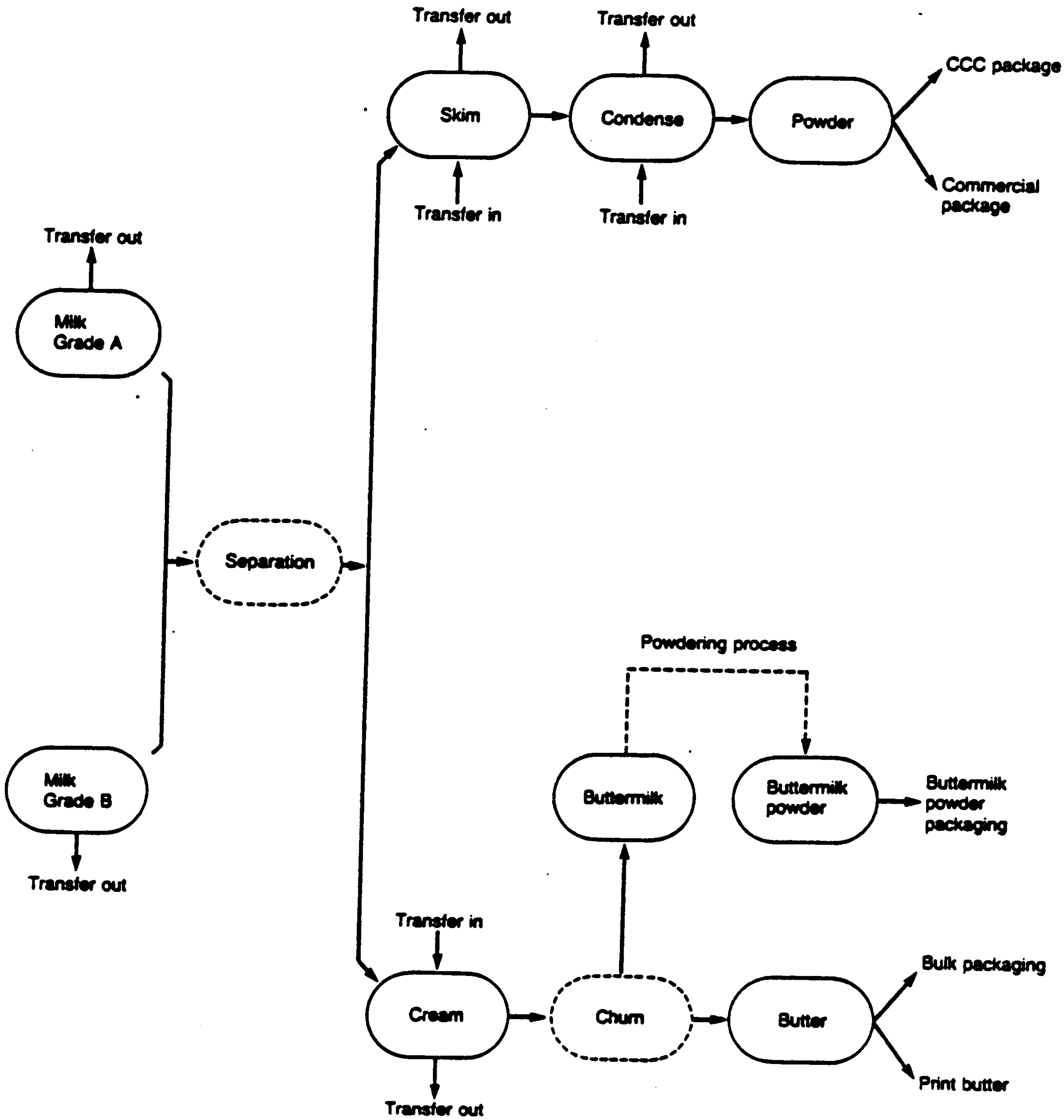

Figure II.5. Simplified Product Flow in a Butter-Powder Plant (Ling, 1983; p. 5)

Table II.9. Calculation of CCC Purchase Prices with Support at $12.60 per cwt

Item	1982 Average
Farm level support price for manufactured milk ($/cwt at 3.67% milkfat)	12.60
Yields per 100 pounds of milk at average test (pounds)	
Butter	4.48
Nonfat Dry Milk (NDM)	8.13
Cheese	10.10
<u>Butter-NDM Price Calculation</u>	
Return to butter-NDM plants ($/cwt)	12.60
CCC manufacturing allowance for converting 100 pounds of raw milk into butter and NDM ($/cwt)	1.22
Value of butter and NDM made from 100 pounds of raw milk ($/cwt)	13.82
Value of NDM per 100 pounds of raw milk ($/cwt)	7.37
Value of butter per 100 pounds of raw milk ($/cwt)	6.45
Butter Purchase Price ($/lb)	1.4390
NDM Purchase Price ($/lb)	.9069
<u>Cheese Price Calculation</u>	
Return to cheese plants ($/cwt)	12.60
CCC manufacturing allowance for converting 100 pounds of raw milk into cheese and whey ($/cwt)	1.37
Value of cheese and whey made from 100 pounds of raw milk ($/cwt)	13.97
Value of whey	.37
Value of cheese per 100 pounds of raw milk ($/cwt)	13.60
Cheese Purchase Price	1.3465

Source: USDA, ASCS. <u>Commodity Fact Sheet</u>. May 1983; Table 3.

nonfat dry milk are calculated by dividing these values by conversion ratios: 4.48 for butter and 8.13 for nonfat dry milk. They were $1.4390 per pound of butter and $.9069 per pound of nonfat dry milk at the plant level respectively in 1982.

II.3.2.3. Market Performance

Production of butter, nonfat dry milk, and American cheese increased from 1975 until 1983 (table II-10). In 1984, production of these products dropped by 12.25, 22.73, and 9.58 percent, respectively, but reached 1983 levels again in 1985. The production of other cheese, however, has steadily increased since 1975. Imports of butter and nonfat dry milk have not substantially changed. Imports of cheese also have steadily increased over the period. Exports of nonfat dry milk and American cheese have steadily increased since 1975. Export of butter drastically increased in 1981 and reached a peak the following year. After 1982, exports of butter remained at a level of between 120 and 180 million pounds.

Since 1979, CCC purchases of manufactured milk products have increased dramatically. As shown in table II-11, total expenditures under the price support program increased four and half times by 1980 compared to 1979. In 1983, total expenditures reached $2,972 million, the largest amount in history, followed by $2,665 million the next year. During the 1984-1985 marketing year, the CCC paid $406 million to purchase butter and butter products and $665 million for nonfat dry milk. The CCC paid $749 million to purchase cheese over the period. Percentage-wise, the CCC paid 22.3, 36.5, and 41.2 percent of total expenditures under price support programs for butter, nonfat dry milk, and cheese, respectively, over the period. During the 1985 marketing year, the CCC purchased 25.9, 67.7, and 22.0 percent of the manufactured milk processed and marketed for butter, nonfat dry milk, and cheese respectively (table II-12). This implies that the nonfat dry milk market is far more protected by the program than the butter and cheese markets in terms of product pounds.

Increased CCC purchase of nonfat dry milk is closely related to imports of casein. A USDA study (1984c; p. 14) argued that casein can very nearly be a pound-for-pound substitute in some food products for nonfat dry milk. A USDA report (1981) estimated that about 330 million pounds

Table II.10. Import-Export and Domestic Production of Selected Manufactured Milk Products, U.S., 1975-1985

	1975	1980	1981	1982	1983	1984	1985
(million pounds)							
Butter							
Import	2	2	3	3	3	3	4
Export	1	1	130	210	119	131	180
Production	984	1,145	1,228	1,257	1,299	1,103	1,289
Nonfat Dry Milk							
Import	2	5	3	2	2	2	3
Export	113	289	356	448	769	617	984
Production	1,001	1,161	1,314	1,401	1,500	1,159	1,390
American Cheese							
Import	16	18	20	18	22	24	20
Export	5	5	19	37	42	59	70
Production	1,660	2,381	2,648	2,759	2,932	2,651	2,854
Other Cheese[a]							
Import	163	213	228	252	265	282	283
Export	4	8	8	26	10	8	16
Production	1,152	1,603	1,629	1,782	1,887	2,023	2,170

[a] Cottage cheese was not included.

Source: USDA, ERS, Dairy Situation and Outlook Yearbook, DS-406, July 1986; Tables 16, 17, 18 and 20, pp. 22-4.

Table II.11. CCC Total Expenditures for Dairy Products under Price Support Program, Selected Years, 1971-1985

Year	Butter	Nonfat Dry Milk	Cheese	Total
(million dollars)				
1971	210.1	154.8	35.5	400.4
1975	67.5	327.9	92.8	488.2
1979	84.0	185.5	20.4	289.9
1980	343.3	527.3	454.6	1,325.2
1981	559.1	728.5	813.4	2,100.9
1982	600.4	883.5	941.9	2,425.7
1983	700.0	982.5	1,289.4	2,971.9
1984	479.5	790.6	1,043.8	2,665.3
1985	592.0	722.6	877.8	2,822.9

[a] Total expenditure includes purchasing payment, storage and handling, transportation, processing and packaging, and other expenses or outlays.

Source: USDA, ASCS, Commodity Fact Sheet, April 1986, Table 9.

Table II.12. Domestic Production and CCC Removals of Butter, Nonfat Dry Milk, and Cheese, 1981-1985

	1981	1982	1983	1984	1985
(million pounds)					
Butter					
Production (A)	1,228	1,257	1,299	1,103	1,289
Removal (B)	352	382	413	202	334
B/A (%)	28.7	30.4	31.8	18.3	25.9
Nonfat Dry Milk					
Production (A)	1,314	1,401	1,500	1,159	1,390
Removal (B)	851	948	1,061	678	941
B/A (%)	64.8	67.7	70.7	58.5	67.7
American Cheese					
Production (A)	2,648	2,759	2,932	2,651	2,854
Removal (B)	563	643	833	447	629
B/A (%)	21.3	23.3	28.4	16.9	22.0

Sources: Table II-10.

USDA, ERS. Dairy Situation and Outlook Yearbook. DS-406, July 1986; Table 22, p. 25.

of nonfat dry milk were displaced by imported casein in 1980. This amount was just over a half of the nonfat dry milk purchased by the CCC over the period. Given that nonfat dry milk could substitute for about 53 percent of imported casein, McDowell (1985; p. 11) suggested that the effective support price for purchasing nonfat dry milk be decreased to enhance the competitiveness of domestic production of nonfat dry milk against imports of casein, and to balance the CCC purchase of butter, nonfat dry milk, and cheese. This suggestion will empirically be examined in this dissertation.

The increasing trend of the CCC net removals of the manufactured dairy products in the 1980's has been primarily caused by higher prices for manufactured dairy products and, thus, a high price for fluid milk. Due to the perishability of the raw milk, an excess supply of raw milk in the industry would be purchased by the government as butter, nonfat dry milk, and cheese under the current regulatory programs. Therefore higher support prices would increase the government net removals.

Such higher dairy support prices were maintained through restrictive import controls preventing low priced foreign dairy products from entering domestic markets. During 1980-1983, most world imports of manufactured milk products, butter, nonfat dry milk, and cheese, were from countries with high domestic support prices and with export subsidies such as the European Economic Community (EEC), other Western European countries, Canada, Oceaninan countries, and the United States, as shown in table II-13. These exports were essentially disposals of surpluses on the world market and caused world prices for manufactured products to fall below what otherwise would have been the free world market price level.

Almost a half of world exports of butter, nonfat dry milk, and cheese were from the EEC. In the case of butter, 78 percent of the world exports were from the EEC and Oceanian countries, while the U.S. shared 5 percent of the world market. The U.S. shared 19 percent of the nonfat dry milk world market, while 63 percent of exports were from the EEC and Oceanian countries. In the cheese market, only 1 percent of exports were from the U.S. while 83 percent were from the EEC, other Western European, and Oceanian countries.

Table II.13. Shares of World Markets (%) for Butter, Nonfat Dry Milk, and Cheese, Major Countries, 1980-1983

Countries	Butter	Nonfat Dry Milk	Cheese
EC - 10[a]	49	44	49
Other Western Europe	5	6	19
Canada	0	9	0
New Zealand	28	17	9
Australia	2	2	6
United States	5	19	1
Total	89	97	84

[a] Intra-EC trade was not included.

Source: USDA, ERS. Dairy Background for 1985 Farm Legslation. Agricultural Information Bulletin No. 474, September 1984; p. 13.

The domestic prices for dairy products in the above mentioned countries including the U.S. were far higher than the world market prices. As shown in table II-14, the U.S. domestic prices for butter, cheese, and nonfat dry milk were 2.24, 2.10, and 1.73 times the world prices, respectively, during 1981-1982. The domestic prices for the dairy products were the lowest in Australia over the period. The prices for butter, cheese, and nonfat dry milk in Australia were \$.7599, \$.7164, and \$.5271 per pound, respectively. They were just 1.2, 1.1, and 1.0 times the world prices, respectively, while the domestic prices for butter and cheese in the EEC were generally higher than the prices in the U.S.[16] Assuming that the domestic prices represent the cost structures of the countries, these comparisons may indicate that Australia has a comparative advantage over the U.S. in dairy product production while the U.S. and EEC are close competitors with each other.

There are two aspects concerning the U.S. dairy industry related to the world trade situation that deserve mention. First, the U.S. import quotas of the dairy products were authorized under Section 22 of the Agricultural Adjustment Act of 1933. Since domestic dairy product prices are approximately two times current world market prices, imports could drastically increase the cost of supporting prices for the U.S. dairy products if the U.S. did away quotas (USDA, 1984b; p. 33). If this took place, the U.S. would support the world market price assuming no change in its domestic programs. Whether the U.S. dairy industry has a comparative advantage over the major exporting countries is still a debatable issue. Johnston, however, argued that Oceanian countries seem to have a comparative advantage over the U.S. in milk production, though their export capacity is quite limited.

Secondly, Johnston analyzed the impacts of domestic dairy subsidy programs in Australia and New Zealand. He concluded that : (1) the Australian dairy industry is more heavily subsidized than the New Zealand dairy industry, (2) New Zealand, however, has a greater comparative advantage in the dairy industry, and (3) removing the subsidies in both countries would favour New Zealand's competitive position in Australia's domestic market and in international markets. According to Buxton and Frick, the Oceanian countries could have expanded production and sales

[16] These comparisons may not be completely accurate since the U.S. domestic prices were the wholesale prices while the EEC prices were the retail prices.

Table II.14. Domestic and World Market Prices for Butter, Cheese, and Nonfat Dry Milk in the Australia, United States, and EEC Countries, 1981-1982

Country	Butter	Cheese	Nonfat Dry Milk
	-- U.S. dollar per pound --		
World Price	.6410	.6421	.5239
Australia[a]	.7599	.7164	.5271
U.S.A.[a]	1.4390	1.3465	.9069
Denmark[b]	1.9570	2.8358	-
Ireland[b]	1.1597	1.9388	-
Netherland[b]	1.9162	2.0068	-
U.K.[b]	1.6172	2.0068	-
West Germany[b]	1.9796	2.8403	-
Italy[b]	2.3783	4.8154	-

Note: The domestic prices for nonfat dry milk were not available.

[a] Wholesale price.

[b] Retail price.

Sources: Table II-9.

USDA, ERS. European Commodity Dairy Sector: Policies, Problems, and Prospects. Staff Report No. AGES 860316, October 1986; pp. 93-5 (Originally U.N. Trade Data).

USDA, ERS. Australian and New Zealand Dairy Industry Programs. Staff Report No. 841228, May 1985; p.17.

by an additional 1.58 million metric tons by 1980 if the world market had no trade barriers. This quantity would have only contributed three percent of the total U.S. market utilization. However, a recent USDA study (1984b; p. 25) argued that varying export levels from foreign countries such as Europe, New Zealand and Australia would induce instability in imports into the U.S. if quotas were abolished.

II.4. Review of Selected Literature on the Structure of Dairy Markets

Most studies of the U.S. dairy market structure under current federal regulating policies utilized market theory of industrial organization to model a classified price system in the fluid milk market associated with a support price program in the manufactured market. This type of study was originally conducted by Gaumnitz and Reed, and Harris. Kessel, Kwoka, and Ippolito and Masson have extended the work of Gaumnitz and Reed, and Harris. These studies have develped important economic implications for the dairy industry: an economic justification for and effect of the discriminating pricing system, and a comparison of welfare effects between regulated and unregulated dairy markets.

Many dairy economists argued that discrimination of milk prices is based on the notion that fluid milk demand is less elastic than that of manufactured milk. Total revenue can therefore be improved by imposing a higher market price on fluid consumption and a lower price on manufactured consumption. Since a two price system increases the price for fluid milk, which is considered a "necessity", and decreases prices for manufactured milk products, most of which are considered relative "luxury" items, Kessel (p. 60) argued that free competition would lower the price for fluid milk and raise prices for manufactured milk products. Furthermore, a two price system in the dairy market results in increased social cost and large transfers of income from consumers to producers (Masson and Eisenstat, 1980, and Dahlgran, 1980). Some dairy economists have stated that a justification of price discrimination in the milk market should be based on the supply side instead of the demand side. Manchester (1983, p. 271) argued that Grade A milk supply in the fluid market should reflect the additional costs of producing and marketing Grade A milk in fluid use which are not incurred in producing and marketing Grade B milk in manufactured use. He claimed that these costs are reflected in the Class I price.

Kessel made a comparison between regulated and unregulated dairy markets in 1964-1965 and did not find a statistically significant relationship between the existence of orders and the levels of Class I prices. Nevertheless, Kessel concluded that "the behaviour of milk prices in Central Illinois, before the advent of regulation, constitutes an important piece of evidence that market forces, in the absence of federal, state and private controls, can provide the consumer with a steady supply of fresh milk at prices as low as or lower than the prices that would have existed under federal controls" (p. 60).

Two cases of a milk market without a federal order system have been cited by Dobson and Buxton, and Dobson and Salathe. The Chicago milk order was terminated in 1966 after 27 years of operation and was restored two years later with expansion and merger with neighboring orders. In 1973, the Mississippi milk order was terminated and merged into the New Orleans order in 1976. Different experiences from the two different orders suggest somewhat different implications. The Mississippi experience suggests at least three possible results when the order program is terminated. First, flat pricing[17] is likely to emerge when the market is competitive. Second, price variability tends to be increased when the market is unregulated. Finally, overall welfare effects are uncertain as to whether producers will be better or worse off without the order system. Dobson and Buxton, however, concluded that when the Chicago order was terminated there was less instability of the type that emerged in the Mississippi order when the order was terminated. The Chicago experience, according to them, suggested opposite relationships from the ones they found in the Mississippi case.

Dobson and Salathe made two important arguments about the expected competitive market in the dairy industry and the reexamination of a classified pricing system which was originally established to maintain "orderly marketing" and "adequate milk supplies." They pointed out that

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[17] The case where fluid and manufactured milk prices tend to equalize. The term "flat pricing" is often used as opposed to the term "two pricing".

the different experiences of the Mississippi and the Chicago orders implied two extreme notions about the need for the existing federal milk marketing order system: "the inherent capacity" of a federal order with classified pricing and pooling to eliminate "disorder" emerged in Mississippi while a competitive market emerged in Chicago.

Thraen, Thraen and Hammond, and Lefrance and de Gorter have introduced elements of risk aversion and the role of rational producer expectations in production and inventory decisions in their dynamic analysis of the dairy market system. Lefrance and de Gorter argued that the distinction between Grade A and Grade B milk producers in the short run is nonexistent because the investment decision by Grade B producers to convert to Grade A producers mainly affects fixed inputs for enhanced sanitary conditions but does not change the fundamental relationship between yield per cow and variable input use. This implies the pattern of short run marginal cost functions for Grade A and Grade B milk production are the same even though total cost is higher for Grade A milk producers.

In their study on the long run impact of alternative price support policies on the levels of dairy production, consumption and market prices, Thraen, and Thraen and Hammond hypothesized two elements which characterize the impact of price support policies: (1) direct price effect, and (2) the effect on producers' perceived risk.[18] According to Thraen and Hammond, under the rational expectation hypothesis, milk producers form their subjective expectations of future milk prices of the dairy market system within which they make their decisions. They found that the dairy price support program has reduced price risks and production cost and, hence, would have shifted the milk supply function up.

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[18] The price support policy has two positive impacts on the market prices. A guaranteed support price level truncates the lower tail of the price distribution and increases producers' expected prices. The support price policy also creates a more stable economic environment which reduces price variations and risk of production. See Gardner et al., pp. 234-5.

II.5. Summary

In this chapter, three aspects of the U.S. dairy industry were discussed. The objectives of two major federal dairy programs, the dairy price support program and the federal milk marketing order program, are to enhance dairy producers' incomes and to provide market stability with adequate milk supplies in the industry. The dairy price support program affects the national manufactured dairy market by standing ready to buy manufactured dairy products at purchase price levels throughout the nation. The federal milk marketing order program affects the local fluid demand and Grade A milk supply by providing classified pricing and pooling.

Evaluation of recent U.S. dairy market performance indicated that since the early 1980s the U.S. dairy industry has been in an extreme surplus situation resulting from federal programs and an improved economic environment. High levels of the Class I minimum prices under the federal order programs have resulted in the overproduction of Grade A milk yielding decreased Class I utilization rates throughout the nation. High levels of government purchase prices for butter, nonfat dry milk, and cheese have led to increasing government purchases of these products and thus increased the government's removal expenditure.

Resulting from a high CCC purchase price level for nonfat dry milk, a substantial amount of commercial demand for nonfat dry milk has been displaced by imported casein. According to a USDA report (1981), about 330 million pounds of nonfat dry milk was displaced by imported casein in 1980. This amount was approximately half of the government purchase of nonfat dry milk in that year. Due to a high purchase price level, more than 60 percent of the domestic production of nonfat dry milk was removed by the government since 1981. In contrast, about 30 percent or less of the domestic production of butter and cheese was removed by the government over the period.

Selected literature concerning the dairy market structure was reviewed in the context of an economic explanation of classified pricing and pooling under the regulation, and a comparison between regulated and unregulated markets was presented. Introduction of major dairy programs and their effects on the dairy market and introduction of processed manufactured milk products provide the background for an economic model of the U.S. dairy industry with a disaggregate manufactured milk sector in the next chapter. Since the surplus problem needs to be explored in disaggregated manufactured milk markets, the economic model of the dairy industry will look into three major manufactured milk markets: butter, nonfat dry milk, and cheese. In so doing, effects of changes in purchase prices for these products can be analyzed on each product level. Issues examined in literature review concerning market regulations provide background for the empirical model of the U.S. dairy industry, presented in Chapter IV.

CHAPTER III

THEORETICAL INTERREGIONAL U.S. DAIRY MODEL WITH DISAGGREGATED MANUFACTURED DAIRY MARKETS

III.1. Introduction

In the previous chapter, a simplified version of an economic model associated with the federal milk marketing order and price support programs was graphically introduced. In the case of a single order, market prices are directly related to the support price level set by the CCC in the manufactured dairy product market, Class II minimum price and the Class I differential set by the local order system. Pooling provisions in an order provide a weighted average price (blend price) for Class I and Class II milk which Grade A milk producers are paid in each order. As discussed in Chapter II, if producers have full information about the market, they would plan their production schedule according to expected blend price levels. Different resource endowments among different regions result in dairy producers operating under different cost structures. These different cost structures combined with different demand situations in various areas play a major role in influencing interregional milk trade in the U.S. dairy market.

The interregional U.S. dairy market model in this chapter is primarily based on assumptions proposed by Ippolito and Masson, Kwoka, and McDowell (1982). They argued that processors are playing a major role in demanding raw milk for either fluid or manufactured milk products. Cross price elasticity effects between fluid and manufactured milk products were assumed to be nonexistent or to be so small that changes in milk prices in one product would not affect the demand for other products. The price elasticity of the manufactured demand was assumed to be greater than that of the fluid demand. The milk was supplied by Grade A and Grade B milk producers. Grade B milk was used only for manufactured milk production while Grade A milk, produced under more stringent sanitary conditions, could be used either for fluid milk or manufactured production.

In this chapter, the theoretical implications of an interregional U.S. dairy industry model with disaggregated national manufactured dairy product markets for butter, nonfat dry milk, and cheese are developed and analyzed. Cross price elasticity effects among these manufactured products are also considered in this chapter.

III.2. Economic Model

III.2.1. Market Demand and Supply Functions[19]

This study assumes that the U.S. dairy market is divided into n regions and the manufactured milk product markets are aggregated at a national level. The Grade A milk may be produced in each region, processed into fluid milk, and marketed in the domestic region or shipped to other regions for fluid use. The rest of the Grade A milk, Class II milk, is processed into manufactured products and marketed in an aggregated national manufactured milk market. Grade B milk may be produced in each region, processed into manufactured milk products, and marketed in the national manufactured milk market. Because of time limitations, the regional demand for manufactured products was not considered. The study assumes that the transportation costs of manufactured milk products are negligible in their national level aggregation.

Plant-level demand for fluid milk in each region can be specified as functions of own price, per capita income, demographic, economic, and time trend factors. Wholesale-level national demand for butter, nonfat dry milk, and cheese can be specified as functions of own and other prices, and other variables specified in the regional fluid milk demand functions. Under the assumption that variables other than price variables are constant over time and region, regional fluid

[19] Regional market demand and supply functions may be expressed by using subscripts such that, for example, YF_j represents the fluid milk quantity demanded in region j and PF_j is the demand price for fluid milk in region j. In this section, these subscripts are not used for simple expressions.

milk demand and national manufactured milk product demand schedules can be constructed in a price-quantity dimension as follows:

$$YF = YF(PF, \varepsilon_F) \qquad \text{(III – 1)}$$

$$Yk = Yk(P2, P3, P4, \varepsilon_k)\ , \quad \text{where } k = 2,3 \text{ and } 4, \text{ and} \qquad \text{(III – 2)}$$

where YF is the quantity of milk (in milk equivalent terms) demanded by processors for fluid milk products; Yk is the quantity of the kth manufactured milk product demanded by consumers (k = 2 for butter, 3 for nonfat dry milk, 4 for cheese); PF is the price paid per unit of milk (in milk equivalent terms) for fluid utilization; Pk is the price paid per unit of the kth manufactured milk product; ε_F and ε_k are disturbance terms with zero means and non-zero variances.

The market supply functions of Grade A and Grade B milk in each region are derived by aggregating individual marginal cost functions.[20] It is assumed that milk producers are price takers. Grade A or Grade B milk produced by all milk producers is considered to have the same quality within the same grade. It is assumed that milk producers have a reliable information set. The regional market supply functions of Grade A and Grade B milk can be specified as functions of supply prices, output prices for hay and cull dairy cows, input factor prices for feed and labor, and interest rates (reflecting the opportunity costs of capital investment). With an assumption of stability in all factors over time and regions except price, similar to the demand function case, supply schedules can be established as a function of prices as follows:

$$XA^* = XA(RA,\ RB,\ \varepsilon_a) \qquad \text{(III – 3.a)}$$

$$XB^* = XB(RA,\ RB,\ \varepsilon_b) \qquad \text{(III – 4.a)}$$

[20] Heady provided a caveat about the market supply function as an aggregation of individual marginal cost functions arguing that existence of pecuniary externalities and non-pecuniary factors such as uncertainty, lack of knowledge, non-monetary goals, lumpiness of fixed factors and joint production of many agricultural products will distort aggregation of these marginal cost curves into a market supply function (pp. 3-25).

where XA* is the desired quantity of Grade A milk produced by Grade A milk producers; XB* is the desired quantity of Grade B milk produced by Grade B milk producers; RA is the price per unit expected to be received by Grade A milk produers; RB is the price per unit expected to be received by Grade B milk producers; and ε_a and ε_b are disturbance terms.

Generally it is expected that RA and RB will be highly correlated, especially when federal programs are prevailing in the dairy market (Dahlgran, 1980; p. 20). This allows equations (III-3.a) and (III-4.a) to be redefined as average regional market supply functions as follows:

$$XA^* = XA(RA) \qquad (III-3.b)$$

$$XB^* = XB(RB). \qquad (III-4.b)$$

Average regional market demand functions arise from (III-1 and 2) by assuming that expected values of error terms are zero.

The relationship between the actual quantity supplied and the desired quantity supplied can be specified by a Nerlovian partial quantity adjustment model as follows:

$$XA_t = aXA_t^* + (1-a)XA_{t-1} \qquad (III-5)$$

$$XB_t = bXB_t^* + (1-b)XB_{t-1} \qquad (III-6)$$

where XA_t is the actual quantity of Grade A milk supplied in period t; XB_t is the actual quantity of Grade B milk supplied in period t; XA_t^* and XB_t^* are defined above for period t; and a and b are coefficients of adjustment speed for Grade A and Grade B milk production respectively. Suppose producers are perfectly foresighted[21] with full market information and no barriers to instantaneous adjustment. Then equations (III-5) and (III-6) can be simplifed into:

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[21] For a detailed understanding, see Dornbusch and Fischer, pp. 421-4.

$XA_t = XA_t^*$ and $XB_t = XB_t^*$, where $a = 1$ and $b = 1$.

If the price levels announced by federal programs remain steady for a reasonable period of time and the market information is effectively provided to dairy producers, then the expected prices will be very close to the actual prices. Provided that full information is available to milk producers, average market supply functions of Grade A and Grade B milk, equations (III-3.b) and (III-4.b) can be rewritten as:

$$XA = XA(RA), \text{ and } XB = XB(RB). \qquad (III-7)$$

III.2.2. Supply Aggregation Conditions

Suppose the U.S. dairy market is a closed economy so that there is no external leakage or injection except for interregional transportation of Grade A raw milk in fluid use.[22] Then the following quantity constraints must be satisfied in the market equilibrium situation.

$$XA_i = \sum_{j=1}^{n} XA_{ij} + XA2_i \quad \text{for all } i, \ i = 1, n \qquad (III-8)$$

$$YF_j = \sum_{i=1}^{n} XA_{ij} \quad \text{for all } j, \ j = 1, n \qquad (III-9)$$

$$XM = \sum_{i=1}^{n} XA2_i + \sum_{i=1}^{n} XB_i \qquad (III-10)$$

where XA_i is Grade A milk produced in region i; XA_{ij} is Grade A milk shipped from region i to region j for fluid purposes; $XA2_i$ is Grade A milk produced in region i for manufactured purposes;

[22] This assumption will be relaxed later by introducing exports, imports, beginning and ending stocks into the model.

YF_j is fluid milk demanded in region j; XM is total raw milk utilized in manufactured use; and XB_i is Grade B milk produced in region i.

In an annual model, in order to dampen variation problems such as seasonality, an annual reserve requirement for each region may be needed to meet the additional demand for milk in peak seasons in deficit regions such as the South Atlantic region.[23] Suppose the annual average reserve ratio of 20 percent is imposed under the federal marketing order program (Christ; McDowell, 1982).[24] Since at least an additional 20 percent of Class I milk, which is otherwise supposed to be classified into Class II milk, should be reserved by requirement, this implies that:

$$\sum_i XA_{ij} \geq (1.2)YF_j, \quad \text{for any j.} \qquad \text{(III} - 11\text{)}$$

This is rewritten as:

$$(1.2)UR_j \leq 1 \;\text{ or }\; UR_j \leq \frac{1}{1.2} \cong (.83), \quad \text{for any j,}$$

where UR_j is a Class I utilization ratio defined as $YF_j/(\sum_i XA_{ij} + XA2_j)$. Therefore, the Class I utilization ratio in any region ranges between zero and .83 once the reserve requirement ratio of 20 percent is imposed.[25]

Raw milk in manufactured use, XM, may be shipped to butter-powder plants, XM23, or cheese plants, XM4. Once raw milk is shipped to the cheese plant, it is processed and manufactured into cheese. Suppose a unit of raw milk is processed into c^4 units of cheese such that c^4XM4 is the amount of cheese processed in the cheese plant. Similarly, once raw milk is shipped into the

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[23] For details see Manchester (1983), p. 226 and Christ, pp. 284-5.

[24] Dobson and Buxton used 37% reserve allowance in their study. They estimated that the seasonal variation requirement of 12% and 25% should be for daily demands as well as unavoidable Class II and Class III uses in bottling plants.

[25] For instance, the highest annual Class I utilization rate in federal order region in 1982 was 0.82 in the South Atlantic region.

butter-powder plant it is processed and manufactured into butter and powder. Suppose a unit of raw milk is equivalent to the c^2 units of butter and c^3 units of powder such that c^2XM23 and c^3XM23 are the amount of butter and powder produced respectively.

From the processors′ point of view, the marginal cost of producing manufactured milk products is equal to the marginal revenue in the cheese market, or butter and powder markets. Since butter and powder are jointly produced, the marginal revenues of butter and powder are added together to equal the marginal cost of production of butter and powder at equilibrium. Competitive market equilibrium conditions for butter, nonfat dry milk, and cheese markets are derived as follows:

$$XM = XM23 + XM4 \qquad \text{(III} - 12)$$

$$c^2XM23 = Y2 \qquad \text{(III} - 13.a)$$

$$c^3XM23 = Y3 \qquad \text{(III} - 14.a)$$

$$c^4XM4 = Y4 \qquad \text{(III} - 15.a)$$

where Yk is the quantity of demand for kth manufactured milk product ($k = 2$ for butter, 3 for nonfat dry milk, and 4 for cheese, respectively).

Under current federal price regulatory programs, these equilibrium conditions are adjusted to reflect the regulated market equilibrium. Once raw milk in manufactured use is shipped to butter-powder plants, it is processed into butter and powder to be marketed for commercial demands and the residual is purchased by the government. Similarly, raw milk distributed to cheese plants is processed into cheese and will be marketed for commercial demands and the residual is purchased by the government. This yields:

$$c^2XM23 = Y2 + QG2 \qquad \text{(III} - 13.b)$$

$$c^3XM23 = Y3 + QG3 \qquad \text{(III} - 14.b)$$

$$c^4XM4 = Y4 + QG4 \qquad (III - 15.b)$$

where QGk is the amount of the government purchase of the kth manufactured milk product.

III.2.3. Classified and Blend Prices

A classified price scheme in each region under the federal marketing order program yields the regulated market price equilibrium conditions as follows:

$$PF_j \geq PI_j^o \quad \text{for all } j \qquad (III - 16)$$

$$PI_j^o = PII_j^o + D_j \quad \text{for all } j \qquad (III - 17)$$

where PI_j^o is a minimum Class I price; PII_j^o is a minimum Class II price; and D_j is a minimum Class I differential in region j.

To represent the pooling provision of region j under the federal marketing order program, it is assumed that the blend price in region j, $\tilde{Pb}_j$, is determined by the total quantity of Class I Grade A milk for fluid purposes pooled in region j, $\sum_{i=1}^{n} XA_{ij}$, and Class II Grade A milk produced in region j, $XA2_j$, and the Class I and Class II minimum prices in region j, PI_j^o and PII_j^o, respectively.[26]

$$\tilde{Pb}_j = \frac{[(PI_j^o \sum_{i=1}^{n} XA_{ij}) + (PII_j^o XA2_j)]}{(\sum_{i=1}^{n} XA_{ij} + XA2_j)}$$

[26] Under the federal marketing order program, the blend price in region j, $\tilde{Pb}_j$, is the Grade A milk supply price in the region since Grade A milk producers in region j will be paid $\tilde{Pb}_j$ if they sell their milk in region j. They will be paid the blend price in other regions if they ship their milk to other regions and sell it. In this case the net price they will be paid is the blend price less transporation cost. At equilibrium blend prices throughout the nation should be aligned in terms of transporation costs of Grade A milk if there are no trade barriers.

$$= \frac{[\{(PII_j^o + D_j)\sum_{i=1}^{n} XA_{ij}\} + (PII_j^o XA2_j)]}{(\sum_{i=1}^{n} XA_{ij} + XA2_j)}$$

$$= PII_j^o + D_j \frac{\sum_{i=1}^{n} XA_{ij}}{(\sum_{i=1}^{n} XA_{ij} + XA2_j)} \quad , \quad \text{for all } j. \qquad (III-18)$$

Since Grade A milk producers are paid the blend price under the federal milk marketing order program, the blend price is the effective demand price for Grade A milk. If the interregional market is in equilibrium under current federal programs, the supply patterns of milk producers associated with any federal order market are determined by the blend prices and transportation costs. Since each producer or his cooperative has some choice as to which federal order pool to participate in, the logical one is the order offering the highest blend price net of transportation cost. The natural result of producers' shipping their milk to more attractive markets will be a structure of blend prices that reflects differences in transportation costs from production areas to consuming areas. Hence, at the regulated market equilibrium, blend prices satisfy the following condition:

$$\tilde{Pb}_i + T_{ij} \geq \tilde{Pb}_j \qquad (III-19)$$

where T_{ij} is a unit transportation cost from region i to region j.

The existence of an effective demand price curve denoted AR for Grade A milk, defined in (III-18), has several economic implications.[27] First, since the average revenue level is higher than the social marginal revenue, dairy producers are led to produce milk at a higher social cost than

[27] For a graphical illustration of an effective demand curve for Grade A milk, see figure II-2 or 3 in Chapter II.

revenue.[28] This results in over-production of Grade A milk and, hence, a social cost associated with resource misallocation is incurred by the economy as a whole. Second, increasing levels of Class I minimum price in the fluid market and dairy support prices in the manufactured market transfer welfare gains from dairy product consumer groups to milk producers. Third, the effects of changes in dairy policy parameters such as support price level or classified prices on prices and quantities are somewhat complicated because of the shape of the AR curve. It is expected that elasticity of AR in the range close to PI^o is much less than that of AR in the range near PII^o.

III.2.4. Prices of Manufactured Products

The long-run market equilibrium condition implies that the supply price for raw milk in manufactured use, RB_i for all i, is equal to the added market prices for butter and nonfat dry milk in milk equivalent terms less the processing cost, AC_{23}, and also equal to the market price for cheese in milk equivalent terms less the processing cost, AC_4.[29] Under the federal marketing order program, it is assumed that federal order sets the Class II minimum price, PII_i^o, equal to the average market revenue for raw milk in manufactured use denoted PM:

$$RB_i = (c^2P2 + c^3P3) - AC_{23} = c^4P4 - AC_4 = PM, \quad \text{and} \qquad \text{(III - 20)}$$

$$PII_i^o = PM . \qquad \text{(III - 21)}$$

Market price conditions under the price support program need discussion since the support and purchase price levels can be determined arbitrarily by the government. Since raw milk can be shipped to either plant, cheese or butter-powder, if the government sets different support price levels in milk equivalent terms between cheese and butter-powder markets, milk producers will desire to sell their milk first to the market which offers higher revenue. This implies that if different market

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[28] For a discussion, see section 3 in Chapter II.

[29] A farm level price for raw milk in manufactured use is derived from the wholesale price for cheese less the processing cost of cheese or from the added wholesale prices for butter and nonfat dry milk less the processing cost of butter-nonfat dry milk. Since butter and nonfat dry milk are jointly produced from the same raw milk, the processing cost of butter and nonfat dry milk may be measured in milk equivalent terms in the model.

prices exist between cheese and butter-powder markets, then raw milk will be shipped to the market with a higher average revenue until the shipment satisfies the maximum capacity of plants in the market. Then the rest of the raw milk will be distributed to the market with a lower average revenue.

Suppose, at the initial equilibrium, the support price and purchase price levels in the market are set by the government such that:

$$PM \geq Pg^{o} = (c^{2}Pg2^{o} + c^{3}Pg3^{o}) - AC_{23} = c^{4}Pg4^{o} - AC_{4}, \quad \text{and} \qquad (III-22)$$

$$Pk \geq Pgk^{o}, \qquad (III-23)$$

where Pg^{o} is a support price level (in milk equivalent terms); Pgk^{o} is a purchase price level (each in its own unit terms) for the kth manufactured product (k is 2 for butter, 3 for nonfat dry milk, and 4 for cheese, repectively); AC_{23} is a unit processing cost of butter-nonfat dry milk; and AC_{4} is a unit processing cost of cheese.

The operation of the price support program, and the classified pricing and pooling provisions of the federal order program in the U.S. dairy industry with disaggregated manufactured milk markets is explained diagramatically in figures II-2 and III-1. The relationship between demand for butter, nonfat dry milk, and cheese, and supply of the aggregate Class II and Grade B milk at the initial equilibrium under the price support program is illustrated in figure III-1. The definition of each panel in figure III-1 is as follows:

(a) Nonfat dry milk (powder) market

(b) Butter market

(c) Raw milk supply in butter-powder use

(d) Cheese market

(e) Raw milk supply in cheese use

(f) Total raw milk supply in manufactured use.

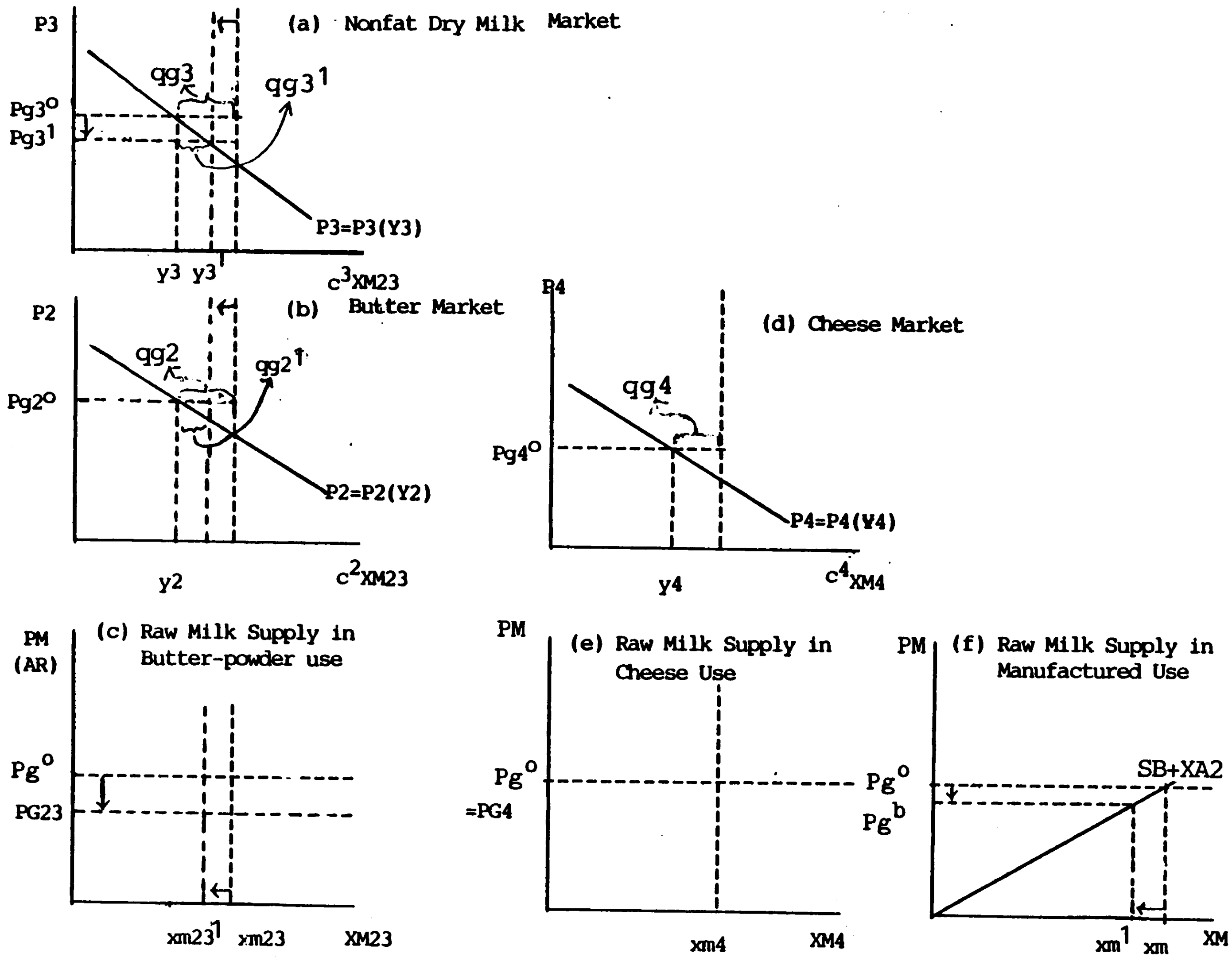

Figure III.1. Demand for Butter, Nonfat Dry Milk, and Cheese, and Supply of Raw Milk in Manufactured Use under Price Support Program

For a simple illustration, it is assumed that the demand for butter, nonfat dry milk, and cheese is affected by its own price only. Given the farm level support price of Pg^o, suppose xm of raw milk in manufactured use (panel f) is supplied to cheese plants and butter-powder plants with the amount of xm4 (panel e) and xm23 (panel c) respectively. Then suppose the government sets the purchase price of $Pg4^o$ in the cheese market (panel d), the private sector would buy y4 of cheese at that price. The excess supply at that price, qg4, is removed by the government. Similarly, suppose the government sets the purchase prices of $Pg2^o$ and $Pg3^o$ in butter and nonfat dry milk markets respectively. Then the private sector demands y2 and y3 of butter and nonfat dry milk respectively at purchase price levels. The remainders, qg2 and qg3, are purchased by the government.

Suppose the government reduces the purchase price for nonfat dry milk from $Pg3^o$ to $Pg3^1$ (panel a) in order to reduce the purchase of nonfat dry milk, while purchase prices for cheese and butter remain the same at $Pg2^o$ and $Pg4^o$ (pannels b and d). Again since butter and nonfat dry milk are jointly produced, the average revenue for raw milk in butter-powder use is the sum of market prices of butter and powder less the processing cost of these products. Given that $Pg3^1$ is the market revenue for powder and $Pg2^o$ for butter, the net total market revenue for butter-powder is lower due to a decrease in the purchase price for nonfat dry milk (pannel c). Since the purchase price for cheese is not changed, the cheese market is not affected. Suppose cheese plants and butter-powder plants are operating at full capacities at the given initial market revenues. Since the net total revenue is lowered, the weighted average revenue for raw milk in manufactured use, Pg^b is also reduced. This implies that manufactured milk market is now in a two-price system. A weighted average revenue induced by the price support program for raw milk in manufactured use, denoted Pg^{b}, can be formulated similarly to the blend price for Grade A milk as follows.

$$Pg^b = \frac{(c^2Pg2^o + c^3Pg3^1 - AC_{23})XM23 + (c^4Pg4^o - AC_4)XM4}{XM23 + XM4}$$

$$= PG23\ \frac{XM23}{XM23 + XM4} + PG4\ \frac{XM4}{XM23 + XM4} \qquad (III-24)$$

where PG23 is $(c^2Pg2^o + c^3Pg3^1) - AC_{23}$ and represents the average revenue for raw milk processed in butter-powder plants, and PG4 is $(c^4Pg4^o) - AC_4$ and represents the average revenue for raw milk processed in cheese plants.

Suppose the government sets purchase prices for butter, nonfat dry milk, and cheese to accrue the same level of average revenue for raw milk such that $(c^2Pg2^o + c^3Pg3^o) - AC_{23} = (c^4Pg4^o) - AC_4 = Pg^o = PG23 = PG4$. Then from equation (III-24):

$$Pg^b = Pg^o \frac{XM23}{XM23 + XM4} + Pg^o \frac{XM4}{XM23 + XM4}$$

$$= Pg^o \left[\frac{XM23 + XM4}{XM23 + XM4} \right] = Pg^o . \qquad (III - 25)$$

Equation (III-22), where the sum of government purchase prices for butter and nonfat dry milk less the processing cost of butter-nonfat dry milk is equivalent to the purchase price for cheese less the processing cost of cheese, is a special case of (III-25). Given that the government purchase prices are set at different levels, the weighted average revenue, Pg^b , is no longer the same as Pg^o. Pg^b is determined by average revenues of raw milk in cheese and butter-nonfat dry milk markets, PG4 and PG23 respectively, and the proportion of raw milk supplied to cheese plants or butter-powder plants to raw milk supplied for manufactured use as illustrated in (III-24).

Due to a decrease in average revenue for raw milk in manufactured use, from Pg^o to Pg^b, the total supply of raw milk is reduced from xm to xm^1 (panel f). Since the cheese market remains the same, only the supply of raw milk in butter-powder use is reduced from xm23 to $xm23^1$ (panel c) by the same quantity that total manufactured raw milk supply is reduced: from xm to xm^1 (panel f). Because of this reduction the supply of butter and powder decreases. In the butter market with the same government purchase price level, the government purchase of butter decreases from qg2 to $qg2^1$ (panel b). In the nonfat dry milk market with the lower government purchase price level, commercial demand increases from y3 to $y3^1$ but governmental demand decreases from qg3 to $qg3^1$ (panel a).

The affects of a change in the CCC purchase price for nonfat dry milk are as follows: (1) the weighted average revenue for raw milk in manufactured use will change; (2) total supply of raw milk in manufactured use will change; (3) since the CCC purchase price for cheese remains the same, the cheese market will not be affected; (4) due to changes in average revenue for raw milk in butter-powder use and raw milk supply for butter-powder purposes, markets for butter and nonfat dry milk will be affected; and (5) the manufactured dairy market is governed by a two-price system, due to different demand prices for raw milk between butter-powder and cheese markets induced by changes in the price support program. The effects of changes in the CCC purchase prices for all dairy products are analogous to the case of a change in the CCC purchase price for nonfat dry milk. The effects, however, will be complicated and simultaneous among markets for butter, nonfat dry milk, and cheese.

III.3. Comparative Statics Analysis

III.3.1. Introduction

Under current federal programs, the U.S. dairy industry is affected by two major policy parameters: minimum Class I differentials of the federal marketing order and the support price of the price support programs. Changes in these policy parameters will affect the industry in several ways.

In this section, the effects of changes in policy parameters such as the support and purchase prices, and import quotas will be analyzed based on the framework discussed in previous sections. McDowell (1982) presented a graphical comparative statics analysis of the effects of changes in the pricing policy instruments (pp. 101-8). His analysis, however, was based on a single-region market model and did not consider interregional shipments and regional blend price alignments. A mathematical comparative statics analysis in the context of an interregional dairy trade model extending McDowell's graphical analysis is presented below.

III.3.2. Initial Model under Current Federal Programs

Under the current federal milk marketing order program, it is assumed that the fluid milk market in any region is regulated with classified pricing and pooling. The fluid milk demand is restrained by the minimum Class I price (PI^{o}). The Grade A milk supply responds to the blend price. Due to a higher level of PI^{o} compared to the blend price and manufactured milk price, a quantity of Grade A milk supplied beyond fluid use is inevitable and the whole portion of the excess supply, Class II milk, is transferred to the manufactured milk markets. Under the current dairy price support program, the excess supplies of the manufactured milk products are purchased at the announced support price levels by the government.

As discussed in the previous sections, the relationships of prices and quantities between fluid milk and manufactured milk product markets can be summarized as follows:

<u>Prices</u>

$$PF_j \geq PI_j^{o} \quad \text{from (III}-16)$$

$$PI_j^{o} = PII^{o} + D_j \quad \text{from (III}-17)$$

$$\tilde{Pb}_j = PII^{o} + D_j UR_j \quad \text{from (III}-18)$$

$$\text{where } UR_j = \frac{\sum_{i=1}^{n} XA_{ij}}{\sum_{i=1}^{n} XA_{ij} + XA2_j}$$

$$RB_j = PM = PII^{o} \geq Pg^{o} \quad \text{from (III}-20 \wedge 22)$$

$$Pg^{o} = \frac{(c^2Pg2^{o} + c^3Pg3^{o} - AC_{23})XM23}{XM23 + XM4} + \frac{(c^4Pg4^{o} - AC_4)XM4}{XM23 + XM4} \quad \text{from (III}-24)$$

$$Pk \geq Pgk^{o} \quad \text{from (III} - 23)$$

Quantities

$$XA_j = XA_j(\tilde{Pb}_j) \quad \text{from (III} - 7)$$

$$XB_j = XB_j(RB_j) \quad \text{from (III} - 7)$$

$$YF_j = YF_j(PF_j) \quad \text{from (III} - 1)$$

$$Yk = Yk(P2, P3, P4) \quad \text{from (III} - 2)$$

$$XA2_j = XA_j - \sum_{i=1}^{n} XA_{ji} \quad \text{from (III} - 8)$$

$$XM = \sum_{j=1}^{n} XA2_j + \sum_{j=1}^{n} XB_j \quad \text{from (III} - 10)$$

$$XM = XM23 + XM4 \quad \text{from (III} - 12)$$

$$QGk = c^k XM23 - Yk \quad \text{for } k = 2, 3 \quad \text{from (III} - 13.\text{b) and (III} - 14.\text{b)}$$

$$QG4 = c^4 XM4 - Y4 \quad \text{from (III} - 15.\text{b)}$$

for $j = 1, n$ and $k = 1,2,3$.

The effects of a change in the support price on the blend price is not straight-forward to analyze because a blend price is a function of Class I and Class II minimum prices, Grade A milk in fluid use pooled in the region, and Class II utilization of Grade A milk in the region. Once a shock is imposed on the blend price, a dynamic process is initiated, which continues until the market system stabilizes at a new equilibrium. Hallberg et al. used this concept by employing an iterative procedure with initially estimated Class I and Class II utilization ratios. Given that the rate of change in the Class I utilization ratio in region j, UR_j, is relatively smaller than the rate of change in the Class I or Class II minimum price, it is expected that the effect of a change in the Class I or Class II minimum price on blend price is direct.

The effect of a change in the support price on the blend price is derived as follows. From equations (III-1, 7, 8) and (III-18), the blend price can be expressed as a function of the Class II minimum price and the Class I utilization rate. Since the Class I utilization rate is also a function of the blend price, the blend price can be written as follows:

$$\tilde{Pb}_j = PII^o + D_j UR_j(\tilde{Pb}_j) \qquad (III-26)$$

Since PII^o is very closely related to Pg^o, it is assumed that $Pg^o = PII^o$. The effect of a change in the support price on the blend price is derived from (III-26).

$$\frac{d\tilde{Pb}_j}{dPg^o} = \frac{d\tilde{Pb}_j}{dPII^o} = 1 + D_j \frac{dUR_j(\tilde{Pb}_j)}{dPII^o} = 1 + D_j \frac{\partial UR_j}{\partial \tilde{Pb}_j} \frac{\partial \tilde{Pb}_j}{\partial PII^o}$$

$$\rightarrow \frac{d\tilde{Pb}_j}{dPg^o} = \frac{1}{[1 - D_j \frac{\partial UR_j}{\partial \tilde{Pb}_j}]}. \qquad (III-27)$$

Equation (III-27) implies that the effect of a change in the support price on the blend price and the effect of a change in the blend price on the Class I utilization rate are interwined. Since the blend price is calculated as a weighted average price, $\frac{d\tilde{Pb}_j}{dPg^o} \leq 1$. If region j is a deficit region, then the blend price is an effective fluid price, PI^o. This implies $\frac{d\tilde{Pb}_j}{dPg^o} = \frac{dPI_j^o}{dPII^o} = 1$ since the minimum Class I price and Class II price are different by the differential, D_j. In a deficit region, the Class I utilization rate stays at 1 such that $\frac{dUR_j}{d\tilde{Pb}_j} = 0$.[30] In general, $\frac{d\tilde{Pb}_j}{dPg^o} < 1$ and this implies $\frac{\partial UR_j}{\partial \tilde{Pb}_j} < 0$

[30] For a discussion about the reserve requirement case, see the section 2.2 in this chapter.

since $D_j > 0$. Therefore the effect of a change in the support price on the blend price is positive but, in general, less than 1.

The Class I utilization rate is expected to increase when the support price is decreased. The degree of change in UR_j, in this case, is dependent upon the local pooling and demand situation. The effect of a change in the support price on the blend price is twofold: a direct effect through a change in Class I minimum price and an indirect effect through changes in fluid consumption, or Class I milk pooled, and Class II milk produced.

III.3.3. Effects of Changes in Policy Parameters

III.3.3.1. Support and Purchase Prices (Support Price Program)

(1) Support Price

Suppose the government reduces the support price level such that $\Delta Pg^o = Pg_1^o - Pg_0^o < 0$. The effects of a change in the support price level, on prices and quantities, are national for both fluid and manufactured milk markets.

Since the Class II minimum price and the support price are closely related, it was assumed that $Pg^o = PII^o$. From (III-19, 22, and 24):

$$dPg^o = dPII^o \rightarrow \frac{dPII^o}{dPg^o} = 1, \text{ and} \qquad \text{(III} - 28\text{)}$$

$$dPI_j^o = dPII^o \ \ (\text{Since } dD_j = 0) \ \ \rightarrow \frac{dPI_j^o}{dPg^o} = \frac{dPII^o}{dPg^o} = 1 \ \text{ for all } j. \qquad \text{(III} - 29\text{)}$$

As derived in (III-27), the effect of a change in the support price on the blend price is:

$$\frac{d\tilde{P}b_i}{dPII^o} = \frac{d\tilde{P}b_i}{dPg^o} = \frac{1}{[1 - D_j \dfrac{\partial UR_j}{\partial \tilde{P}b_j}]} \leq 1 \ \text{ for all i, and} \qquad \text{(III} - 30\text{)}$$

$$\frac{dXA_i}{dPg^o} = \frac{\partial XA_i}{\partial \tilde{Pb}_i} \frac{\partial \tilde{Pb}_i}{\partial Pg^o} > 0 \quad \text{for all i, since} \quad \frac{\partial XA_i}{\partial \tilde{Pb}_i} > 0. \tag{III-31}$$

Since $dRB_i = dPI I^o$:

$$\frac{dXB_i}{dPg^o} = \frac{\partial XB_i}{\partial RB_i} \frac{\partial RB_i}{\partial Pg^o} = \frac{\partial XB_i}{\partial RB_i} > 0 \quad \text{for all i, and} \tag{III-32}$$

$$\frac{dYF_j}{dPg^o} = \frac{\partial YF_j}{\partial PI_j^o} \frac{\partial PI_j^o}{\partial Pg^o} = \frac{\partial YF_j}{\partial PI_j^o} < 0 \quad \text{for all j.} \tag{III-33}$$

Suppose government purchase prices for butter, powder and cheese are such that:

$$dPg^o = d(c^2Pg2^o + c^3Pg3^o) = d(c^4Pg4^o) \tag{III-34}$$

and the change of the support price is equally split between butter and nonfat dry milk markets,[31] then from (III-34):

$$\frac{dPgk^o}{dPg^o} = \frac{1}{2c^k}, \quad \text{for } k = 2,3 \text{ and,}$$

$$\frac{dPgk^o}{dPg^o} = \frac{1}{c^k}, \quad \text{for } k = 4. \tag{III-35}$$

From (III-1.b), (III-22), and (III-35):

$$\frac{dYk}{dPg^o} = \frac{\partial Yk}{\partial Pk} \frac{\partial Pk}{\partial Pgk^o} \frac{\partial Pgk^o}{\partial Pg^o} = \frac{\partial Yk}{\partial Pk} \frac{1}{2c^k} < 0 \quad \text{for } k = 2, 3 \text{ and} \tag{III-36}$$

$$\frac{dYk}{dPg^o} = \frac{\partial Yk}{\partial Pk} \frac{\partial Pk}{\partial Pgk^o} \frac{\partial Pgk^o}{\partial Pg^o} = \frac{\partial Yk}{\partial Pk} \frac{1}{c^k} < 0, \quad \text{for } k = 4. \tag{III-37}$$

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31 See Table 3 in Commodity Fact Sheet, USDA, ASCS, March, 1984.

From (III-31) and (III-33):

$$\frac{dXA2_i}{dPg^o} = \frac{dXA_i}{dPg^o} - \frac{d\sum_{j=1}^{n} XA_{ij}}{dPg^o} > 0 \quad \text{for all i.} \qquad (III-38)$$

From (III-32) and (III-33):

$$\frac{dXM}{dPg^o} = \frac{d(XM23 + XM4)}{dPg^o} = \sum_{i=1}^{n} \frac{d(XB_i + XA2_i)}{dPg^o} > 0. \qquad (III-39)$$

From (III-13.b) to (III-15.b), (III-37) and (III-39):

$$\frac{dQGk}{dPg^o} = \frac{c^k dXM23}{dPg^o} - \frac{dYk}{dPg^o} > 0 \quad \text{for } k = 2, 3, \text{ and}$$

$$\frac{dQGk}{dPg^o} = \frac{c^k dXMk}{dPg^o} - \frac{dYk}{dPg^o} > 0, \text{ for } k = 4. \qquad (III-40)$$

Due to the decreased support price level, the Grade A and Grade B milk supplied in all regions would drop (III-31 and III-32) while the quantity demanded in the fluid and manufactured markets would increase (III-33, 36 and 37). Due to these changes in supply and demand in both markets, the Class II milk supply is reduced (III-38) and the CCC purchases of manufactured milk products would drop (III-40).

(2) Purchase Prices

In the previous chapter, it was shown that the nonfat dry milk market in the 1980s was relatively over-protected by the price support program compared to butter and cheese markets.[32] In order to balance the market protection, the CCC may change the purchase price for nonfat dry milk markets without altering other purchase price levels.

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[32] During the 1984-1985 marketing year, the CCC purchased 68 percent of the nonfat dry milk marketed while 26 and 22 percent of butter and cheese, respectively, marketed were purchased by the CCC over the period.

The analysis of this case is analogous to that in the previous section. The effect, however, of a change in the purchase price for nonfat dry milk is restricted, in the short-run, to nonfat dry milk and butter markets, and raw milk supply for manufactured use. Suppose the government reduces the purchase price for nonfat dry milk only such that $\Delta Pg3^o = Pg3^o_1 - Pg3^o_0 < 0$. Then as discussed above, a weighted average revenue formula (III-24) gives the following relationship:

$$\frac{dPg^b}{dPg3^o} = c^3\left(\frac{XM23}{XM23 + XM4}\right) > 0\,. \qquad \text{(III} - 41\text{)}$$

Equation (III-41) implies that the manufactured milk price, Pg^b, is now decreased due to a decrease in the nonfat dry milk price, $Pg3^o$. This would yield a decrease in raw milk supply in manufactured use as equation (III-39) implies. Therefore:

$$\frac{dXM}{dPg3^o} = \frac{\partial XM}{\partial Pg^b}\frac{\partial Pg^b}{\partial Pg3^o} > 0. \qquad \text{(III} - 42\text{)}$$

Given that cheese plants are operating at the full capacities and the cheese price is not changed, equation (III-42) further implies that:

$$\frac{dXM}{dPg3^o} = \frac{d(XM23 + XM4)}{dPg3^o} = \frac{dXM23}{dPg3^o} > 0 \quad \text{where} \quad \frac{dXM4}{dPg3^o} = 0. \qquad \text{(III} - 43\text{)}$$

The effects of a change in the purchase price for nonfat dry milk on changes in government purchases of butter, nonfat dry milk, and cheese are derived as follows:

$$\frac{dQG2}{dPg3^o} = \frac{d(c^2XM23 - Y2)}{dPg3^o} = \frac{d(c^2XM23)}{dPg3^o} > 0,$$

$$\frac{dQG3}{dPg3^o} = \frac{d(c^3XM23 - Y3)}{dPg3^o} = \frac{d(c^3XM23)}{dPg3^o} - \frac{dY3}{dPg3^o} > 0, \quad \text{and}$$

$$\frac{dQG4}{dPg3^o} = \frac{d(c^4XM4 - Y4)}{dPg3^o} = \frac{d(c^4XM4)}{dPg3^o} - \frac{dY4}{dPg3^o} = 0. \qquad \text{(III} - 44\text{)}$$

Results derived in equation (III-44) are graphically explained in figure III-1. The effect of a reduction in the purchase price on the government purchase of nonfat dry milk is reflected by (1) decreases in raw milk supply in butter-powder use and (2) increases in nonfat dry milk demand, while the government purchase for butter is affected by decreases in raw milk supply in butter-powder use. Under the assumption that cheese plants are operating at the full capacity, the cheese market is not affected by a change in the nonfat dry milk price.

Under the assumption that there are no cross price elasticity effects among these product demands, effects of changes in the purchase prices for butter, nonfat dry milk, and cheese are derived in a similar manner. Suppose the government drops the purchase prices such that net return to butter-powder plants are equal to net return to cheese plants. In this case, the farm level support price is equivalent to net returns to both plants in milk equivalent terms. This implies that $\Delta Pg^o = (c^2 \Delta Pg2^o) + (c^3 \Delta Pg3^o) = c^4 \Delta Pg4^o$, where $\Delta Pgk^o = Pgk_1^o - Pgk_0^o < 0$, for $k = 2,3,4$. Therefore:

$$\frac{dPg^o}{dPgk^o} = c^k, \text{ and } \frac{dXM}{dPgk^o} = \frac{\partial XM}{\partial Pg^o}\frac{\partial Pg^o}{\partial Pgk^o} = c^k \frac{\partial XM}{\partial Pg^o} > 0 \text{ for } k = 2,3 \text{ and } 4. \qquad (III-45)$$

Equation (III-45) can be further extended as follows:

$$\frac{dXM23}{dPgk^o} > 0, \text{ for } k = 2,3, \text{ and } 4 \ \frac{dXM4}{dPg4^o} > 0. \qquad (III-46)$$

The effects of changes in purchase prices on changes in the government purchases are derived as follows:

$$\frac{dQG2}{dPg2^o} = \frac{d(c^2 XM23 - Y2)}{dPg2^o} = \frac{d(c^2 XM23)}{dPg2^o} - \frac{dY2}{dPg2^o} > 0,$$

$$\frac{dQG3}{dPg3^o} = \frac{d(c^3 XM23 - Y3)}{dPg3^o} = \frac{d(c^3 XM23)}{dPg3^o} - \frac{dY3}{dPg3^o} > 0, \quad \text{and}$$

$$\frac{dQG4}{dPg4^o} = \frac{d(c^4XM4 - Y4)}{dPg4^o} = \frac{d(c^4XM4)}{dPg4^o} - \frac{dY4}{dPg4^o} > 0. \qquad (III-47)$$

Equations (III-47) imply that the effects on changes in the government purchases of butter, nonfat dry milk, and cheese are due to (1) changes in raw milk supply in butter-powder or cheese use and (2) changes in demand for butter, nonfat dry milk, or cheese.

Under the assumption that the demand for milk products is affected by direct and cross price elasticity effects, the amount of change in demand for milk products due to changes in purchase prices varies depending on the direction and magnitude of the cross price elasticity effects. In this case, (III-36) and (III-37) can be rewritten as:

$$\frac{dYk}{dPg^o} = \sum_{j=2}^{4} \frac{\partial Yk}{\partial Pj} \frac{\partial Pj}{\partial Pgj^o} \frac{\partial Pgj^o}{\partial Pg^o} = \sum_{j=2}^{4} \frac{\partial Yk}{\partial Pj} \frac{1}{c^j}, \quad \text{for any } k = 2,3 \text{ or } 4. \qquad (III-48)$$

Equation (III-48) implies that the effects of changes in government support/purchase prices on changes in demand for milk products, assuming cross price elasticity effects are effective, are determined by values of $(\frac{\partial Yk}{\partial Pj}\frac{1}{c^j})$ for any k and j, where j and k = 2,3 or 4. The value of c^j is positive for any j. The value of $(\frac{\partial Yk}{\partial Pj})$ is negative when $k=j$ and varies when $k \neq j$ depending on the sign of the cross price elasticity.[33] Since the total effects of changes in purchase prices on changes in demand for milk products are indeterminate, the effects on changes in government purchases of butter, powder, and cheese, $(\frac{dQGk}{dPg^o})$, for all $k = 2,3$ and 4, are also indeterminate as implied in (III-40).

III.3.3.2. Increases in Import Quotas of Dairy Products

Under federal regulatory programs, increases in import quotas for butter, nonfat dry milk, and cheese would not affect the market prices because the purchase prices are prevailing in the markets. Under these circumstances, increases in import quotas for butter, nonfat dry milk, and cheese would

[33] Any pair of goods (k, j), where $k \neq j$, for which $(\frac{\partial Yk}{\partial Pj}) > 0$ are called (gross) substitutes and any pair for which the opposite holds, (gross) complements.

aggravate the surplus problems resulting in increasing government purchases for these products. Since increases in import quotas would increase the total supply of butter, nonfat dry milk, and cheese, equation (III-47) indicates that changes in the support/purchase price levels under an increasing quota system would have to be larger than the support/purchase price levels under the 1982 quota system in order to decrease government purchases.

Extending equations (III-13.b, 14.b and 15.b), the dairy product market equilibrium conditions are rewritten as:

$$c^2XM23 + IM2 = Y2 + QG2 \qquad \text{(III} - 13.c)$$

$$c^3XM23 + IM3 = Y3 + QG3 \qquad \text{(III} - 14.c)$$

$$c^4XM4 + IM4 = Y4 + QG4 \qquad \text{(III} - 15.c)$$

where IM2 is a quantity of imported butter; IM3 is a quantity of imported nonfat dry milk; and IM4 is a quantity of imported cheese.

Therefore equation (III-47) is rewritten as:

$$\frac{dQG2}{dPg2^o} = \frac{dIM2}{dPg2^o} + \frac{d(c^2XM23 - Y2)}{dPg2^o},$$

$$\frac{dQG3}{dPg3^o} = \frac{dIM3}{dPg3^o} + \frac{d(c^3XM23 - Y3)}{dPg3^o}, \quad \text{and}$$

$$\frac{dQG4}{dPg4^o} = \frac{dIM4}{dPg4^o} + \frac{d(c^4XM4 - Y4)}{dPg4^o}. \qquad \text{(III} - 49)$$

Signs of equations in (III-49) depend on the magnitude of the first and second arguments of the right hand sides of equations. The sign of the second argument of each equation in (III-49) is positive as shown in (III-47).[34] The sign of the first argument of each equation is negative when

[34] Under an assumption that cross price elasticity effects are effective, the effects of changes in purchase prices on total changes in demand may be indeterminate as was discussed in the previous section.

$\Delta Pgk^o < 0$ for $k=2,3$, and 4 since $\Delta IMk > 0$. Since changes in import quotas are determined exogenously the magnitude of the first argument of each equation becomes smaller, while the magnitude of the second argument of each equation becomes larger, as a change in the purchase price level becomes greater.

Therefore the equations in (III-49) imply that the purchase price levels should be dropped in order to decrease the government purchases under an increasing quota system. Due to a drop of the purchase price levels, consumers for fluid milk and manufactured milk products would gain more (III-33, 36 and 37) while milk producers would lose more (III-31 and 32).

III.4. Adjustment of Demand Functions Due To Cross Price Elasticity Effects

In order to reflect cross price elasticity effects on quantities of demand, relevant demand functions were adjusted as follows. In figure III-2, the demand curve for butter is defined as $P_B = a + bQ_B$ where P_B and Q_B are initial equilibrium price and quantity of butter respectively; and a and b represent an intercept and a slope repectively ($a > 0$ and $b < 0$). The direct and cross price elasticities of butter and cheese are defined as:

(1) direct price elasticity

$$\varepsilon_B = \frac{\Delta Q_B}{\Delta P_B}\ \frac{P_B}{Q_B}\,, \quad \text{and} \quad \varepsilon_C = \frac{\Delta Q_C}{\Delta P_C}\ \frac{P_C}{Q_C}$$

(2) cross price elasticity

$$\varepsilon_{BC} = \frac{\Delta Q_B}{\Delta P_C}\ \frac{P_C}{Q_B}\,, \quad \text{and} \quad \varepsilon_{CB} = \frac{\Delta Q_C}{\Delta P_B}\ \frac{P_B}{Q_C}$$

where ΔQ_B and ΔP_B are changes in quantity and price for butter respectively; ΔQ_C and ΔP_C are changes in quantity and price for cheese respectively; and P_C and Q_C are initial equilibrium price and quantity of cheese respectively.

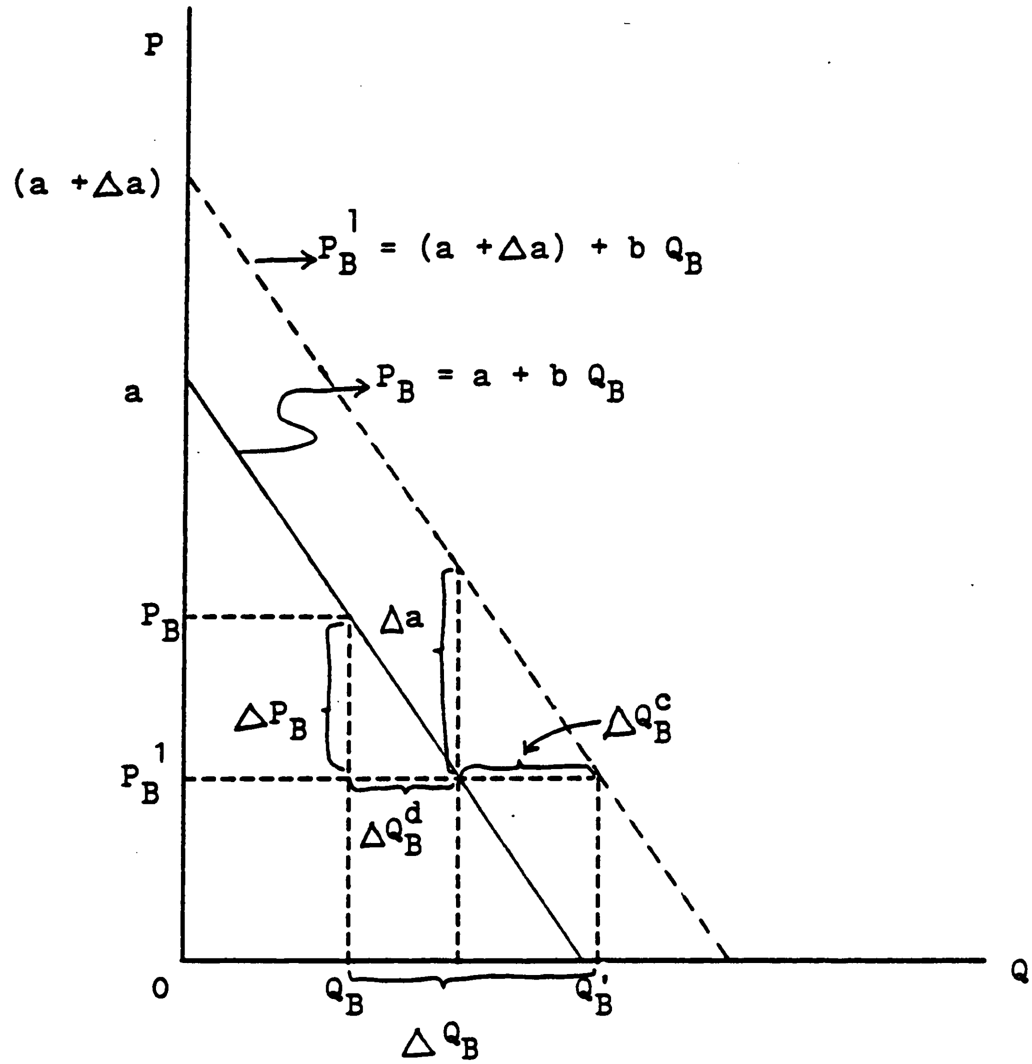

Figure III.2. Adjustment of a Demand Curve for Butter when Cross Elasticity Effect of Cheese is Significant

The effect of changes in prices for butter and cheese on the change in quantity of demand for butter is illustrated in figure III-2. It is assumed that both prices for butter and cheese are decreased such that $P_B^1 - P_B = \Delta P_B < 0$ and $\Delta P_C < 0$. It is also assumed that cross price elasticities between butter and cheese are negative such that $\varepsilon_{BC} < 0$ and $\varepsilon_{CB} < 0$, and that demand for butter or cheese is not affected by change(s) in price(s) for nonfat dry milk or other milk product. As illustrated in figure III-2, the change in the quantity of butter demanded, $Q_B^1 - Q_B = \Delta Q_B$, due to changes in prices for butter and cheese, ΔP_B and ΔP_C respectively, is divided into two effects: (1) a direct effect represented by ΔQ_B^d; and (2) a cross effect represented by ΔQ_B^c. Given that direct and cross price elasticities, and changes in prices for butter and cheese are known, change in the quantity of demand for butter is derived from the definition of a direct price elasticity of butter and cross price elasticity of butter with respect to cheese as follows:

(1) $$\varepsilon_B = \frac{\Delta Q_B^d}{\Delta P_B}\frac{P_B}{Q_B} \rightarrow \Delta Q_B^d = \Delta P_B \varepsilon_B \frac{Q_B}{P_B}$$

(2) $$\varepsilon_{BC} = \frac{\Delta Q_B^c}{\Delta P_C}\frac{P_C}{Q_B} \rightarrow \Delta Q_B^c = \Delta P_C \varepsilon_{BC} \frac{Q_B}{P_C}\ , \quad \text{and}$$

(3) $$\Delta Q_B = \Delta Q_B^d + \Delta Q_B^c \,.$$

The original demand curve for butter defined as $P_B = a + bQ_B$ reflects the direct effect only when the price for butter changes from P_B to P_B^1. In order to reflect the cross effect as well as direct effect, the demand curve for butter should be shifted outward by ΔQ_B^c or upward by Δa. Keeping the same slope of demand curve of b, the new demand curve is defined as $P_B^1 = (a + \Delta a) + bQ_B$ where $\Delta a = b\Delta Q_B^c$. The new demand curve for cheese can be derived in a similar manner. Once Δa is calculated based on changes in prices, cross price elasticities, and initial equilibrium prices and quantities, one can estimate a new demand curve, P_B^1. Measuring the cross price elasticity effect in this way allows a measurement of the direct and cross effects separately even when there is no change in own price. Adjusting elasticity without a shift in the demand curve may not capture the independent cross price elasticity effect and result in a biased measure of the elasticity effect.

III.5. Supply and Demand Functional Forms

The accurate estimation and the choice of appropriate functional forms of supply and demand curves is crucial in order to conduct a relevant investigation of the effects of a policy (Just and Hallman). Many studies, however, have relied on linear supply and demand functional forms due to the computational restrictions of their objective functions. This study will use a linear functional form for demand curves and a nonlinear functional form for supply curves as McDowell (1982) did.

III.5.1. Supply Functions

The exponential form with constant supply elasticity is employed in this study for the supply functions of Grade A and B milk. In a price-quantity dimension, the supply function is defined that price is an exponential function of quantity as follows:

$$P^s = AQ^\alpha \qquad \text{(III} - 50\text{.a)}$$

where P^s is a supply price in a regulated market; Q is a quantity supplied to a regulated market; A is a technical parameter; and α is the inverse of the own price elasticity (η).

From (III-50.a), taking a total derivative:

$$\frac{dP^s}{dQ} = \alpha AQ^{\alpha-1} = \alpha\frac{AQ^\alpha}{Q} = \alpha\frac{P^s}{Q}$$

$$\rightarrow \alpha = \frac{dP^s}{dQ}\,\frac{Q}{P^s} = \left(\frac{dQ}{dP^s}\,\frac{P^s}{Q}\right)^{-1} = \eta^{-1} \qquad \text{(III} - 51\text{.a)}$$

Once the price, quantity and elasticity are given the coefficient A is calculated from (III-50.a) and (III-51.a). Since the supply functions are at the farm level, the prices used in deriving the supply functions should be average prices received from processors less producer incurred costs such as assembly costs. Quantities used should be on an annual basis.

Since the price and quantity data are observed under federal regulatory programs, the calculation of the supply functions by (III-50.a) and (III-51.a) would reflect a larger quantity at each price than would the unobserved competitive supply function under the assumption that the observed data reflects a stability induced supply shift.[35] Therefore, the supply function in the competitive market should be adjusted so that the quantity supplied at any price level is reduced (Whipple, p. 34).

The competitive market supply function is of the form:

$$P_c^s = (1+\delta)^\alpha A Q^\alpha \qquad \text{(III} - 50.\text{b)}$$

where P_c^s is a supply price in a competitive market; parameter A is calculated from (III-50.a) with given price (P^s), quantity (Q), and an elasticity (η); δ is an assumed percentage supply shift due to dairy market deregulation, stated as a decimal; and α is the inverse of η. From (III-50.a and 50.b), P_c^s can be rewritten in terms of P^s as follows:

$$P_c^s = (1+\delta)^\alpha A Q^\alpha = (1+\delta)^\alpha P^s \rightarrow dP_c^s = (1+\delta)^\alpha dP^s.$$

Taking a total derivative of equation (III-50.b) with respect to Q:

$$\frac{dP_c^s}{dQ} = \alpha(1+\delta)^\alpha A Q^{\alpha-1} = \frac{\alpha(1+\delta)^\alpha A Q}{Q} = \frac{\alpha P_c^s}{Q}$$

$$\rightarrow \alpha = \frac{dP_c^s}{dQ}\ \frac{Q}{P_c^s} = (1+\delta)^\alpha \frac{dP^s}{dQ}\ \frac{Q}{(1+\delta)^\alpha P^s}$$

$$= \frac{dP^s}{dQ}\ \frac{Q}{P^s} = (\frac{dQ}{dP^s}\ \frac{P^s}{Q})^{-1} = \eta^{-1}. \qquad \text{(III} - 51.\text{b)}$$

III.5.2. Demand Functions

A linear form with a variable elasticity is used for demand functions of fluid milk and the

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[35] In this dissertation, however, it was assumed that supply curve did not shift due to regulations.

manufactured milk products such as butter, nonfat dry milk and cheese. In a price-quantity dimension, the demand function is defined as follows:

$$P^d = a + bQ, \quad a > 0 \text{ and } b < 0 \qquad \text{(III} - 52)$$

where P^d is demand price; Q is quantity demanded ; a is the intercept; and b is the slope of the demand curve. By taking a total derivative of (III-52) and by defining ε as the own price elasticity of demand:

$$\frac{dP^d}{dQ} = b \rightarrow \frac{dP^d}{dQ} \; \frac{Q}{P^d} = \frac{1}{\varepsilon} = b\frac{Q}{P^d} \rightarrow b = \frac{1}{\varepsilon} \; \frac{P^d}{Q} \qquad \text{(III} - 53)$$

Hence once the price, quantity and elasticity are given, the slope, b, and the intercept, a, are determined by (III-52) and (III-53). Suppose the elasticity is at the wholesale level rather than at the plant level. Assuming that the marketing margin is constant regardless of quantity levels, the plant level demand curve may be derived directly from the wholesale level demand curve simply by substracting the marketing margin from the intercept of the wholesale level demand curve.

Given that the demand functions are linear, the elasticity of the plant level demand can be derived from the given price, quantity, elasticity at the wholesale level, and marketing margin. Suppose the wholesale demand curve (D^R), defined $P^d_R = a + bQ$ where P^d_R is a wholesale demand price, is presented in figure III-3. Given that the marketing margin (m) is known, the plant level demand curve can be plotted by vertically shifting down D^R by the marketing margin. Hence the plant level demand curve (D^F) is derived as $P^d_F = (a - m) + bQ$. Define P_R as the market price at the wholesale level and P_F, at the plant level such that $P_F = P_R - m$. The point elasticity at C (ε^R) is equivalent to the ratio of the distance between P_R and the origin (O) to the distance between the intercept of D^R, a, and P_R.[36] Hence $\varepsilon^R = P_R/(a - P_R)$. Similarly the point elasticity at $C^I(\varepsilon^F)$ is equivalent to the ratio of the distance between P_F and the origin (O) to the distance between the intercept of D^F, (a - m), and P_F . Therefore $\varepsilon^F = PF/\{(a - m) - P_F\}$. Since $P_F = P_R - m$, the

[36] For a complete proof, see Ferguson, p. 122.

denonminator $\{(a - m) - P_F\}$ is rewritten as $(a - P_R)$. Since the denominators for ε^R and ε^F are the same, ε^F can be defined by ε^R, P_F and P_R as follows:

$$\varepsilon^F = (\frac{P_F}{P_R})\varepsilon^R \qquad \text{(III} - 54)$$

III.6. Summary

In this chapter, an economic model of the U.S. dairy industry under current federal programs was developed. The manufactured milk market was disaggregated into butter, nonfat dry milk, and cheese markets. Regional farm level supply functions of Grade A and Grade B milk were assumed to be known and no barriers for instantaneous adjustment were allowed. Regional farm level demand functions for fluid milk and national wholesale level demand functions for butter, nonfat dry milk, and cheese were also assumed to be known. Supply aggregation conditions and classified, blend, and manufactured milk product price conditions under current federal programs were discussed in this chapter.

The effects of changes in policy parameters, the government support and purchase price levels, and import quotas, on the markets were analyzed in the context of a mathematical comparative statics analysis. A change in the government support price levels would affect all markets throughout the nation. Increases in import quotas would result in increasing government purchases under current programs. With increases in these quotas, the purchase price levels should be dropped further in order to decrease government purchases. Assuming that cross price elasticity effects among butter, nonfat dry milk, and cheese markets exist, the government would affect each manufactured milk product market with various impacts by altering the levels of purchase prices for nonfat dry milk, butter, and/or cheese.

The economic model of the U.S. dairy industry described in this chapter provides the background for establishing an empirical mathematical programming problem of the interregional U.S. dairy trade model in the next chapter and the theoretical mathematical programming model

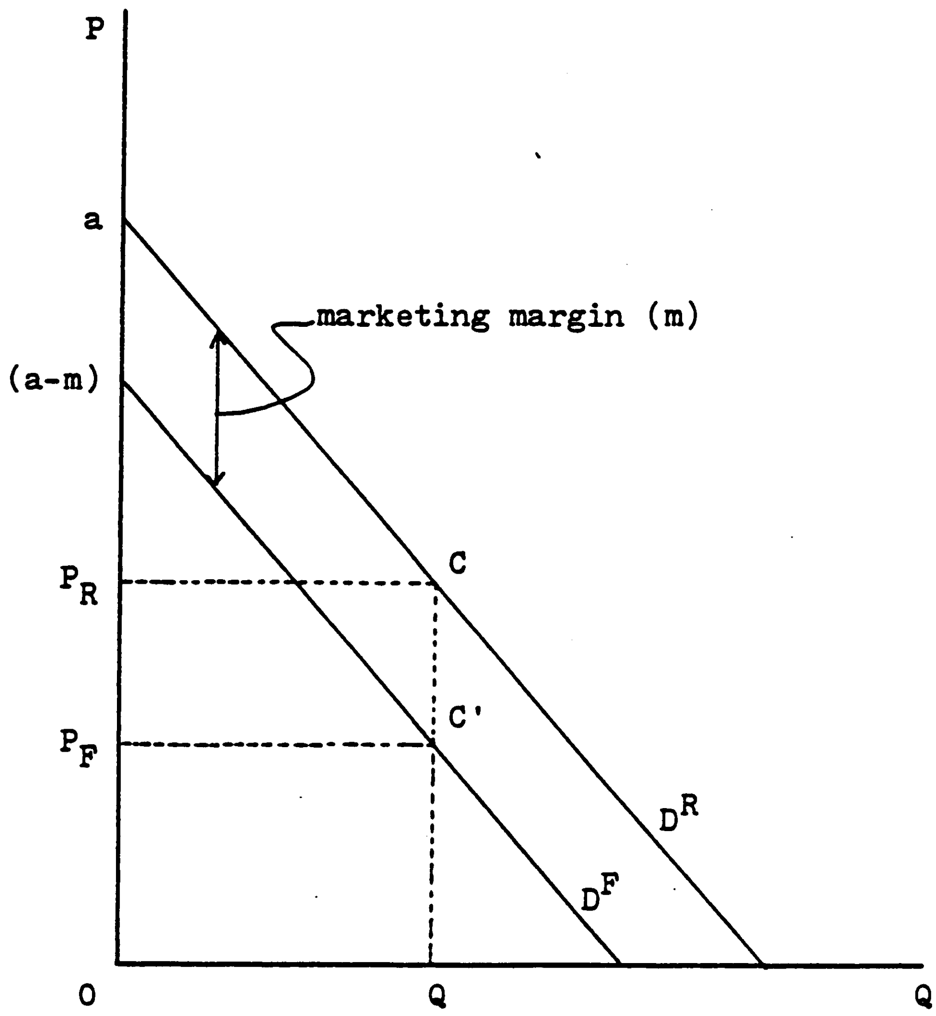

Figure III.3. Elasticities of Demands: Plant and Wholesale Levels in Appendix B. The discussion of the mathematical comparative statics analysis in this chapter furnishes the basis of setting policy options, which will be discussed in Chapter V.

CHAPTER IV

EMPIRICAL MODEL OF THE U.S. DAIRY INDUSTRY

IV.1. Introduction

In this chapter a linear programming model of the U.S. interregional dairy trade model is specified. Due to the nonlinear nature of the mathematical problem of the model, a separable programming method is utilized for linearization. The mathematical problem is an extention of McDowell (1982) in terms of disaggregating the manufactured milk sector into butter, nonfat dry milk, and cheese markets. Spatial price equilibrium conditions in the dairy industry are established in the model based on the blend price alignment. The spatial price equilibrium model developed by Takayama and Judge (1971) was adapted[37] by including additional constraints on the market due to government regulatory programs. The adapted model reflects the effects of government purchases of butter, nonfat dry milk, and cheese under the price support program, and a pooling and classified scheme under a marketing order program. Another unique extension made in this study is the specification of the manufactured milk market not only in terms of the products themselves, but also including non-zero cross price elasticities. Further experimentation with the separable programming specification has allowed the market clearing solution to be found within the context of the constrained model.

[37] The spatial price equilibrium model was developed by Enke, and Samuelson and reformulated by Takayama and Judge (1971).

IV.2. Spatial Equilibrium Framework

IV.2.1. Basic Assumptions

The U.S. dairy industry is treated as a sector isolated from the rest of the economy assuming that all other prices and consumer incomes are constant. It is assumed that only prices of Grade A, Grade B, fluid, and manufactured milk products are permitted to change. The regional demand functions of fluid milk are at the plant level. The national demand functions of butter, nonfat dry milk, and cheese are at the wholesale level. It is assumed that Grade A milk for fluid purposes is assembled, processed and distributed at constant average costs so that the plant level demand function is derived from the wholesale demand function by subtracting these costs, at all quantities, resulting in a parallel shift. The plant level demand function of fluid milk is assumed to be known. Since the manufactured milk product markets are influenced by the government purchase price levels at the wholesale level, the demand functions for butter, nonfat dry milk, and cheese are specified at the wholesale level. The wholesale level demand function is used for a comparison of the difference, if any, between marketing margins set by the government and the actual margins.

Other than market regulation, the industry is assumed to be competitive. This implies that the milk producers take the market clearing prices, regulated or unregulated, as given and consider them as marginal revenues. The rational profit maximizing milk producers optimize their output level where the marginal revenue equals the marginal cost of milk production. Grade A milk producers will also export their milk to other markets where market prices are greater than their marginal production costs plus transportation costs.

Sanitation regulations do not allow a milk producer to produce both Grade A and Grade B milk. The requirement of high sanitation for Grade A milk production results in higher fixed and variable production costs than Grade B production. In the short-run, however, it is assumed that the shape of marginal cost functions for Grade A and Grade B milk production are the same except for differences in variable cost (Lefrance and de Gorter). Producers may convert from Grade A to Grade B or from Grade B to Grade A in the long-run. The model specified in this study does not consider conversion of milk producers. It is assumed that supply functions for Grade A and Grade B milk are known for each region.

IV.2.2. More Assumptions under Current Federal Programs

Under the current government regulatory programs, the government is expected to support the price of all milk at the announced level by purchasing the excess supply of milk as manufactured products. Under the assumption that the marketing margins are constant, a farm level floor price for raw milk in manufactured use can be derived by subtracting a marketing margin from the purchase price.[38]

It is assumed that all Grade A milk in the dairy industry is sold in regulated markets with classified pricing according to its usage and pooling of revenues for producers based on minimum prices within its own market. The basic formula price for the federal order classified pricing system is the monthly average price paid to the Grade B milk producers in the Minnesota-Wisconsin region. The minimum Class II price for all federal markets in month t is the basic formula price for month t. The minimum Class I price in all federal markets in month t + 2 is the basic formula price in month t plus the Class I differential.

Under regulatory programs, dairy producers are expected to obtain perfect information about market prices. The minimum fluid prices are known with certainty a month ahead because the basic formula price is known at the end of a month and the Class I differential is constant. Since the support price maintains a floor price in the manufactured milk market, it directly affects the basic formula price.

Information including estimates of the Class I utilization rate and the over-order premium would help Grade A milk producers to form an expectation of the weighted average revenue or the blend price for the following month. If the market is in a relatively stable situation, the expected blend price is likely to be close to the actual blend price. Grade B milk producers receive the manufacturing milk price guaranteed by the price support program.

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[38] For a further discussion, see the section 3.2.2. in Chapter II.

Based on the economic model of the dairy industry discussed in Chapter III, a mathematical specification of the interregional dairy trade model is introduced in the following section. Its goal is to maximize the area between Grade A and Grade B milk supply functions, and fluid and manufactured milk product demand functions subject to constraints incorporating the regulated market institutions. In Chapter III, demand for butter, nonfat dry milk, and cheese was specified as a function of own price as well as other prices. In this chapter, it is assumed that each demand is a function of its own price only for computational (maximizing the area between demand and supply curves) purposes. Cross price elasticity effects are considered in each function by shifting the demand curve. It is assumed that cross price elasticities between fluid and manufactured milk products demand are zero.

IV.2.3. Mathematical Specification[39]

IV.2.3.1. Supply and Demand Functions

Suppose farm level supply functions for Grade A and Grade B milk for each region are defined as follows:

$$xa_i = xa_i\,(ra_i),$$

$$xb_i = xb_i\,(\mathrm{rb}_i), \quad \text{for all } i = 1, n, \qquad (IV-1)$$

where xa_i is the quantity of Grade A milk produced in region i; xb_i is the quantity of Grade B milk produced in region i; ra_i is the supply price for Grade A milk in region i; and rb_i is the supply price for Grade B milk in region i.

The regional plant level demand functions for fluid and the wholesale level demand functions for the manufactured milk products: butter, nonfat dry milk, and cheese are specified as follows:

[39] Full specification of the mathematical problem is discussed in Appendix C. Unless otherwise noted, the definition of the notation is the same as in Chapter III except that the letters are in lower case.

$$yf_j = yf_j\,(pf_j), \quad \text{for all } j = 1, n,$$

$$y2 = y2\,(p2),$$

$$y3 = y3\,(p3),$$

$$y4 = y4\,(p4), \qquad (IV-2)$$

where yf_j is the quantity of fluid milk demanded in region j; y2 is the quantity of butter demanded at the national level; y3 is the quantity of nonfat dry milk demanded at the national level; y4 is the quantity of cheese demanded at the national level; pf_j is the demand price for fluid milk in region j; p2 is the national demand price for butter; p3 is the national demand price for nonfat dry milk; and p4 is the national demand price for cheese.

The above defined supply and demand functions are rewritten in inverted forms as follows:

$$ra_i = sa_i\,(xa_i)$$

$$rb_i = sb_i\,(xb_i), \quad \text{for all } i \qquad (IV-3)$$

$$pf_j = df_j\,(yf_j), \quad \text{for all } j$$

$$p2 = d2\,(y2)$$

$$p3 = d3\,(y3)$$

$$p4 = d4\,(y4). \qquad (IV-4)$$

It is assumed that the technologies of producing Grade A and Grade B milk are independent. The supply functions are assumed to be continuous, differentiable and monotonically increasing functions. The demand functions are assumed to be continuous, differentiable, and monotonically decreasing functions. Fluid and manufactured milk products are considered to be normal commodities.

IV.2.3.2. Transportation

The unit transportation costs are assumed to be constant for all inter- and intra-region shipments. Hence the total transportation costs are linearly detemined by the distance between two points between or within any regions. Actual shipments may occur in three cases: (1) Grade A milk for fluid processing, (2) Grade A milk for manufactured processing, and (3) Grade B milk for manufactured processing. It is assumed that shipments for manufactured processing are restricted to intraregional shipments. Hence in this model interregional trade of milk occurs in case one only. It is assumed that the transportation costs of intraregional shipments are zero in this study. The transported quantity and the unit transportation cost vectors for milk among regions are defined as follows:

$$X_i = (xa_{ij}) \quad j = 1, n \quad \text{for all } i, \text{and} \qquad (IV-5)$$

$$T_i = (ta_{ij}) \quad j = 1, n \quad \text{for all } i, \qquad (IV-6)$$

where xa_{ij} is the quantity of Grade A milk shipped from region i to region j; and ta_{ij} is the unit transportation cost from region i to region j, given : $ta_{ii} = ta_{jj} = 0$.

The total transportation cost incurred for any region i is derived by:

$$T_i X_i = \sum_{j=1}^{n} ta_{ij} xa_{ij} \quad \text{for all } i. \qquad (IV-7)$$

The overall transportation costs for the U.S. dairy market is written as:

$$TX = \sum_{i=1}^{n} T_i X_i \qquad (IV-8)$$

Equation (IV-8) can be rewritten as:

$$TX = \sum_{i=1}^{n}\sum_{j=1}^{n} ta_{ij} xa_{ij} \qquad (IV-9)$$

IV.2.3.3. Objective Function

The objective function of the study is to maximize net social payoff defined as the sum of consumer and producer surplus less total social cost.[40] In this case the total social cost is the total transportation cost as described in (IV-8 or 9), and total processing cost of manufactured milk products.

Define a quasi-welfare function for fluid milk demand, and Grade A and Grade B milk supplies for each region as:

$$W_i \equiv W_i(xa_i^*, xb_i^*, yf_i^*; y2^*, y3^*, y4^*)$$

$$= \int_0^{yf_i^*} pf_i dyf_i - \int_0^{xa_i^*} ra_i dxa_i - \int_0^{xb_i^*} rb_i dxb_i$$

$$= \int_0^{yf_i^*} df_i(yf_i) dyf_i - \int_0^{xa_i^*} sa_i(xa_i) dxa_i - \int_0^{xb_i^*} sb_i(xb_i) dxb_i, \qquad \text{for all } i \qquad (IV-10)$$

[40] The original concept of the net social payoff function is the area under the excess-demand curves in each region less total transportation cost (Samuelson, pp. 287-92). Takayama and Judge (1971) reformulated it as the sum of consumer and producer surplus in a competitive market situation. The net social payoff function is sometimes called a quasi-welfare function.

where the superscript asterisks represent optimal levels of supply and demand in each region. The properties of the quasi-welfare function described in (IV-10) are as follows:

$$\frac{\partial W_i}{\partial yf_i} = df_i(yf_i) = pf_i \ ,$$

$$\frac{\partial W_i}{\partial xa_i} = -sa_i(xa_i) = -ra_i \ , \text{'and'}$$

$$\frac{\partial W_i}{\partial xb_i} = -sb_i(xb_i) = -rb_i \ , \quad \text{for all } i \ . \qquad (IV-11)$$

These properties are derived from the first-order conditions for optimizing the unconstrained objective function described in (IV-10). The partial derivatives are the regional demand and supply prices for fluid milk, Grade A and Grade B milk respectively.

The second partial derivatives of the objective function are derived as follows:

$$\frac{\partial^2 W_i}{\partial yf_i^2} = \frac{d(df_i(yf_i))}{dyf_i} < 0 \ ,$$

$$\frac{\partial^2 W_i}{\partial xa_i^2} = \frac{d(-sa_i(xa_i))}{dxa_i} < 0 \ , \text{'and'}$$

$$\frac{\partial^2 W_i}{\partial xb_i^2} = \frac{d(-sb_i(xb_i))}{dxb_i} < 0, \quad \text{for all i.} \qquad (IV-12)$$

The negativity of the second partial derivatives imples that the quasi-welfare function W_i is a strictly concave function with respect to yf_i, xa_i, and xb_i.

Since the demand functions for butter, nonfat dry milk, and cheese are aggregate ones at the national level, define a "quasi-welfare function" for national manufactured milk product demands as:

$$W_m \equiv W_m(y2^*, y3^*, y4^*; xa_i^*, xb_i^*, yf_i^*)$$

$$= \int_0^{y2^*} p2dy2 + \int_0^{y3^*} p3dy3 + \int_0^{y4^*} p4dy4$$

$$= \int_0^{y2^*} d2(y2)dy2 + \int_0^{y3^*} d3(y3)dy3 + \int_0^{y4^*} d4(y4)dy4 \qquad (IV-13)$$

with similar properties as described for (IV-11 and IV-12).

The social quasi-welfare function of the U.S. dairy market can be derived from equations (IV-10) and (IV-13) as follows:

$$W = \sum_{i=1}^{n} W_i + W_m. \qquad (IV-14)$$

The transportation sector is assumed to be exogenous and the unit transportation cost and the total transportation cost are defined in (IV-8 and IV-9) respectively. The net social quasi-welfare function is derived as follows:

$$NW \equiv \sum_{i=1}^{n} W_i + W_m - \sum_{i=1}^{n}\sum_{j=1}^{n} ta_{ij}xa_{ij} - (ac_{23}xm23 + ac_4xm4)$$

$$= W - TX - (ac_{23}xm23 + ac_4xm4) \qquad (IV-15)$$

where ac_{23} and xm23 are unit processing cost and quantity of raw milk used in butter-powder plants, respectively; and ac_4 and xm4 are unit processing cost and quantity of raw milk used in cheese plants, respectively. The net social quasi-welfare function is a concave function since W is strictly concave and TX, $ac_{23}xm23$ and ac_4xm4 are linear functions.

IV.2.3.4. Constraints

In this section constraints are discussed and specified. Constraints incorporating the unregulated milk market situation are introduced first. Then constraints incorporating the federal marketing order and price support regulations are specified.

In an unregulated market, constraints on demand, supply and product flows still exist, at least in the short run. The first constraint in a competitive market is as follows:

$$xa_i \geq \sum_{j=1}^{n} xa_{ij} + xa2_{ii}, \quad \text{for all i.} \tag{IV – 16}$$

Constraint (IV-16) states that the quantity of Grade A milk produced in region i is at least as great as the sum of all shipments of Grade A milk in fluid use and Grade A milk in manufactured use. The Grade A milk in manufactured use is processed only in region i and marketed in the national manufactured market.

$$xb_i \geq xb_{ii}, \quad \text{for all i.} \tag{IV – 17}$$

Constraint (IV-17) states that the quantity of Grade B milk produced in region i is at least as great as the total shipment or use of Grade B milk. Grade B milk is processed only in region i and consumed in the national manufactured market.

$$\sum_{i=1}^{n} xa_{ij} \geq yf_j \quad \text{for all j.} \tag{IV – 18}$$

Constraint (IV-18) states that there is no excess demand for the fluid milk in any region at equilibrium. The fluid consumption in region j does not exceed the total shipment of Grade A milk into region j.

$$\sum_{j=1}^{n} xa2_{jj} + \sum_{j=1}^{n} xb_{jj} \geq xm23 + xm4 . \qquad (IV-19)$$

Constraint (IV-19) states that there is no excess demand for manufactured milk at equilibrium. Total shipments of Grade B milk and Grade A milk in manufactured use are at least as great as the sum of the raw milk demanded in cheese, xm4, and butter-powder, xm23, use.

$$c^k xm23 + BSk + IMk \geq ESk + EXk + yk, \quad \text{for } k = 2,3, \qquad (IV-20.a)$$

where BSk is a beginning stock of kth product (k = 2 for butter and 3 for nonfat dry milk); IMk is imports; ESk is an ending stock; and EXk is an export. Constraint (IV-20.a) states that the supply side of the butter (k = 2) or nonfat dry milk (k = 3) market consists of production, beginning stocks, and imports of butter or nonfat dry milk, respectively, and the demand side consists of ending stocks, export, and commercial demand for butter or nonfat dry milk, respectively. The supply side is greater than or equal to the demand side.

$$c^4 xm4 + BS4 + IM4 \geq ES4 + EX4 + y4 \qquad (IV-21.a)$$

Constraint (IV-21.a) states that the supply side of the cheese market is greater than or equal to the demand side.

$$rb_i \geq (c^2p2 + c^3p3) - ac_{23}, \quad \text{for all i.} \tag{IV - 22}$$

Constraint (IV-22) states that at equilibrium the supply price of Grade B milk in any region is at least equal to the sum of average revenues, converted into milk equivalents, of butter and nonfat dry milk less processing cost. Since butter and nonfat dry milk are jointly produced in the plant, the values of butter and nonfat dry milk add up together and equal the supply price of Grade B and Grade A milk in manufactured use.

$$rb_i \geq (c^4p4) - ac_4, \quad \text{for all i.} \tag{IV - 23}$$

Constraint (IV-23) states that the supply price of Grade B milk is at least equal to the demand price, converted into milk equivalents, for cheese less processing cost.

$$ra_i \geq pf_j - ta_{ij}, \quad \text{for all i and j.} \tag{IV - 24}$$

Constraint (IV-24) states that the supply price of Grade A milk in region i is at least equal to the demand price for fluid milk in region j less transportation cost from region i to region j.

$$ra_i \geq rb_i, \quad \text{for all i.} \tag{IV - 25}$$

Constraint (IV-25) states that the supply price of Grade A milk for fluid use is at least equal to the supply price of Grade B milk in any region.

Two major pricing regulations must be considered in order to model the federal marketing order program. The classified pricing regulation sets the minimum Class II and minimum Class I prices based on the basic formula price, and the minimum Class I differential for each region. The pooling provision provides a weighted average revenue, or blend price, to the Grade A milk producers. Hence, in the regulated market equilibrium, the supply price for Grade A milk is set equal to the blend price and the fluid demand price is set equal to the minimum Class I price. The minimum Class II price is set equal to the average price for the national manufactured milk market Pm^{o}. The average price for the national manufactured milk market is closely related to the basic formula price determined in the competitive manufactured milk market in Minnesota and Wisconsin. Since Pm^{o} is a sum of average revenue for butter and nonfat dry milk, and an average revenue for cheese, minimum Class II and Class I prices are defined as:

$$pm^{o} = (c^{2}p2 + c^{3}p3) - ac_{23} = c^{4}p4 - ac_{4}, \text{ and} \qquad (IV-26)$$

$$pf_{j} \geq pm^{o} + D_{j}, \quad \text{for all j.} \qquad (IV-27)$$

Constraint (IV-27) states that the fluid demand price in region j is at least equal to the minimum Class I price, which is equivalent to the minimum Class II price plus Class I differential in region j, defined as $pf_j^o = pm^o + D_j$ for all j.

$$ra_{i} \geq \frac{pf_{j}^{o}\sum_{l=1}^{n} xa_{lj} + pm^{o}xa2_{jj}}{\sum_{l=1}^{n} xa_{lj} + xa2_{jj}} - ta_{ij} = \tilde{pb}_{j} - ta_{ij}, \quad \text{for all i and j.} \qquad (IV-28)$$

Constraint (IV-28) states that the Grade A supply price in region i is at least equal to the blend price in region j less transportation cost from region i to region j. Constraint (IV-28) is a counter-part of the constraint (IV-24) in the competitive market case.

From (IV-22, 23) and (IV-26), the following constraint is developed:

$$rb_i \geq pm^o, \quad \text{for all i.} \qquad (IV-29)$$

Constraint (IV-29) states that the supply price of Grade B milk in region i is at least equal to the floor price for the raw milk in manufactured use. Suppose the federal order requires a certain level of average reserve requirement ratio, say R, for each market.[41] Then the amount of Grade A milk pooled in demand region j is at least equal to the fluid quantity demanded in region j times (1+R):

$$\sum_{i=1}^{n} xa_{ij} \geq (1+R)\, yf_j, \quad \text{for all j.} \qquad (IV-30)$$

Once the CCC sets the support price, Pg°, the support price will be a market clearing price in the manufactured market as long as the market is in an excess supply situation. In order to maintain the market price at the level of an announced price, the CCC intervenes in the butter, nonfat dry milk and cheese markets by purchasing products.[42]

A couple of constraints are added or adjusted to reflect the regulation effect of the support price program. Now define Qgk as the quantity purchased by the CCC in the form of butter (k=2), nonfat dry milk (k=3) and cheese (k=4). Equation (IV-20.a) and (IV-21.a) are now rewritten as:

$$c^k xm23 + BSk + IMk \geq ESk + EXk + yk + QGk, \quad \text{for } k = 2,3, \text{ and} \qquad (IV-20.b)$$

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[41] Refer to the section 2.2 in Chapter III for a discussion.

[42] The support price and the purchasing price are intended to be used differently here. The support price is for milk equivalents and the purchase prices are for pounds of butter, nonfat dry milk or cheese. For more discussion, refer to the disaggregate manufactured milk market in the section 2.4 in Chapter III.

$$c^4xm4 + BS4 + IM4 \geq ES4 + EX4 + y4 + QG4. \qquad (IV-21.b)$$

The demand price for manufactured milk, as an aggregate, is at least equal to the support price level. Here the support price is considered as a floor price. The support price is calculated as a weighted average of purchase prices for butter, nonfat dry milk, and cheese.

$$Pm^o \geq Pg^o = \frac{[(c^2Pg2^o + c^3Pg3^o - ac_{23})xm23 + (c^4Pg4^o - ac_4)xm4]}{(xm23 + xm4)}. \qquad (IV-31)$$

IV.3. Analytical Model

IV.3.1. Separable Programming

The basic concept of separable programming developed by Duloy and Norton, and utilized by McDowell (1982) is primarily based on the Rieman integral which segments the domain of the integral in the nonlinear objective function into a finite number of subintervals (Purcell, p. 209).[43] By the definition of the Rieman integral, the sum of the linear approximation functions times the length of the corresponding subintervals in the given interval are said to be integrable if the norm of the partitions of the domain is sufficiently small.[44]

The value of the unconstrained Lagrangian objective function in each of the subinterval steps is the value of the integrals evaluated from zero to the upper bound of each subinterval. In this case, since supply and demand functions are defined as functions of quantities (see (IV-1) and (IV-2)), each subinterval for the problem is represented by the amount of the quantity for each step.

Suppose the Grade A milk supply function in region i described in (IV-1) is to be integrated from zero to a certain level of quantity, say xa_i. And suppose the interval of the Grade A milk

[43] The separable programming technique was first utilized in a dairy model by McDowell (1982).

[44] The norm is defined as the longest subinterval of the partitions of the domain.

quantity supplied, $[0, xa_i]$, is divided into m subintervals.[45] Define each boundary of the subinterval as xa_{it}, where t = 1,2,...,m such that $xa_{im} = xa_i$. Then the area under the Grade A milk supply function in region i at any quantity step t is defined as folows:

$$\Gamma a_{it} = \int_0^{xa_{it}} [sa_i(xa_i)]dxa_i \quad \text{for any } t = 1, m. \qquad \text{(IV} - 32)$$

Now suppose the real equilibrium supply in region i, say xa_i^*, is located in between xa_{it} and xa_{it+1} such that $xa_{it} < xa_i^* < xa_{it+1}$. This implies the area under the supply curve from zero to xa_i^* can be expressed as a linear combination of the area under the supply curve from zero to xa_{it} and the area under the supply curve from zero to xa_{it+1}. That is

$$\Gamma a_i^* = u_{it}\Gamma a_{it} + u_{it+1}\Gamma a_{it+1}, \quad \text{where } u_{it} + u_{it+1} \leq 1, \quad \text{and } i = 1, n. \qquad \text{(IV} - 33)$$

In general (IV-33) may be rewritten as

$$\Gamma a_i^* = \sum_{t=1}^{m} u_{it}\Gamma a_{it}, \qquad \text{for all } i \qquad \text{where} \quad \sum_{t=1}^{m} u_{it} \leq 1. \qquad \text{(IV} - 34)$$

In separable programming, u_{it} acts as a supply activity variable for the corresponding quantity step level t, and Γa_{it} is a coefficient for a supply activity variable of the objective function.

IV.3.1.1. Objective Functions and Constraints for Demand and Supply Functions

The area under any supply or demand function may be formulated like (IV-34). From (IV-3) and (IV-4), each corresponding value of the integral of the supply or demand function, that is, the coefficient for each supply or demand activity, is defined as:

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[45] The length of the each subinterval does not necessarily have to be equal.

$$\Gamma a_{it} = \int_0^{xa_{it}} [sa_i(xa_i)] dxa_i$$

$$\Gamma b_{it} = \int_0^{xb_{it}} [sb_i(xb_i)] dxb_i$$

$$\Delta f_{jt} = \int_0^{yf_{jt}} [df_j(yf_j)] dyf_j$$

$$\Delta k_t = \int_0^{yk_t} [dk(yk)] dyk \qquad \text{(IV} - 35\text{)}$$

for all i,j, and t, and k = 2,3,4. Each activity variable for the respective coefficent is defined as: u_{it} is the Grade A milk supply activity associated with quantity, xa_{it}, for region i at quantity step t; v_{it} is the Grade b milk supply activity associated with quantity, xb_{it}, for region i at quantity step t; s_{jt} is the fluid milk demand activity associated with quantity, yf_{jt}, for region j at quantity step t; and qk_t is the manufactured milk demand activity associated with quantity, yk_t, at quantity step t.

Now the nonlinear portion of the original objective function, (IV-10) and (IV-13), is rewritten as follows using separable programming:

$$\sum_i Wi + Wm \rightarrow \sum_j \sum_t s_{jt} \Delta f_{jt} + \sum_t \sum_k qk_t \Delta k_t - \sum_i \sum_t u_{it} \Gamma a_{it} - \sum_i \sum_t v_{it} \Gamma b_{it} . \qquad \text{(IV} - 36\text{)}$$

The other linear portion of the objective function, defined in (IV-15), is added to the equation specified in (IV-36). The overall constrained objective function is now to be maximized with respect to s, q2, q3, q4, u, v, and the shipment xa_{ij} subject to the corresponding constraints. The stepwise linearization of an objective function specified in (IV-36) brings in additional quantity, price, and convex constraints associated with demand and supply functions. The additional constraints are due to the linearization of a nonlinear function.

Suppose xa^* and ra^* represent the actual optimal supply quantity and price in a supply function, $ra = sa(xa)$. In figure IV-1, the adjacent quantity steps to xa^* are denoted by xa_t and xa_{t+1} and the corresponding price steps are denoted by ra_t and ra_{t+1}. Now suppose xa^* is expressed by the convex combination of xa_t and xa_{t+1} as $xa^* = u_t xa_t + u_{t+1} xa_{t+1}$ where $u_t + u_{t+1} \leq 1$. Since price and quantity are in a one-to-one relationship and the supply function is monotonically increasing, the convex combination of the price with ratios of u_t and u_{t+1} is higher than ra^*. This implies that if the solution is determined by the equality of xa^* with the convex combination of xa_t and xa_{t+1} with u_t and u_{t+1}, the equilibrium price is over-estimated (at point a). Similarly, if the solution is determined by the equality of ra^* with the convex combination of ra_t and ra_{t+1} with u_t^1 and u_{t+1}^1, the equilibrium quantity is under-estimated (at point b). Hence, by forcing the convex combinations of price and quantity to be greater than the actual price and quantity, the estimated quantity and price will be an approximation of the actual quantity and price as follows:

$$\rho_t xa_t + \rho_{t+1} xa_{t+1} > xa^*$$

$$\rho_t ra_t + \rho_{t+1} ra_{t+1} > ra^* \qquad (IV-37)$$

where $\rho_t + \rho_{t+1} \leq 1$, and $t = 1, m$.

A demand function, monotonically decreasing, needs the analogous constraints in separable programming. In general, the demand and supply functions described in (IV-1) and (IV-2) need the following additional constraints in separable programming.

(1) Grade A supply

$\sum_t u_{it} xa_{it} - xa_i \geq 0$, the linear combination of Grade A milk supplied, $\sum_t u_{it} xa_{it}$, is greater than or equal to xa_i, the actual amount, of Grade A milk supplied.

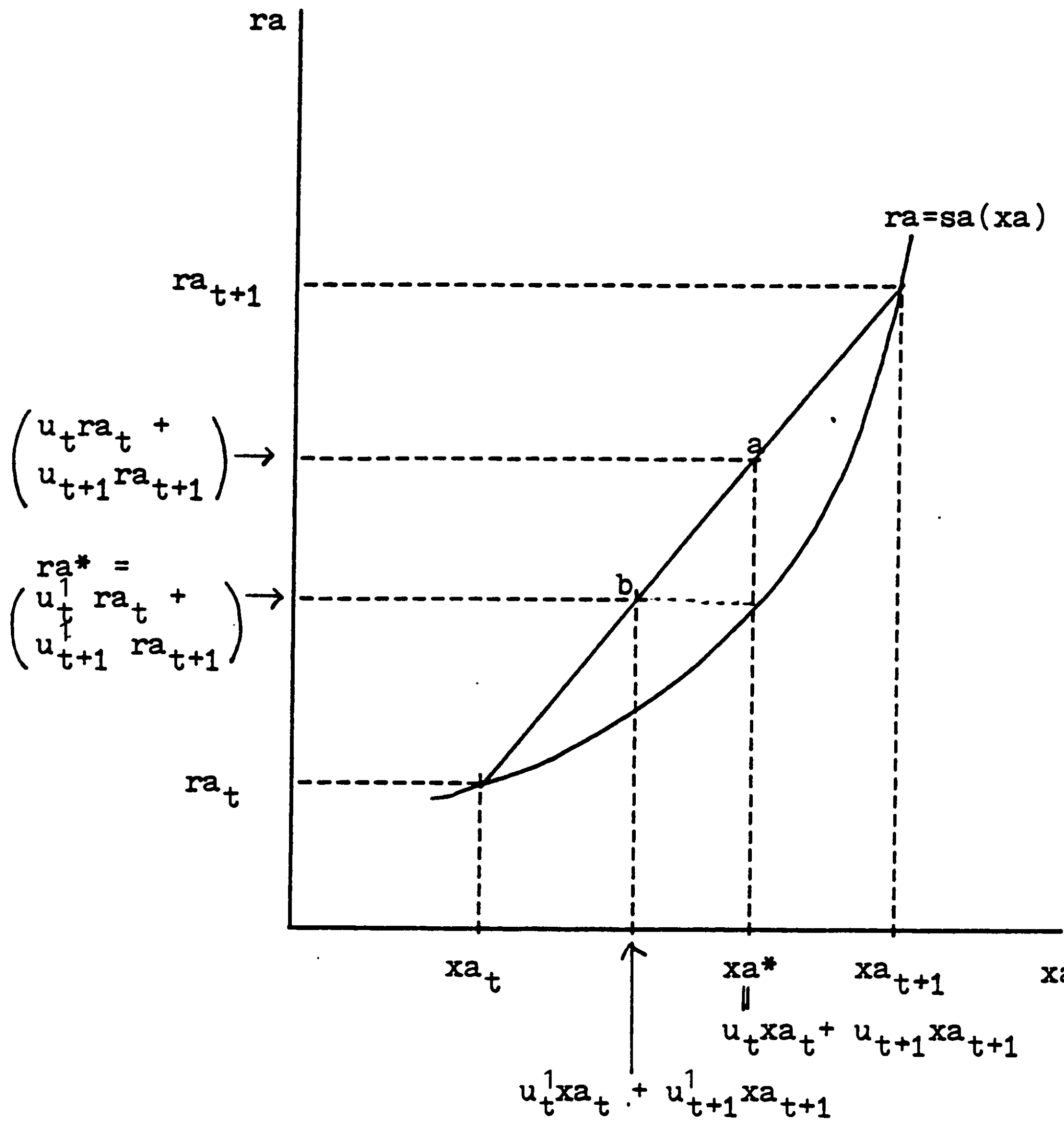

Figure IV.1. Convex Combination of a Supply Curve

$\sum_t u_{it}ra_{it} - ra_i \geq 0,$ the supply price of Grade A milk as calculated by activity steps along the supply function, $\Sigma_t u_{it}ra_i$, may not be less than ra_i, the actual supply price to be used in other restrictions.

$1 - \sum_t u_{it} \geq 0,$ the level of any particular activity or the sum of activity levels cannot be greater than one.

(2) Grade B supply

$\sum_t v_{it}xb_{it} - xb_i \geq 0,$ the linear combination of Grade B milk supplied, $\sum_t v_{it}xb_{it}$, is greater than or equal to xb_i, the actual amount, of Grade B milk supplied.

$\sum_t v_{it}rb_{it} - rb_i \geq 0,$ the supply price of Grade B milk as calculated by activity steps along the supply function, $\sum_t v_{it}rb_i$, may not be less than rb_i, the actual supply price to be used in other restrictions.

$1 - \sum_t v_{it} \geq 0,$ the level of any particular activity or the sum of activity levels cannot be greater than one.

(3) Fluid demand

$yf_j - \sum_t s_{jt}yf_{jt} \geq 0,$ the linear combination of the quantity of fluid milk consumed, $\sum_t s_{jt}yf_{jt}$, may be no greater than the actual quantity demanded, yf_j.

$pf_j - \sum_t s_{jt}pf_{jt} \geq 0,$ the linear combination of the price of fluid in the demand function, $\sum_t s_{jt}pf_{jt}$, is at least as great as the actual price used in other constraints in the model.

$1 - \sum_t s_{jt} \geq 0,$ the level of any particular activity or sum of activity levels cannot be greater than one.

(4) Manufactured demand

$yk - \sum_t qk_t yk_t \geq 0,$ the linear combination of kth manufactured milk product consumed, $\sum_t qk_t yk_t$, may be no greater than the actual quantity demanded, yk.

$pk - \sum_t qk_t pk_t \geq 0,$ the price of kth manufactured milk product as calculated by activity steps along the demand function, $\sum_t qk_t pk_t$, is at least as great as the actual demand price used in other constraints in the model.

$1 - \sum_t qk_t \geq 0,$ the level of any particular activity or sum of activity levels cannot be greater than one.

IV.3.1.2. Blend Price Constraint

As discussed above, the full set of constraints, either in the competitive or regulated markets, is a set of linear functions except for the blend price constraint. In this section how the blend price constraint, which is nonlinear by nature, is modified into the linear specification will be discussed.

Under a pooling system of the federal marketing order program, the Grade A milk producers are paid a weighted average, blend, price. Since Grade A producers are paid the blend price, they consider the blend price as an effective demand price and try to match it to their Grade A milk supply price. If the market is in equilibrium, the Grade A supply price will be equal to the blend price. Suppose the blend price in region i, $\tilde{Pb}_i$, is defined as follows:

$$\tilde{Pb}_i = \frac{PI_i^o \sum_j xa_{ji} + PII_i^o xa2_{ii}}{\sum_j xa_{ji} + xa2_{ii}} \qquad \text{(IV} - 38\text{)}$$

where $PI_i^o = PII_i^o + D_i$; PII_i^o is the minimum Class II price,; D_i is the Class I differential; $\sum_j xa_{ji}$ is the amount of Grade A milk pooled into region i, from the j supply region where j = 1, n, in fluid use; and $xa2_{ii}$ is the amount of Grade A milk in manufactured use in region i.

Equation (IV-38) implies that the blend price in each region is determined by the total demand for Grade A milk in fluid use, $\sum_j xa_{ji}$, and for Grade A milk in manufactured use, $xa2_{ii}$, given minimum Class I and Class II prices. Within the region, the market price equilibrium condition is that Grade A milk supply price equals the blend price less the transportation cost. Therefore the blend price is generally bounded by the total quantity of Grade A milk pooled, the quantity of Grade A milk in manufactured use, and Class I and II minimum prices in its own region.

Due to the nonlinear nature of the blend price function, it needs to be linearized through separable programming.[46] Suppose the pooling activity is defined by w_{it} in region i at quantity step t associated with the Grade A milk quantity pooled in region i, za_{it}, and the corresponding blend price, pa_{it}, where i = 1, n and t = 1, m. Then optimal quantity and price for the blend scheme is constrained by the following:

$$\sum_j xa_{ji} - \sum_t w_{it} za_{it} \geq 0$$

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[46] Since the minimum Class I price is fixed at PI^o, the demand for the fluid milk is also fixed at yI^o. This implies $\sum_j xa_{ji} = yI_i^o$. The Grade A milk produced in region i may be processed in fluid use or in manufactured use. Hence $xa_i = xa_{ii} + \sum_{j \neq i} xa_{ji} + xa2_{ii}$. Equation (IV-38) may be simplified as,

$$\tilde{Pb}_i = PI_i^o - D_i \frac{xa2_{ii}}{\sum_j xa_{ji} + xa2_{ii}}.$$

Since each xa_{ji}, for any region j, is not constant, even though their sum is constant, the blend price is inversely related to each xa_{ji}. This means the blend price is a nonlinear function of the quantity of Grade A milk supply.

$$ra_i - \sum_t w_{it} pa_{it} \geq 0$$

$$1 - \sum_t w_{it} \leq 0 , \quad \text{for all i.}$$

These constraints imply that the quantity of Grade A milk pooled in region i, $\sum_j xa_{ji}$, has to be greater than or, at least, equal to the convex combination of the quantity step defined by za_{it}. Similarly the supply price of Grade A milk,[47] ra_i , has to be greater than or, at least, equal to the convex combination of the price step defined by pa_{it} . Since the original nonlinear blend price constraint is strictly convex, the linearized blend price constraint of the separable programming formulation is convex. The convexity of the linearized blend price constraint will force the convex combinations of each quantity and price solution to be close to the actual solution for the nonlinear mathematical problem.

IV.3.2. Linear Programming Model

In the unregulated market case, the additional constraints for quantity, price and convexity in each function are added to the institutional constraints specified in (IV-16) to (IV-25). In the regulated market case, the additional constraints for the blend price portion and for the quantity, price and convexity in each function are added to the institutional constraints specified in (IV-16) to (IV-31). The full specification of the separable programming model of the U.S. dairy industry under 1982 federal programs is derived as follows:

$$\max W = \sum_j \sum_t s_{jt} \Delta f_{jt} + \sum_t \sum_k qk_t \Delta k_t - \sum_i [\sum_t u_{it} \Gamma a_{it} + \sum_t v_{it} \Gamma b_{it}]$$

---

[47] Again, at equilibrium, the supply price of Grade A milk in region i, ra_i, is expected to be equal to the blend price in region i, pa_i.

$$+\sum_{k=2}^{4} Pgk^{o}Qgk - \sum_{i}\sum_{j} ta_{ij}xa_{ij} - (ac_{23}xm23 + ac_{4}xm4)$$

$$+\sum_{i} \lambda 1_{i}(xa_{i} - \sum_{j} xa_{ij} - xa2_{ii})$$

$$+\sum_{i} \lambda 2_{i}(xb_{i} - xb_{ii})$$

$$+\sum_{j} \lambda 3_{j}[\sum_{i} xa_{ij} - (1 + R)yf_{j}]$$

$$+ \quad \lambda 4_{a}[\sum_{j}(xa2_{jj} + xb_{jj}) - (xm23 + xm4)]$$

$$+\sum_{k=2}^{3} \lambda 5_{bk}[c^{k}xm23 + (BSk - ESk) + (IMk - EXk) - (yk + Qgk)]$$

$$+ \quad \lambda 5_{b4}[c^{4}xm4 + (BS4 - ES4) + (IM4 - EX4) - (y4 + Qg4)]$$

$$+\sum_{i} \lambda 6_{j}(pf_{j} - pf_{j}^{o})$$

$$+ \quad \lambda 7(xm23^{o} - xm23)$$

$$+ \quad \lambda 8(xm4^{o} - xm4)$$

$$+\sum_{i}\sum_{j} \lambda 9_{ij}(ra_{i} + ta_{ij} - ra_{j})$$

$$+\sum_{i} \lambda 10_{i}(rb_{i} - pm^{o})$$

$$+\sum_{i} \lambda 11_{ix}(\sum_{t} u_{it}xa_{it} - xa_{i})$$

$$+\sum_{i} \lambda 11_{ir}(\sum_{t} u_{it}ra_{it} - ra_{i})$$

$$+\sum_{i} \lambda 11_{ic}(1 - \sum_{t} u_{it})$$

$$+\sum_{i} \lambda 12_{ix}(\sum_{t} v_{it}xb_{it} - xb_{i})$$

$$+\sum_i \lambda 12_{ir}(\sum_t v_{it} rb_{it} - rb_i)$$

$$+\sum_i \lambda 12_{ic}(1 - \sum_t v_{it})$$

$$+\sum_j \lambda 13_{jy}(yf_j - \sum_t s_{jt} yf_{jt})$$

$$+\sum_j \lambda 13_{jp}(-pf_j + \sum_t s_{jt} pf_{jt})$$

$$+\sum_j \lambda 13_{jc}(1 - \sum_t s_{jt})$$

$$+\sum_k \lambda 14_{yk}(yk - \sum_t qk_t yk_t)$$

$$+\sum_k \lambda 14_{pk}(pk - \sum_t qk_t pk_t)$$

$$+\sum_k \lambda 14_{ck}(1 - \sum_t qk_t)$$

$$+\sum_i \lambda 15_{iz}(-\sum_t w_{it} za_{it} + \sum_j xa_{ji})$$

$$+\sum_i \lambda 15_{ir}(-\sum_t w_{it} pa_{it} + ra_i)$$

$$+\sum_i \lambda 15_{ic}(1 - \sum_t w_{it}) \qquad (IV-39)$$

IV.3.2.1. Kuhn-Tucker Conditions

In this section, the Kuhn-Tucker conditions for linearized Lagrangian net social quasi-welfare functions, specified under the regulated market case, are derived and economic implications of the conditions are discussed. The Kuhn-Tucker conditions for each case of constrained optimization problem provide conditions for the market as well as the locational price equilibria. The Kuhn-Tucker conditions also provide optimal values for Lagrangian multipliers of the problem which may be used as the shadow prices in the market. Once the mathematical problem is converted into the linear programming problem, shadow prices for the dual of the linear problem may be used as a proxy for shadow prices in the market.

Derivation of the Kuhn-Tucker conditions for the optimal solutions to the separable programming problems are analogous to those of the nonlinear mathematical problems.[48] The major difference is that the first-order Kuhn-Tucker conditions for separable programming problems are derived from the first derivatives of the constrained objective function with respect to the each stepwise activity variable, actual quantity variables along with shipments, and Lagrangian multipliers. The Kuhn-Tucker conditions for the regulated market case are specified as follows:

$$(1)\ \frac{\partial W}{\partial s_{jt}} = \Delta f_{jt} - \lambda 13_{jy} yf_{jt} - \lambda 13_{jp} pf_{jt} - \lambda 13_{jc} \leq 0$$

$$(2)\ \frac{\partial W}{\partial qk_{jt}} = \Delta k_t - \lambda 14_{yk} yk_t - \lambda 14_{pk} pk_t - \lambda 14_{ck} \leq 0$$

$$(3)\ \frac{\partial W}{\partial u_{it}} = -\Gamma a_{it} - \lambda 11_{ix} xa_{it} - \lambda 11_{ir} ra_{it} - \lambda 11_{ic} \leq 0$$

$$(4)\ \frac{\partial W}{\partial v_{it}} = -\Gamma b_{it} - \lambda 12_{ix} xb_{it} - \lambda 12_{ir} rb_{it} - \lambda 12_{ic} \leq 0$$

$$(5)\ \frac{\partial W}{\partial w_{it}} = -\lambda 15_{iz} za_{it} - \lambda 15_{ir} pa_{it} - \lambda 15_{ic} \leq 0$$

$$(6)\ \frac{\partial W}{\partial xa_i} = \lambda 1_i - \lambda 11_{ix} \leq 0$$

$$(7)\ \frac{\partial W}{\partial xb_i} = \lambda 2_i - \lambda 12_{ix} \leq 0$$

---

[48] See Appendix B for a derivation of and discussion about the nonlinear mathematical specification and Kuhn-Tucker conditions.

(8) $\frac{\partial W}{\partial yf_j} = -(1+R)\lambda 3_j + \lambda 13_{jy} \leq 0$

(9) $\frac{\partial W}{\partial yk} = -\lambda 5_{bk} + \lambda 14_{yk} \leq 0$

(10) $\frac{\partial W}{\partial xm23} = -ac_{23} - \lambda 4_a + \sum_{k=2}^{3} c^k \lambda 5_{bk} - \lambda 7 \leq 0$

(11) $\frac{\partial W}{\partial xm4} = -ac_4 - \lambda 4_a + c^4 \lambda 4_{b4} - \lambda 8 \leq 0$

(12) $\frac{\partial W}{\partial xa_{ij}} = -ta_{ij} - \lambda 1_i + \lambda 3_j \leq 0$

(13) $\frac{\partial W}{\partial xa2_{ii}} = -\lambda 1_i + \lambda 4_a \leq 0$

(14) $\frac{\partial W}{\partial xb_{ii}} = -\lambda 2_i + \lambda 4_a \leq 0$

(15) $\frac{\partial W}{\partial Qgk} = Pgk^o - \lambda 5_{bk} \leq 0$

(16) $\frac{\partial W}{\partial \lambda} \geq 0$

for all λ, i, j, t, and k, and where $\Delta = (c^4 Pg4^o - c^2 Pg2^o - c^3 Pg3^o) - (ac_4 - ac_{23})$.

The inequality conditions will change into equality conditions if the problem has interior solutions. Kuhn-Tucker conditions (1) through (5) are associated with each supply, demand or blend price activity and do not have real economic implications. Conditions (6) through (11), and (15) represent the consumer and producer market equilibrium conditions. Conditions (12) through (14) represent the local market price equilibria. Condition (16) reflects the market equilibrium condition including additional regulated market equilibrium conditions such as blend price alignment, classified pricing, and the support price.

Implications of conditions (6) to (9) are similar to the conditions in the competitive market case. Since condition (8) is incorporated with the reserve requirement, the imputed price for the fluid market is now the shadow price for the fluid demand function constraint divided by $(1+R)$, $\frac{\lambda 13_y}{(1+R)}$. Conditions (10) and (11) imply that shadow prices for the quantity balance constraints for the raw milk in manufactured use are equal to the imputed market prices for manufactured milk products less actual processing cost and shadow prices for the capacity constraints.

Condition (12) implies that the imputed market supply price for Grade A milk in region i is less than or equal to the imputed market demand price for fluid milk and the transportation cost. Readers should note that the imputed market price for fluid milk in region j, $\lambda 3_j$, is no longer close to the actual Class I minimum price due to the reserve requirement constraint. Furthermore, under the marketing order program, Grade A milk producers receive a blend price, not fluid price, in each order. This fact requires that the model incorporates an additional spatial price equilibrium condition associated with $\lambda 9$ as outlined in (IV-39). Spatial equilibrium conditions represented by Kuhn-Tucker conditions and the additional one associated with $\lambda 9$ are compared as follows:

$-ta_{ij} - \lambda 1_i + \lambda 3_j \leq 0$ from condition (12)

$-ta_{ij} - ra_i + ra_j \leq 0$ additional condition associated with $\lambda 9$.

Condition (12) also implies a relationship between the Grade A milk supply price and fluid price within the region. In this case it is assumed the transportation cost is zero ($ta_{jj} = 0$). Therefore:

$$(17) \quad \frac{\partial W}{\partial xa_{jj}} = -\lambda 1_j + \lambda 3_j + \lambda 15_{jz} \leq 0 \;\rightarrow\; \lambda 3_j \leq \lambda 1_j - \lambda 15_{jz}.$$

Condition (17) is a special case of condition (12) and implies that the imputed market supply price for Grade A milk and demand price for fluid milk in region j differ by $\lambda 15_{jz}$, which is a shadow price of a quantity portion of the linear approximation of the blend price constraint.

Suppose the imputed Grade A milk supply price, $\lambda 1$, is very close to the actual market price, ra. Plugging (17) into (12), condition (12) is rewritten as:

$$(18)\ (-ta_{ij} - \lambda 1_i + \lambda 3_j) \rightarrow (-ta_{ij} - \lambda 1_i + \lambda 1_j - \lambda 15_{jz})$$

$$\rightarrow \{-(ta_{ij} + \lambda 15_{jz}) - ra_i + ra_j\}.$$

Since ta_{ij} and $\lambda 15_{jz}$ are positive, $ta_{ij} < ta_{ij} + \lambda 15_{jz}$ from conditions (12) and (18). This yields $ra_j - ra_i \leq ta_{ij} + \lambda 15_{jz}$. Therefore Kuhn-Tucker condition (12) provides an overestimate of spatial equilibrium price alignment and should be superseded by the additional equilibrium condition associated with $\lambda 9$.

In a regulated market case, the shadow prices $\lambda 3_j$ and $\lambda 4$ are directly affected by the price regulation, classified pricing and the support price. If the conditions associated with $\lambda 4_s$ are fully satisfied, then $\lambda 4_s$ is constant at Pg^o, the support price level. Since Grade B milk is used in manufactured milk only, the shadow price for Grade B milk supply, $\lambda 2_i$, is equal to Pg^o. The value of $\lambda 1_i$, the shadow price for Grade A milk supply may differ in each region depending on the fluid demand situation in all regions and the marginal cost structure of Grade A milk producers in region i. Assuming that the production behavour of Grade A milk producers is affected by the set of blend prices, the locational market price equilibrium condition is superseded by the regulated locational equilibrium condition: $ra_i + ta_{ij} \geq ra_j$. This discussion of shadow prices was primarily drawn from McDowell (1982).

IV.3.3. Relationship Between Producer Surplus and Shadow Prices

In an unregulated market problem with quantity balance constraints only (see IV-39), the shadow prices, or duals, on the quantity constraints represent the market equilibrium prices of the corresponding commodity (Klein and Roe). In a regulated market problem with a mixture of quantity balance and price regulating constraints, the interpretation of shadow prices on the price constraints is rather complicated. In general, however, the shadow prices on the price constraints are expected to represent the marginal utility of the net social welfare functions.

Under the assumption that the subinterval of the quantity steps is fairly small, the solution of the linearized constrained objective function can be a close approximation of the solution to the nonlinear constrained objective function. Given the above assumption, the shadow prices of the convexity constraints such as $\lambda 11_{ic}$ through $\lambda 15_{ic}$ in (IV-39) are related to the consumer and producer surplus. For instance, from the Kuhn-Tucker conditions for the Grade B milk supply activity in the regulated market case as outlined in (4):

$$\frac{\partial W}{\partial v_{it}} = -\Gamma b_{it} + \lambda 12_{ix} xb_{it} + \lambda 12_{ir} rb_{it} - \lambda 12_{ic} = 0$$

and:

$$\lambda 12_{ix} = \lambda 2_i = rb_i = Pg^{o} \quad \text{from Kuhn-Tucker conditions (7), (12), and (14)}.$$

Therefore:

$$\lambda 12_{ic} = (-\Gamma b_{it} + rb_i xb_{it}) + \lambda 12_{ir} rb_{it}$$

The term $(-\Gamma b_{it} + rb_i xb_{it})$ is producer surplus at the quantity of xb_{it} Grade B milk supply. As illustrated in (IV-39), $\lambda 12_{ir}$ is a Lagrangian multiplier associated with the linear approximation of the Grade B milk supply price constraint. Suppose the real Grade B milk supply price, rb_i, is not exactly the same as the linearly approximated Grade B milk price, $\sum_t v_{it} rb_{it}$ so that $\lambda 12_{ir}$ is zero, then the shadow price of the convexity of the Grade B milk supply activities, $\lambda 12_{ic}$, represents the producer surplus of Grade B milk.

Since Grade A milk may be used for fluid or manufactured purposes, the shadow price on the convexity constraint of the Grade A milk supply activities varies depending on the market situation. Suppose region i is an importing market. This implies Grade A milk produced in region i and imported milk pooled in region i are used for fluid milk products consumed in region i and additional reserve requirements. In this case the value for xa_{ij}, $i \neq j$, is zero and the following relationship can be derived from (12):

$$\lambda 1_i = \lambda 3_i + \lambda 15_{iz}$$

Notice that $\lambda 3_i$ is a shadow price for fluid demand with the reserve requirement constraint. Since region i is assumed a deficit area, $\lambda 3_i$ is now greater than the minimum Class II price, Pm, in order to attract Grade A milk from other regions. The shadow price, $\lambda 3_i$, continues to stay higher than Pm untill the constraint is fully satisfied.

The Kuhn-Tucker condition for the Grade A milk supply activity (3) is

$$\frac{\partial W}{\partial u_{it}} = - \Gamma a_{it} - \lambda 11_{ix} xa_{it} - \lambda 11_{ir} ra_{it} - \lambda 11_{ic} \leq 0$$

and

$$\lambda 11_{ix} = \lambda 1_i = \lambda 3_i + \lambda 15_{iz} = ra_i$$

where $\lambda 15_{iz} \wedge \lambda 11_{ir}$ represent shadow prices for the pooling constraint of Grade A milk supply and the linearization constraint of Grade B milk supply price respectively. As is the case of $\lambda 12_{ir}$, $\lambda 11_{ir}$ can be assumed to be zero, and:

$$\lambda 11_{ic} = -\Gamma a_{it} + (\lambda 3_i + \lambda 15_{iz}) xa_{it}$$

The term $(\lambda 3_i + \lambda 15_{iz})$ is an imputed market equilibrium supply price for Grade A milk in deficit region i. Hence the dual of the convex constraint of Grade A milk, $\lambda 11_{ic}$, in region i represents the producer surplus of the Grade A milk.

In a surplus region, the imputed market equilibrium supply price is restricted to Pg^o with the same analogy. In this case,

$$\lambda 11_{ic} = - \Gamma a_{it} + Pg^o xa_{it}$$

The interpretation of shadow prices of the convexity constraints of the fluid and the manufactured milk demand activities are analogous to the supply case. That is shadow prices of the convexity in demand case represent the consumer surplus for the respective consumption activities.[49]

IV.3.4. Separable Programming Matrix Tableau

In order to illustrate the full specification of the separable programming matrix tableau of a simplified version of the empirical model used in this dossertation, based on (IV-39) several additional assumptions, are imposed as follows:

1. The U.S. dairy market is divided into two regions only.

2. Region 1 may export the Grade A milk to the region 2 with the unit transporation cost of ta_{12}.

3. Under regulations, the farm level support price Pg^{o}, is calculated by a weighted average revenue formula given $Pg2^{o}$, $Pg3^{o}$, and $Pg4^{o}$ for butter, powder, and cheese less marketing margin, m23 and m4, respectively. It is assumed that a net return to cheese plants is identical to a net return to butter-powder plants. The Class II minimum price is Pm^{o}. If the market is in a surplus situation, it is assumed that $Pm^{o} = Pg^{o}$. The Class I minimum price is Pm^{o} plus the Class I differential, D_i . Hence $pf_j = Pm^{o} + D_j$ where $j = 1, 2$.

4. The initial actual market prices represent the market equilibrium prices. On the supply side, there are two supply prices, Grade A and Grade B. It is expected that the Grade A supply price is equal to the blend price and the Grade B supply price is equal to Pm^{o} within the region. On the demand side there are five demand prices, fluid, butter, cheese, nonfat dry milk and support prices.

5. The plant capacities for cheese and butter-powder are assumed to be given depending upon market prices for butter, powder, and cheese. The full capacity of cheese plants is defined as $xm4^{o}$ and that of butter-powder plants is defined as $xm23^{o}$.

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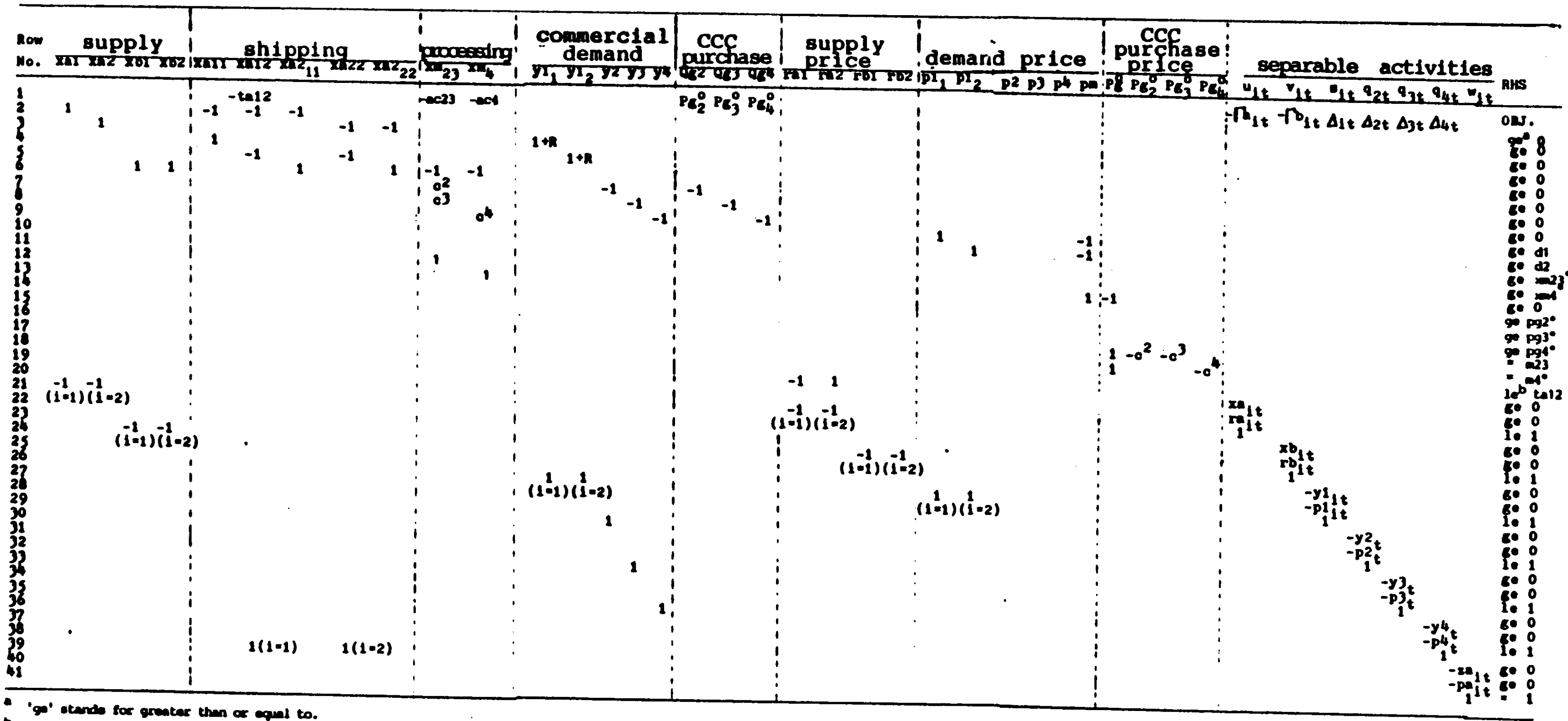
[49] Discussion about rents associated with the support program follow in Appendix B.



a 'ge' stands for greater than or equal to.
b 'le' stands for less than or equal to.

Figure IV.2. L.P. Matrix Tableau for Simplified Two Region U.S. Dairy Interregional Trade Model

The Linear Programming (L.P.) matrix tableau of the simplified two region dairy trade model is illustrated in figure IV-2. Rows 2 through 6 are representative of the quantity balance constraints. Rows 7 to 9 are simple tranfer rows for each manufacutred milk quantity. Additional price constraints due to the regulatory policy are reflected in rows 10, 11 and 14 to 19. Rows 12 and 13 represent the plant capacities of butter-powder and cheese. Row 20 is a locational price equilibrium condition under the blend price scheme. The rest of the rows after 21 are the separable programming part of the problem. In this simplified problem, beginning and ending stocks, and imports and exports are excluded for simplicity. Additional equality constraints can be added to consider the exogeneity of these activities.

IV.3.5. Solution Computation

The computation for the model is primarily divided into two portions. The first portion is to use a matrix generating FORTRAN program to generate the coefficients for activity variables for each row including separable portions (see Appendix E). The program was originally developed by Paul Chang and Terry L. Roe and modified by McDowell (1982) to include the blend pricing scheme. The program was converted to IBM compatible FORTRAN by Todd Pukanecz and Pyengmu Bark. After generating the linear programming matrix coefficients associated with the strict linear and separable portions of the problem, the program is designed to set up a Mathematical Programming System (MPS) input data file (see Appendix E). The linear programming problem in conjunction with the FORTRAN program were solved by utilizing the MPS Linear Programming package installed on the IBM computer at Virginia Polytechnic Institute and State University.

CHAPTER V

SIMULATION RESULTS

V.1. Introduction

In this chapter, results of the U.S. interregional dairy trade model are discussed. Comparisons of actual and simulated results for the 1982 market situation are drawn first.[50] Several problems with the results of the simulation are also discussed. In the second section, comparisons between the market results of the 1982 simulation without classified pricing, pooling, and price supports, and the market results for 1982 with regulations are made. In the third section, dairy price policy options of changing the CCC support and purchase prices are discussed. Policy options of changing the support and purchase prices were combined in two ways. The first was to decrease the support price level for manufactured milk from $12.60 per cwt to $9.60 per cwt by $1.00 per cwt. The second was to split a decrease in the support price between butter and nonfat dry milk with ratios of 0 to 1.0 (Option 1), 0.5 to 0.5 (Option 2), and 0.16 to 0.84 (Option 3). These policy options were applied to the 1982 system and to the 1985 federal marketing order system. The effects of changing these policy options on the national and regional markets and on welfare are discussed.

In the fourth section, results of simulations of simultaneous market clearing situations in butter and nonfat dry milk markets under the 1982 system and a new quota system are discussed. In order to solve simultaneous market clearing situations for butter and nonfat dry milk under the 1982 and a new quota system, iterative procedures were employed. Import quotas were increased by 10 percent of the 1982 commercial demand for butter, nonfat dry milk, and cheese.

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[50] The 1982 market was selected for the analysis due to the fact that, after 1982, the market was affected by provisions to reduce the government's role established by the Dairy Production Stabilization Act of 1983 and the dairy title of the Food Security Act of 1985.

V.2. Comparison of Actual and Simulated 1982 U.S. Dairy Market Situation

The simulated prices and quantities for the 1982 U.S. dairy market tions were very close to the actual (1982) market prices and quantities except for shipments. As is shown in table V-1, percentage differences between actual and simulated Grade A milk supply prices ranged from 3.85 to 0.00 percent on the regional basis. The Grade A milk supply price in the West Northcentral region was over-estimated by 1.82 percent and prices in the South Atlantic and East Southcentral regions were under-estimated by 3.85 and 2.47 percent respectively. Percentage differences between actual and simulated Grade A milk supply ranged from 2.77 to 0.14 percent. Grade A milk supplied from the South Atlantic and East Southcentral regions were under-estimated by 2.77 and 1.80 percent respectively. Estimated Grade A milk supply prices and quantities except for the South Atlantic, East Southcentral and West Northcentral regions were greater than 99 percent of actual prices and quantities. Simulated prices and quantities of Grade B milk supply were almost the same as actual ones.

While simulated prices and quantities of Grade A milk supply of the 1982 U.S. dairy industry seemed to be fairly close to the actual ones, comparison of actual and simulated shipments showed some significant differences especially in the West Northcentral region. Based on calculations from table V-1, about 3 billion pounds of raw milk were imported by this region. The simulation, however, showed that about 1 billion pounds of Grade A milk for fluid use was transferred from the West Northcentral to the South Atlantic region. Simulation of shipments of Grade A milk from the Northeast and East Southcentral regions was under-estimated by about 1.7 billion pounds and 0.5 billion pounds respectively and shipments from the East Northcentral region were over-estimated by about 0.9 billion pounds.

Inconsistency of simulated as compared to actual shipment patterns in terms of spatial Grade A milk supply price alignment was apparent as shown in table V-1. For example, the actual lowest Grade A milk supply price was $131.7 per thousandweight (twt) in the West Northcentral region, and the highest one was $146.6 per twt in the West Southcentral. Since the seasonal movements of Grade A milk supply prices in nine regions were in the same direction through the year (USDA,

Table V.1. Comparison of Actual and Simulated Supply Side, 1982

Region	Prices Actual	Prices Simulated	Prices % of Difference	Quantities Actual	Quantities Simulated	Quantities % of Difference
	- $/thousandweight-			- billion pounds -		
Grade A						
Northeast	140.0	139.2	-0.57	29.014	28.941	-0.25
E. Northcentral	135.4	135.8	0.30	29.871	29.912	0.14
W. Northcentral	131.7	134.1	1.82	14.385	14.463	0.54
South Atlantic	155.7	149.7	-3.85	6.176	6.005	-2.77
E. Southcentral	145.5	141.9	-2.47	3.837	3.768	-1.80
W. Southcentral	146.6	146.0	-0.41	7.289	7.271	-0.25
Mountain	140.2	139.7	-0.36	5.269	5.260	-0.17
Southwest	134.4	134.4	0.00	13.887	13.882	-0.04
Northwest	135.4	135.7	0.21	4.318	4.324	0.14
Total				114.046	113.826	-0.19
Grade B						
E. Northcentral	126.0	126.0	0.00	7.486	7.483	-0.04
W. Northcentral	126.0	126.0	0.00	8.304	8.303	-0.01
E. Southcentral	126.0	126.0	0.00	.897	.897	0.00
W. Southcentral	126.0	126.0	0.00	.207	.207	0.00
Mountain	126.0	126.0	0.00	1.655	1.655	0.00
Southwest	126.0	126.0	0.00	.579	.579	0.00
Northwest	126.0	126.0	0.00	.139	.139	0.00
Total				19.267	19.263	-0.02
Net Export						
Northeast				4.115	2.441	
E. Northcentral				1.004	1.912	
W. Northcentral				-3.233	1.158	
South Atlantic				-2.779	-5.207	
E. Southcentral				1.363	.854	
W. Southcentral				- .911	-1.158	
Mountain				.183	-	
Southwest				-	-	
Northwest				- .119	-	

1984a; Table 32), it is unrealistic to assume that the West Northcentral region was a deficit region at some point in time, at least, over the period of analysis. Furthermore, the quantity of fluid milk demand in the West Northcentral region was only 4.6 billion pounds in 1982 (table V-2), which was about 32 percent of the total Grade A milk produced in the region yielding the lowest Class I utilization rate among nine regions. Therefore it appears that the simulated shipment of Grade A milk from the West Northcentral region may reflect a more realistic situation for the 1982 U.S. dairy industry, than the "actual" numbers from published sources.

The significant difference in shipments between the actual and the simulated ones in the Northeast, East Northcentral, and East Southcentral regions is inevitable for two reasons in addition to the inaccuracy of data problem. The first is the selection of origins and destinations among regions. Even though these trade points were selected based on sound judgment, it is almost impossible to cover every micro level shipment between/among regions which may have been counted in the actual shipments. Second, since the model is an annual one, the simulated shipments represent annual average ones, while actual shipments were the aggregated ones during a year. It may be possible that the annual average shipments are less than the aggregated day-to-day or month-to-month shipment data would indicate.

Since the model employs the static cross-sectional data for an analysis, usual measurements for forecasting accuracy may not be applicable. Babb et al. (1977, p. 94) used Theil's inequality statistics, and McDowell (1982, p. 161) used the modified Theil's inequality statistics. Let the modified Theil's inequality statistics be defined as:

$$\mathrm{R} = 1 - \frac{\sqrt{\Sigma(P_i - A_i)^2}}{\sqrt{\Sigma P_i^2} + \sqrt{\Sigma A_i^2}} \qquad (V-1)$$

where R is the degree of forecasting accuracy; P_i is the simulated value for observation i; and A_i is the actual value for observation i.

Since the model simulated prices and quantities, values for R are caculated separately for simulations of prices and quantities of Grade A and Grade B milk supply. Simulations of shipments were included in the calculation of the values. R for the simulation is:

Table V.2. Comparison of Actual and Simulated Demand, 1982

Region	Prices		Quantities	
	Actual	Simulated	Actual	Simulated
	- $/thousandweight -		- billion pounds(m.e.) -	
Fluid				
Northeast	157.2	157.2	11.208	11.208
E. Northcentral	150.1	150.1	11.287	11.287
W. Northcentral	147.9	147.9	4.581	4.581
South Atlantic	162.0	162.0	7.388	7.388
E. Southcentral	154.6	154.6	1.613	1.613
W. Southcentral	155.9	155.9	5.650	5.650
Mountain	151.6	151.6	2.813	2.813
Southwest	145.2	145.2	6.049	6.049
Northwest	149.3	149.3	1.797	1.797
Total			52.386	52.386
	- $/hundred pounds -		-hundred million pounds-	
Manufactured Milk Product[c]				
Butter	143.90	143.90	7.024	7.024
Nonfat Dry Milk	90.69	90.69	4.477	4.477
Cheese	134.65	134.65	20.640	20.639
	- $/thousandweight -		- billion pounds(m.e.) -	
Other	126.00	126.00	28.400	28.400
Raw Milk in Manufactured Use			80.704	80.704

$$R_p = 1 - \frac{\sqrt{56.22}}{\sqrt{178234.91} + \sqrt{175832.29}} = .9911, \quad \text{and} \qquad (V-2)$$

$$R_q = 1 - \frac{\sqrt{23.44}}{\sqrt{2454.06} + \sqrt{2431.55}} = .9510 \qquad (V-3)$$

where R_p represents the degree of price forecasting accuracy and R_q, the degree of quantity forecasting accuracy of the model. Results in (V-2) and (V-3) imply that the model simulated the supply prices of the 1982 U.S. dairy market situation with 99.11 percent of accuracy and the supply quantities with 95.10 percent of accuracy, repectively.

The results of the simulations for fluid milk and manufactured milk products of butter, nonfat dry milk, cheese, and the other category were almost the same as actual ones (tables V-2 and V-3). The only differences betweeen actual and simulated quantities were the production and CCC purchase of cheese product (table V-3). They were under-estimated by 0.81 and 3.49 percent respectively.

Even though the model seemed to simulate the overall 1982 U.S. dairy market with high accuracy, there are several technical problems associated with the inaccuracy of the simulation. Since the model utilized a linear approximation approach to a non-linear mathematical problem employing a separable programming technique, the accuracy of the model largely depends upon the length of subintervals of the domain, reflected by magnitudes of quantity steps, of supply, demand, and blend price functions. The length of subintervals may be reduced either by increasing numbers of subintervals within a given domain or by reducing the range of the domain with given numbers of subintervals.[51] The former approach would require increased computing space and time, and thus increased costs. The latter approach would represent a "grid search" method which would need several iterations to reach a solution, and thus would increase costs. Based on the modified Theil's inequality statistics, it was decided that the established subintervals yielding results in tables V-1, 2, and 3 are small enough to provide appropriate results. In early stages of the analysis, it was ascertained changing intervals did not substantially affect the results.

[51] For a discussion, refer to the section 3.1 in Chapter IV.

Table V.3. Comparison of Actual and Simulated Manufactured Milk Products Market Situation, 1982

Item	Butter		Nonfat Dry Milk		Cheese	
	Actual	Simulated	Actual	Simulated	Actual	Simulated
(hundred million pounds)						
Beginning[a] Stock	4.290	4.290	8.900	8.900	8.890	8.890
Import[a]	.030	.030	.020	.020	.180	.180
Production	11.194	11.194	14.010	14.010	27.815	27.590
Total Supply	15.514	15.514	22.930	22.930	36.885	36.660
Ending[a] Stock	4.670	4.670	8.972	8.972	9.820	9.820
Government Purchase	3.820	3.820	9.481	9.481	6.425	6.201
Commercial Demand	7.024	7.024	4.477	4.477	20.640	20.640
Total Demand	15.514	15.514	22.930	22.930	36.885	36.661

[a] Treated as exogenous variables.

The first cause of model inaccuracy is related to the position of demand, supply and blend price functions based on estimated functional parameters. The second problem arises from two sources: (1) inaccuracy of data for supply and demand functions such as prices, quantities, elasticities, and specification of functional forms; and (2) rounding errors of estimated functional parameters such as intercepts and slopes of demand and blend price functions, and/or technical coefficients and exponents of supply functions

The third problem is due to the enforcement of spatial blend price equilibrium constraints. Since the objective function of the model is maximized, the interregional shipment would not occur unless the occurrence of shipments increased total surplus of the model. However, once the blend price alignment constraints were added in the model, shipment activities were reduced to satisfy these constraints. The tendency of reducing shipment activities of the model resulted in selecting combinations of the first and the last subinterval points of the blend price functions in one or two regions, usually region(s) where a large volume of shipment occurred. This problem could be minimized by further narrowing the range of the domain of the quantity step. However, such a procedure was beyond the scope of this dissertation. Errors in simulation of Grade A milk supply prices and quantities in the East Northcentral and West Northcentral regions were also undoubtedly partly due to this problem.

V.3. Comparison of Unregulated and Regulated Markets

The result of the simulation for the 1982 annual market without classified pricing, pooling, and price supports is illustrated and compared to the result for the 1982 annual market with regulations in table V-4. It was assumed that the government regulations did not affect shifts in Grade A and Grade B milk supply in this comparison. Under this assumption, the competitive market price for manufactured milk was lower than the regulated market price for manufactured milk by \$10.96 per thousandweight (twt) or by 8.90 percent. The market price for manufactured milk would have been \$115.04 per twt if the dairy market had no government intervention in 1982.

Table V.4. Comparison of Unregulated and Regulated Dairy Markets, 1982 Simulation [a]

Region	Grade A Supply				Grade B Supply			
	Competitive		Regulated		Competitive		Regulated	
	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity
Northeast	115.61	26.400	139.2	28.941				
E. Northcentral	116.23	27.000	135.8	29.912	115.04	7.048	126.0	7.483
W. Northcentral	116.43	13.819	134.1	14.463	115.04	8.061	126.0	8.303
South Atlantic	125.25	5.300	149.7	6.005				
E. Southcentral	119.81	3.170	141.9	3.768	115.04	.820	126.0	.897
W. Southcentral	118.14	6.330	146.0	7.272	115.04	.195	126.0	.207
Mountain	115.04	4.794	139.7	5.260	115.04	1.585	126.0	1.655
Southwest	117.71	13.480	134.4	13.882	115.04	.567	126.0	.579
Northwest	115.04	4.031	135.7	4.324	115.04	.134	126.0	.139
Total		104.324		113.827		18.410		19.263

Region	Fluid Demand				Manufactured Demand			
	Competitive		Regulated		Competitive		Regulated	
	Price	Quantity	Price	Quantity	Price	Quantity	Price	Quantity
Northeast	115.61	11.573	157.2	11.208				
E. Northcentral	116.23	11.587	150.1	11.287				
W. Northcentral	116.43	4.699	147.9	4.581				
South Atlantic	125.25	7.698	162.0	7.388				
E. Southcentral	119.81	1.674	154.6	1.613				
W. Southcentral	118.14	5.880	155.9	5.650				
Mountain	115.04	2.894	151.6	2.813				
Southwest	117.71	6.181	145.2	6.049				
Northwest	115.04	1.850	149.3	1.797				
Total		54.036		52.386	115.04	69.500	126.0	67.436

[a] Units for price and quantity are $ per thousandweight milk equivalent and billion pounds of raw milk respectively.

The highest Grade A milk supply price in the competitive market situation was $125.25 per twt in the South Atlantic region and the lowest one was $115.04 per twt in the Mountain and North West regions.

Due to a higher manufactured milk price in the regulated market situation than the competitive market price, Grade A milk supply (blend) prices in the regulated market situation were higher than the competitive prices by $16.7 per twt to $27.9 per twt, or by 14.2 percent to 23.6 percent on a regional basis. Blend prices in the West Southcentral, Mountain, Northeast, and South Atlantic were higher than competitive prices by more than 20 percent. Due to different elasticities of Grade A milk supplies in the nine regions (see table C-8 in Appendix C), the effects of the regulated market on quantities of Grade A milk supplied differed by region. The greatest increase in the quantity of Grade A milk supplied due to the regulations was 18.9 percent in the East Southcentral region and the lowest one was 3.0 percent in the Southwest region. In the West Southcentral region, the quantity of Grade A milk supplied in the regulated market was 14.9 percent higher than that in the absence of regulations. The national average increase was 9.5 billion pounds milk equivalent or 9.1 percent.

Fluid demand prices in the regulated market situation were higher than prices in the competitive market situation by $27.5 per twt to $41.6 per twt or by 23.4 percent to 36.0 percent. The differences in fluid demand prices between the competitive and regulated markets in the Northeast, South Atlantic, West Southcentral, and Mountain regions were more than $35 per twt. Since the fluid demand was inelastic, the differences in quantities of fluid demand between competitive and regulated markets were in the range of 2.1 percent to 4.0 percent while the national average difference was 3.1 percent.

The welfare effects of the regulations on the dairy market are shown in table V-5. Given the assumption that regulations had no impact on the milk supply, they lead to a loss in fluid and manufactured milk consumers surplus of about $1901.26 million and $750.49 million, respectively, in 1982. Grade A and Grade B milk producers gained about $2017.01 million and $206.54 million, respectively. The loss experienced by manufactured milk consumers is due to the fact that the simulated competitive equilibrium price was lower than the regulated 1982 manufactured milk price.

Table V.5. Effects of Dairy Marketing Regulation on Milk Producers and Consumers Surplus, 1982

Region	Fluid Milk Consumers[a]	Manufactured Milk Consumers[a]	Grade A Milk Producers[a]	Grade B Milk Producers[a]	Net Effects
(million dollars)					
Northeast	-473.705		636.869	-	-34.180
East Northcentral	-387.496		298.694	79.697	-31.031
West Northcentral	-146.004		265.128	89.703	- 6.655
South Atlantic	-277.157		141.120	-	-14.170
East Southcentral	- 57.126		78.069	9.421	- 7.395
West Southcentral	-224.881		161.622	2.218	-15.808
Mountain	-104.373		121.218	17.703	- 6.519
Southwest	-168.071		227.990	6.333	- 4.227
Northwest	- 62.450		86.297	1.465	- 3.505
Total	-1901.263	-750.491	2017.007	206.540	-123.490[b] -548.625[c] -672.115[d]

[a] Based on figure B-1.

[b] Total deadweight losses in fluid demand and Grade A supply sides defined by Dahlgran (1980, p. 289) due to regulations.

[c] Deadweight losses in manufactured demand and Grade B supply sides defined by Dahlgran (1980, p. 289) due to regulations.

[d] Total deadweight losses in the dairy industry due to regulations.

Similarly, the loss incurred by fluid consumers was due to a higher regulated fluid milk price, Class I price, in 1982. On a regional basis, fluid consumers in the Northeast, East Northcentral, South Atlantic and West Southcentral regions suffered about 70 percent of the national loss. Fluid consumers in each above mentioned region lost 6.20, 5.12, 7.89, and 7.92 percent of their surpluses, respectively, while the nation as a whole lost 5.89 percent of the total surplus. Grade A milk producers in the Northeast, East Northcentral, West Northcentral and Southwest (California) regions received about 70 percent of the national gains caused by the regulations. The rate of increase in producers' surplus in each above mentioned region was 31.20, 15.78, 21.83 and 17.56 percent, respectively, while the national average rate of increase was 24.66 percent. Due to higher levels of Grade A milk supply (blend) prices, milk producers in deficit regions such as the South Atlantic, East Southcentral, and West Southcentral gained relatively more benefit. Their gains were more than 36 percent. Gains of Grade B milk producers were largely allocated to the West and East Northcentral, and the Mountain.

Due to market regulations, the U.S. dairy industry suffered about $672.12 million of net social costs without including the administrative costs of regulatory programs for 1982. About $123.49 million of net social costs associated with deadweight losses occurred in fluid demand and Grade A milk supply over the period. Net social costs in the manufactured demand and Grade B milk supply were about $548.63 million. As far as the fluid milk market is concerned, the Northeast and East Northcentral were the two regions which suffered most from the relatively large net social costs of $65.22 million, consisting of 53 percent of the total net social cost in the nation.

V.4. The Dairy Price Support Program

The analysis of effects of changes in CCC purchase prices on dairy markets depends upon the price level for raw milk in manufactured use and the purchase price levels for butter, nonfat dry milk, and cheese set by the government. Due to the complexity of the relationship among the price for raw milk in manufactured use and prices for butter, nonfat dry milk, and cheese, the study simplified the relationship such that the price for raw milk in manufactured use at the plant level is equivalent to the net return to butter-powder plants and cheese plants.

As shown in table V-6, the actual decrease in the support price level was split between butter and nonfat dry milk by 16 and 84 percent, respectively, after July 1, 1985 by the government. According to the USDA, the decrease or increase of the support price was split about equally between butter and nonfat dry milk prior to 1985. This indicates that an arbitrary split of a decrease in the support price between butter and nonfat dry milk may be utilized as a policy option to control the dairy product markets.

In order to reflect the direct and cross price elasticity effects of various purchase price levels on butter, nonfat dry milk, and cheese demand, the study assumed that each demand curve is shifted by an aggregate amount of the cross price elasticity effects.[52] Since changes in purchase prices for butter, nonfat dry milk, and cheese are arbitrarily determined here, the magnitude of a shift in each demand curve is derived from each cross price elasticity and the change in the purchase price levels of other products.

V.4.1. Policy Options

In order to analyze the effects of changes in the support and purchase price levels, the study assumed that the government drops the support price level from $12.60 per cwt to $11.60 per cwt for an initial step and drops further down to $9.60 per cwt by $1.00 per cwt increments. These steps in the reduction of the support price level were adopted from the dairy provisions of the 1985 Farm Bill.

The stepwise reduction in the support price level was applied to the 1982 system and the 1985 Farm Bill system in terms of the federal marketing order system. Class I differentials of the two systems on a regional basis are illustrated in table V-7. Since the decrease in the support price level may be arbitrarily split between butter and nonfat dry milk, three approaches were taken under each federal marketing order system. The first approach was to allocate the whole decrease in the

52 For a discussion, see the section 4 in Chapter III.

Table V.6. Changes in CCC Purchase Prices, 1982 and 1985

Item	1982	1985	Change
(dollars per hundredweight)			
Support price for raw milk in manufactured use	12.60	11.60	-1.00
Return to butter-powder plants	12.60	11.60	-1.00
CCC manufacturing allowance for converting 100 pounds of raw milk into butter and nonfat dry milk	1.22	1.22	
Value of butter and nonfat dry milk made from 100 pounds of raw milk	13.82	12.82	-1.00
Value of butter	6.42	6.26	-0.16[a]
Value of nonfat dry milk	7.40	6.56	-0.84[a]
	13.82	12.82	-1.00
Return to cheese plants	12.60	11.60	-1.00
CCC manufacturing allowance for converting 100 pounds of raw milk into cheese and whey	1.37	1.37	
Value of cheese and whey	13.97	12.97	-1.00
Value of whey	.36	.36	
	13.61	12.61	-1.00
(dollar per pound)			
CCC purchase prices			
butter	1.4390	1.4033	-.0357
nonfat dry milk	.9069	.8036	-.1033
cheese	1.3465	1.2475	-.0990

[a] It is assumed that a decrease in the support price was split equally between butter and nonfat dry milk prior to July 1, 1985.

Source : USDA. Commodity Fact Sheet. April 1984 and April 1986, Table 3.

Table V.7. Regional Class I Differentials under 1982 and 1985 Farm Bill System

Region	Federal Order Marketing System	
	1982	1985
(dollars per thousandweight)		
Northeast	31.2	34.1 (2.9)
E. Northcentral	24.1	26.4 (2.3)
W. Northcentral	21.9	23.8 (1.9)
South Atlantic	36.0	44.4 (8.4)
E. Southcentral	28.6	35.5 (6.9)
W. Southcentral	29.9	38.9 (9.0)
Mountain	25.6	27.1 (1.5)
Southwest	19.2	19.2 (0.0)
Northwest	23.3	23.3 (0.0)

Note: Figures in parentheses are changes in the Class I differentials compared to the 1982 federal marketing system.

support price to nonfat dry milk while holding the butter price unchanged (Option 1). The second approach was to split the decrease equally between butter and nonfat dry milk (Option 2). And, the last approach was to split the decrease based on the actual 1985 situation with 16 percent for butter and 84 percent for nonfat dry milk (Option 3).

These three approaches were selected based on the fact that the first two approaches may represent two extreme cases while the last one may be closer to the actual situation assuming that the government holds the split ratio reported in 1985 until the support price level is dropped to $9.60 per cwt. Policy options of changes in the government support and purchase prices are summarized in table V-8.

V.4.2. Effects on Grade A and Grade B Supply and Fluid Demand

Changes in the government purchase prices for manufactured milk products affect the Grade A milk supply and fluid milk demand through the local marketing order system. Since the local Class II minimum price is based on the manufactured milk price and the Class I minimum (fluid) price is a Class II minimum price plus the Class I differential, fluid demand and Grade A milk supply are tied with these two minimum prices. A blend price is a Class II minimum price plus some fraction of the Class I differential depending on each market situation and Class I utilization. Hence changes in the purchase prices for butter, nonfat dry milk, and cheese would affect prices for Grade A and Grade B milk supply, and fluid demand.

V.4.2.1. National Average Market Results

The national average market results for Grade A and Grade B milk supply, and fluid milk demand are listed in table V-9. Figures in table V-9 represent changes in simulated prices, quantities, and producer or consumer surplus in each market under the assumption that the support price level is dropped from $12.60 per cwt to $9.60 per cwt by $1.00 decrements under the 1982 and the 1985 Farm Bill system.

Due to the stepwise reduction of the support price level, prices for Grade A and Grade B milk supply and fluid demand would also decrease. The Grade A milk supply price would decrease

Table V.8. Summary of Policy Options of Changes in Government Support/Purchase Prices

Support Price Level ($/cwt)	Federal Order Marketing System: 1982 Split Ratio for Butter (%) Option 1	2	3	1985 Farm Bill Split Ratio for Butter (%) Option 1	2	3
12.60	Basis			Basis		
11.60	0	50	16	0	50	16
10.60	0	50	16	0	50	16
9.60	0	50	16	0	50	16

Sources: USDA. Commodity Fact Sheet. 1984 and 1986, Table 3.

Table V. 9. Effects of Changes in Support Price Levels on National Average Market (Grade A, Grade B, and Fluid Milk) Results under 1982 and 1985 Farm Bill System

Milk Market	Support Price Level ($/cwt) 11.60	10.60	9.60
1982 System			
Grade A Supply			
Price($/twt)	-9.2(-6.67)	-9.5(-7.38)	-9.4(-7.88)
Production(bil. lbs)	-3.915(-3.44)	-4.165(-3.79)	-4.292(-4.06)
Surplus($ mil.)	-1028.3(-9.81)	-1019.3(-10.78)	-974.2(-11.55)
Grade B Supply			
Price($/twt)	-10.0(-7.94)	-10.0(-8.62)	-10.0(-9.43)
Production(bil. lbs)	-0.777(-4.03)	-0.807(-4.37)	-0.840(-4.75)
Surplus($ mil.)	-188.8(-11.48)	-180.9(-12.43)	-172.6(-13.54)
Fluid Demand			
Price($/twt)	-10.0(-6.52)	-10.0(-6.97)	-10.0(-7.50)
Demand(bil. lbs)	0.462(0.90)	0.462(0.87)	0.462(0.86)
Surplus($ mil.)	526.2(1.73)	530.9(1.72)	535.2(1.70)
Net Surplus($ mil.)	-690.2(-1.63)	-674.4(-1.60)	-616.6(-1.49)
1985 Farm Bill System			
Grade A Supply			
Price($/twt)	-8.6(-6.18)	-9.9(-7.61)	-9.4(-7.79)
Production(bil. lbs)	-3.832(-3.35)	-4.132(-3.74)	-4.292(-4.20)
Surplus($ mil.)	-1020.0(-10.91)	-1014.8(-10.62)	-970.7(-11.36)
Grade B Supply			
Price($/twt)	-10.0(-7.94)	-10.0(-8.62)	-10.0(-9.43)
Production(bil. lbs)	-0.777(-4.03)	-0.807(-4.37)	-0.840(-4.75)
Surplus($ mil.)	-188.8(-11.48)	-180.9(-12.43)	-172.6(-13.54)
Fluid Demand			
Price($/twt)	-10.0(-6.36)	-10.0(-6.79)	-10.0(-7.29)
Demand(bil. lbs)	0.462(0.89)	0.462(0.88)	0.462(0.90)
Surplus($ mil.)	524.2(1.74)	528.9(1.72)	533.4(1.71)
Net Surplus($ mil.)	-679.8(-1.61)	-671.3(-1.61)	-614.2(-1.50)

Note: Figures in the parentheses are proportional changes(percentage).

by \$0.92 per cwt, \$0.95 per cwt, and \$0.94 per cwt, respectively, under the 1982 system for each stepwise \$1.00 decrement of the support price level. Under the 1985 Farm Bill system, the price would drop by \$0.86 per cwt, \$0.95 per cwt, and \$0.94 per cwt, respectively. Prices for Grade B supply and fluid demand would drop by the same magnitude as the support price does, \$1.00 per cwt. Due to a decreasing trend in Grade A milk supply price, overall Grade A milk production would decrease by about 4 billion pounds for each price decrease. Overall Grade B milk production would decrease by about 800 million pounds, and fluid demand would increase by 462 million pounds for each price decrease.

Grade A milk producers' surplus would decrease by \$1028 million, \$1019 million, and \$974 million under the 1982 system for each respective stepwise reduction of the support price level. Under the 1985 Farm Bill system, it would decrease by \$1020 million, \$1015 million, and \$971 million, respectively. Grade B milk producers would lose about \$180 million with each support price level reduction under each system.

Due to a decrease in fluid price, fluid milk consumers would gain about \$500 million under each system per \$1.00 per cwt decrease in the support price. Net economic loss to Grade A and Grade B milk producers, and fluid consumers less transportation costs would be \$690 million, \$674 million, and \$616 million under the 1982 system with each respective stepwise reduction of the support price level. Under the 1985 Farm Bill system, net economic loss would be \$680 million, \$671 million, and \$614 million, respectively.

V.4.2.2. Regional Market Results

The regional market results are discussed in terms of changes in regional Grade A milk supply prices, and producer and consumer's surplus. Given that fluid demand in all regions is satisfied at the Class I minimum prices due to the existence of interregional trade and reserve requirements, the change in the Class I minimum price is the same as the change in the support price. The change in the Grade B milk supply price is also indentical to the change in the support price. Average rate of change in the regional Grade A milk supply price per unit of change in the support price level in each stepwise reduction of the support price level are listed in table V-10. An economic insight on the changes in the Grade A milk supply prices has been discussed by McDowell (1982, p. 168). In his discussion, he explained that changes in blend prices are reflected in Class I utilization and elasticities of supply and demand. According to him, the average rate of change in regional Grade A milk supply price tends to be relatively lower in a region where the Class I utilization ratio is higher, and supply and demand functions are more inelastic than in a region where the utilization ratio is lower and the demand functions are more elastic.

Results shown in table V-10 are consistent with this explanation. For instance, average rates of change in blend prices in the South Atlantic and East Southcentral regions were the lowest under the 1982 and the 1985 Farm Bill system at the $11.60 per cwt support price level. The elasticities of Grade A milk suuply and fluid demand in these two regions were most inelastic, 0.700 and 0.985 for supply, and 0.185 and 0.167 for demand, respectively. The average rate of change in the blend price in the Southwest region was the highest at .98 under each system, where the supply and demand were most inelastic at .222 and .115, respectively.

The average rate of change in the blend price varies as the support price level drops in several regions. The rate of change increases as the support price level drops in the East Northcentral, South Atlantic, and East Southcentral regions. The rate of change in the Northeast increases in absolute terms from 0.90 to 0.97 then drops to 0.95 under the 1982 system. Under the 1985 Farm Bill system, the rate of change in the Northeast decreases from 0.94 to 0.90 then drops to 0.89. These trends are due to the existence of interregional trade among surplus and deficit regions. The results of the simulation for the U.S. dairy market imply that Grade A milk for fluid purposes would flow: (1) from the Northeast region to the South Atlantic region, (2) from the East Northcentral region to the East Southcentral region, (3) from the West Northcentral region to the West Southcentral region, and (4) from the East Southcentral region to the South Atlantic region. As long as shipment patterns stay the same, pairwise changes in blend prices among trading regions would follow. In table V-10, it is shown that the average rate of change in the East Northcentral and East Southcentral regions, in the East Southcentral and South Atlantic regions, and in the West Northcentral and West Southcentral regions, respectively, would be identical.

Table V .10. Average Rate of Change of Regional Grade A Milk Supply Price Per Unit of Change in Support Price Level

Option & Region	Support Price Level ($/cwt) 11.60	10.60	9.60	Initial Class I Utilization[a]
1982 System				
1. NE(Northeast)	.90	.97	.95	.431
2. EN(East Northcentral)	.89	.91	.93	.398
3. WN(West Northcentral)	.96	.95	.95	.348
4. SA(South Atlantic)	.88	.91	.92	.653
5. ES(East Southcentral)	.89	.91	.93	.546
6. WS(West Southcentral)	.95	.95	.95	.659
7. MN(Mountains)	.94	.94	.93	.535
8. SW(Southwest)	.98	.98	.98	.436
9. NW(Northwest)	.96	.96	.95	.416
1985 Farm Bill System				
1. NE(Northeast)	.94	.90	.89	.431
2. EN(East Northcentral)	.84	.94	.93	.420
3. WN(West Northcentral)	.91	.95	.95	.392
4. SA(South Atlantic)	.84	.94	.93	.563
5. ES(East Southcentral)	.84	.94	.93	.482
6. WS(West Southcentral)	.91	.95	.95	.551
7. MN(Mountains)	.94	.93	.93	.533
8. SW(Southwest)	.98	.98	.98	.436
9. NW(Northwest)	.96	.96	.95	.416

[a] Calculated from the 1982 simulation results.

Table V .11. Welfare Effects of Changes in Support Prices on Actual Changes in Regional Surpluses under 1982 and 1985 Farm Bill System

Market and Region	Support Price Level ($/cwt)					
	11.60		10.60		9.60	
	1982	1985	1982	1985	1982	1985
(million dollars)						
Grade A Supply						
Northeast	-255.9	-269.6	-266.8	-249.0	-250.1	-236.7
E. Northcentral	-259.0	-248.2	-254.1	-263.8	-243.3	-250.0
W. Northcentral	-136.4	-131.3	-132.8	-133.0	-128.9	-129.2
South Atlantic	-52.1	-49.8	-51.2	-53.1	-49.2	-50.6
E. Southcentral	-32.3	-31.1	-31.1	-32.4	-29.1	-30.0
W. Southcentral	-68.1	-65.6	-64.8	-65.0	-61.4	-61.9
Mountain	-48.1	-48.7	-46.8	-46.8	-44.8	-45.0
Southwest	-134.8	-134.8	-132.2	-132.2	-129.5	-129.5
Northwest	-40.9	-40.9	-39.4	-39.4	-37.9	-37.9
Grade B Supply [a]						
E. Northcentral	-72.9		-68.9		-64.7	
W. Northcentral	-81.9		-79.7		-77.3	
E. Southcentral	-8.6		-7.9		-7.2	
W. Southcentral	-2.0		-1.9		-1.8	
Mountain	-16.2		-15.6		-14.9	
Southwest	-5.7		-5.6		-5.5	
Northwest	-1.3		-1.3		-1.3	
Fluid Demand						
Northeast	112.5	112.3	113.4	113.1	114.3	114.0
E. Northcentral	113.4	113.1	114.2	114.0	115.0	114.8
W. Northcentral	46.0	45.9	46.4	46.3	46.7	46.6
South Atlantic	74.3	73.6	75.1	74.4	76.0	75.3
E. Southcentral	16.2	16.1	16.4	16.3	16.6	16.5
W. Southcentral	56.8	56.3	57.5	57.0	57.9	57.4
Mountain	28.2	28.3	28.5	28.5	28.7	28.6
Southwest	60.7	60.7	61.2	61.2	61.7	61.7
Northwest	18.1	18.1	18.2	18.2	18.3	18.3

[a] Welfare effects on the regional Grade B supply sides are the same under the 1982 and 1985 Farm Bill system since Grade B milk supply price levels are the same.

Table V.12. Welfare Effects of Changes in Support Prices on Proportional Changes (%) in Regional Surpluses under 1982 and 1985 Farm Bill System

Market and Region	Support Price Level ($/cwt)					
	11.60		10.60		9.60	
	1982	1985	1982	1985	1982	1985
Grade A Supply						
Northeast	-9.47	-9.85	-10.94	-10.09	-11.52	-10.66
E. Northcentral	-10.60	-9.97	-11.60	-11.77	-12.56	-12.65
W. Northcentral	-9.36	-8.86	-10.02	-9.84	-10.81	-10.61
South Atlantic	-9.87	-9.28	-10.74	-10.91	-11.56	-11.66
E. Southcentral	-12.03	-11.34	-13.12	-13.33	-14.13	-14.24
W. Southcentral	-10.65	-10.06	-11.29	-11.08	-12.06	-11.87
Mountain	-9.67	-9.72	-10.44	-10.34	-11.15	-11.05
Southwest	-8.83	-8.83	-9.50	-9.51	-10.28	-10.28
Northwest	-9.93	-9.93	-10.62	-10.62	-11.43	-11.43
Grade B Supply[a]						
E. Northcentral	-12.82		-13.90		-15.15	
W. Northcentral	-10.37		-11.26		-12.31	
E. Southcentral	-15.11		-16.36		-18.82	
W. Southcentral	-12.66		-13.77		-15.13	
Mountain	-11.48		-12.49		-13.63	
Southwest	-9.55		-10.37		-11.39	
Northwest	-11.38		-11.93		-13.54	
Fluid Demand						
Northeast	1.55	1.53	1.57	1.51	1.59	1.57
E. Northcentral	1.58	1.53	1.57	1.52	1.60	1.58
W. Northcentral	1.64	1.59	1.64	1.58	1.66	1.64
South Atlantic	2.30	2.22	2.30	2.19	2.37	2.32
E. Southcentral	2.17	2.10	2.17	2.08	2.23	2.20
W. Southcentral	2.17	2.10	2.17	2.08	2.24	2.18
Mountain	1.59	1.55	1.59	1.53	1.61	1.59
Southwest	1.59	1.54	1.59	1.53	1.60	1.59
Northwest	1.73	1.67	1.73	1.65	1.74	1.72

[a] Welfare effects on the regional Grade B supply sides are the same under the 1982 and 1985 Farm Bill system since Grade B milk supply price levels are the same.

Source: Table V-11.

Welfare effects of changes in the support price level on a regional basis are presented in tables V-11 and 12. Grade A milk producers in the Northeast and East Northcentral regions would lose about $250 million per $1.00 per cwt decrease in the support price, while the West Northcentral and Southwest (California) Grade A milk producers would lose about $130 million. Grade A milk producers in other regions would lose less than $70 million per $1.00 per cwt decrease in the support price, while Grade B milk producers in the East Northcentral and West Northcentral regions would lose more than $60 million in each region. Consumers in the Northeast and East Northcentral regions would gain more than $110 million per $1.00 per cwt decrease in the support price, while consumers in the West Northcentral region would gain $46 million. Consumers in the deficit regions, the South Atlantic and West Southcentral. would gain $75 million and $57 million per $1.00 per cwt decrease in the support price, respectively.

Examinning the proportional changes in table V-12, Grade A milk producers in the East Southcentral and East Northcentral regions would suffer more from the loss of producer's surplus as support price declines than producers in other regions. Generally, Grade A milk producers would lose about 9 to 10 percent of their surplus due to each $1.00 per cwt decrease in the support price. Grade A milk producers would lose their surplus relatively more as the support price level drops. Grade B milk producers would generally experience a similar pattern to Grade A milk producers. Consumers in the South Atlantic, West Southcentral, and East Southcentral regions would gain by about 2.2 percent per $1.00 decrease in the support price level. Consumers' surplus in other regions would increase by 1.5 to 1.7 percent.

V.4.3. Effects on the Manufactured Milk Product Markets

In the previous section, the study discussed the market results for Grade A and Grade B milk supply, and fluid demand due to changes in the support price levels. In this section, national manufactured milk product market results due to changes in the purchase price levels are discussed.

V.4.3.1. Market Results

In table V-13, simulated prices, quantities, and consumer surplus are presented under three cases of spliting the $1.00 decrease in the support price level between butter and nonfat dry milk. The first column in the table denoted 12.60 represents the 1982 manufactured market results for comparison purposes. In case of allocating a $1.00 per cwt decrement in the support price to nonfat dry milk only (Option 1), butter price would remain at $1.4390 per pound while nonfat dry milk and cheese prices would drop by $.123 and $.099 per pound as the support price decreses by $1.00 per cwt. Under Option 1, butter demand would increase by 16.2 million pounds per $1.00 per cwt decrease in the support price due to cross price elasticity effects. Nonfat dry milk and cheese demand would increase by 54.8 million pounds and 68.2 million pounds per $1.00 per cwt decrease in the support price, respectively, due to direct and cross price elasticity effects.

In case of allocating a $1.00 per cwt decrement in the support price with fifty percent to butter and nonfat dry milk each (Option 2), butter and nonfat dry milk prices would decrease by $.1116 per pound and $.0615 per pound, repectively, as the support price decreases by $1.00 per cwt. The change in cheese price is the same as in Option 1. Under Option 2, butter and nonfat dry milk demand would increase by 29.1 million and 26.7 million pounds, respectively, per $1.00 per cwt decrease in the support price. Cheese demand would decrease by 98.3 million pounds per $1.00 per cwt decrease in the support price.

In case of allocating a $1.00 per cwt decrement in the support price with sixteen percent to butter and eightyfour percent to nonfat dry milk (Option 3), butter and nonfat dry milk prices would drop by $.0357 per pound and $.1033 per pound, respectively, due to the $1.00 per cwt decrease in the support price. Again, the change in the cheese price is the same as in Option 1 and Option 2. Under Option 3, butter demand would increase by 20.3 million pounds per $1.00 per cwt decrease in the support price while nonfat dry milk demand would increase by 78.5 million pounds.

V.4.3.2. Changes in Demand for Butter, Nonfat Dry Milk, and Cheese Due To a Unit Price Change

Changes in demand for butter, nonfat dry milk, and cheese per unit price decrease under the three options, splitting $1.00 per cwt decrease in the support price between butter and nonfat dry milk by 0 to 100 (Option 1), 50 to 50 (Option 2), and 16 to 84 (Option 3) percent, repsectively, are listed in table V-14. Total changes in demand (total price elasticity effects) for butter, nonfat dry

Table V.13. Simulated National Manufactured Milk Market Results under Three Options of Changing in Split Ratio (between Butter and Nonfat Dry Milk) of a Decrease in the Support Price Level at $11.60, $10.60, and $9.60 per cwt, 1982

Milk Market	Support Price Level ($/cwt)			
	12.60[a]	11.60	10.60	9.60
Option 1[b]				
Butter				
Price($/100 lbs)	143.90	143.90	143.90	143.90
Demand(100 mil lbs)	7.024	7.186	7.347	7.509
Surplus($ mil)	3017.1	3157.5	3301.1	3447.9
Nonfat Dry Milk				
Price($/100 lbs)	90.69	78.39	66.09	53.79
Demand(100 mil lbs)	4.777	5.025	5.572	6.120
Surplus($ mil)	245.9	309.8	380.9	459.4
Cheese				
Price($/100 lbs)	134.65	124.75	114.85	104.95
Demand(100 mil lbs)	20.640	21.332	22.024	22.717
Surplus($ mil)	4185.6	4472.1	4767.2	5071.7
Option 2[c]				
Butter				
Price($/100 lbs)	143.90	132.74	121.58	110.40
Demand(100 mil lbs)	7.024	7.315	7.606	7.897
Surplus($ mil)	3017.1	3272.3	3537.9	3813.8
Nonfat Dry Milk				
Price($/100 lbs)	90.69	84.54	78.39	72.24
Demand(100 mil lbs)	4.477	4.744	5.010	5.276
Surplus($ mil)	245.9	276.1	308.0	341.5
Cheese				
Price($/100 lbs)	134.65	124.75	114.85	104.95
Demand(100 mil lbs)	20.640	21.623	22.606	23.590
Surplus($ mil)	4186.5	4595.0	5022.4	5468.9
Option 1[d]				
Butter				
Price($/100 lbs)	143.90	140.33	136.76	133.19
Demand(100 mil lbs)	7.024	7.227	7.430	7.633
Surplus($ mil)	3017.1	3194.0	3455.4	3562.9
Nonfat Dry Milk				
Price($/100 lbs)	90.69	80.36	70.03	59.69
Demand(100 mil lbs)	4.477	4.935	5.410	5.850
Surplus($ mil)	245.9	298.8	359.1	419.8
Cheese				
Price($/100 lbs)	134.65	124.75	114.85	104.95
Demand(100 mil lbs)	20.640	21.425	22.352	22.996
Surplus($ mil)	4186.5	4511.3	4842.2	5197.1

[a] $12.60/cwt represents the actual 1982 support price level.

[b] Option 1 assumes that a $1.00 per cwt decrease in the support price is fully allocated to a nonfat dry milk price.

[c] Option 2 assumes that a $1.00 per cwt decrease in the support price is equally split between butter and nonfat dry milk prices.

[d] Option 3 assumes that a $1.00 per cwt decrease in the support price is split by 16% for butter and 84% for nonfat dry milk.

milk, and cheese are the sum of changes due to direct and cross price elasticity effects. Direct price elasticity effects are represented by changes in demand due to a change in own price and are identical regardless of the options. Cross price elasticity effects are represented by changes in demand due to changes in other prices under given options. In this study, total elasticity effects were measured as changes in demand per unit change in own price.

Option 3 changes demand for butter most yielding a 568.1 million pound increase per $1.00 per pound decrease in the butter price. More than 85 percent of the increase in the demand for butter is due to cross price elasticity effects. Option 1 has the most effect on change in demand for nonfat dry milk with a 444.8 million pound increase per $1.00 per pound decrease in the powder price. Unlike butter demand, more than 90 percent of the increase in demand for nonfat dry milk is due to direct price elasticity effects. This implies that nonfat dry milk demand would not be seriously affected by changes in prices for butter and cheese. As shown in table V-14, butter demand per unit price change ($1.00 per pound decrease) would increase from 260 million pounds under Option 2 to 570 million pounds under Option 3 while changes in demand for nonfat dry milk varies between 440 million and 430 million pounds under the three options. Changes in demand for cheese would be the largest under Option 2 yielding 994 million pounds of increase per $1.00 per pound decrease in price.

The fact that each option favors a different milk product demand provides economic insight into potential pricing policy in manufactured milk product markets. First, changes in prices for cheese and nonfat dry milk would play a major role in controlling butter demand. Figures shown in table V-14 suggest that a change in butter price may not be effective in terms of changing quantities of butter demanded. Second, a change in the price for nonfat dry milk would be the most effective tool to alter the nonfat dry milk demand level. Third, cheese demand would be affected by a change in its own price as well as by a change in other prices. Therefore various types of policy options could be determined based on these findings depending on which market policy makers would like to focus on.

Table V .14. Changes in Demand for Butter, Nonfat Dry Milk and Cheese per $ 1.00 per pound Decrease Under Three Options

	Option 1[a]	Option 2[b]	Option 3[c]
(million pounds)			
Changes in demand for Butter due to			
Direct price elasticity effect	-	81.5	81.5
Cross price elasticity effect	-	179.0	486.6
Total elasticity effect	-	260.5	568.1
Changes in demand for Nonfat Dry Milk due to			
Direct price elasticity effect	407.5	407.5	407.5
Cross price elasticity effect	37.3	25.2	35.0
Total elasticity effect	444.8	432.7	442.5
Changes in demand for Cheese due to			
Direct price elasticity effect	508.8	508.8	508.8
Cross price elasticity effect	190.8	484.9	284.9
Total elasticity effect	699.6	993.7	793.7

Note: Changes in demand are calculated based on the direct and cross price elasticities reported in table C-3.

a Option 1 assumes that a $1.00 per cwt decrease in the support price is fully allocated to a nonfat dry milk price.

b Option 2 assumes that a $1.00 per cwt decrease in the support price is equally split between butter and nonfat dry milk.

c Option 3 assumes that a $1.00 per cwt decrease in the support price is split by 16% for butter and 84% for nonfat dry milk.

Source: Table V-13.

V.4.3.3. Consumer Surplus

Changes in consumer surplus in butter, nonfat dry milk, and cheese markets under three options are presented in table V-15. It was assumed that each market is cleared at given purchase prices. When markets are in excess demand situations, government will sell stocks to meet the demand. Butter consumers would gain the most under Option 2, by $255 million at $11.60 per cwt, $266 million at $10.60 per cwt, and $276 million at $9.60 per cwt. Nonfat dry milk consumers would gain the most under Option 1, by $64 million at 11.60 per cwt, $71 million at 10.60 per cwt, and $79 million at $9.60 per cwt. Option 2 would favor the cheese consumer the most yielding a $409 million increase at $11.60 per cwt, $427 million at $10.60 per cwt, and $447 million at $9.60 per cwt. The overall consumer's gain in manufactured milk product markets would be the most under Option 2. Consumers would gain $980 million, $1021 million, and $1060 million at $11.60, $10.60, and $9.60 of support price levels, respectively. Option 3 would result in the second most consumers' gain.

On a proportional basis, nonfat dry milk consumers would gain more than 20 percent at each support price level under Option 1 while they would gain less than 13 percent under Option 2. Butter consumers would gain about 8 percent under Option 2 while gaining about 4.5 percent under Option 1. Cheese consumers would gain about 9 percent under Option 2 and 6.5 percent under Option 1. Net manufactured milk consumer's surplus gain would be 7.3 to 7.8 percent under Option 2, 6.2 to 6.7 percent under Option 3, and 5.9 to 6.2 percent under Option 1, respectively. The overall absolute changes in manufactured milk consumer's surplus would slightly increase as the support price drops, while, on the contrary, the overall proportional changes in manufactured milk consumers' surplus would slightly decrease.

V.4.3.4. CCC Purchases of Butter, Nonfat Dry milk, and Cheese

In this section, simulated CCC purchases of butter, nonfat dry milk, and cheese under the various options are discussed. CCC expenditures based on CCC purchases are discussed after that. In table V-16, comparisons of CCC purchases and CCC expenditures in the manufactured milk

Table V.15. Effects of Changes in Support and Purchase Prices on Manufactured Milk Product Consumers' Surplus

Milk Market	Support Price Level ($/cwt) 11.60	10.60	9.60
(million dollars)			
Butter			
Option 1 [a]	140.4 (4.45)	143.6 (4.55)	146.8 (4.45)
Option 2 [b]	255.2 (8.46)	265.6 (8.12)	275.9 (7.80)
Option 3 [c]	176.9 (5.86)	181.9 (5.70)	187.0 (5.53)
Nonfat Dry Milk			
Option 1	63.9 (26.00)	71.1 (23.00)	78.5 (20.60)
Option 2	30.2 (12.30)	31.9 (11.55)	33.5 (10.88)
Option 3	52.9 (21.50)	60.3 (20.18)	60.7 (16.90)
Cheese			
Option 1	285.6 (6.82)	295.1 (6.60)	304.5 (6.39)
Option 2	408.5 (9.76)	427.4 (9.30)	446.5 (8.89)
Option 3	324.8 (7.76)	336.9 (7.47)	348.9 (7.20)
Changes in total manufactured milk product consumers' surplus [d]			
Option 1	777.8 (6.21)	805.7 (6.05)	833.7 (5.91)
Option 2	981.8 (7.83)	1020.8 (7.55)	1059.8 (7.29)
Option 3	842.5 (6.72)	872.6 (65.2)	902.9 (6.15)

Note: Figures in parentheses are proportional changes (percentage).

[a] Option 1 assumes that a $1.00 per cwt decrease in the support price is fully allocated to a nonfat dry milk price.

[b] Option 2 assumes that a $1.00 per cwt decrease in the support price is equally split between butter and nonfat dry milk.

[c] Option 3 assumes that a $1.00 per cwt decrease in the support price is split by 16% for butter and 84% for nonfat dry milk.

[d] Includes consumers' surplus of other milk products.

Source: Table V-13.

Table V.16. CCC Purchases and Expenditures under Three Options, 1982 and 1985 Farm Bill System

CCC purchases and expenditures by split option	12.60	11.60 System 1982	11.60 System 1985	10.60 System 1982	10.60 System 1985	9.60 System 1982	9.60 System 1985
CCC Purchases		-- hundred million pounds --					
Butter	3.820						
Option 1 [a]		-0.099	0.258	-3.050	-2.674	-6.073	-5.674
Option 2 [b]		-0.228	0.128	-2.216	-2.933	-5.369	-6.062
Option 3 [c]		-0.140	0.216	-3.220	-2.757	-6.198	-5.798
Nonfat Dry Milk	9.481						
Option 1		4.230	4.676	0.192	0.662	-3.936	-3.437
Option 2		4.511	4.958	2.212	1.224	-1.727	-2.594
Option 3		4.320	4.767	0.354	0.842	-3.668	-3.168
Cheese	6.425						
Option 1		7.972	7.972	7.280	7.280	6.587	6.587
Option 2		7.681	7.681	6.698	6.698	5.714	5.714
Option 3		7.879	7.879	6.953	7.093	6.308	6.308
CCC Expenditures		--- million dollars ---					
Butter	549.7						
Option 1		-	37.1	-	-	-	-
Option 2		-	17.0	-	-	-	-
Option 3		-	30.4	-	-	-	-
Nonfat Dry Milk	859.8						
Option 1		331.6	366.6	12.7	43.7	-	-
Option 2		381.4	419.1	166.3	95.9	-	-
Option 3		347.1	383.0	24.8	58.9	-	-
Cheese	825.5						
Option 1		994.5	994.5	836.1	836.1	691.3	691.3
Option 2		950.2	950.2	769.2	769.2	599.7	599.7
Option 3		982.9	982.9	798.5	814.7	662.0	662.0
Total CCC Exp.	2235.0						
Option 1		1326.1	1398.2	848.8	879.8	691.3	691.3
Option 2		1339.6	1379.0	935.5	865.1	599.7	599.7
Option 3		1330.1	1396.3	823.3	720.9	662.0	662.0

Support Price Level ($ / cwt)

[a] Option 1 assumes that a $1.00 per cwt decrease in the support price is fully allocated to a nonfat dry milk price.

[b] Option 2 assumes that a $1.00 per cwt decrease in the support price is equally split between butter and nonfat dry milk.

[c] Option 3 assumes that a $1.00 per cwt decrease in the support price is split by 16% for butter and 84% for nonfat dry milk.

market under three options at each support price level: $12.60, $11.60, $10.60, and $9.60 per cwt respectively, are presented.

As shown in table V-16, the butter market would be at an equilibrium when the support price level is near $11.60 per cwt. Under the 1982 federal marketing order system, Option 1 at $11.60 per cwt would result in the smallest CCC selling stocks of butter, 9.9 million pounds. Under the 1985 Farm Bill system, Option 2 at $11.60 per cwt would yield the lowest CCC purchase, 12.8 million pounds. Nonfat dry milk would be at an equilibrium when the support price is between $10.60 and $9.60 per cwt. The CCC purchase of cheese would decrease as the support price drops but the market would still be in a surplus situation.

The comparison of the results of CCC purchases under various options has implications about purchase pricing policy in the manufactured milk markets. Considering that the butter market is highly affected by changes in other prices, especially cheese price, changes in cheese and butter prices should be considered together even if policy focuses on the butter market. Since nonfat dry milk is mostly affected by its own price, a change in nonfat dry milk price alone could be a major tool for altering the nonfat dry milk market. Considering that a change in butter price affects the cheese demand to some extent, a combination of changes in cheese and butter prices could be used as a policy tool for the cheese market. A substantial amount of CCC expenditures would be saved in butter and nonfat dry milk markets when the support price level drops from $12.60 per cwt to $11.60 per cwt under the various options. More than $500 million would be saved in the butter market and more than $400, in the nonfat dry milk market under the 1982 and the 1985 Farm Bill system of the federal marketing order. About an additional $300 million would be saved in the nonfat dry milk market when the support price level drops further to $10.60.[53]

[53] In this analysis, CCC revenues incurred from selling stocks were not discussed since one of major concerns in the U.S. dairy has been increasing trend of government expenditures.

V.5. Increases in Import Quotas

V.5.1. Policy Option

In the previous section, a stepwise reduction of the support price level was assumed. It was also assumed that purchase prices for butter, nonfat dry milk, and cheese are decreased or held constant as to compare previous levels, and, thus, accrue identical net return to cheese and butter-powder plants. It was further assumed that the market price for the raw milk in manufactured use is equivalent to net returns to cheese and butter-powder plants.

In this section, a simultaneous market clearing situation regardless of above mentioned assumptions in butter and nonfat dry milk markets under the 1982 system (federal programs and import quotas) was simulated. This implied "zero levels" of CCC purchases of butter and nonfat dry milk under a two-price system in the manufactured milk market. Then a simultaneous market clearing situation in butter and nonfat dry milk markets under the assumption that import quotas are increased by 10 percent of the 1982 commercial demand for butter, nonfat dry milk, and cheese (see table V-17) was simulated.

V.5.2. Market Clearing in Butter and Nonfat Dry Milk Markets With No Government Purchases

V.5.2.1. 1982 System With 1982 Quota

Results of a simulated market clearing situation in butter and nonfat dry milk markets under the 1982 system are compared to the actual 1982 market results in table V-18. Market clearing prices for butter and nonfat dry milk would be $2.6060 per pound and $0.0467 per pound, respectively.[54] The market clearing prices for butter and nonfat dry milk would result in $10.83 per cwt of net return to butter-powder plants while cheese price ($1.174 per pound) would yield $10.86 per cwt of net return to cheese plants. An average raw milk price for manufactured use was

[54] The cross price elasticity effects are not included in this analysis. Since the optimal average raw milk price and manufactured milk product prices are now determined by iterative procedures, accurate measure of the cross price elasticity effects is difficult to obtain.

Table V.17 Imports of Butter, Nonfat Dry Milk, and Cheese in 1982 and Increasing Import Quota Option[a]

Item	1982	Increasing Quota	Change
(million pounds)			
Butter	3.0	70.24	+ 67.24
Nonfat Dry Milk	2.0	44.77	+ 42.77
Cheese	18.0	206.40	+188.40

[a] In this option, import quotas are increased by 10 percent of the 1982 current commercial demands for butter, nonfat dry milk, and cheese.

Source: Table C-15.

calculated based on the equation (III-24), resulting in $10.85 per cwt. Readers should note that raw milk in manufactured use would be sold to cheese plants first until plants are operating at their full capacity due to a difference between net returns to cheese plants and to butter-powder plants. It was assumed that the total capacity of cheese plants was 2,752 million pounds.[55]

Under a simultaneous market clearing situation in butter and nonfat dry milk markets, commercial demand for butter would decrease from 702.4 million pounds to 607.0 million pounds while commercial demand for nonfat dry milk would increase from 447.7 million pounds to 798.4 million pounds as compared to the actual 1982 market results. Commercial demand for cheese would increase from 2,064.0 million pounds to 2,151.7 million pounds while the government purchase for cheese would decrease from 642.5 million pounds to 525.3 million pounds. Butter production would decrease from 1,119.4 million pounds to 642.0 million pounds and nonfat dry milk production would decrease from 1,401.0 pounds to 803.6 million pounds.

Butter consumers would lose about $770 million while nonfat dry milk consumers would gain about $536 million. Overall consumer's surplus in the manufactured milk markets would gain about $638 million. About $1,618 million of direct program (the price support) cost would be saved.

V.5.2.2. 1982 System With Increased Import Quotas

A comparison of market clearing situations under the 1982 quota system and an incaresing import quota system is also drawn in table V-18. Under an increased import quota, imports of butter, nonfat dry milk, and cheese would increase by 67.4 million, 42.77 million, and 188.40 million pounds, respectively. The increase in import quotas by 10 percent of the 1982 commercial demand for butter, nonfat dry milk, and cheese caused market clearing price for butter to drop by $0.1634 per pound and market clearing price for nonfat dry milk to increase by $0.0604 per pound. Cheese price would drop by $0.0181 per pound. Raw milk price would drop by $0.19 per cwt.

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[55] As indicated in Appendix C, an estimated maximum capacity of cheese plants in 1982 was 3,005.4 million pounds. The author found that the market clearing prices for butter and nonfat dry milk would not be obtained if cheese plants are operating at the full capacity of 3,005.4 million pounds. 2,752 million pounds represented the actual total production of cheese in 1982.

Table V.18 **Comparison of the Actual 1982 Market Results and Market Clearing Situations in Butter and Nonfat Dry Milk Markets**, with No Government Purchases in These Markets

Item	Actual Market Results			Market Clearing Situation (1982)			Market Clearing Situation (Increasing Quota)[a]		
	Butter	Nonfat Dry Milk	Cheese	Butter	Nonfat Dry Milk	Cheese	Butter	Nonfat Dry Milk	Cheese
Price ($/100 lbs)[b]	143.90	90.69	134.65	260.60	4.67	117.40	244.26	10.71	115.59
Demand (mil lbs)	1084.4	1395.8	2677.3	607.0	798.4	2677.0	620.3	773.7	2865.4
Commercial	702.4	447.7	2034.8	607.0	798.4	2151.7	620.3	773.7	2160.9
CCC Purchase	382.0	948.1	642.5	-	-	525.3	-	-	704.5
Ending Stock	467.0	897.2	982.0	467.0	897.2	982.0	467.0	897.2	982.0
Total Demad	1551.4	2293.0	3659.3	1074.0	1695.6	3659.0	1087.3	1670.9	3847.4
Production	1119.4	1401.0	2752.3	642.0	803.6	2752.0	588.1	736.1	2752.0
Import	3.0	2.0	18.0	3.0	2.0	18.0	70.2	44.8	206.4
Beginning Stock	429.0	890.0	889.0	429.0	890.0	889.0	429.0	890.0	889.0
Total Supply	1551.4	2293.0	3659.3	1074.0	1695.6	3659.0	1087.3	1670.9	3847.4

a Based on the assumption that import quotas are increased by 10% of the 1982 commercial demands.

b Raw milk prices in manufactured use in the 1982 case and market clearing situation cases are $12.60, $10.85, and $10.66 per cwt, respectively. The latter two prices are calculated as weighted averages based on the equation (III-24) in Chapter III.

Sources: Tables V-18 and C-15.

Due to the changes in manufactured milk product prices, commercial butter demand would increase by 13.3 million pounds while nonfat dry milk demand would decrease by 24.7 million pounds. Commercial demand for cheese would increase by 9.2 million pounds and government purchases would increase by 179.2 million pounds. Due to a lower raw milk price, butter and nonfat dry milk production would drop by 54 million pounds and 68 million pounds, respectively. This is equivalent to a 1.2 billion pound decrease in raw milk in manufactured use.

V.6. Aggregate Consumers and Producers' Surplus

Aggregated consumers' and producers' surplus under various options is summarized in table V-19. The government intervened in markets by purchasing excess milk products or selling its stocks in order to clear markets at given purchase price levels under both the 1982 and 1985 Farm Bill systems. In the case of market clearing without government purchases of butter and nonfat dry milk under the 1982 system and with increasing import quota, the government only purchased cheese in order to clear the market.

In all cases, aggregate consumers and producers' surpluses increase as raw milk (support) price in manufactured use declines from $12.60 per cwt to $9.60 per cwt. At a $12.60 per cwt support price level, aggregate surpluses were $55.037 billion with the 1982 system and $54.980 with the 1985 Farm Bill system. Aggregate surpluses would be the largest when the support price level is $9.60 per cwt under Option 2 in both 1982 and 1985 systems, yielding $56.136 billion and $56.082 billion, respectively. While the largest surplus occurs at the support price of $9.60 per cwt, substantial differences among support price levels and options were not observed.

V.7. Summary

Policy options were selected in terms of changing the support/purchase price levels and import quotas under existing federal regulatory programs. Changes in support/purchase price levels

Table V.19. Aggregate Consumers and Producers' Surpluses under Policy Options[a]

Options	Support Price Level ($/cwt) 11.60	10.60	9.60
	------ billion dollars -----		
1982 System			
Option 1	55.133	55.269	55.493
Option 2	55.337	55.688	56.136
Option 3	55.197	55.543	55.691
1985 Farm Bill System			
Option 1	55.073	55.213	55.436
Option 2	55.277	55.632	56.082
Option 3	55.138	55.345	55.637
Market Clearing without Government Purchases of Butter and Nonfat Dry Milk[b]			
1982 ($10.85/cwt)		54.463	
Increasing Quotas ($10.66/cwt)		54.493	

[a] It is assumed that markets are cleared by government intervention (purchase or selling) where markets experience excess demand or supply.

[b] Market clearing in Butter and nonfat dry milk markets only; the government clears market through purchasing the surface.

[c] Actual surpluses in 1982 were $55.037 billion at $12.60 per cwt.

on the dairy market are more effective than changes in Class I differentials in several ways. First, changes in the support price level would cause a relatively uniform change in the Grade A milk supply prices throughout the nation. The average change in Grade A milk supply prices per unit change in the support price would vary from $0.88 per cwt to $0.98 per cwt. Second, decreases in the support/purchase price levels would increase demand for manufactured milk products, decrease supply of raw milk in manufactured use, and, hence, decrease government purchases of butter, nonfat dry milk, and cheese. This yields a decrease in government expenditures. Finally, changes in purchase prices would affect changes in demands for butter, nonfat dry milk, and cheese through direct and cross price elasticity effects.

The results of the simulations suggest that a $1.00 per cwt decrease in the support price level would decrease raw milk in manufactured use by about four billion pounds. A decrease in the raw milk supply and an increase in demand for manufactured milk products would result in a decrease in government purchases. According to the results of the simulations, the butter market would be at an equilibrium when the support price is near $11.60 per cwt. The nonfat dry milk would be at an equilibrium when the support price is somewhere between $10.60 and $9.60 per cwt, while the cheese market would remain in a surplus situation even when the support price drops to $9.60 per cwt.

Given that nonfat dry milk demand is not seriously affected by other prices, policy options directed at the nonfat dry milk price would influence that market more directly. The results of the simulations suggest that the nonfat dry milk market would be at an equilibrium if the nonfat dry milk price is slightly lower than $0.6609 per pound while holding butter and cheese prices at $1.4390 and $1.3465 per pound, respectively.

Changes in the support price level by $1.00 per cwt would decrease Grade A and Grade B milk producer's surplus by about $1 billion and $180 million, respectively, while increasing fluid consumer's surplus by about $530 million. Changes in consumer's surplus in butter, nonfat dry milk, and cheese markets would vary depending on the purchase price levels due to cross price elasticity effects. Cheese and butter consumers would gain more when a split ratio of the decrease in the support price to butter, between butter and nonfat dry milk, gets larger. This would yield greater net consumer's surplus in the manufactured milk market.

Finally, results for simultaneous market clearing situations in butter and nonfat dry milk markets with no government purchases of these products under the 1982 import quota and an increasing import quota system suggest that the current purchase price for butter is about one half of the market clearing price. The results also suggest that the current purchase price for nonfat dry milk is too high as compared to the market clearing price. Increases in import quotas of butter and cheese by 10 percent of the 1982 commercial demand would drop market clearing prices for butter and cheese by $0.1634 and $0.0181 per pound, respectively. An increase in the import quota of nonfat dry milk would increase the market clearing price by $0.0604 per pound. This would decrease the raw milk price by $0.19 per cwt and result in a 1.2 billion pound decrease in raw milk used in manufacturing.

CHAPTER VI

SUMMARY AND CONCLUSION

VI.1. Summary

Compared to the 1930's, the current U.S. dairy industry faces an improved market environment fostered by government programs, efficient communication and transportation systems, and improved biotechnology. Some dairy eoconomists such as Kessel, and Knutson have stated that today's dairy industry would not experience market instability which existed prior to the 1930s if the dairy industry was in a perfectly competitive environment. Nonetheless government price stabilizing regulations continue to be imposed on the dairy industry influencing the rational dairy producer's production decisions. This study reviewed theoretical explanations and empirical investigations of the effects of the federal government regulatory programs and a consequent trend towards overproduction of the dairy industry.

In order to simulate interregional dairy trade under various policy options, this study applied a separable programming technique to a nonlinear mathematical model of the industry developed under a spatial equilibrium framework. The model extended earlier work by disaggregating the manufactured milk market into butter, nonfat dry milk, and cheese markets and by reestablishing institutional constraints as necessitated by the disaggregation of the manufactured milk market in order to maintain an enforcement of the blend price alignment. The model was also utilized to draw a comparison of market results and welfare effects between the competitive and regulated markets.

Utilizing disaggregated manufactured milk product demand functions for butter, nonfat dry milk, and cheese, the direct and cross price elasticity effects of the changes in product prices were estimated and incorporated in an interregional dairy trade model. In this way, this study was able to look into each manufactured milk product market with more accuracy while relating these manufactured milk product markets to the raw milk supply in manufactured use.

Under a spatial equilibrium framework, the U.S. dairy industry was divided into nine regions. It was assumed that the fluid milk demand and the Grade A and Grade B milk supply exist on a regional basis. It wasaalso assumed that, under the federal marketing order system, only Grade A milk for fluid purposes may be shipped from one region to another based on the blend prices and transportation costs between the two regions. Since Grade A milk producers are actually paid the blend price under the federal marekting order system, shipments could occur when the difference between the blend price is greater than the transportation cost between two regions under the assumption that there are no trade barriers. It was also assumed that transportation costs of the manufactured milk products within a region can be ignored. The manufactured milk product markets were aggregated at the national level.

Due to the perishability of the raw milk, excess supply of raw milk in the industry was purchased by the government in the form of butter, nonfat dry milk, and cheese as was the case under existing regulatory programs. Fluid milk demand was affected by the Class I price set by the local market order while Grade A milk supply was affected by the blend price determined by the local pooling scheme. Due to higher levels of the Class I minimum prices than blend prices, Class II milk, which was Grade A milk supplies less fluid milk demand, was transferred to the manufactured milk sector and consumed as butter, nonfat dry milk, and cheese. The private demand for butter, nonfat dry milk, and cheese was affected by the purchase prices set by the government. The supply of Grade B and Class II milk was affected by the support price which was calculated based on the purchase prices for butter, nonfat dry milk, and cheese.

It was noted that a high level of the support price or purchase prices would result in an increased surplus situation in the industry by signaling high supply and demand prices. Nonetheless, the support price has been maintanined at a high level by the government with the help of a quota system. Due to the quota system, the U.S. support price level has been kept as high as about two times the world competitive price. Therefore free trade could drastically increase the governmental cost of supporting prices for U.S. dairy products at current levels.

The economic effects of the government regulatory programs were looked into by measuring the market results and welfare effects of changes in policy instruments, the support/purchase prices, and import quotas. The effects of changes in the support/purchase prices were quite different from the effects of changes in the Class I differentials. A change in the Class I differential in a particular region may have an impact on the region only. However, a change in the blend price due to a change in the Class I differential in the region may result in changes in the blend prices in other regions through changes in shipments among regions. Generally only local fluid milk demand and Grade A milk supply were affected by a change in the Class I differential. If Class I differentials among several regions were changed together, the effects on the Grade A milk supply may be inter and multiregional. The fluid demand in the region, however, was not influenced by changes in the Class I differentials in other regions. Due to different price elasticities of fluid milk demand and Grade A milk supply, Class I utilization, and transportation costs among regions, the effects of changes in the Class I differentials on the change in Grade A milk supply price would vary by region. Since the effects of changes in the Class I differentials were on a regional basis, the federal marketing order program can be utilized effectively to alter the market results in a specific region.

The Class II minimum price set by the federal marketing order is generally close to the support price level. Since all the Class II minimum prices are closely related to the support price, a change in the support price level affects the fluid and Grade A milk markets throughout the nation. A change in the support price level also affects the manufactured milk and Grade B milk markets throughout the nation. Therefore the effect of a change in the support price level is nation-wide and greater than the effect of a change in the Class I differential in terms of changes in the Grade A milk supply prices. The effect of a change in the support price on the changes in the Grade A milk supply prices varies based on the price elasticities of the Grade A milk supply curves and shapes of the effective demand curve of Grade A milk for fluid purposes.

By supporting market prices for butter, nonfat dry milk, and cheese and by imposing a quota restriction on the import of such dairy products into the domestic markets, the government ensures that raw milk producers obtain the target (support) price for milk delivered to milk processing plants. Different levels of the purchase prices for butter, nonfat dry milk, and cheese would imply a case in which the net return to cheese plants is not equivalent to the net return to butter-powder plants. In this case, the raw milk producers will likely be paid based on a two-price system and the raw milk will be shipped to the plants where a higher net return prevails until the plants are operating at their full capacity.

Because of the two price system in the manufactured milk market, there may be no single manufactured milk price. One possible case, however, is that manufactured milk price could be calculated as a weighted average depending on net returns of cheese and butter-powder plants, and the proportions of the raw milk distributed to cheese and butter-powder plants, respectively. Under this scenario once the federal order sets the Class II minimum price based on the manufactured milk price calculated as a weighted average, the Class I and Class II milk supply will be determined based on the blend and fluid prices, and the Grade B milk supply will be determined based on the manufactured milk price.

Policy options with respect to changes in the support and purchase prices were based on a stepwise reduction of the support price level from $12.60 per cwt to $9.60 per cwt in $1.00 per cwt decrements. The effects of changes in the purchase prices on the market results and welfare changes were measured under the 1982 system and the dairy provisions of the 1985 Farm Bill system in terms of the federal marketing order system. Due to the complexity of the calculation of a weighted average price for manufactured milk, it was assumed that the support price for the raw milk delivered to milk processing plants was equal to the net returns to both cheese and butter-powder plants.

Three approaches were taken in terms of splitting a decrease in the support price between butter and nonfat dry milk. The first two approaches represented two extreme cases of a zero split to butter price and an equal split between butter and nonfat dry milk. The third one represented the actual 1985 situation with splitting a $1.00 decrease per cwt as 16 percent to butter and 84 percent to nonfat dry milk. Changes in the private demand for manufactured milk products due to changes in the purchase prices were measured by the direct and cross price elasticity effects.

Either under the 1982 system or the 1985 system of the federal marketing order, Grade A and Grade B milk producers would lose about $1 billion and $0.2 billion, respectively, due to $1.00 per cwt decrease in the support price level. Fluid demand consumers would gain about $0.7 billion. Butter and cheese consumers would gain the most, $.26 billion and $.43 billion respectively, under the option of an equal split between butter and nonfat dry milk. They would gain the least, $.14 billion and $.29 billion respectively, under the option of a zero split to buter. Nonfat dry milk consumers would benefit the most, $.07 billion, under the option of a zero split to butter and the least, $.03 billion, under the option of an equal split.

On a regional basis, Grade A milk producers in the Northeast, East Northcentral, West Northcentral, and Southwest regions would suffer the most in actual terms due to a decrease in the support price. The Northeast and West Northcentral Grade B milk producers would suffer the most in actual terms. Fluid consumers in the Northeast, East Northcentral, and South Atlantic regions would gain the most in actual terms. In proportional terms, Grade A milk producers in the East Northcentral, East Southcentral, and West Southcentral regions, and Grade B milk producers in the East Southcentral and West Southcentral regions would suffer the most. Fluid consumers in the deficit regions, the South Atlantic, East Southcentral, and West Southcentral regions would gain the most.

Changes in demand for dairy products were measured in terms of direct and cross price elasticity effects. Demand for butter was affected the most by changes in other prices. A change in demand for butter due to the cross price elasticity effect would be 17.9 million pounds per $0.10 per pound change in butter price when prices for nonfat dry milk and cheese were decreased by $.0615 per pound and $.099 per pound, respectively, under an equal split option. It would be 48.7 million pounds per $.10 per pound change in butter price when prices for nonfat dry milk and cheese were decreased by $.1033 per pound and $.099 per pound, respectively, under an option of 16 percent split to butter. A change in demand for butter due to the direct price elasticity effect would be 8.15 million pounds per $0.10 per pound change in butter price.

Demand for cheese was affected by the cheese price and other prices. A change in demand for cheese due to the direct price elasticity effect would be 50.9 million pounds per $0.10 per pound change in cheese price. A change in demand for cheese due to the cross price elasticity effect would be the most at 48.5 million pounds per $.10 per pound change in cheese price when prices for butter and nonfat dry milk were decreased by $.1116 per pound and $.0615 per pound, respectively, under an equal split option. It would be the least at 19.1 million pounds per $.10 per pound change in cheese price when butter price remained at $1.4390 per pound and only nonfat dry milk price was decreased by $.123 per pound under an option of a zero split to butter. Demand for nonfat dry milk was affected mostly by own price. Overall, demand for nonfat dry milk would increase by 40.8 million pounds per $.10 per pound change due to the direct price elasticity effect and increase by 3.7 million pounds per $.10 per pound change due to the cross price elasticity effect.

Under the option of a zero split to butter price, the butter market would be close to a market clearing situation when the support price level drops to $11.60 per cwt, while the butter price remains at $1.4390 per pound, than under any other option due to the significant cross price elasticity effects on the butter demand. At a $11.60 per cwt support price level, the nonfat dry milk and cheese prices would be $.7839 and $1.2475 per pound, respectively. Similarly, the nonfat dry milk market would be closer to a market clearing situation under the zero split option than under any other option when the support price level drops to $10.60 per cwt while the nonfat dry milk price drops to $.6609 per pound. At a $10.60 per cwt support price level, butter and cheese prices would be $1.4390 and $1.1485 per pound, respectively. Due to a lower cheese processing cost, the cheese market would be in an excess supply situation even when the support price level drops to $9.60 per cwt regardless of options of splitting a $1.00 decrease per cwt of support price.

A market clearing situation in butter and nonfat dry milk markets, that is when there is no government purchases of these two commodities, suggests that butter price should be raised and nonfat dry milk price should be dropped. If the import quota is increased by 10 percent of the 1982 commercial demand for butter, nonfat dry milk, and cheese, the market clearing price for butter would drop while the market clearing price for nonfat dry milk would increase. About $.19 per cwt decrease in raw milk price is expected under an increasing import quota system as compare to the 1982 system. This would result in a 1.2 billion pound decrease in raw milk supply for butter-powder purposes. This is equivalent to a 54 million pound decrease in butter production and a 68 million pound decrease in nonfat dry milk production.

Net consumers and producers' surpluses were greater when the support price level was lower. Consumers as a whole would be better off if butter price drops more than nonfat dry milk price does, in milk equivalent terms.

VI.2. Conclusions

Surplus problems in the U.S. dairy industry have been developing since the beginning of the 1980s and have recently lead to calls for political action to resolve them. Whether the dairy producers receive appropriate market prices generating appropriate incomes or not seems to be of little importance. Nevertheless, today's dairy industry is surrounded by an improved market atmosphere due to a highly developed infrastructure and technology. The competitive dairy market structure may not be far off the realistically plausible market structure in the near future. The competitive market solution may, at least, provide a goal for policy makers to aim at as they attempt to resolve the chronic surplus problem in the dairy industry.

Policy options incorporating changes in pricing parameters available under the current government dairy programs and import quotas may be effectively used to influence the dairy industry to move toward the market clearing equilibrium. The effects of these policy options on market results and welfare effects vary on a regional basis. The options also have different impacts on the participants in the dairy industry.

A change in the support price level affects Class I, Class II minimum prices, and blend prices. This study has shown that a $1.00 per cwt decrease in the support price level would decrease raw milk in manufactured use by more than 4 billion pounds. This implies that, based on the 1982 marketing situation, the supply of the raw milk in manufactured use would be decreased by 13.41 billion pounds when the support price level is reduced to $9.60 per cwt from $12.60 per cwt.[56]

Since the CCC purchases and import quota restrictions are applied to the manufactured milk product forms of butter, nonfat dry milk, and cheese, the market clearing price for the raw milk delivered to the manufacturing processing plants should be directly linked to the product prices. In general, the market price for the raw milk in manufactured use is derived from the product price less the processing cost, converted to milk equivalent terms. Hence the market price for the raw milk represents the net return to the processing plants of dairy products.

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[56] During the 1982-1983 marketing year the net removal of the CCC was 14.3 billion pounds in milk equivalents (see table II-1).

Since butter and nonfat dry milk are jointly produced, the market price for the raw milk delivered to butter-powder plants is derived as the sum of the butter price and nonfat dry milk price less the processing cost, converted to milk equivalent terms. This allows room for various combinations of purchase prices for butter and nonfat dry milk which may be selected as target prices for the products under the CCC purchase program. Due to direct and cross price elasticity effects among butter, nonfat dry milk, and cheese, different combinations of purchase prices for these dairy products could result in a wide range of demand effects among these products.

The relationship among the support price for the raw milk in manufactured use and the purchase prices for the dairy products conveys several important economic implications about the manufactured milk market. The CCC stands ready to buy excess dairy products at the purchase price levels, which are the marketing allowances plus the support prices. Given that the government provides a guaranteed floor price, processors with lower average processing costs than the marketing allowances would increase demand for the raw milk until the plants are operating at full capacity. Therefore the raw milk would be shipped first to the plants with a greater gap between the marketing allowances and the average processing costs. The rest of the raw milk would then be shipped to the other plants. This study has shown that the gaps between the marketing allowances and the average processing costs of the sampled plants for cheese and butter-powder were \$.2405 and \$.1238 per cwt, respectively. Assuming average costs of the sampled plants represented the actual average processing costs and the purchase prices for butter, nonfat dry milk, and cheese yielded the identical net returns to cheese and butter-powder plants, the cheese plants would operate at full capacity when the support price declines. This situation would not change as long as the changes in the purchase prices result in the identical net returns to cheese and butter-powder plants.

A two-price system for raw milk in manufactured use is likely to prevail once the purchase prices would no longer yield the identical net returns to cheese and butter-powder plants. In the two-price system, manufactured milk price may be calculated as a weighted average in order to determine the national average manufactured milk price and Class II minimum price. Utilizing purchase price levels and proportions of the raw milk delivered to cheese plants and butter-powder plants, an iterative procedure may be required to derive an optimal manufactured milk price.

Several policy implications can be drawn based on the results of the analysis in this study. First, the study estimated that a competitive market equilibrium price in 1982 for raw milk in manufactured use would be about $11.50 per cwt in milk equivalent terms with existing import quotas in place. This implies that the 1982 dairy industry under existing federal dairy programs would approximately be in market clearing situation when the government reduces the support price to about $10.00 per cwt. This study suggests that the government decrease the support price of raw milk in manufactured use to somewhere between $10.60 per cwt and $9.60 per cwt from $12.60 per cwt as established in dairy provisions of the 1985 Farm Bill in order to lead the dairy industry to a market clearing situation.

Second, considering various direct and cross price elasticity effects among manufactured milk products: butter, nonfat dry milk, and cheese, the study suggests that a larger proportion of the decrease in the support price of raw milk in manufactured use be allocated to nonfat dry milk than to butter in order to reduce the government's purchase of nonfat dry milk relatively more than government's purchases of other manufactured milk products. This suggestion is roughly consistent with results from the market clearing simulation in butter and nonfat dry milk markets, which indicated 1982 nonfat dry milk price ($.9069 per pound) was substantially higher than the simultaneous market clearing price for nonfat dry milk ($.0467 per pound) in 1982. Third, if the U.S. dairy industry did away the dairy price support program, the government still can decrease milk price by relaxing import quotas of manufactured milk products. As discussed in the previous section, an increase of import quotas by 10 percent of the 1982 commercial demand would decrease milk price in manufactured use by $.19 per cwt. This would reduce butter production by 54 million pounds and nonfat dry milk production by 68 million pounds.

These policy implications, however, should be evaluated with care. Aggregate consumers and producers' surpluses do ntt differ substantially among policy options. Under existing federal dairy programs, it is likely that to resolving the over-protection problem of nonfat dry milk would lead to a lower social welfare level (in terms of producers' and consumers' surpluses) in the dairy industry.

Being an annual model, fixed beginning and ending stocks were assumed. Government selling would occur and increase in butter and nonfat dry milk markets as the support price declines in order to clear markets at announced purchase price levels. In the short-run, announced purchase price levels may be maintained. In the long-run, however, market prices would tend to move up, in an excess demand situation, as government stocks decrease unless the industry opens up markets to foreign imports. Therefore market prices will tend to be more reluctant to move down as lower purchase prices are applied. Through a dynamic adjustment process, markets would eventually be at new equilibria at higher market prices than announced purchase prices.

VI.3. Limitations

There are several limitations to this study. It incorporated manufactured dairy product markets at the national level assuming that the transportaion costs of these dairy products were zero. Due to this limitation, a single national market price for the raw milk in manufactured use was estimated while Grade A, Grade B, and fluid milk prices were estimated on a regional basis.

Dividing the U.S. dairy market into nine regions may not be sufficient for this study to capture the characteristics of the local order markets and overall milk shipment flows. Given that a nine region division is somewhat broad in terms of a single regional price, interregional shipments were underestimated by ignoring shipments within the regions and shipments between trading points clustered at the regional border lines.

Lack of sufficient data for processing costs and capacities of butter-powder and cheese plants weakened the confidence of the results of this study on the disaggregate manufactured milk products. Since these two factors play a major role in allocating the raw milk in manufactured use and in determining the average manufactured milk price, the market results could have been different if improved data were utilized.

One of the significant limitations of this study in terms of prices, quantities, and shipment flows is the fact that this study was based on an annual model. Being an average annual model, this study cannot help confounding the most important characteristics of the fluid milk in the dairy industry: perishability, day-to-day production, and week-to-week delivery of the raw milk. Due to this limitation, this study is most likely to fail to capture the seasonality problems in the supply and demand sides, especially in the deficit regions.

Another significant limitation of this study is that the model was based on a static analysis. As a static analysis does, this study also fails to take into account the adjustment process of supply and demand, which is considered in a long-run model. Due to this limitation, this study could not solve the problem of shifts in the market equilibrium once the exogeneous policy options were imposed.

There are two major limitations of the separable programming approach utilized in this study. A linear approximation approach to a nonlinear problem requires the establishment of a number of intervals and lengths of intervals. Since these cannot be infinite and infinitesimal a certain degree of inaccuracy in separable programming method's solution was inevitable.

Another limitation, which may be considered more significant, is due to the fact that the model was incomplete in terms of providing a set of internally determined optimal market prices once a policy parameter was given. As discussed in Chapter III, the complexity of the calculation of a weighted average price for the raw milk in manufactured use stems from the fact that the raw milk supply in cheese use and butter-powder use is determined endogeneously by the manufacturted milk price.[57] This implies that an optimal manufactured milk price has to be determined either endogeneously in the model or exgeneously. Either way may require an iterative procedure for a solution.

Separable programming was not further developed to take this problem into account mostly due to a time constraint. Due to this limitation, this study utilized a simplified assumption that net returns to cheese plants and net returns to butter-powder plants are identical so that the average raw milk price is equivalent to these net returns. This confines pricing options of changes in the purchase prices to ceretain bounds.

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[57] For a complete discussion, refer to the section 2.4 in Chpater III.

VI.4. Suggestions for Further Studies

Considering the two significant limitations of this study, it is strongly desirable to extend the annual interregional dairy trade model to a quarterly or bi-annual time frame. In so doing, the accuracy of the model can be improved by capturing the seasonal variations of supply and demand for fluid milk.

The effects of the stability induced dairy programs on the dairy market would result in an eventual shift in supply curve. By allowing an eventual shift in milk supply within a long-run framework, an extension of the interregional dairy trade model could be a quasi-dynamic model.

By utilizing imports and exports of dairy products as endogenous sectors, the model can also be extended to an international dairy trade model. The model can be further extended by disaggregating world import and export sectors into several major dairy areas such as the EEC, Australia, New Zealand, and Canada. In this way, the effects of pricing policy options could be more effectively analyzed within the context of international trade model. Other non-pricing policy options could also be analyzed.

Lastly, considering an inaccuracy of a separable programming technique due to linear approximation procedure, the study suggests utilization of a non-linear programming algorithm, which recently have become more available, for future analysis.

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APPENDICES

APPENDIX A

WELFARE EFFECTS: PRODUCER AND CONSUMER SURPLUS

A.1. Introduction

Under the neoclassical framework, it is assumed that producers are profit maximizers and consumers are utility maximizers. In a perfectly competitive situation both producers and consumers are price takers. Suppose there are no externalities in the competitive market so that producers are technologically independent and consumers′ preferences are independent. This implies that output level of each producer is determined only by his own input and output decisions, not by input or output decisions of other producers and that the preference of each consumer is affected only by his own choice of commodity bundles not by the choice of others. Finally suppose that, under these assumptions, there exists a competitive market equilibrium such that all markets clear and there is no excess demand or excess supply. In a general equilibrium setting, when a competitive equilibrium exists it attains Pareto optimality.

Although the Pareto principle provides a reasonable creterion for comparison of different states of the economy, it also has some significant limitations. One of them is that many Pareto optimal alternatives are simply not comparable (Just et al., 1982; p. 30). Because of this limitation, the Pareto principle must be used with caution. Quoting Just et al. (1982; pp. 31-2):

> From a policy point of view, the Pareto criterion favors the status quo since the range of choices that represent Pareto improvements depends critically on the initial distribution of income. The Pareto criterion cannot be used to choose among widely different income distributions. Furthermore, many Pareto optimal policy choices may exist which correspond simply to different income distributions. Perhaps not all first-best, Pareto-optimal, choices are superior to some second-best choice. ... Thus, the Pareto criterion alone appears to constitute an insufficient basis for applied economic welfare analysis of public policy alternatives.

Kaldor, and Hicks (1939) developed a concept called the "compensation principle" hoping that it would be a better device for evaluating policy alternatives. The compensation principle is briefly defined as if: State B is preferred to State A if, in making the move from State A to State

B, the gainers can compensate the losers such that every one can be made better off. According to them the principle is stated in terms of potential compensation rather than actual compensation. The payment of compensation, therefore, involves a value judgement. As far as policy is concerned, whether the compensation should be paid to losers or not is a subjective matter. Since the compensation principle does not rule out subjectivity of the policy decision, the concept of a social welfare function was developed by Bergson.[58] The social welfare function is simply a function of the utility levels of all individuals such that a higher value of the function is preferred to a lower one. The welfare function provides a rule that can rank all states of society and determine which first-best state on the grand utility possibilities frontier represents the social optimum. More detailed discussions about properties and existence of the social welfare functions are considered beyond the scope of the study. The study simply assumes that the function exists with similar properties to an individual utility function.

A.2. Consumer and Producer Surplus

The effect of changes in market prices on the consumer welfare is usually evaluated by measuring the increase or decrease in the area under a market demand curve less total actual payment for total quantity demanded. The total amount the consumer would be willing to pay for the changes in market prices is called consumer surplus. Since the demand curve may not be a single one, as Marshallian demand curves and Hicksian demand curves can be different, the measure of the welfare impact of a price change may not be unique. Compensating variation is defined as the amount of income that one would have to pay the consumer in new state to make him just as happy as he was in the original state. Compensating variation, C, can be defined formally by the use of the indirect utility and expenditure functions:[59]

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[58] Since Abram Bergson used this concept first, such a social function is also called Bergsonian welfare function.

[59] See Chapters 3 and 7, Varian.

$$v(p^1, y^o + C) = v(p^o, y^o)$$

or

$$C = e[p^1, v(p^o, y^o)] - e[p^o, v(p^o, y^o)] \qquad (A-1)$$

where v is an indirect utility function; e is an expenditure function; p^o is a market price in the original state; p^1 is a market price in the new state; and y^o is an income level in the original state.

Equivalent variation is defined to be the amount of income that one would have to take away from the consumer at price p^o to make him as well off as he would be at price p^1. Equivalent variation, E, is defined by:

$$v(p^o, y^o - E) = v(p^1, y^o)$$

or

$$E = e[p^1, v(p^1, y^o)] - e[p^o, v(p^1, y^o)] \qquad (A-2)$$

The relationship between compensating variation and equivalent variation and "the area under the demand curve" is depicted in figure A-1. Hicksian demand curves are steeper curves labelled h(P,v) and Marshallian curve is labelled X(P,y). Consider one commodity, x, and the price changes from p^o to p^1. Then the Hicksian demand for the commodity x is given by

$$h(p, v^o) \equiv \frac{\partial e(p, v^o)}{\partial p} \qquad (A-3)$$

Integrating the Hicksian demand function between p^o and p^1 gives

$$\int_{p^o}^{p^1} h(p, v^o) = e(p^1, v^o) - e(p^o, v^o) = \text{area a} = C \qquad (A-4)$$

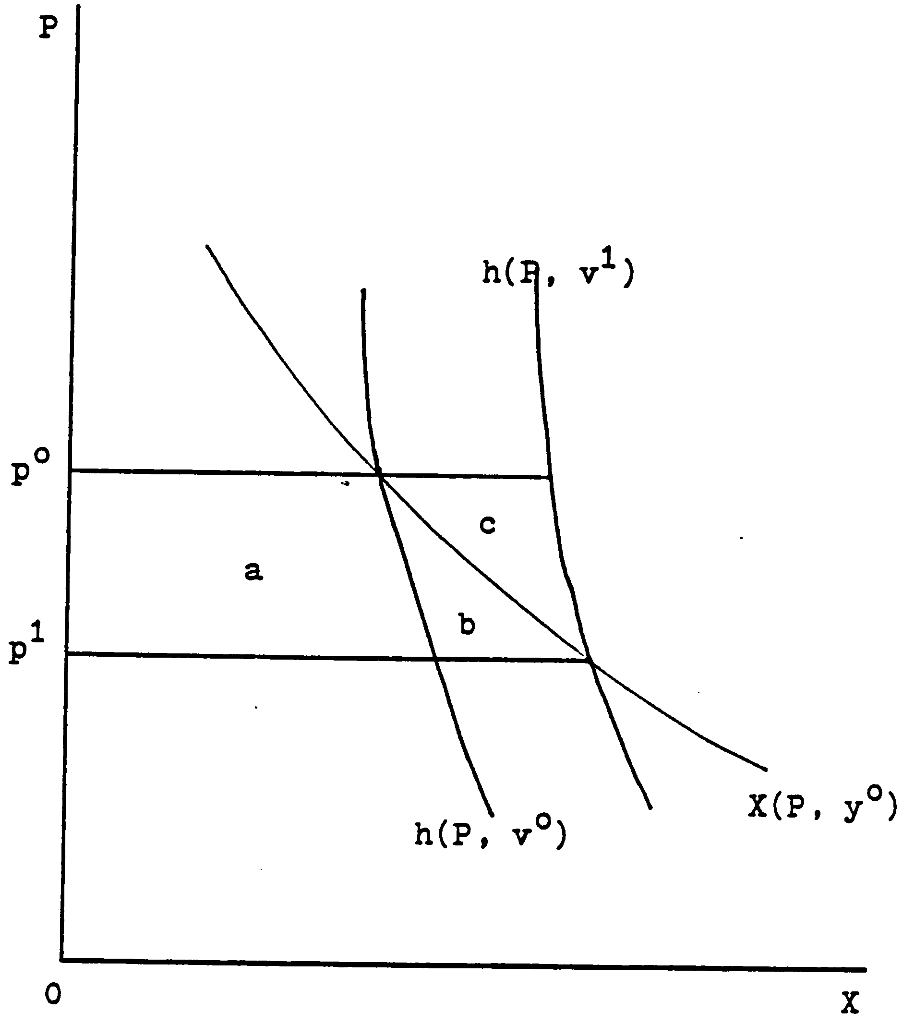

Figure A.1. Areas of Hicksian and Marshallian Demands (Varian, 1978; p. 211) and

$$\int_{p^o}^{p^1} h(p, v^1) = e(p^1, v^1) - e(p^o, v^1) = \text{area}(a + b + c) = E \qquad (A-5)$$

It is clear that the area under the Marshallian demand curve, area (a + b), is between C and E. Since the Hicksian demand curves are not observed in the real world, the amounts of C and E are not directly derived. However, these welfare measures can be used to construct a useful bound on consumer's surplus based on the Marshallian demand curve, which is observed in the real world.

Recall Slutsky's equation:

$$\frac{\partial x(p, y^o)}{\partial p} = \frac{\partial h(p, y^o)}{\partial p} - \frac{\partial x(p, y^o)}{\partial y}\ x \qquad (A-6)$$

If x is a normal good, then $\frac{\partial x(p, y^o)}{\partial y}$ is positive. This implies the Hicksian demand curve is always steeper than the Marshallian demand curve. The total actual amount the consumers are willing to pay under the Marshallian demand regime is defined by:

$$\int_{p^1}^{p^o} x(p, y^o) = \text{area}(a + b) = A \qquad (A-7)$$

And, as discussed, the absolute amount of A is between those of C and E.

$$|C| \leq |A| \leq |E| \qquad (A-8)$$

The implication of equation (A-8) is well expressed in Varian. To quote:

> This expression may often be useful in practice: it says that, if a cost benefit study shows that the cost of a project outweighs the area under a Marshallian demand curve, then the costs are certainly greater than the compensating variation (p. 211).

The relationship between A and C in constant income elasticity cases is easily derived from the definitions of income elasticity, and Marshallian and Hicksian demand functions. In a practical way, however, the percentage error resulting from using A rather than the exact measure C is likely to be quite small (Hicks, 1956, p. 65; Blakley and Riley, p. 1). Equation (A-6), Slutsky's equation, suggests that compensating and equivalent variations will be identical if the income elasticity is zero or indifference curves shift vertically with parallel. Hence, in a zero income elasticity case, the measure of consumer surplus using an ordinary demand curve does not result in any difference from the measure using Hicksian demand curve.

Producer's surplus is the amount of producer's profit and rent (Varian p. 214). Suppose the market supply curve is represented by aggregated firms' marginal cost (MC) curves as illustrated in figure A-2.[60] Market clearing price and quantity are p^* and y^* respectively. Since the supply curve is just the aggregated marginal cost (MC) curve, producer's surplus is defined as follows:

$$p^* y^* - \int_0^{y^*} MC(y)dy = p^* y^* - C(y^*) + C(0) = \text{area d.} \qquad (A-9)$$

Since C(0) implies the rent payment to the fixed factors, equation (A-9) proves that producer's surplus is just profit plus rent.

Suppose each individual consumer is assumed to be a utility maximizer with a given income level. For simplicity, assume each individual has a zero income elasticity of demand for the commodity. Under this assumption, the ordinary market demand function, $Q^d = x(p)$, can be considered as the sum of individual's compensated demand functions (Currie et al., p. 759). Assume that the producers are profit maximizers with given technology in a competitive market situation so that each individual is simply given a market clearing price and optimizes output with the given price. Without loss of any generality, the market supply function, $Q^s = g(p)$, is assumed to be the sum of individual's marginal cost functions. The consumer and producer surplus in the

[60] The market supply curve may not start at the origin as figure A-2 illustrates. An individual firm's supply curve is a marginal cost curve above the average variable cost. Since each firm's average variable cost differs, the aggregated marginal cost curve is flatter than firm's marginal cost curve and starts close to the origin.

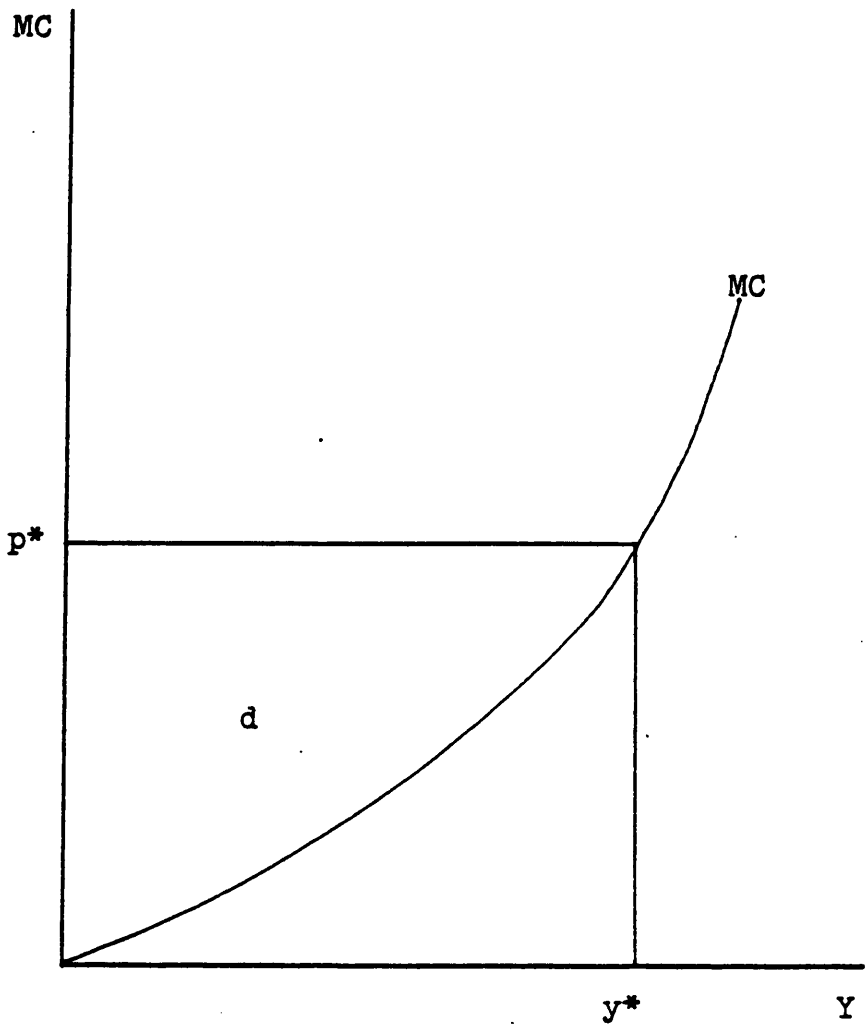

Figure A.2. Producer's Surplus (Varian, 1978; p. 214) competitive market and regulated market, under the support price program, situations are lustrated in figure A-3. It is assumed that consumers and producers are mere price takers in both cases.

Suppose the market is at a competitive equilibrium at the price of p^o and quantity level of q^o. Using equations (A-7) and (A-9) consumer and producer surplus at p^o and q^o in the competitive market equilibrium case are derived as follows:

$$\text{Consumer Surplus (C.S.)} = \int_{p^o}^{p^m} x(p)dp = \text{area } (a + b + c), \qquad (A-10)$$

$$\text{Producer Surplus (P.S.)} = \int_{0}^{p^o} g(p)dp = \text{area } (e + f), \qquad (A-11)$$

and total producer and consumer surplus is:

$$T.S. = C.S. + P.S. = \int_{p^o}^{p^m} x(p)dp + \int_{0}^{p^o} g(p)dp$$

$$= \text{area } (a + b + c + e + f). \qquad (A-12)$$

Now suppose the market is regulated by the price support program and the government sets p^1 as the support price and purchases q^g at that price. Since the market price is increased from p^o to p^1, consumer and producers' welfare is also changed. The changes in consumer and producers' surplus are derived as follows:

$$\Delta C.S. = \int_{p^1}^{p^m} x(p)dp - \int_{p^o}^{p^m} x(p)dp$$

$$= \int_{p^1}^{p^o} x(p)dp$$

$$= - \text{area } (b + c) \qquad (A-13.a)$$

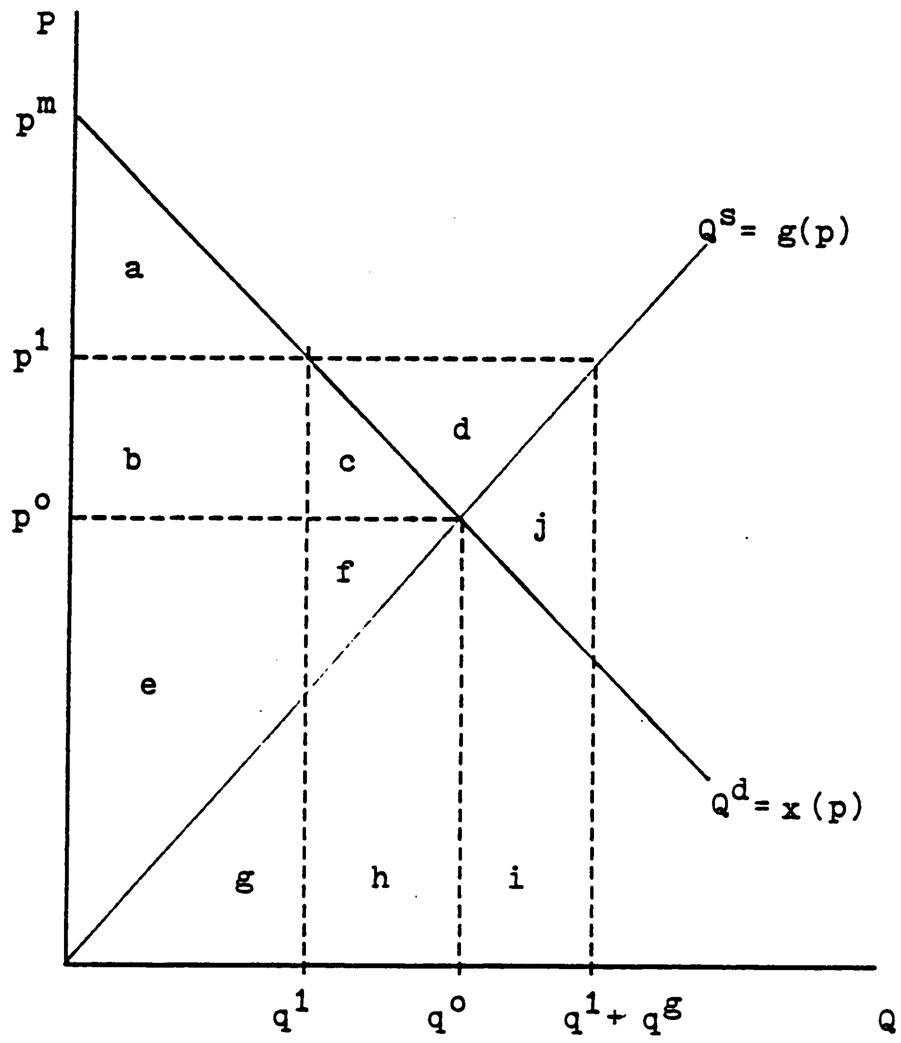

Figure A.3.. Consumer and Producer Surplus (Free Market and Regulated Market)

$$\Delta P.S. = \int_0^{p^1} g(p)dp - \int_0^{p^o} g(p)dp$$

$$= \int_{p^o}^{p^1} g(p)dp$$

$$= \text{area } (b + c + d), \qquad (A-14.a)$$

and the net change in total producer and consumer surplus is:

$$\Delta T.S. = \Delta C.S. + \Delta P.S.$$

$$= \int_{p^1}^{p^o} x(p)dp + \int_{p^o}^{p^1} g(p)dp$$

$$= \text{area } d. \qquad (A-15)$$

Equations (A-13.a, 14.a and 15) imply that due to the change in market price from p^o to p^1; (1) consumers lose their surplus by the area of (b + c), (2) producers gain their surplus by the area of (b + c + d), (3) there is a net gain of area d for the society of producer and consumer surplus, and (4) the purchasing expenditure (p^1xq^g) for the price support program is represented by the area of (c + d + f + j + h + i), which is the cost to the public.

The market supply and demand functions can also be written in inverse forms so that price is a function of a quantity.[61] In this case the surplus would be derived in integrals with ranges over quantity instead of price. Suppose the inverse supply and demand functions are derived as follows:

$$Q^s = g(P^s) \rightarrow P^s = g^{-1}(Q^s) \text{ and } Q^d = x(P^d) \rightarrow P^d = x^{-1}(Q^d). \qquad (A-16)$$

Then:

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[61] The inverse forms of supply and demand functions will be utilized for an empirical analysis of interregional U.S. dairy trade model.

$$\Delta C.S. = [\int_0^{q_1} x^{-1}(Q)dQ - p^1q^1] - [\int_0^{q_0} x^{-1}(Q)dQ - p^o q^o]$$

$$= -\int_{q^1}^{q^o} x^{-1}(Q)dQ - p^1q^1 + p^o q^o$$

$$= -\text{ area } (c + f + h) - \text{ area } (b + e + g) + \text{ area } (e + f + g + h)$$

$$= -\text{ area } (b + c)\,, \qquad (A-13.b)$$

and

$$\Delta P.S. = [p^1(q^1 + q^g) - \int_0^{(q^1+q^g)} g^{-1}(Q)dQ] - [p^o q^o - \int_0^{q^o} g^{-1}(Q)dQ]$$

$$= p^1(q^1 + q^g) - p^o q^o - \int_{q^o}^{(q^1+q^g)} g^{-1}(Q)dQ$$

$$= \text{ area } (b + e + g + c + f + h + d + j + i) - \text{ area } (e + g + f + h) - \text{ area } (j + i)$$

$$= \text{ area } (b + c + d)\,. \qquad (A-14.b)$$

A.3. Consumer and Producer Surplus in the Dairy Industry: National Fluid and Manufactured Market Case

In this section, measurement of consumer and producer surplus in a simplified national dairy industry will be discussed. Suppose the U.S. dairy industry consists of a fluid milk market and a manufactured milk market. The fluid milk is supplied by Grade A milk producers and the manufactured milk may be supplied by Grade B milk producers and, possibly, Grade A milk producers. The demand for fluid milk and manufactured milk is assumed to have zero income effects. Grade A milk producers and Grade B producers are assumed to be technologically independent.

The U.S. dairy industry under current federal programs is illustrated in figure A-4. Grade A and Grade B milk supply curves are labelled as SA and SB respectively. Class I and Class II milk classifications by the federal order are represented by XI and XII. The demand curves for fluid milk and manufactured milk are labelled as YF and YM respectively. The amount of each type of milk demanded is represented by XI and Ym respectively. The total amount of Grade B milk supplied is represented by Xb so that the total amount of raw milk supplied in manufactured use is labelled as (Xb + XII). Given the support price set at Pg^o, the CCC purchases Qg of manufactured milk. The federal marketing order sets the minimum Class I and Class II prices as PI^o and PII^o respectively resulting in the effective demand curve, AR, as shown in figure A-4(a).

Under this assumption, Grade A milk producers will be paid the blend price, $\tilde{P}b$, through an order, and Grade B milk producers will be paid Pg^o in the manufactured market. Since the fluid milk price is fixed at PI^o, the Class I minimum price, fluid milk consumption is limited to XI. Similarly since the manufactured milk price is fixed at Pg^o , manufactured milk consumption is limited to Ym.

Therefore, under the regulatory dairy programs, the consumer surplus in the fluid market is restricted to the area of a triangular abP_I^o in figure A-4(a). Similarly the consumer surplus in the manufactured market is the area of a triangular efP_g^o in figure A-4(b). The producers surplus for Grade A milk producers is the area of a triangular $\tilde{P}bcd$ (figure A-4(a)) and that for Grade B milk producers, ghXII (figure A-4(b)). Several implications for welfare effects of changes in policy parameters are suggested. First, suppose Class I differential is reduced by the federal order. This brings down PI^o, the Class I minimum price, and shifts down the effective demand curve (AR) for Grade A milk. Due to lowered fluid and blend prices in the fluid market, fluid consumers will gain and Grade A producers will lose. There is no change in welfare in the manufactured market except for a reduction in government purchases, Qg. Second, suppose the support price level is reduced

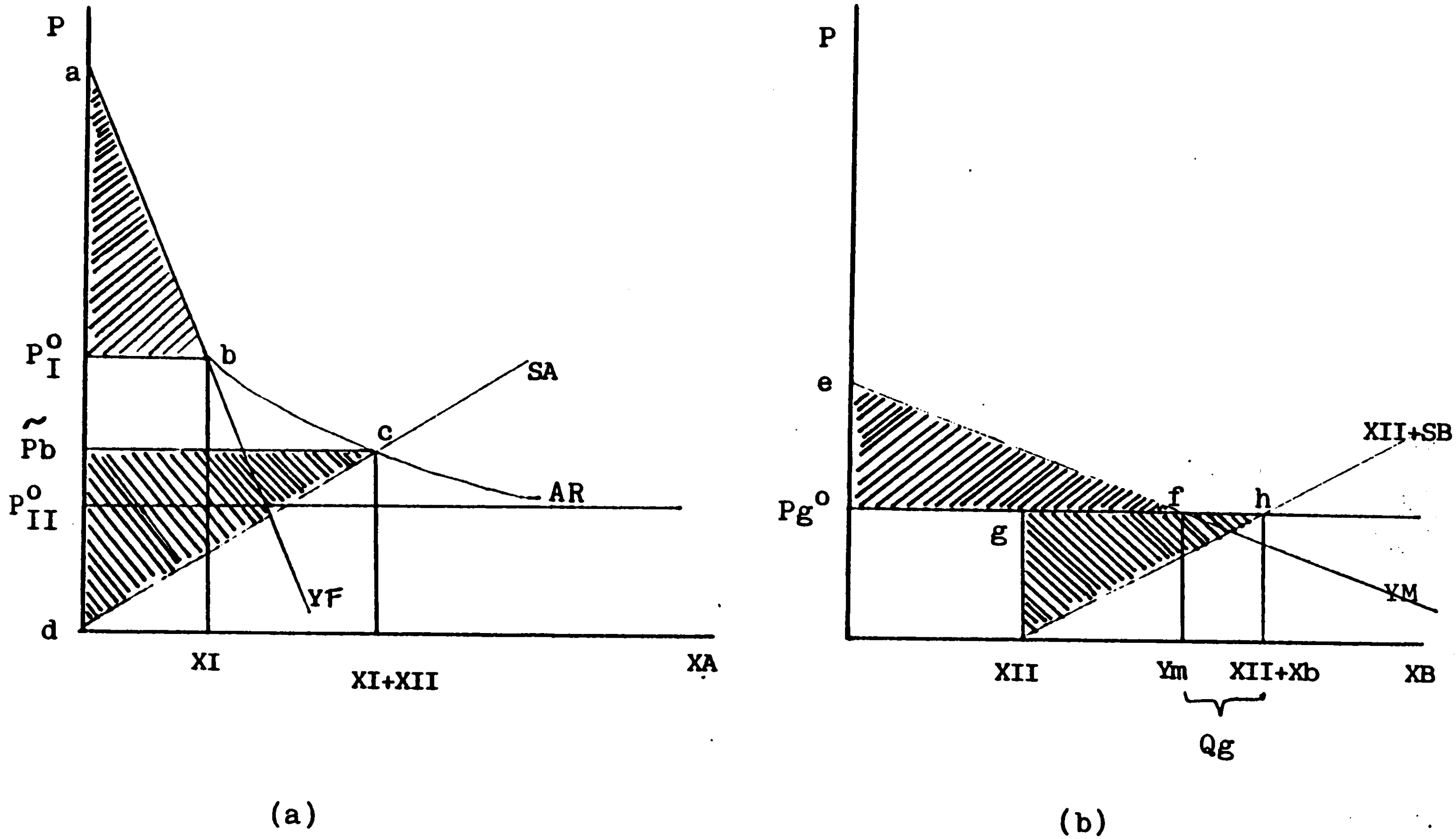

Figure A.4. Consumer and Producer Surplus in the U.S. Dairy Industry under Current Federal Programs by law and the federal order maintains the same Class I differential. Since Pg^o is reduced, PII^o also falls. This means PI^o is also decreased. In this case, the consumers of fluid milk and manufactured milk products both gain while producers of Grade A and Grade B milk lose. Third, suppose the support price level is reduced while Class I differential is increased. If the new PI^o is lower than the previous PI^o than the impact would be similar to the second case. But if the new PI^o is higher than or at least equal to the previous PI^o then the fluid consumer will not gain at all while manufactured consumer will gain and all producers will lose.

Several possible combinations of changing alternative policy parameters, the support and purchase price levels and Class I differentials, would result in different welfare impacts.[62] Different levels of Class I differentials among regions in the U.S. dairy industry will also result in different regional welfare impacts.

[62] For more detailed analysis of effects of changes in policy parameters on the dairy industry, see the section 3 in Chapter III.

APPENDIX B

MATHEMATICAL PROBLEM OF THE U.S. INTERREGIONAL DAIRY TRADE MODEL

B.1. Nonlinear Mathematical Programming Specification

The objective of the mathematical model maximizing the net quasi-welfare function subject to constraints can be specified as a Lagrangian net social quasi-welfare function. Since the objective function is concave, the Kuhn-Tucker conditions are necessary and sufficient for a local maximum if the constraint functions are convex. If the contraint functions are convex, compact and nonempty, then by the Weierstrass theorem the objective function has a global maximum either in the interior or on the boundary of the opportunity set defined by the constraint functions (Takayama (1974); p. 29 and 68).

It was already shown that the objective function is a concave function. Most of the constraint functions discussed in this section are linear constraints. The nonlinear constraints are the blend price constraints defined in equation (IV-28) under the pooling system of the federal marketing order program. Since the blend price function is downward sloping at a decreasing rate the opportunity set above the function is convex.

B.1.1. Unregulated Market Case

The maximizing problem of the Lagrangian net social quasi-welfare function under a competitive market situation in the dairy industry is specified below. The function is embodied by equations (IV-15) to (IV-25) described in Chapter IV. The function is to be maximized with respect to the quantities supplied, transported, and consumed subject to the relevant constraints.

$$\max W = \sum_{j=1}^{n} \int_0^{yf_j} df_j(yf_j) dyf_j + \sum_{k=2}^{4} \int_0^{yk} dk(yk) dyk$$

$$- \sum_{i=1}^{n} [\int_0^{xa_i} sa_i(xa_i) dxa_i + \int_0^{xb_i} sb_i(xb_i) xb_i]$$

$$- \sum_{i=1}^{n} \sum_{j=1}^{n} ta_{ij} xa_{ij} - (ac_{23} xm23 + ac_4 xm4)$$

$$+ \sum_{i=1}^{n} \lambda 1_i [xa_i - \sum_{j=1}^{n} \mathrm{xa}_{ij} - xa2_{ii}]$$

$$+ \sum_{i=1}^{n} \lambda 2_i [\mathrm{xb}_i - \mathrm{xb}_{ii}]$$

$$+ \sum_{j=1}^{n} \lambda 3_j [\sum_{j=1}^{n} xa_{ij} - yf_j]$$

$$+ \lambda 4 [\sum_{j=1}^{n} (xa2_{jj} + \mathrm{xb}_{jj}) - (xm23 + xm4)]$$

$$+ \lambda 5 [xm23 - \frac{y2}{c^2}]$$

$$+ \lambda 6 [xm23 - \frac{y3}{c^3}]$$

$$+ \lambda 7 [xm4 - \frac{y4}{c^4}]$$

$$+\sum_{i=1}^{n} \lambda 8_i[\mathrm{rb}_i + ac_{23} - \sum_{k=2}^{3} c^k pk]$$

$$+\sum_{i=1}^{n} \lambda 9_i[\mathrm{rb}_i + ac_4 - c^4 p4]$$

$$+\sum_{i=1}^{n}\sum_{j=1}^{n} \lambda 10_{ij}[\mathrm{ra}_i + \mathrm{ta}_{ij} - pf_j]$$

$$+\sum_{i=n}^{n} \lambda 11_i[\mathrm{ra}_i - \mathrm{rb}_i]\,. \qquad (B-1)$$

In a perfect competitive market situation, the last four constraints, associated with $\lambda 8$-$\lambda 11$, are expected to be satisfied by the Kuhn-Tucker optimality conditions.[63] The Kuhn-Tucker optimality conditions for (B-1) are:

$$\frac{\partial W}{\partial xa_i} = \frac{\partial W_i}{\partial xa_i} + \lambda 1_i = -ra_i + \lambda 1_i \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa_i} xa_i = 0$$

$$\frac{\partial W}{\partial xb_i} = \frac{\partial W_i}{\partial xb_i} + \lambda 2_i = -rb_i + \lambda 2_i \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xb_i} xb_i = 0$$

$$\frac{\partial W}{\partial yf_j} = \frac{\partial W_j}{\partial yf_j} - \lambda 3_j = pf_j - \lambda 3_j \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial yf_j} yf_j = 0$$

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[63] The objective funtion is specified in terms of quantities subject to the quantity balance constraints and price constraints. Hence if the problem is optimized in terms of quantity, the price constraints, for instance, the last four constraints in (B-1), are automatically satisfied. However, this is true only if the market is not influenced by any price regulations. Once a price regulation is imposed, it should be reflected in the constraints either in terms of price or quantity.

$$\frac{\partial w}{\partial y2} = \frac{\partial Wm}{\partial y2} - \frac{\lambda 5}{c^2} = p2 - \frac{\lambda 5}{c^2} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y2} y2 = 0$$

$$\frac{\partial w}{\partial y3} = \frac{\partial Wm}{\partial y3} - \frac{\lambda 6}{c^3} = p3 - \frac{\lambda 6}{c^3} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y3} y3 = 0$$

$$\frac{\partial w}{\partial y4} = \frac{\partial Wm}{\partial y4} - \frac{\lambda 7}{c^4} = p4 - \frac{\lambda 7}{c^4} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y4} y4 = 0$$

$$\frac{\partial w}{\partial xm23} = -\, ac_{23} - \lambda 4 + \lambda 5 + \lambda 6 \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xm23} xm23 = 0$$

$$\frac{\partial w}{\partial xm4} = -\, ac_4 - \lambda 4 + \lambda 7 \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xm4} xm4 = 0 \qquad (B-2)$$

$$\frac{\partial W}{\partial xa_{ij}} = -ta_{ij} - \lambda 1_i + \lambda 3_j \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa_{ij}} xa_{ij} = 0$$

$$\frac{\partial W}{\partial xa2_{ii}} = -\, \lambda 1_i + \lambda 4 \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa2_{ii}} xa2_{ii} = 0$$

$$\frac{\partial W}{\partial xb_{ii}} = -\, \lambda 2_i + \lambda 4 \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xb_{ii}} xb_{ii} = 0 \qquad (B-3)$$

$$\frac{\partial W}{\partial \lambda 1_i} = xa_i - \sum_{j=1}^{n} xa_{ij} - xa2_{ii} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 1_i} \lambda 1_i = 0$$

$$\frac{\partial W}{\partial \lambda 2_i} = xb_i - xb_{ii} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 2_i} \lambda 2_i = 0$$

$$\frac{\partial W}{\partial \lambda 3_i} = \sum_{i=1}^{n} xa_{ij} - yf_j \geq \quad \text{and} \quad \frac{\partial W}{\partial \lambda 3_j} \lambda 3_j = 0$$

$$\frac{\partial W}{\partial \lambda 4} = \sum_{j=1}^{n}(xa2_{jj} + xb_{jj}) - (xm23 + xm4) \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 4}\lambda 4 = 0$$

$$\frac{\partial W}{\partial \lambda 5} = xm23 - \frac{y2}{c^2} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 5}\lambda 5 = 0$$

$$\frac{\partial W}{\partial \lambda 6} = xm23 - \frac{y3}{c^3} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 6}\lambda 6 = 0$$

$$\frac{\partial W}{\partial \lambda 7} = xm4 - \frac{y4}{c^4} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 7}\lambda 7 = 0, \text{ for all i and j.} \qquad (B-4)$$

Suppose that for this problem the regional optimal consumption of fluid and manufactured milk products, and the regional optimal quantity of Grade A and Grade B milk are positive for all regions. The derived Kuhn-Tucker conditions for the problem would then provide the following economic implications. Equations (B-2) imply that

$$ra_i = \lambda 1_i\,,\ rb_i = \lambda 2_i\,, pf_j = \lambda 3_j\,,\ \text{and}$$

$$(c^2 p2 + c^3 p3 - ac_{23}) = c^4 p4 - ac_4 = pm = \lambda 4, \quad \text{for all i and j.} \qquad (B-5)$$

This implies that the imputed or shadow market supply prices and demand prices are exactly same as the regional supply prices and demand prices respectively. This satisfies regional consumer equilibrium and regional producer equilibrium and, thus, corresponds to the social Pareto optimality conditions.[64] Equations in (B-3) reflect the locational price equilibrium conditions and equations in (B-4) represent the market equilibrium conditions yielding no excess demand or excess supply. Therefore the total consumer expenditure is equal to the total production costs plus total trasportation and processing costs. Mathematically from (B-3 and 4):

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[64] For more details, see Takayama and Judge (1971), Chapter 2.

$$\sum_{i=1}^{n}\sum_{j=1}^{n}(pf_j - ra_i - ta_{ij})xa_{ij}^* + \sum_{i=1}^{n}(pm - ra_i)xa2_{ii}^* + \sum_{i=1}^{n}(pm - rb_i)xb_{ii}^*$$

$$= \sum_{j=1}^{n}pf_jyf_j^* + \sum_{k=2}^{4}c^kpkyk^* - \sum_{i=1}^{n}ra_ixa_i^* - \sum_{i=1}^{n}rb_ixb_i^*$$

$$- \sum_{i=1}^{n}\sum_{j=1}^{n}ta_{ij}xa_{ij}^* - ac_{23}xm23 - ac_4xm4 = 0. \qquad (B-6)$$

The Kuhn-Tucker conditions in (B-3) have other implications. Since Grade A milk can be utilized in fluid use or in manufactured use, the supply price of Grade A milk is determined differently in two cases: (1) the case where Grade A milk is utilized only in fluid use, and (2) the case where Grade A milk is first utilized in fluid use and the remainder of Grade A milk is utilized in manufactured use. The first case is the short-run two equilibrium market price case, where Grade A milk supply price is higher than Grade B milk supply price. The second case is the short-run single equilibrium market price case, where Grade A milk supply price and a Grade B milk supply price tend to equalize in an equilibrium situation.

The first case of no Grade A milk in manufactured use implies $xa2_{ii}^* = 0$ in equation (B-5). Hence $\lambda 4 \leq ra_i$. This means that the supply price of the Grade A milk and transportation cost is higher than, or at least equal to, the imputed demand price for raw milk in manufactured use. Since Grade B milk cannot be processed into fluid milk, it is likely that each market, fluid and manufatured, has different equilibrium market prices, where $pf_i = ra_i$, $pm = rb_i$ and $ra_i > rb_i$. Suppose $xa2_{ii}^* > 0$ for the second case. Then (B-3) implies $ra_i = rb_i = pf_i = \lambda 4$: the milk market in any region is cleared at one equilibrium price.

B.1.2. Regulated Market Case Under Current Federal Programs

Under the current federal programs, the manufactured milk product price is regulated by the price support program and the fluid milk price is regulated by classified pricing and pooling provisions of the federal marketing order program. Classified pricing regulates the demand price for the fluid milk by setting the minimum Class I price. The pooling system provides a weighted average revenue, blend price, which Grade A milk producers are paid. Hence demand prices for both markets are regulated by the government. The supply price for Grade A milk is affected by the government. These constraints were specified in (IV-26) through (IV-31) in Chapter IV.

Due to these regulations, the net social quasi-welfare function is now maximized subject to additional constraints. The consumer surplus for fluid and manufactured milk is bounded by the minimum Class I price and the support price respectively. Similarly, the producer surplus for the Grade A and Grade B milk is bounded by the blend price and the support price. The measure of total surplus is discussed in Appendix A.

In this section, measuring consumer and producer surplus by using an integral formulation is briefly discussed and a mathematical formulation of a Lagrangian net social quasi-welfare function follows. For simplicity in exposition, it is assumed that the fluid and manufactured markets are aggregated. Suppose sa(xa) and sb(xb) represent the supply functions for Grade A and Grade B milk respectively. Similarly, it is assumed that df(yf) and dm(ym) denote the demand functions for fluid and manufactured milk products respectively. The total surplus is divided as follows in terms of figure B-1.

	Market A	Market B
Consumer Surplus	a	j
Producer Surplus	c+d+h+f	k+m+n
Total Surplus	a+c+d+h+f	j+k+m+n

In general the area under the demand curve less area under the supply curve represents the consumer and producer surplus. Under regulation, market A is in equilibrium where yI^o and xa represents the quantity demanded at PI^o and supplied at ra respectively. Similarly, market B is in equilibrium where ym represents the quantity demanded by consumers and (xb + xa2) represents the quantity supplied by Grade B and Grade A milk producers at Pg^o. In order to maintain the

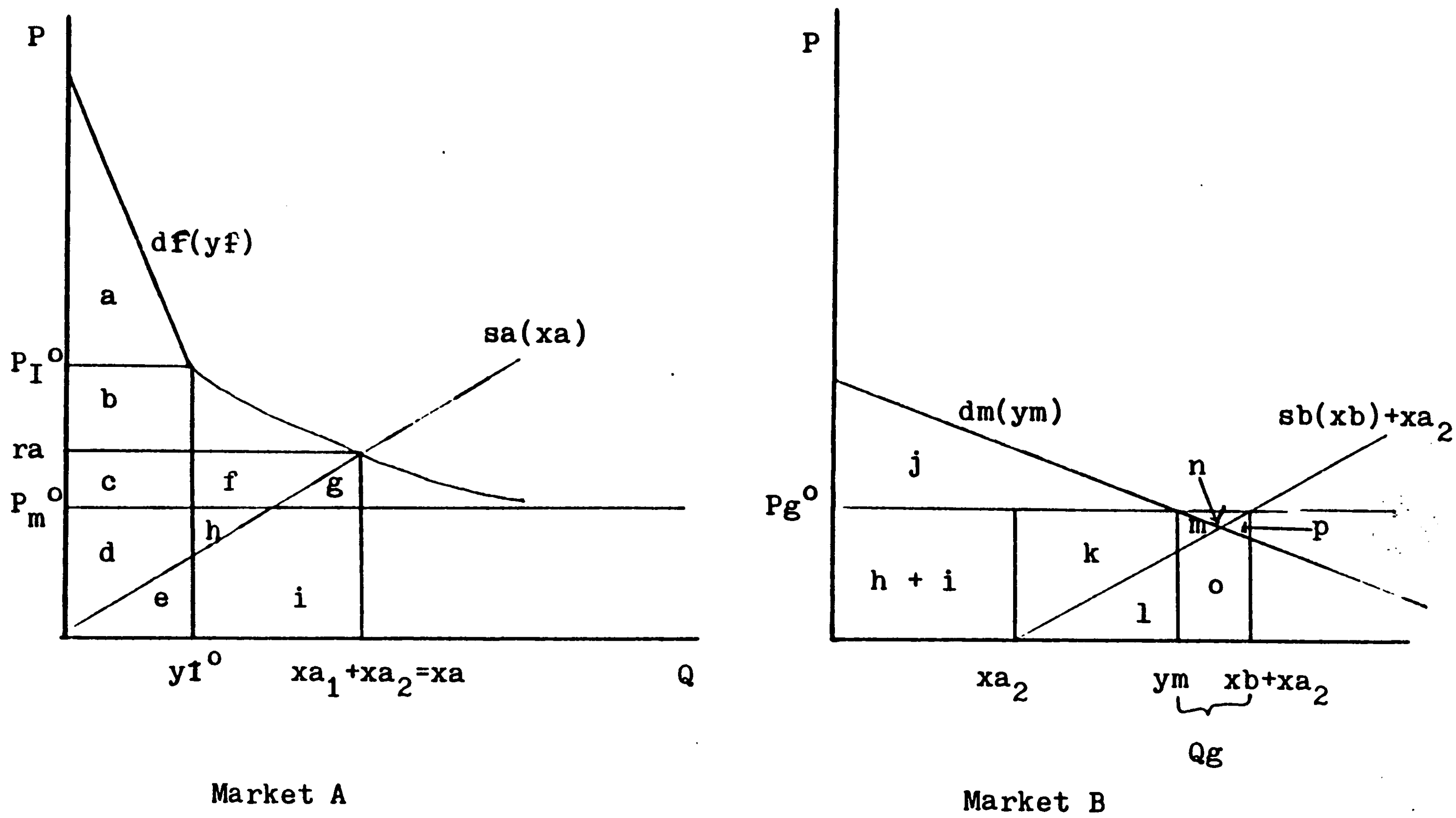

Figure B.1. Consumer and Producer Surplus of Milk Markets under Current Federal Programs support price level, Pg^{o}, the government purchases Qg amount of manufactured milk products at that price.

Areas a and j, total consumer surplus, are derived by the following integral formulations:

$$\text{Area a} = \int_0^{yI^{o}} df(yf)dyf - PI^{o}yI^{o} \qquad (B-7)$$

$$\text{Area j} = \int_0^{ym} dm(ym)dym - Pg^{o}ym. \qquad (B-8)$$

Similarly, for the total producer surplus, the integral formulations are specified as

$$\text{Area } (c+d+h+f) = (ra)(xa) - \int_0^{xa} sa(xa)dxa \qquad (B-9)$$

$$\text{Area } (k+m+n) = (Pg^{o})(xb) - \int_0^{xb} sb(xb)dxb. \qquad (B-10)$$

From (B-7) to (B-10), the total consumer and producer surplus is

$$\text{Area } (a+c+d+f+h+j+k+m+n)$$

$$\equiv W + Wm$$

$$= \int_0^{yI^{o}} df(yf)dyf + \int_0^{ym} dm(ym)dym - \int_0^{xa} sa(xa)dxa - \int_0^{xb} sb(xb)dxb$$

$$- PI^{o}yI^{o} - Pg^{o}ym - (ra)(xa) - (Pg^{o})(xb). \qquad (B-11)$$

Since (ra) is equal to a blend price[65] at equilibrium,

$$(ra)\,(xa) = PI^{o}yI^{o} + pm^{o}xa2 = PI^{o}yI^{o} + (Pg^{o})\,(xa2). \qquad (B-12)$$

Hence (B-11) is rewritten as

$$W + Wm = \int_0^{yI^{o}} df(yf)dyf + \int_0^{ym} dm(ym)dym - \int_0^{xa} sa(xa)dxa - \int_0^{xb} sb(xb)dxb$$

$$+ Pg^{o}\,Qg \qquad (B-13)$$

where Qg = xa2 + xb - ym. Equation (B-13) can be expressed in disaggregated formulation in terms of regions and manufactured products such as the one in (B-1).

The blend price constraint, (IV-28) in Chapter IV, can be rewritten as follows:

$$ra_i + ta_{ij} \geq \{(\pi_j^{o}\sum_k xa_{kj} + pm^{o}xa2_{jj})(\sum_k xa_{kj} + xa2_{jj})^{-1}\}$$

$$= [\{(pm^{o} + D_j)\sum_k xa_{kj} + pm^{o}xa2_{jj}\}(\sum_k xa_{kj} + xa2_{jj})^{-1}]$$

$$= \{pm^{o}(\sum_k xa_{kj} + xa2_{jj}) + D_j\sum_k xa_{kj}\}(\sum_k xa_{kj} + xa2_{jj})^{-1}$$

$$= pm^{o} + D_j\sum_k xa_{kj}(\sum_k xa_{kj} + xa2_{jj})^{-1}$$

$$= \tilde{pb}_j\,. \qquad (B-14)$$

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[65] $ra = \dfrac{PI^{o}yI^{o} + Pm^{o}xa2}{xa}$, where $xa = yI^{o} + xa2 = xa1 + xa2$.

The Lagrangian net social quasi-welfare function under current regulations is specified as follows. The function is to be maximized with respect to the quantities supplied, transported and consumed subject to the relevant constraints.

$$\max W = \sum_{j=1}^{n} \int_0^{yI_j^o} df_j(yf_j)dyf_j + \sum_{k=2}^{4} \int_0^{yk} dk(yk)dyk$$

$$- \sum_{i=1}^{n} [\int_0^{xa_i} sa_i(xa_i)dxa_i + \int_0^{xb_i} sb_i(xb_i)xb_i] + \sum_{k=2}^{4} Pgk^o Qgk$$

$$- \sum_{i=1}^{n} \sum_{j=1}^{n} ta_{ij} xa_{ij} - (ac_{23} xm23 + ac_4 xm4)$$

$$+ \sum_{i=1}^{n} \lambda 1_i [xa_i - \sum_{j=1}^{n} xa_{ij} - xa2_{ii}]$$

$$+ \sum_{i=1}^{n} \lambda 2_i [xb_i - xb_{ii}]$$

$$+ \sum_{j=1}^{n} \lambda 3_j [\sum_{j=1}^{n} xa_{ij} - (1 + R) yf_j]$$

$$+ \lambda 4 [\sum_{j=1}^{n} (xa2_{jj} + xb_{jj}) - (xm23 + xm4)]$$

$$+ \lambda 5 [xm23 - \frac{1}{c^2} (y2 + Qg2)]$$

$$+ \lambda 6[xm23 - \frac{1}{c^3}(y3 + Qg3)]$$

$$+ \lambda 7[xm4 - \frac{1}{c^4}(y4 + Qg4)]$$

$$+ \sum_{j=1}^{n} \lambda 8_j [pf_j - \pi_j^o]$$

$$+ \lambda 9[Pg^o - \frac{(c^2Pg2^o + c^3Pg3^o - ac_{23})xm23 + (c^4Pg4^o - ac_4)xm4}{xm23 + xm4}]$$

$$+ \lambda 10_{23}(xm_{23}^o - xm23)$$

$$+ \lambda 10_4(xm4^o - xm4)$$

$$+ \sum_{i=1}^{n} \lambda 11_i [rb_i - pm^o]$$

$$+ \sum_{i=1}^{n}\sum_{j=1}^{n} \lambda 12_{ij}[ra_i + ta_{ij} - \{pm^o + D_j \sum_{l} xa_{lj} (\sum_{l} xa_{lj} + xa2_{jj})^{-1}\}] \qquad (B-15)$$

where xm_{23}^o and xm_4^o represent total maximum capacities of butter-powder plants and cheese plants, respectively. In the regulated market case, the purchase prices may vary in temrs of net return to plants. For instance, if butter and nonfat dry milk prices are low such that net return to cheese plants are higher, then raw milk in manufactured use will be shipped to cheese plants until the cheese plants are operating at the full capacities.

In a perfectly competitive market, it was shown above that the imputed demand and supply prices are exactly equal to the market demand and supply prices. These market equilibrium prices are determined by the perfectly competitive market mechanism. With government programs, however, the government regulates markets in order to achieve its goals. Because of this the imputed prices may no longer be equal to the market prices under regulations. Hence the price constraints due to regulations expressed in (B-15) may not be consistent with the Kuhn-Tucker optimality conditions.

The Kuhn-Tucker optimality conditions for (B-15) are as follows:

$$\frac{\partial W}{\partial xa_i} = -ra_i + \lambda 1_i + \lambda 12_{ij}[\frac{\partial ra_i}{\partial xa_i}] \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa_i} xa_i = 0$$

$$\frac{\partial W}{\partial xb_i} = -rb_i + \lambda 2_i \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xb_i} xb_i = 0$$

$$\frac{\partial W}{\partial yf_j} = pf_j - (1+R)\lambda 3_j + \lambda 8_j[\frac{\partial pf_j}{\partial yf_j}] \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial yf_j} yf_j = 0$$

$$\frac{\partial W}{\partial y2} = p2 - \frac{\lambda 5}{c^2} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y2} y2 = 0$$

$$\frac{\partial W}{\partial y3} = p3 - \frac{\lambda 6}{c^3} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y3} y3 = 0$$

$$\frac{\partial W}{\partial y4} = p4 - \frac{\lambda 7}{c^4} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial y4} y4 = 0$$

$$\frac{\partial W}{\partial Qg2} = Pg^o 2 - \frac{\lambda 5}{c^2} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial Qg2} Qg2 = 0$$

$$\frac{\partial W}{\partial Qg3} = Pg^o 3 - \frac{\lambda 6}{c^3} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial Qg3} Qg3 = 0$$

$$\frac{\partial W}{\partial Qg4} = Pg^o 4 - \frac{\lambda 7}{c^4} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial Qg4} Qg4 = 0$$

$$\frac{\partial W}{\partial xm23} = -\, ac_{23} - \lambda 4 + \lambda 5 + \lambda 6$$

$$+\lambda 9(c^4Pg4^o - c^2Pg2^o - c^3Pg3^o + ac_{23} - ac_4)\frac{xm4}{(xm23 + xm4)^2} - \lambda 10_{23} \leq 0$$

$$\text{and} \quad \frac{\partial W}{\partial xm23} xm23 = 0$$

$$\frac{\partial W}{\partial xm4} = -ac_4 - \lambda 4 + \lambda 7$$

$$+\lambda 9(c^2Pg2^o + c^3Pg3^o - c^4Pg4^o - ac_{23} + ac_4)\frac{xm23}{(xm23 + xm4)^2} - \lambda 10_4 \leq 0$$

$$\text{and} \quad \frac{\partial W}{\partial xm4} xm4 = 0 \qquad (B-16)$$

$$\frac{\partial W}{\partial xa_{ij}} = -ta_{ij} - \lambda 1_i + \lambda 3_j + \lambda 12_{ij}\{D_j xa2_{jj}(\sum_{l} xa_{lj} + xa2_{jj})^{-2}\} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa_{ij}} xa_{ij} = 0$$

$$\frac{\partial W}{\partial xa2_{ii}} = -\lambda 1_i + \lambda 4 - \lambda 12_{ii}\{D_i \sum_{l} xa_{li}(\sum_{l} xa_{li} + xa2_{ii})^{-2}\} \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xa2_{ii}} xa2_{ii} = 0$$

$$\frac{\partial W}{\partial xb_{ii}} = -\lambda 2_i + \lambda 4 \leq 0 \quad \text{and} \quad \frac{\partial W}{\partial xb_{ii}} xb_{ii} = 0 \qquad (B-17)$$

$$\frac{\partial W}{\partial \lambda 1_i} = xa_i - \sum_{j=1}^{n} xa_{ij} - xa2_{ii} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 1_i} \lambda 1_i = 0$$

$$\frac{\partial W}{\partial \lambda 2_i} = xb_i - xb_{ii} \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 2_i} \lambda 2_i = 0$$

$$\frac{\partial W}{\partial \lambda 3_i} = \sum_{i=1}^{n} xa_{ij} - (1 + R)yf_j \geq \quad \text{and} \quad \frac{\partial W}{\partial \lambda 3_j} \lambda 3_j = 0$$

$$\frac{\partial W}{\partial \lambda 4} = \sum_{j=1}^{n}(xa2_{jj} + xb_{jj}) - (xm23 + xm_4) \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 4}\lambda 4 = 0$$

$$\frac{\partial W}{\partial \lambda 5} = xm23 - \frac{1}{c^2}(y2 + Qg2) \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 5}\lambda 5 = 0$$

$$\frac{\partial W}{\partial \lambda 6} = xm23 - \frac{1}{c^3}(y3 + Qg3) \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 6}\lambda 6 = 0$$

$$\frac{\partial W}{\partial \lambda 7} = xm4 - \frac{1}{c^4}(y4 + Qg4) \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 7}\lambda 7 = 0 \qquad (B-18)$$

$$\frac{\partial W}{\partial \lambda 8_j} = pf_j - \pi_j^o \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 8_j}\lambda 8_j = 0$$

$$\frac{\partial W}{\partial \lambda 9} = Pg^o - \frac{[(c^2Pg2^o + c^3Pg3^o - ac_{23})xm23 + (c^4Pg4^o - ac_4)xm4]}{xm23 + xm4} \geq 0$$

$$\text{and} \quad \frac{\partial W}{\partial \lambda 9}\lambda 9 = 0$$

$$\frac{\partial W}{\partial \lambda 10_{23}} = xm23^o - xm23 \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 10_{23}}\lambda 10_{23} = 0$$

$$\frac{\partial W}{\partial \lambda 10_4} = xm4^o - xm4 \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 10_4}\lambda 10_4 = 0$$

$$\frac{\partial W}{\partial \lambda 11_i} = rb_i - pm^o \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 11_i}\lambda 11_i = 0$$

$$\frac{\partial W}{\partial \lambda 12_{ij}} = ra_i + ta_{ij} - \tilde{pb}_j \geq 0 \quad \text{and} \quad \frac{\partial W}{\partial \lambda 12_{ij}}\lambda 12_{ij} = 0 \qquad (B-19)$$

for all i and j, and k = 2,3 and 4.

Equations in (B-16) represent regional consumer and producer equilibrium conditions and equations in (B-17) represent locational equilibrium conditions. Market equilibrium conditions are reflected by equations in (B-18). Additional equilibrium conditions in a regulated market are represented by equations in (B-19).

If all quantities are positive then equations in (B-16) imply that:

$$ra_i = \lambda 1_i + \lambda 12_i \left[\frac{\partial ra_i}{\partial xa_i} \right] \quad \text{and} \quad rb_i = \lambda 2_i + \lambda 11_i \left[\frac{\partial rb_i}{\partial xb_i} \right]$$

$$pf_j = (1 + R)\lambda 3_j - \lambda 8_j \left[\frac{\partial pf_j}{\partial yf_j} \right], \text{ for all i and j, and}$$

$$c^2Pg2^o = \lambda 5, \quad c^3Pg3^o = \lambda 6, \; c^4Pg4^o = \lambda 7, \quad \text{and}$$

$$Pm^o = Pg^o = \lambda 4 = -\, ac_{23} + \lambda 5 + \lambda 6$$

$$+ \lambda 9 \frac{(c^4Pg4^o - c^2Pg2^o - c^3Pg3^o - ac_{23} - ac_4)(xm4)}{(xm23 + xm4)^2} - \lambda 10_{23}$$

$$= -\, ac_4 + \lambda 7 - \lambda 9 \frac{(c^4Pg4^o - c^2Pg2^o - c^3Pg3^o - ac_{23} - ac_4)(xm23)}{(xm23 + xm4)^2} - \lambda 10_4 \,. \qquad (B-20)$$

Since the market is regulated, the imputed supply and demand prices are not equal to the market supply and demand prices. The difference between $\lambda 1_i$ and ra_i, $\lambda 12_i[\frac{\partial ra_i}{\partial xa_i}]$, is the extra marginal cost that the society has to pay to maintain the classfied pricing and the pooling systems. Since the reserve requirement has to be met, the fluid price is forced to be π_j^o. In a surplus region, Grade A milk may no longer be needed to meet the reserve requirement. Hence the extra unit of the Grade A milk supplied is now paid pm^o and the imputed value for $\lambda 3_j$ for the extra unit becomes pm^o. In a deficit region, however, Grade A milk is still needed to meet the reserve requirement. This deficiency leads to the importation of Grade A milk from surplus regions, and the inflow of Grade A milk continues until the total supply satisfies the total demand $(1 + R)yI_j^o$. The imputed value for the fluid milk, $\lambda 3_j$, becomes $\pi_j^o/(1 + R)$ in the deficit region. As mentioned, the locational price equilibrium conditions are reflected in (B-17) and the market equilibrium conditions yielding no excess demand and excess supply are represented by (B-18).

Since the federal marketing order provides a two-price system with the pooling provision, it is necessary to understand the relationship between regulated market equilibrium prices and the imputed prices. In Chapter III, it was pointed out that when the Class I utilization ratio is less than one in any region the effective demand curve in that region can be specified by (B-14). This implies that the blend price is between the minimum Class I price, π_j^o , and the minimum Class II price, pm^o in region j. In other words, the average revenue for Grade A milk is determined by the effective demand curve in the range between pf_j^o and pm^o. The market supply price tends to match this average revenue at equilibrium. In reality, however, due to the two-price system Grade A milk supplied for fluid milk is paid pf_j^o and the extra Grade A milk supplied for manufactured milk products is paid pm^o.

Since Grade A milk producers are price takers, they optimize output level by setting the marginal costs of producing the last unit of milk equal to the average revenue, the blend price. Under regulation, however, the society as a whole is now willing to pay pm^o for the rest of Grade A milk in manufactured use. Therefore current federal regulations induce society to pay a higher social cost. This implies that the imputed market supply and demand prices are now restricted by a non-market mechanism, the government.

Due to the distortion in the market prices, the locational price equilibrium condition in (B-17) is not satidfied in the actual locational price equilibrium. Since Grade A milk producers consider the blend price as the marginal revenue, they satisfy the actual locational price equilibrium conditions specified in the last two equations in (B-19).

B.2. Interregional Equilibrium Conditions

The additional constraints, derived in (B-19), arise directly from the charateristics of the regulating programs and reflect the actual regulated market conditions. As discussed, due to market distortions, actual solutions may not be equal to the corresponding imputed values. The Kuhn-Tucker conditions, however, are expected to be consistent with the market equilibrium conditions described in (B-16, 17 and 18). Since prices and quantities are functionally duals, the values of Lagrangian multipliers of price constraints reflect the marginal changes of quantities.

B.2.1. Grade A and Fluid Milk

The relationship between the fluid milk demand price and Grade A supply price is reflected in Kuhn-Tucker conditions of (B-16, 17 and 18). From (B-16):

$$pf_j - (1+R)\lambda 3_j + \lambda 8_j\left[\frac{\partial pf_j}{\partial yf_j}\right] = 0 \quad \text{if} \quad yf_j > 0, \ \text{and}$$

$$-ra_i - \lambda 1_i + \lambda 12_{ij}\left[\frac{\partial ra_i}{\partial xa_i}\right] = 0 \quad \text{if} \quad xa_i > 0.$$

From (B-17):

$$-ta_{ij} - \lambda 1_i + \lambda 3_j - \lambda 12_{ij} - \Omega_j = 0 \quad \text{if} \quad xa_{ij} > 0$$

where $\Omega_j = D_j xa2_{jj}(\sum_i xa_{ij} + xa2_{jj})^{-2}$.

By substituting for $\lambda 1_i$ and $\lambda 3_j$, these three conditions may be simplified into one as follows:

$$pf_j + \lambda 8_j\left[\frac{\partial pf_j}{\partial yf_j}\right] - (1+R)\left[ra_i + ta_{ij} + \lambda 12_{ij}\left(\Omega_j - \frac{\partial ra_i}{\partial xa_i}\right)\right] = 0. \qquad (B-21)$$

Due to the reserve requirement the minimum Class I price is always effective and the blend price is upper bounded by the reserve requirement ratio yielding $\lambda 8_j$ and $\lambda 12_{ij}$ not being zero. Rewriting (B-21):

$$\lambda 12_{ij} = \frac{\left[\pi_j^o + \lambda 8_j \dfrac{\left(\frac{\partial pf_j}{\partial yf_j}\right)}{(1+R)} - ra_i - ta_{ij}\right]}{\left[\Omega_j - \dfrac{\partial ra_i}{\partial xa_i}\right]}, \quad \text{for all i and j.} \qquad (B-22)$$

Since $\lambda 8_j$ and $(\frac{\partial pf_j}{\partial yf_j})$ are both negative, the multiplication of these two is positive, and the sign of the numerator is positive. Since the denominator is negative, the multiplier for the blend price constraint, $\lambda 12_{ij}$, is negative. This implies the additional locational price equilibrium associated with $\lambda 12_{ij}$ in (B-19) is satisfied with the equality condition, i.e., $ra_i + ta_{ij} - \tilde{pb}_j = 0$, for all i and j. According to McDowell (1982, p. 95), $\lambda 12_{ij}$ represents a subsidy rerceived for milk moving to fluid use.

In his discussion, McDowell argued that the minimum Class I prices should be aligned such that $\pi_j^o - \pi_i^o < ta_{ij}$, where i is the more surplus region of the two in order to prevent processors from "undermining the system by driving local Grade A producers to a lower fluid utilization rate, and lower blend price" (p. 96). In reality, however, Grade A milk producers in region i compare the difference in the blend prices in region i and j. If the difference is greater than their transportation costs, they are tempted to ship their milk to region j. Therefore, from the modeling standpoint, the minimum Class I price alignment should be replaced by the blend price alignment such that $\tilde{pb}_j - \tilde{pb}_i < ta_{ij}$, where i is the more surplus region of the two.[66]

B.2.2. Grade A and Manufactured Milk

The relationship between the marginal revenue of manufactured milk and the marginal cost of Grade A milk production may be derived in a similar fashion. From (B-16),

$$pm - \lambda 4 = 0 \quad \text{when} \quad yk > 0 \quad \text{for all } k$$

$$-ra_i + \lambda 1_i + \lambda 12_{ij}[\frac{\partial ra_i}{\partial xa_i}] = 0 \quad \text{when} \quad xa_i > 0$$

and from (B-17):

$$-\lambda 1_i + \lambda 4 + \lambda 12_{ii}\Omega_i = 0 \quad \text{when} \quad xa2_{ii} > 0$$

where $\Omega_i = D_i \sum_I xa_{Ii} (\sum_I xa_{Ii} + xa2_{ii})^{-2}$.

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[66] This implies that $D_j UR_j - D_i UR_i < ta_{ij}$, where D is a Class I differential and UR is a Class I utilization ratio. It is expected that $UR_i < UR_j$, where i is the surplus region.

By substituting $\lambda 4$ and $\lambda 1_i$:

$$pm^o - ra_i + \lambda 12_{ii}[\Omega_i - \frac{\partial ra_i}{\partial xa_i}] = 0$$

and rearranging for $\lambda 12_{ij}$:

$$\lambda 12_{ii} = -\frac{[pm^o - ra_i - ta2_{ii}]}{[\Omega_i - \frac{\partial ra_i}{\partial xa_i}]}, \quad \text{for all i.} \qquad (B-23)$$

$\lambda 12_{ii}$ is negative since nominator is positive and denominator is negative in (B-23). This satisfies the equality condition of additional locational equilibrium associated with $\lambda 12_{ii}$ in (B- 19), i.e., $ra_i - \tilde{p}b_i = 0$, for all i.

B.2.3. Grade B and Manufactured Milk

In order to analyze the relationship between the supply price of Grade B milk, or raw milk in manufactured use, and the demand prices of manufactured milk products under federal regulatory programs, it is important to understand the nature of support prices for butter, nonfat dry milk and cheese and their relationships to the supply price for raw milk in manufactured use. It is assumed that processing plants are operating at full capacity at given market prices, which are generally determined by the CCC purchase price levels. As the last equation in (B-5) implies, at the competitive market equilibrium, average revenue in the butter-powder market, $(c^2P2 + c^3P3 - ac_{23})$, is equivalent to average revenue in the cheese market $(c^4P4 - ac_4)$. This implies that a unit of raw milk in manufactured use is paid the same price regardless of its purpose. Similarly, suppose, the purchase prices for butter and powder, and the purchase price for cheese are set at a same price level by the government such that $Pg^o = (c^2Pg2^o + c^3Pg3^o) - ac_{23} = (c^4Pg4^o) - ac_4$. In this case, raw milk in manufactured use, butter-powder or cheese, will be paid the same price, Pg^o, guaranteed by the support program. In this case, the last equation in (B-20) is simplified as:

$$Pm^o = Pg^o = \lambda 4 = PG23 = PG4.$$

In this case, a weighted average revenue, Pg^b, for raw milk in manufactured use is as follows:

$$Pg^b = \frac{(PG23)xm23 + (PG4)xm4}{xm23 + xm4}$$

$$= \frac{Pg^o(xm23 + xm4)}{xm23 + xm4}$$

$$= Pg^o = Pm^o .$$

From (B-16):

$$rb_i - \lambda 2_i - \lambda 11_i[\frac{\partial rb_i}{\partial xb_i}] = 0, \quad \text{if} \quad xb_i > 0, \text{ and}$$

$$pm^o - \lambda 4 - \lambda 10_{23} = pm^o - \lambda 4 - \lambda 10_4 = 0.$$

This implies that $\lambda 10_{23} = \lambda 10_4 = \lambda 10$. Since marginal revenues are the same for both markets, shadow prices for capacity constraints are the same.

From (B-17):

$$-\lambda 2_i + \lambda 4 = 0 \quad \text{if} \quad xb_{ii} > 0.$$

Rearranging these three conditions into one:

$$rb_i - pm^o - \lambda 11_i[\frac{\partial rb_i}{\partial xb_i}] + \lambda 10 = 0. \qquad (B-24)$$

Solving for $\lambda 11_i$ from (B-24):

$$\lambda 11_i = \frac{(rb_i - pm^o) + \lambda 10}{[\frac{\partial rb_i}{\partial xb_i}]} . \qquad (B-25)$$

Since pm^o represents the market average revenue for raw milk in manufactured use and rb_i represents the supply price for raw milk, $(rb_i - pm^o)$ is zero at equilibrium. As capacity constraints are relaxed, marginal cost for raw milk increases yielding $\lambda 10 = \lambda 10_{23} = \lambda 10_4 < 0$. Hence numerator is negative. Since Grade B supply function is upward sloping denominator is positive. Therefore $\lambda 11_i$ is negative. The value for $\lambda 11_i$ is a basis for a possible subsidy for a certain market once the manufactured market prices are differentiated by the support price program.

Suppose, as we discussed before, the government drops the purchase price for nonfat dry milk, from Pg_3^0 to Pg_3^1, while keeping prices for butter and cheese at the previous level. This implies PG4 > PG23, and a weighted average revenue for raw milk, Pg^b, is defined as:

$$Pg^b = (PG23^1)(\frac{xm23}{xm23 + xm4}) + (PG4)(\frac{xm4}{xm23 + xm4}).$$

Since Pg^b is a convex combination of $PG23^1$ and PG4, the value of Pg^b is lower than PG4 and higher than $(PG23^1)$. This implies that marginal revenue of cheese market is higher than marginal cost of production of raw milk in manufactured use. In the short-run, the difference between marginal revenue and marginal cost represents a net profit, or rent, and reflected by the shadow price $\lambda 11_i$ based on (B-25). From (B-16):

$$-\lambda 4 + PG4 + \lambda 9(PG23^1 - PG4)\frac{xm23}{(xm23 + xm4)^2} - \lambda 10_4 = 0.$$

Rewriting (B-24):

$$rb_i - PG4 - \lambda 9(PG23^1 - PG4)\frac{xm23}{(xm23 + xm4)^2} + \lambda 10_4 - \lambda 11_i[\frac{\partial rb_i}{\partial xb_i}] = 0. \qquad (B-26)$$

Solving for $\lambda 11_i$ from (B-26):

$$\lambda 11_i = \frac{(rb_i - PG4) - \lambda 9(PG23^1 - PG4)[\frac{xm23}{(xm23 + xm4)^2}]}{[\frac{\partial rb_i}{\partial xb_i}]} + \lambda 10_4 . \qquad (B-27)$$

Define average net profit accrued in the cheese market as $\Pi = PG4 - Pg^b > 0$, and the difference between average revenue of cheese and butter-powder market as $\Delta = PG4 - PG23^1 > 0$. Then:

$$\Pi = PG4 - Pg^b$$

$$= PG4 - [\frac{(PG23^1)xm23 + (PG4)xm4}{xm23 + xm4}]$$

$$= (PG4 - PG23^1)(\frac{xm23}{xm23 + xm4})$$

$$= \Delta(\frac{xm23}{xm23 + xm4}) . \qquad (B-28)$$

At equilibrium $(rb_i - PG4) = Pg^b - PG4 = -\Pi$. Therefore (B-27) can be rewritten as:

$$\lambda 11_i = \frac{-\Pi - \lambda 9(-\Delta)\frac{xm23}{(xm23 + xm4)^2} + \lambda 10_4}{[\frac{\partial rb_i}{\partial xb_i}]}$$

$$= \frac{\Pi[\frac{\lambda 9}{(xm23 + xm4)} - 1] + \lambda 10_4}{[\frac{\partial rb_i}{\partial xb_i}]} . \qquad (B-29)$$

$\lambda 9$ is a shadow price of a weighted average revenue constraint for raw milk in manufactured use and negative. $\lambda 10_4$ is a shadow price for the cheese plant capacity and also negative. Hence the numerator of (B-29) is negative, and denominator is positive, yielding negative $\lambda 11_i$, which represents a subsidy received for raw milk moving to cheese plants.

The difference between shadow prices for cheese plant capacity and butter-powder capacity, $\lambda 10_4$ and $\lambda 12_{23}$ respectively, can be expressed in terms of average revenue of cheese and butter-powder. From (B-16):

$$\lambda 4 = \lambda 5 + \lambda 6 + \lambda 9 \Delta \frac{xm4}{(xm23 + xm4)^2} - \lambda 10_{23}$$

$$= \lambda 7 - \lambda 9 \Delta \frac{xm23}{(xm23 + xm4)^2} - \lambda 10_4.$$

Since $\lambda 5 = c^2 Pg2^o$, $\lambda 6 = c^3 Pg3^1$, and $\lambda 7 = c^4 Pg4^o$:

$$(\lambda 10_4 - \lambda 10_{23}) = (\lambda 7 - \lambda 5 - \lambda 6) - \lambda 9 \frac{\Delta}{(xm23 + xm4)}$$

$$= (c^4 Pg4^o - c^2 Pg2^o - c^3 Pg3^1) - \lambda 9 \frac{\Delta}{(xm23 + xm4)}$$

$$= (PG4 - PG23^1) - \lambda 9 \frac{\Delta}{(xm23 + xm4)} + (ac_4 - ac_{23})$$

$$= \Delta - \lambda 9 \frac{\Delta}{(xm23 + xm4)} + (ac_4 - ac_{23})$$

$$= \Delta (1 - \frac{\lambda 9}{xm23 + xm4}) + (ac_4 - ac_{23}). \qquad (B - 30)$$

Equation (B-30) reflects that the difference between $\lambda 10_4$ and $\lambda 10_{23}$ is represented by the difference of market average revenues between cheese and butter-powder, defined as Δ, times a proportional weight induced by a two price-system in the manufactured milk markets, defined as $[1 - \frac{\lambda 9}{(xm23 + xm4)}]$, where $\lambda 9$ represents a marginal effect on quantity associated with a weighted average revenue constraint, and the differnce beteeen processing costs of cheese and butter-powder.

APPENDIX C

MODEL PARAMETERS AND DATA COLLECTION

C.1. Introduction

In this appendix estimated elasticities and functional forms of demand and supply curves will be discussed. Numerous studies have estimated milk supply and demand functions and computed their elasticities.[67] This study does not estimate supply and demand functions on the grounds that the results are expected to be similar to those already estimated and estimating these functions may be considered another separate study in terms of its scope. It was decided instead that appropriate elasticities would be chosen from those already estimated and the functional forms in a price-quantity dimension would be developed based on these elasticities.

The study assumes that the United States dairy market is divided into nine regions. The price and quantity variables are developed for a nine-region 1982 annual model.[68] In order to establish the initial equilibrium prices and quantities in 1982, the study uses a secondary data and some simplified assumptions.[69]

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[67] For a complete list of those studies, refer to AAEA (1986).

[68] The most recent year during which the industry has operated without a diversion or dairy termination program was 1982.

[69] Each assumption will be discussed in appropriate sections in this appendix.

C.2. Model Parameters

C.2.1. Elasticities

C.2.1.1. Supply

In his recent study on the U.S. milk production factors, Buxton (1985) estimated long-run (four years) and short run (one year) price elasticities of both Grade A and B milk supplies in nine-regions, consisting of 48 states of the United States. Buxton estimated annual milk marketings for years 1951 through 1982 as functions of all milk prices, corn price, beef cattle price, alfalfa hay price, unemployment rate, and time. The corn price variable was replaced by the 16-percent dairy ration price variable in six Northeastern States and Nevada where no corn price was available. All milk prices are weighted average of prices for the current year, employing the lags of 1,2 and 3 years. A time variable was statistically significant. This may imply that the structure of milk supply has been changing gradually either through tenological change and/or other reasons such as the positive effect of the stability induced by government programs.

The long-run estimated elasticities of supply functions in the 48 states are shown in table C-1. It is assumed that the elasticities of Grade A and B milk supply functions are the same. Following the procedure of Ippolito and Masson (p. 53) the long-run supply elasticities of milk output will be used to estimate the supply curves for the study.

C.2.1.2. Demand

Fluid Demand

The elasticities of fluid demand functions estimated by Boehm are used in this study. In his estimation, Boehm used quarterly data for 1966-1975 in 22 Standard Metropolitan Statistical Areas (SMSA) to estimate the per capita demand for fluid milk. According to Boehm, a weighted average of whole fluid milk composite demand was developed as a function of its own composite retail

Table C.1. Long-Run Supply Elasticities of Milk Production in 48 States, U.S.

Region and State	Long-Run Elasticity	Period	Region and State	Long-Run Elasticity	Period
Northeast	0.495		South Central	0.679	
Ohio	–[a]	68-82	Alabama	.609	60-82
Pennsylvania	.588	68-82	Arkansas	.960	60-82
Rhode Island	.327	68-82	Louisiana	.523	60-82
Vermont	.518	68-82	Mississippi	.517	68-82
Virginia	1.164	68-82	Oklahoma	.544	51-82
West Virginia	.160	68-82	Tennessee	.790	68-82
Conneticut	-1.302[a]	68-82	Texas	.710	51-82
Delaware	.382	68-82	Mountain States	0.466	
Maine	.523	68-82	Colorado	.527	68-82
Maryland	.119	68-82	Montana	.320	60-82
Masschusetts	.380[a]	68-82	Nevada	.657	68-82
New Hampshire	.131[a]	68-82	Utah	.510	68-82
New Jersey	.961	68-82	Wyoming	.218[a]	51-82
New York	.629	68-82	Southwest	0.289	
Corn Belt	0.428		Arizona	.752	51-82
Illinois	.558	68-82	California	.222	51-82
Indiana	.771	68-82	New Mexico	1.329	51-82
Iowa	.220[a]	68-82	Northwest	0.384	
Kentucky	1.161	68-82	Idaho	.304	51-82
Michigan	.277	68-82	Oregon	.377	51-82
Missouri	.172	51-82	Washington	.448	51-82
Lake States	0.575				
Minnesota	.210	68-82			
Wisconsin	.748	68-82			
South East	0.714				
Florida	1.003	60-82			
Georgia	.691	68-82			
North Carolina	.439	68-82			
South Carolina	.639	68-82			
Plains	0.596				
Kansas	1.159	68-82			
Nebraska	.225	60-82			
South Dakota	.496	68-82			
North Dakota	.528	60-82			
UNITED STATES	.510[b]				

[a] Not significant at the 80 percent level of confidence.
[b] Based on States with significant coefficients at 80 percent.

Source: Buxton (1985), pp. 12-3.

price, the retail prices of frozen concentrated orange juice and coffee, a retail price index for a non-dairy food bundle, average per capita income, and demographic and seasonal variables.

Because of high cross-sectional and seasonal correlations among observations, Boehm utilized a generalized least square method to estimate coefficients in the regression. The estimated elasticities of own price and income are shown in table C-2. Based on Boehm's estimation, it is assumed that the fluid consumption is affected little by income change in the U.S.

Manufactured Milk Demand

The elasticities of demand for butter, nonfat dry milk and other, and cheese estimated by Huang are used in this study. He estimated a demand matrix for 40 food items and 1 non-food item utilizing annual data for 1953-1983. Using a constrained maximum likelihood method incorporating into estimation the parameteric restrictions derived from demand theory such as homogeneity condition, symmetry, Cournot and Engel aggregations, he directly estimated a complete demand system.

Direct and cross elasticities at the retail level of selected dairy products are shown in table C-3. The last column in table C-3 represents the income elasticity of each selected dairy product. Direct elasticity of cheese was -0.3319 while cross elasticities with respect to nonfat dry milk, and butter were -0.0675 and -0.2409 respectively. Income elasticity of cheese was 0.5927. Direct elasticity of nonfat dry milk was relatively elastic at -0.8255 while cross elasticities were -0.1395 and 0.0877 with respect to cheese and butter respectively. Income elasticity of nofat dry milk was -0.2664. Direct elasticity of butter was -0.1670 and cross elasticities with respect to cheese, and nonfat dry milk were -0.4609 and 0.0803 respectively. Income elasticity of butter was 0.0227. According to Huang, direct elasticity of nonfat dry milk was only significantly different from zero. Income elasticity of cheese was only significantly different from zero.

Based on the given standard errors of estimated elasticities, it is likely that only cheese and butter are complementary to each other. This implies that if either cheese or butter price drops, the demand for butter or cheese will significantly increase. If both prices drop together, then the effects on changes in demand for cheese and butter will be greater than the effects of changes in own prices. Cross elasticities other than butter and cheese were not significantly different from zero. Since this

Table C.2. Own Price and Income Elasticities for SMSA Consumption units, 1966-1975

SMSA Unit	Own Price Elasticity	Average Income Elasticity
Baltimore, MD	- .147	.073
Boston, MA	- .107	.063
Buffalo, NY	- .132	.068
Cleveland, OH	- .104	.070
New York, NY	- .136	.088
Philadelphia, PA	- .147	.077
Pittsburg, PA	- .121	.063
Washington, D.C.	- .147	.089
Chicago, IL	-. 115	.074
Cincinnati, OH	- .112	.061
Detroit, MI	- .099	.068
St. Louis, MO	- .120	.068
Milwaukee, WI	- .099	.066
Minneapolis-St. Paul, MN	- .073	.056
Atlanta, GA	- .185	.089
Dallas, TX	- .154	.081
Houston, TX	- .169	.081
Kansas City, MO	- .129	.074
San Francisco, CA	- .108	.082
Los Angeles, CA	- .113	.081
San Diego, CA	- .119	.072
Seattle, WA	- .113	.067
U.S. Average	- .122	.073

Source: Boehm; Table 8, p. 41.

Table C.3. Direct, Cross and Income Elasticities of Selected Dairy Products, U.S., Retail Demand

price / quantity	Fluid Milk	Cheese	Nonfat Dry Milk and Other	Butter	Income
Fluid Milk	-0.2588	0.1026	0.0743	0.0020	-0.0029
	(.1205)	(.0240)	(.0411)	(.0250)	(.0686)
Cheese	0.4531	-0.3319	-0.0675	-0.2409	0.5927
	(.1088)	(.1174)	(.0479)	(.0577)	(.1197)
Nonfat Dry Milk and Other	0.7125	-0.1395	-0.8255	0.0877	-0.2664
	(.3939)	(.1010)	(.2642)	(.1134)	(.2230)
Butter	0.0138	-0.4609	0.0803	-0.1670	0.0227
	(.1787)	(.1109)	(.1033)	(.1748)	(.1915)
Expenditure Weight	0.0156	0.0034	0.0016	0.0018	0.0224

Note: The figures in parentheses are the standard errors of estimated elasticities.

Source: Huang (1985), pp. 46-51.

study analyzes the dairy industry with an annual model, the income effect is not considered and treated as zero.

C.3. Regions

The United States is divided into nine regions (table C-4 and figure C-1) and each region is treated as a federal milk marketing order.

The regions are almost identical to those defined by the USDA, Agricultural Marketing Service (AMS) in reporting regionally aggregated federal milk marketing order statistics. Since the study is assumed to include all milk marketed, a slight modification in the definition of regions was made. For regions not regulated by the federal order, it was assumed that all milk is consumed in the region where it is produced. Due to a large volume of production, California is treated as a region by itself.[70]

C.4. Supply

The regional supply functions of Grade A and Grade B milk in the model are specified by utilizing actual prices and quantities for 1982, and selected estimated long-run elasticities of supply functions.

C.4.1. Supply Quantities

The aggregation procedure for regional supply is separated into Grade A and Grade B milk.

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[70] California is under a state milk marketing order.

Table C.4. Production and Consumption Regions[a] of U.S. Dairy Industry

No.	Regions	States [b]
1.	Northeast(NE)	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia (13)
2.	East Northcentral (EN)	Illinois, Indiana, Michigan, Ohio, Wisconsin (5)
3.	West Northcentral (WN)	Iowa, Kansas, Minnesota, Missouri, Nebraska, North-Dakota, South Dakota (7)
4.	South Atlantic (SA)	Florida, Georgia, North-Carolina, South Carolina, Alabama (5)
5.	East Southcentral (ES)	Kentucky, Tennessee (2)
6.	West Southcentral (WS)	Arkansas, Louisiana, Mississippi, Oklahoma, Texas (5)
7.	Mountain (MN)	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming (8)
8.	Southwest (SW)	California (1)
9.	Northwest (NW)	Oregon, Washington (2)

[a] Due to a transportation restriction, Hawaii and Alaska are not included.

[b] Numbers in parentheses are total numbers of states categorized in each region.

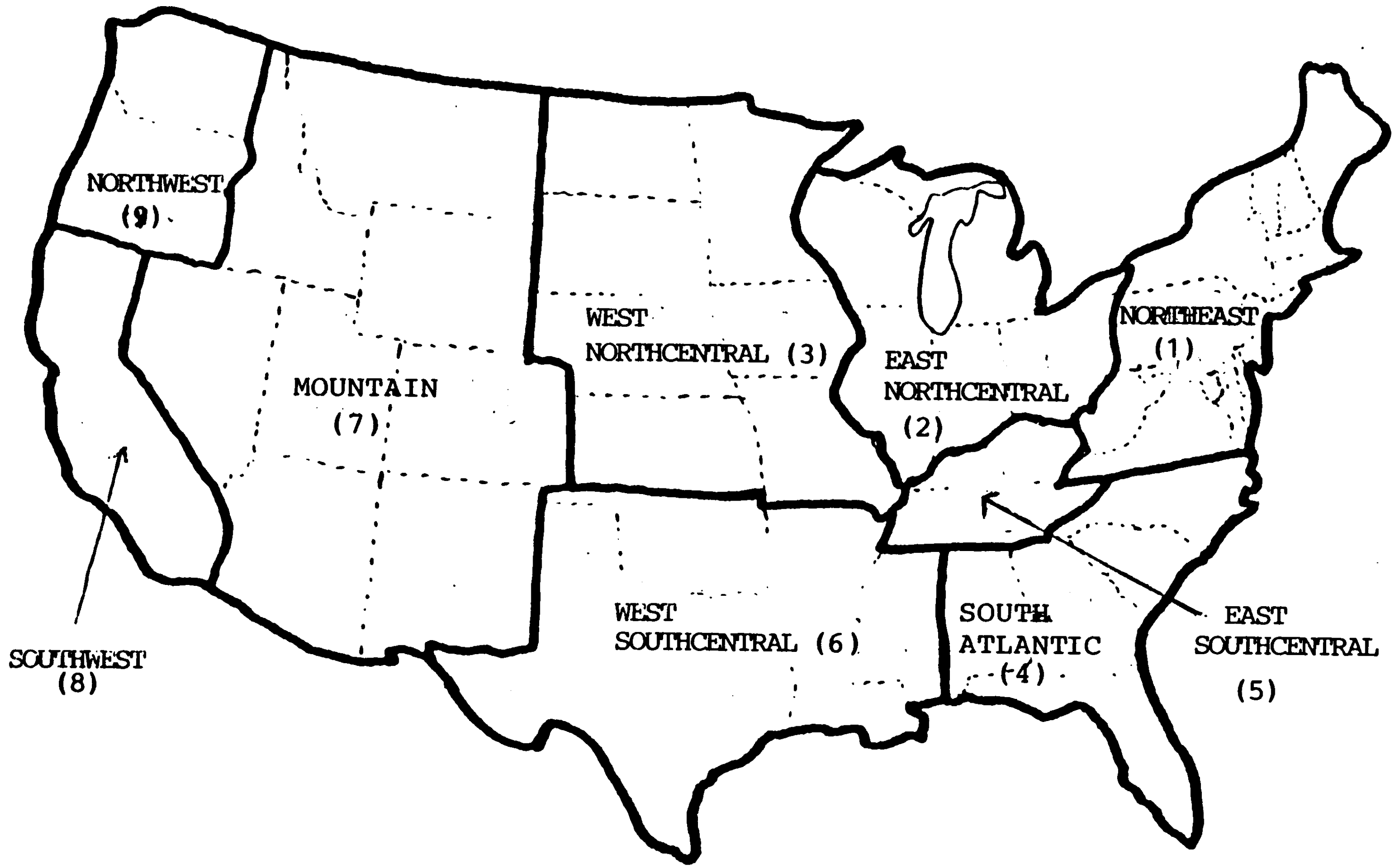

Figure C.1. Production and Consumption Regions of U.S. Dairy Industry

Table C.5. National and Regional Grade A Milk Marketings, 1982

Region	Grade A Marketings	Milk Deliveries to Handlers Regulated By		Federal Order Producer Deliveries	Total Supplied[b]	Net Export[c]
		Federal	State[a]			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
(billion pounds milk equivalent)						
Northeast	29.014	24.704	4.310	22.386	24.899 [e]	4.115
E. Northcentral	29.871	29.384	.487	28.380	28.867	1.004
W. Northcentral	14.385	13.740	.645	16.973	17.618	-3.233
South Atlantic	6.176	4.208	1.968	5.191 [d]	8.955 [f]	-2.779
E. Southcentral	3.837	3.670	.167	2.307	2.474	1.363
W. Southcentral	7.289	7.060	.229	7.971	8.200	- .911
Mountain	5.269	4.603	.666	4.420	5.086	.183
Southwest	13.887	.077	13.810	-	13.810	-
Northwest	4.318	4.135	.183	4.254	4.437	- .119
Total	114.046	91.582	22.465	91.882	114.346	

a Milk deliveries to handlers regulated by state is calculated by subtracting milk deliveries to handlers by federal from Grade A milk marketed.

b Total Grade A milk supplied is calulated as the sum of federal order producer deliveries and milk deliveries regulated by state. The exceptions are the Northeast and South Atlantic regions where state regulated shipments are accounted for.

c Quantity of Grade A milk net exported is calculated as the difference between Grade A milk marketed and total Grade A milk supplied.

d Reported data for Alabama-West Florida area for 1982 are for May through December only. Annual figure for the region was adjusted proportionally.

e About 1.796 billion pounds of state regulated Grade A milk was exported to the South Atlantic region.

f. About 1.796 billion pounds of state regulated Grade A milk was imported from the North East region.

Sources: USDA, SRS. Milk Production, Disposition, and Income: 1983 Summary. Da 1-2, 1984; p. 7 (for column i).

USDA, AMS. Federal Milk Order Market Statistics: 1984 Annual Summary. Statistical Bulletin No. 711, 1984; p. 17 and pp. 30-1 (for columns ii and iv)

North Carolina Milk Commission. North Carolina Dairy Report. Vol. 35, No. 1, 1983; table 8.

C.4.1.1. Grade A Milk

The quantity of Grade A milk supplied from each region was calculated by aggregating annual milk marketed for each group of states reported in Milk Production, Disposition, and Income (USDA, Statistical Reporting Service, 1983). These figures are shown in the first column (column i) of table C-5. From Federal Milk Order Market Statistics (USDA, Agricultural Marketing Service, 1984), milk deliveries to federally regulated plants by state of origin were obtained and they are shown in the second column (column ii) of table C-5. Therefore the differences between figures in the first column and the second column represents the milk quantity not federally regulated.[71] These figures are shown in the third column (column iii).

The demand for Grade A milk by processors in each region is reported as federal order producer deliveries in the fourth column (column iv) of table C-5. It was assumed that milk not federally regulated is consumed in the region of its production.[72] The total Grade A milk delivered in each region is the sum of federal order producer deliveries (column iv) and the state regulated milk marketed (column iii) except for the Northeast and South Atlantic regions. The quantity of net exports (column vi) is the difference between the federal order marketing (column i) and the total milk supplied (column v). The quantity of federal exports and imports are simply the difference between federal order deliveries into a region (column iv) and federal order shipments originating from a region (column ii). A discrepancy of 0.3 million pounds which exists is due to rounding errors.

C.4.1.2. Grade B milk

Quantities of Grade B milk marketed are aggregated from the milk marketed from the state in the region. The small amount of Grade B milk produced in Pennsylvania (NE), Virginia (NE), North Carolina (SA), and South Carolina (SA) are placed in adjacent regions. The amount of Grade B milk produced in Pennsylvania was placed in the East Northcentral (EN), and the others

[71] It is assumed that milk not federally regulated is regulated under a state milk marketing order.

[72] The exception is the milk moving from the Northeast to the South Atlantic region.

into the East Southcentral (ES). Grade A and Grade B milk marketed by region is shown in table C-6.

C.4.2. Supply Prices

The Grade A milk supply price, blend price, in each region is calculated using the blend price formula with a given Class II minimum price, Class I utilization rate, and Class I differential in each region. Since manufactured milk product markets are on the national level, the Grade B milk supply price is assumed to be the same throughout the nation. Furthermore, under current federal dairy programs, the Grade B milk supply price is expected to be at the same level as the CCC support price.

C.4.2.1. Grade A milk Supply (Blend) Price

The Class I utilization rate in each region is based on the Federal Milk Order Market Statistics and California State Statistics. The regional federal order Class I utilization rate was calculated as a weighted average. The Class I differential in each region was a weighted average of the federal order minimum Class I differentials plus the over-order premiums as reported in Dairy Market Statistics (1983). The derivation of regional blend prices are shown in table C-7.

C.4.2.2. Grade B milk Supply Price

It is assumed that the equilibrium Grade B milk supply price in 1982 was \$126.0 per thousandweight (twt) at an average milk fat test level throughout the nation.

C.4.3. Estimated Regional Milk Supply Functions

The long-run elasticities of Grade A milk supply in 48 states estimated by Buxton (1985) was averaged into nine regional supply elasticities (table C-8). Regional supply elasticities were calculated as a weighted average on the basis of milk production in each state in the region. To simulate all possible interregional shipments, supply quantities were assigned based on where the

Table C.6. National and Regional Total Milk Supply, 1982

Region	Grade A Marketed from	Grade A Delivered to	Grade B Delivered to	Total Milk Delivered
(billion pounds milk equivalent)				
Northeast	29.014	24.899	-[a]	24.899
E. Northcentral	29.871	28.867	7.486	36.353
W. Northcentral	14.385	17.618	8.304	25.922
South Atlantic	6.176	8.955	-[b]	8.955
E. Southcentral	3.837	2.474	.897	3.371
W. Southcentral	7.289	8.200	.207	8.407
Mountain	5.269	5.086	1.655	6.741
Southwest	13.887	13.810	.579	14.389
Northwest	4.318	4.437	.139	4.576
Total	114.046	114.346	19.267	133.613

[a] Grade B milk produced in Pennsylvania and Virginia was placed to East Northcentral and East Southcentral respectively.

[b] Grade B milk produced in North and South Carolina was placed to East Southcentral.

Sources: Table C-5.

USDA, SRS. Milk Production, Disposition, and Income: 1983 Summary. Da 1-2, 1984; p. 7.

Table C.7. Regional Grade A Milk Supply Prices, 1982

Region	Class I Utilization Rate	Class I Differential ($/twt)	Blend[a] Price ($/twt)
Northeast	.450	31.2	140.0
E. Northcentral	.391	24.1	135.4
W. Northcentral	.260	21.9	131.7
South Atlantic	.825	36.0	155.7
E. Southcentral	.682	28.6	144.6
W. Southcentral	.689	29.9	146.6
Mountain	.553	25.6	140.2
Southwest	.438	19.2	134.4
Northwest	.405	23.3	135.4

[a] The blend price is derived from the blend price formula

$$\tilde{Pb} = PII^{o} + D \times UR$$

where $\tilde{Pb}$ is a blend price; PII^{o} is a manufacturing or Class II minimum price; D is a Class I differential; and UR is a Class I utilization rate. The calculation of the blend price is based on PII^{o} of $ 126.0 per thousandweight (twt).

Sources: USDA, AMS. Federal Milk Market Order Statistics:1983 Annual Summary. Statistical Bulletin No. 711, 1984; pp. 30-1, p. 58, p. 64 and p. 68

USDA, AMS. Dairy Market Statistics; 1983 Annual Summary. 1984; pp. 44-6.

Table C.8. Regional Quantity, Price, and Elasticity of Grade A and Grade B Milk, 1982

Region	Grade A Milk			Grade B Milk		
	Price ($/twt)	Quantity (bil lbs)	Elasticity[a]	Price ($/twt)	Quantity (bil lbs)	Elasticity[b]
Northeast	140.0	29.014	.495	-	-	-
E. Northcentral	135.4	29.871	.658	126.0	7.486	.658
W. Northcentral	131.7	14.385	.325	126.0	8.304	.325
South Atlantic	155.7	6.176	.700	-	-	-
E. Southcentral	145.5	3.837	.985	126.0	.897	.985
W. Southcentral	146.6	7.289	.654	126.0	.207	.654
Mountain	140.2	5.269	.478	126.0	1.655	.478
Southwest	134.4	13.887	.222	126.0	.579	.222
Northwest	135.4	4.318	.424	126.0	.139	.424

[a] Elasticities were calculated as weighted averages based on proportions of milk production in each state in the region.

[b] Elasticities of Grade B milk supply were assumed to be the same as those of Grade A milk supply.

Sources: Tables C-1, 6, and 7.

milk was marketed from. The estimated parameters of Grade A and Grade B milk supply functions in nine regions are shown in table C-9.

C.5. Demand

The regional demand functions of fluid milk and manufactured milk products such as butter, nonfat dry milk, and cheese are specified by utilizing actual prices and quantities for 1982, and selected estimated elasticities of demand functions.

C.5.1. Fluid Milk

The regional fluid milk quantities demanded were derived by applying the weighted average Class I utilization rate to the quantity of Grade A milk supplied in each region (table C-10). It was assumed that the state regulated milk was utilized as federal order regulated milk. The minimum Class I and Class II prices were calculated using the national average manufacturing price, $126.0 per thousandweight (twt), and the weighted average of federal order Class I differentials (table C-11).

C.5.1.1. Estimated Regional Fluid Demand Functions

The study used the fluid demand elasticities derived from the regional retail estimates of Boehm. Utilizing data for the 1966-1975 period, Boehm estimated nine regional fluid demand functions based on economic, demographic, and seasonal variables in twenty two metro cities (see table C-2). Regional projections were made for 1975 through 1990. This study utilized the 1982 projection. An adjustment was made by using population proportions to match up elasticties in the regions defined in table C-4.

A national average marketing margin was used to derive the fluid demand functions at the plant level. The average gross margin for milk processors and distributors was estimated to be $8.53 per hundredweight in 1981 by Jones(pp. 2-3; 10). Assuming that the margin would increase by

Table C.9. Estimated Parameters of Grade A and Grade B Milk Supply Functions ($P = A\, Q^a$) in Nine Regions

	Values of Estimated Parameters			
	Grade A Milk		Grade B Milk	
Region	A	a	A	a
Northeast	.1553694606	2.020	-	-
E. Northcentral	.7755305171	1.520	5.9118661	1.520
W. Northcentral	.0360402763	3.077	.1869798	3.077
South Atlantic	11.5533456802	1.429	-	-
E. Southcentral	37.1516571045	1.015	140.7009277	1.015
W. Southcentral	7.0318622589	1.529	1400.5112304	1.529
Mountain	4.3336839676	2.092	43.9171905	2.092
Southwest	.0009583314	4.505	1477.0170898	4.505
Northwest	4.2984409332	2.358	13230.0351562	2.358

Source: Calculated applying regional quantities, prices, and elasticities reported in table C-8 to a functional form specified in the section . 5.1 in Chapter III (see equations III-50.a and 51.a).

Table C.10. Regional Utilization of Grade A Milk, 1982

Region	Grade A Milk Delivered (bil. lbs.)	Grade A Milk Utilized in Fluid Milk (bil. lbs.)	Class I Utilization (ratio)
Northeast	24.899	11.205	.450
E. Northcentral	28.867	11.287	.391
W. Northcentral	17.618	4.581	.260
South Atlantic	8.955	7.388	.825
E. Southcentral	2.474	1.613	.652
W. Southcentral	8.200	5.650	.689
Mountain	5.086	2.813	.553
Southwest	13.810	6.049	.438
Northwest	4.437	1.797	.405
U.S.	114.346	52.383	.458

Sources: Tables C-6 and 7.

Table C.11. Regional Class I, II Prices and Differentials, 1982

Region	Class I Price (i)	Class II Price (ii)	Differential (i-ii)
(dollars per thousandweight)			
Northeast	157.2	126.0	31.2
E. Northcentral	150.1	126.0	24.1
W. Northcentral	147.9	126.0	21.9
South Atlantic	162.0	126.0	36.0
E. Southcentral	154.6	126.0	28.6
W. Southcentral	155.9	126.0	29.9
Mountain	151.6	126.0	25.6
Southwest	145.2	126.0	19.2
Northwest	149.3	126.0	23.3

Source: Table C-7.

about the same amount as it did the previous year, it was assumed that the average marketing margin in 1982 was $8.87 per hundredweight. Retail and plant level elasticities are shown in table C-12. Regional fluid demand functions are shown in table C-13.

C.5.2. Manufactured Milk Products

There are two problems in relating the quantites of manufactured milk products to the quantities of raw milk in manufacturd use: (1) raw milk in manufactured use may be used for milk products other than butter-nonfat dry milk and cheese, and (2) nonfat dry milk production may be divided into human-food use and other uses. The trend in utilization of raw milk in butter-nonfat dry milk and cheese prodcts during 1981-1985 is shown in table C-14. Over the period, 62 to 66 percent of the raw milk was utilized in butter-nonfat dry milk and cheese production. About 34 percent of raw milk was distributed to cheese plants, and 28-32 percent to butter-nonfat dry milk plants. In 1982, 31.0 percent of total raw milk was utilized for butter-nonfat dry milk production, and 34.1 percent for cheese production, totaling 65.1 percent for both purposes. It was assumed that the rest of the milk is used in other products and is treated as a residual.

The supply and demand situation for butter, nonfat dry milk, and cheese in 1982 is shown in table C-15. In 1982, about 1,194 million pounds of butter was produced from raw milk in manufactured use and 3.0 million pounds was imported. Beginning stocks were 429 million pounds and ending stocks were 467 million pounds, accumulating 38 million pounds at the end of the year. Out of 1,084 million pounds of net butter supply, about 382 million pounds was purchased by the government in 1982.

The supply and demand situation for nonfat dry milk in 1982 was different from the situation for butter. In 1982, about 1,401 million pounds of nonfat dry milk for use in human-food was produced and only 2 million pounds was imported. The net supply of nonfat dry milk was about 1,396 million pounds. About 68 percent of net supply was purchased by the government, and 32 percent was utilized for commercial demands. The proportion of beginning and ending stocks to the net supply was approximately 64 percent. The amount of cheese production in 1982 was about 2,782 million pounds. About 18 million pounds of cheese were imported over that year. The net

Table C.12. Regional Fluid Demand Elasticities

Region	Retail Level		Plant Level[a]	
	Elasticity(E_R)	Price(P_R) ($/twt)	Elasticity(E_F)	Price(P_F) ($/twt)
Northeast	.193	245.9	.123	157.2
E. Northcentral	.187	238.8	.118	150.1
W. Northcentral	.194	236.6	.121	147.9
South Atlantic	.287	250.7	.185	162.0
E. Southcentral	.263	243.3	.167	154.6
W. Southcentral	.263	244.6	.168	155.9
Mountain	.190	240.3	.120	151.6
Southwest	.186	233.9	.115	145.2
Northwest	.204	238.0	.128	149.3

[a] $$E_F = E_R \left(\frac{P_F}{P_R} \right)$$

Source: Tables C-2 and 11.

Table C.13. Estimated Parameters of Fluid Demand Functions (P = a + bQ) in Nine Regions

Region	P ($/twt)	Q (bil lbs)	Elasticity	Estimated Parameters	
				a	b
Northeast	157.2	11.208	.123	1435.25	-114.03
E. Northcentral	150.1	11.287	.118	1422.13	-112.70
W. Northcentral	147.9	4.581	.121	1370.21	-266.82
South Atlantic	162.0	7.388	.185	1037.68	-118.53
E. Southcentral	154.6	1.613	.167	1080.35	-573.93
W. Southcentral	155.9	5.650	.168	1083.88	-164.24
Mountain	151.6	2.813	.120	1414.93	-449.11
Southwest	145.2	6.049	.115	1407.81	-208.73
Northwest	149.3	1.797	.128	1315.71	-649.09

Source: Calculated applying regional quantities, prices, and elasticities reported in tables C-10 and C-12 to a functional form specified in the section 5.2 in Chapter III (see equations III-52 and 53).

Table C.14. Utilization of Raw Milk in Butter-Nonfat Dry Milk and Cheese Products, 1981-1985

Year	Total Raw Milk in Manufactured Use (i)	Raw Milk Utilized in			Ratio	
		Nonfat Dry Milk and Butter (ii)	Cheese (iii)	Total (ii+iii)	$(\frac{ii}{i})$	$(\frac{iii}{i})$
(billion pounds milk equivalent)						
1981	77.9	24.6	26.2	50.8	.316	.336
1982	80.6	25.0	27.2	52.2	.310	.341
1983	84.0	25.8	29.3	55.1	.307	.349
1984	77.3	21.5	26.4	47.9	.278	.342
1985	83.5	24.4	28.6	53.0	.292	.343

Source: USDA, SRS. Milk Production, Disposition, and Income. 1982, 1984 and 1986; p. 12.

Table C.15. Net Supply and Demand for Butter, Nonfat Dry Milk, and Cheese, U.S., 1982

Item	Butter	Nonfat Dry Milk	Cheese
(million pounds)			
Beginning Stock	429.0	890.0	889.0
Ending Stock	467.0	897.2[b]	982.0
Net Stock	-38.0	- 7.2	-93.0
Import	3.0	2.0	18.0
Production	1,119.4[a]	1,401.0	2,752.3
Net Supply	1,084.4	1,395.8	2,677.3
Demand			
Government	382.0	948.1	642.5
Commercial	702.4[b]	447.7	2,034.8[b]
Total Demand	1,084.4	1,395.8	2,677.3

[a] Calculated from raw milk in butter use, 24,987 million pounds milk equivalent.

[b] Calculated as residuals and may not be equal to the reported numbers.

Sources: USDA, ERS. Dairy Situation and Outlook Yearbook. April 1986, Tables 16, 17 and 20.

USDA, SRS. Milk Production, Dispostion, and Income: 1984 Summary Milk Production Series. May 1985; p. 12.

supply of cheese was 2,707 million pounds and 76 percent of the net supply was utilized for commercial demands.

A couple of adjustments were made in table C-15 for the purpose of simulating the 1982 U.S. dairy model. The actual reported commercial disappearances of butter, nonfat dry milk, and cheese (table 11 in Dairy Situation and Outlook Yearbook, 1986) did not exactly fit the balanced net supply and demand shown in table C-15. Commercial demand for butter and cheese was clculated and the remainder was treated as a residual. The actual reported amount of commercial demand for butter and cheese was 897.3 and 2,166.8 million pounds respectively.[73] The calculated amount of commercial demand for nonfat dry milk in 1982 was unusually low at 62.9 million pounds while the reported demand was 447.7 million pounds. The reported amount of demanded nonfat dry milk in 1982 was used in this study based on the finding that the calulated amount of demand for nonfat dry milk fluctuated inconsistently relative to changes in the market price during the period of 1980-1985 (table C-16). Since there was not enough information about nonfat dry milk for use in nonhuman-food, the study assumed that the portion of nonfat dry milk consumed for other non-humand-food use was absorbed by an unknown demand at the same market price as nonfat dry milk for human-food purposes. The result of this assumption was that the model counted the producer surplus of all the raw milk in nonfat dry milk use as consumer surplus of nonfat dry milk, for human-food.

Other manufactured milk products were aggregated into one demand sector and treated as a residual. It was assumed that the other milk products are measured in milk equivalent terms and the demand function is known at the plant level. The estimated parameters of demand functions for manufactured milk products of butter, nonfat dry milk, and cheese, and other products are shown in table C-17.

[73] The calculated quantity of the commercial demand for butter does not include the amount of butter processed from whey cream and other fluid milk products.

Table C.16. Comparison of Demand for Nonfat Dry Milk, Calculated and Reported, 1980-1985

Year	Calculated[a]	Reported	Price Index (1982=100)
(million pounds)			
1980	429.7	538.9	94.92
1981	162.7	464.1	99.96
1982	62.9	447.7	100.00
1983	317.0	459.9	100.04
1984	642.6	497.8	97.58
1985	689.4	435.0	90.23

[a] Calculated as a residual based from table 20 (p. 24) in Dairy Situation and Outlook Yearbook, USDA, April 1986.

Source: USDA, ERS. Dairy Situation and Outlook Yearbook. April, 1986; Tables 11 and 20.

Table C.17. Estimated Parameters of Manufactured Dairy Product Demand Functions (P = c + dQ)

Product	Price(P)[a]	Quantity(Q)	Elasticity	Estimated Parameters[b]	
				c	d
	-$/100 lbs-	-100 mil lbs-			
Butter	143.90	7.024	.167	1003.00	-122.31
Nonfat Dry Milk	90.69	4.477	.826	200.57	- 24.54
Cheese	134.65	20.640	.332	540.34	- 19.64
	- $/twt -	- bil lbs -			
Other Products	126.00	28.400	.352	483.95	- 12.60

a Prices(P) for butter, nonfat dry milk, and cheese are calculated based on the farm-level support price, $12.60 per hundredweight and the marketing margins.

b Estimated parameters are calculated applying prices, quantities, and elasticities to a functional form specified in the section 5.2 in Chapter III (see equations III-52 and 53).

Sources: USDA, ASCS. Commodity Fact Sheet. April 1986; Table 2.

Tables C-3 and 15.

C.6. *Processing Costs of Manufacturing Butter, Nonfat Dry Milk, and Cheese*

The cost of processing manufacturing raw milk into butter, nonfat dry milk, and cheese wea calculated based on the study by Ling. According to Ling (pp. 6-7), the average combined cost of manufacturing butter and nonfat dry milk at four sample cooperative plants for 1981-1982 was \$.0507 and \$.1069 per pound of butter and nonfat dry milk respectively. These costs are equivalent to \$.2271 and \$.8691 per cwt in milk equivalent terms respectively. Since butter and nonfat dry milk are joint products, the total average processing cost of manufacturing one hundredweight of raw milk into 4.48 pounds of butter and 8.13 pounds of nonfat dry milk was \$1.0962. The average combined costs of manufacturing cheese at five sample cooperative plants over the period was \$.0752 per pound of cheese or \$.7595 per cwt in milk equivalent terms (Ling, p. 3).

Assuming that these average processing costs of sample cooperative plants represent the average processing costs of butter-nonfat dry milk and cheese plants in the U.S., changing government purchase prices for butter, nonfat dry milk, and cheese will have various impacts on the distribution of raw milk to butter-nonfat dry milk and cheese plants. Comparisons of sampled average processing costs and 1982 CCC marketing margins are shown in table C-18.[74]

C.7. *Plant Capacities of Cheese, Butter, and Nonfat Dry Milk*

The average capacity utilization rates of cheese, butter, and powder plants between 1981-1982 were estimated by Ling based on data from five cheese and powder cooperative plants, and four butter cooperative plants. The simple 12-month average rates of utilization for cheese, butter, and powder plants were 91.6, 78.2, and 82.2 percent respectively (table C-19).
Cheese plant No. 4 operated with higher than 100 percent utilization each month over the period and plant No. 3 operated with a range of 92.4 and 123.4 percent yielding 103.1 percent as a

[74] The CCC adds CCC marketing margins to the support price (farm level) in order to calculate purchase prices (wholesale level) for butter, nonfat dry milk, and cheese (see table II-4).

Table C.18. Comparisons of Sample Processing Costs and CCC Marketing Margins, 1982

Product	Sample Processing Costs	CCC Marketing Margins
(dollars per hundredweight milk equivalent)		
Butter-Nonfat Dry Milk	1.0962	1.22
Cheese	.7595	1.00[a]

[a] Value of whey ($ .37) was subtracted from the CCC margin for cheese manufacturing.

Sources: Ling (1983), p. 3 and pp. 6-7.

USDA, ASCS. Commodity Fact Sheet. May 1983; Table 3.

Table C.19. Comparison of Rates of Capacity Utilization[a] of Cheese, Butter, and Nonfat Dry Milk Plants, 1981-1982

Plant No.	Cheese	Butter	Nonfat Dry Milk
(% of plant capacity)			
Plant # 1	83.8	78.7	82.4
Plant # 2	86.6	80.6	95.5
Plant # 3	100.0[b]	63.2	72.9
Plant # 4	100.0[b]	90.3	91.4
Plant # 5	87.5		69.0
Simple Average	91.6	78.2	82.2

[a] 12-month simple average rate of utilization.

[b] Reported over 100 percent.

Source: Ling (1983), Table 18, p. 23.

12-month average rate of utilization. In this study, the rate of utilization of both plants was adjusted to 100 percent as a maximum capacity.

A comparison of estimated maximum capacity of cheese, butter, and powder plants and actual production during 1980-1985 is presented in table C-20.
The estimated maximum plant capacities of cheese, butter, and powder were 3005.4 million pounds, 1607.4 million pounds, and 1702.9 million pounds, respectively. According to table C-20, each production level reached a peak in 1983. The ratio of the highest cheese production (1983) for recent five years to the maximum plant capacity in 1982 was 97.4 percent. The ratios of the highest butter and powder production (1983) to the maximum capacities in 1982 were about 80.8 and 82.3 percent respectively (table C-20).

C.8. Transportation Matrix

In this study, it was assumed that intraregional shipments of raw milk for fluid and manufactured purposes did not incur significant transportation costs from the modeling stand point. Only interregional transfers of Grade A milk for fluid purposes resulted in transportation costs that should be modeled. That is, interregional shipments of milk for manufactured use was not permitted. Since the U.S. market was divided into nine regions, each regional market is relatively large in terms of shipping and receiving points.

Based on economic and demographic facts such as demand concentration, potential deficit or surplus, and possible competition with adjacent points of alternative supply, origins and destinations of Grade A milk were selected as shown in table C-21 and figure C-2. The road-distance between two points was measured from the 1982 edition of the Rand McNally Road Atlas. Given that the average cost of hauling raw milk per truck ranges between \$.35 and \$.40 per cwt per hundred miles (McDowell, 1986b; p. 12), the transportation cost was assumed to be \$.35 per cwt per hundred miles. A set of a unit transporation costs between possible trade points is shown in the last column of table C-21.

Table C.20. Production of Cheese, Butter, and Nonfat Dry Milk 1980-1985

Year	Cheese	Butter	Nonfat Dry Milk
(million pounds)			
1980	2375.8 (.791)	1145.3 (.713)	1160.7 (.682)
1981	2642.3 (.879)	1228.2 (.764)	1314.3 (.772)
1982	2752.3 (.916)	1257.0 (.782)	1400.5 (.823)
1983	2927.7 (.974)	1299.2 (.808)	1499.9 (.881)
1984	2648.5 (.882)	1103.3 (.686)	1160.7 (.682)
1985	2854.4 (.950)	1247.8 (.777)	1390.0 (.816)
Estimated Maximum Capacity in 1982[a]	3005.4	1607.4	1702.9

[a] Calculated by dividing 1982 actual production by simple average rate of capacity utilization.

[b] The figures in parentheses are utilization rate based on the estimated maximum capacity in 1982.

Sources: Table C-19.
USDA, ERS. Dairy Situation and Outlook Yearbook. DS-406, July 1986, Table 1, p. 13.

Table C.21. Interregional Transportation Matrix

Code	Region From	Region To	Origin	Destination	Distance (miles)	Unit Transporation Cost ($/twt)[a]
A12	NE	EN	Syracuse(NY)	Cleveland(OH)	347	12.15
A14	NE	SA	Bristol (VA)	Atlanta (GA)	337	11.80
A15	NE	ES	Bristol (VA)	Memphis (TN)	481	16.84
A21	EN	NE	Cleveland(OH)	Syracuse (NY)	347	12.15
A23	EN	WN	Madison (WI)	Kansas City(MO)	479	16.77
A24	EN	SA	Cincinatti(OH)	Atlanta (GA)	483	16.91
A25	EN	ES	Louisville(KY)	Nashiville(TN)	174	6.09
A32	WN	EN	Des Moines(IO)	Indianapolis(IN)	479	16.77
A34	WN	SA	St. Luois (MO)	Atlanta (GA)	565	19.78
A35	WN	ES	Kansas City (MO)	Memphis (TN)	482	16.87
A36	WN	WS	Kansas City (MO)	Oklahoma City (OK)	345	12.08
A46	SA	ES	Atlanta(GA)	Jackson (MS)	399	13.97
A54	ES	SA	Knoxville(TN)	Atlanta (GA)	224	7.84
A56	ES	WS	Nashiville(TN)	Jackson (MS)	414	14.49
A65	WS	ES	Oklahoma (OK)	Memphis (TN)	476	16.66
A76	MN	WS	Las Cruces(NM)	Lubbock (TX)	360	12.60
A79	MN	NW	Ontario (ID)	Portland (OR)	376	13.16
A89	SW	NW	Red Bluff(CA)	Eugene (OR)	345	12.08
A97	NW	MN	Portland (OR)	Ontario (ID)	376	13.16
A98	NW	SW	Eugene (OR)	Red Bluff (CA)	345	12.08

[a] Calculated based on the average transportation cost of $ .35 per hundredweight per hundred miles.

Source: McDowell (1986 (b)), p. 12.
<u>Rand McNally Road Atlas</u>, 1982, p. 105.

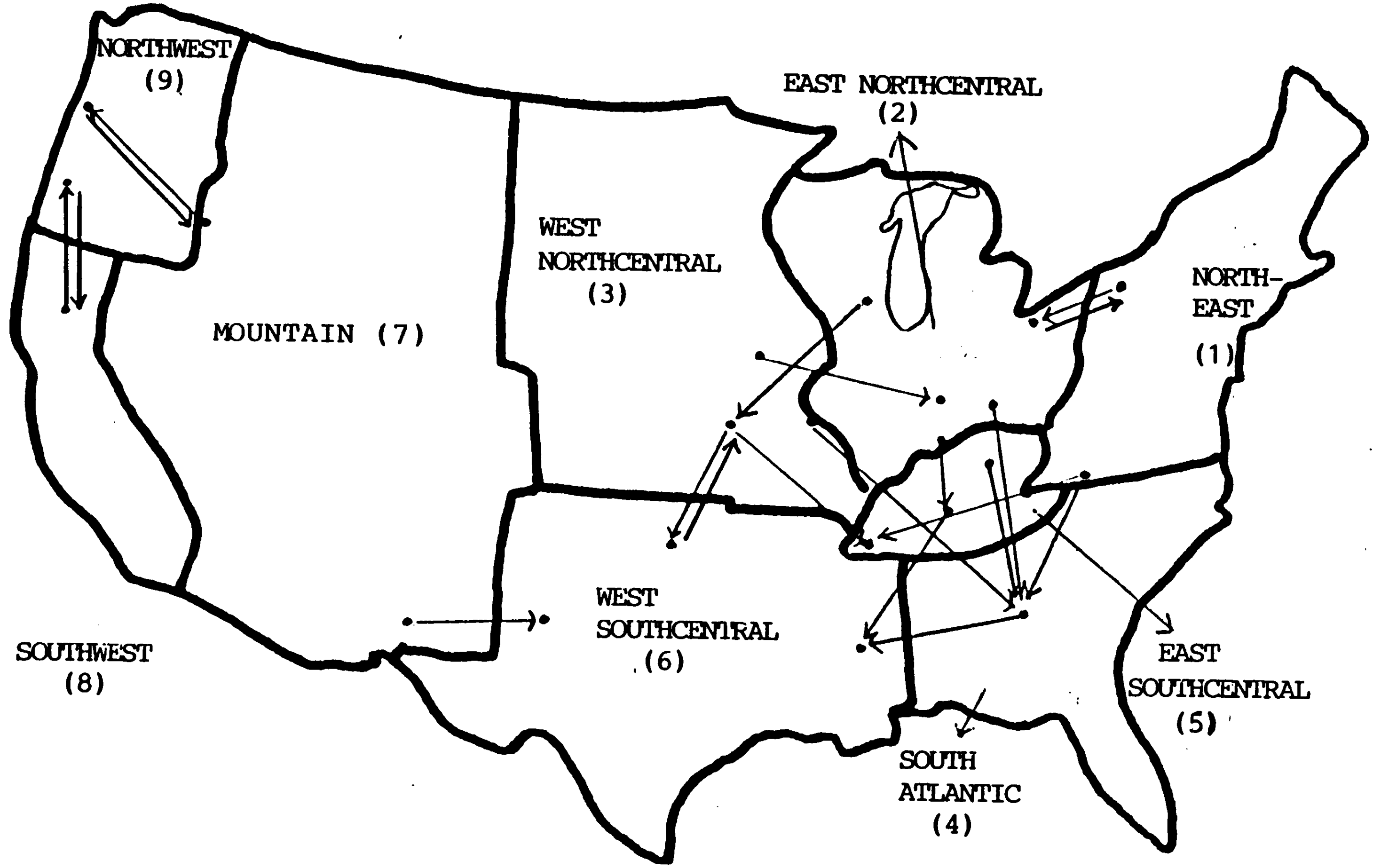

Figure C. 2. Interregional Transportation Mapping

APPENDIX D

SIMULATED MARKET RESULTS

In this appendix simulated market results of prices, quantities, transportation, and consumers/producers' surplus on a regional basis for each option are presented. Options applied for simulations were fully discussed in Chapters I and V. In each table, market results for Grade A, Grade B, and fluid milk are introduced on a regional basis in the upper two segments of the table. The top segment (with a heading GRADE A, GRADE B AND FLUID MILK MARKET) of the table shows regional prices and quantities of Grade A and Grade B milk supplies and fluid milk demand. The second segment (with a heading GRADE A, GRADE B AND FLUID MILK MARKET) from the top draws Grade A and Grade B milk producers' surplus and fluid milk consumers' surplus on a regional basis. The third segment (with a heading SHIPMENT) from the top shows quantities of Grade A milk transported for fluid purposes. The last segment (with a heading MANUFACTURED MILK MARKET) of the table introduces prices and quantities, government purchases or sales, and consumers' surplus for butter, cheese, nonfat dry milk, and other products. It also shows direct government expenditures in case that the government purchase exists.

Headings and lables used in the table are defined as follows:

(1) Headings used in the top segment of the table

OBS : Can be ignored

QA1 : Can be ignored

PA : Grade A milk supply (blend) price (dollars per thousandweight)

QA : Grade A milk supply quantity (billion pounds)

QB1 : Can be ignored

PB : Grade B milk supply price (dollars per thousandweight)

QB : Grade B milk supply quantity (billion pounds)

QF1 : Can be ignored

PF : Fluid milk price (dollars per thousandweight)

QF : Fluid milk quantity (billion pounds)

(2) Headings used in the second segment of the table

OBS : Can be ignored

PSA : Grade A milk producers' surplus (million dollars)

PSB : Grade B milk producers' surplus (million dollars)

PSSUM : Sum of PSA and PSB (million dollars)

CSF : Fluid milk consumers' surplus (million dollars)

SURPLUS : Sum of PSA, PSB and CSF (million dollars)

(3) Headings used in the third segment of the table

OBS : Can be ignored

CODE : Direction of milk shipment

SHIPMENT : Quantity of Grade A milk transported for fluid purposes (hundred million pounds)

(4) Headings used in the bottom segment of the table

OBS : Can be ignored

ITEM : Name of manufactured milk products

PM : Market price for manufactured milk products (dollars per hundred pounds)

QM : Market quantity of manufactured milk products (hundred million pounds)

QGD : Quantity of CCC purchases (hundred million pounds)

QGS : Quantity of CCC sales (hundred million pounds)

SURPLUS : Manufactured milk consumers' surplus (million dollarss)

PROGCOST : Direct government expenditures when the CCC buys excess supplies of milk products (million dollarss)

(5) Labels in REGION columns in the first, second and third segments of the table

1NE : Northeast

2EN : East Northcentral

3WN : West Northcentral

4SA : South Atlantic

5ES : East Southcentral

6WS : West Southcentral

7MN : Mountain

8SW : Southwest

9NW : Northwest

(6) Labels in CODE column in the third segment of the table

A14 : Direction of milk shipment from the Northeast to the South Atlantic

A25 : Direction of milk shipment from the East Northcentral to the East Southcentral

A36 : Direction of milk shipment from the West Northcentral to the West Southcentral

A54 : Direction of milk shipment from the East Southcentral to the South Atlantic

(7) Labels in ITEM column in the bottom segment of the table

BUTTER : Butter

CHEESE : Cheese

NONFAT : Nonfat dry milk

OTHER : Other manufactured milk products

Table D. 1. 1982 System With Support Price of $12.60/cwt

1982

GRADE A, GRADE B AND FLUID MILK MARKET 1

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	139.190	28.941		.	.	F1	157.2	11.2080
2	2EN	A2	135.810	29.912	B2	126	7.4830	F2	150.1	11.2869
3	3WN	A3	133.955	14.463	B3	126	8.3035	F3	147.9	4.5810
4	4SA	A4	149.740	6.055		.	.	F4	162.0	7.3881
5	5ES	A5	141.900	3.768	B5	126	0.8971	F5	154.6	1.6130
6	6WS	A6	146.035	7.271	B6	126	0.2070	F6	155.9	5.6500
7	7MN	A7	139.710	5.260	B7	126	1.6550	F7	151.6	2.8130
8	8SW	A8	134.365	13.882	B8	126	0.5790	F8	145.2	6.0490
9	9NW	A9	135.717	4.324	B9	126	0.1389	F9	149.3	1.7970
				=======			=======			=======
				113.826			19.2635			52.3860

GRADE A, GRADE B AND FLUID MILK MARKET 2

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2701.6	0.00	2701.6	7162.2	9863.8
2	2EN	2443.8	568.69	3012.4	7178.5	10191.0
3	3WN	1457.7	789.61	2247.3	2799.7	5047.0
4	4SA	527.6	0.00	527.6	3234.8	3762.4
5	5ES	268.5	56.94	325.4	746.6	1072.0
6	6WS	639.7	15.77	655.4	2621.5	3276.9
7	7MN	497.2	141.09	638.3	1776.9	2415.2
8	8SW	1526.4	59.70	1586.1	3818.8	5404.8
9	9NW	412.0	12.29	424.3	1048.0	1472.3
		=======	=======	=======	=======	=======
		10474.4	1644.10	12118.5	30386.9	42505.4

SHIPMENT 3

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.44083
2	2EN	A25	1.91189
3	3WN	A36	1.15827
4	5ES	A54	2.76635
			=======
			8.16037

MANUFACTURED MILK MARKET 4

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.0240	3.82025	.	3017.1	549.73
2	CHEESE	134.65	20.6395	6.13053	.	4186.5	825.48
3	NONFAT	90.69	4.4771	9.48086	.	245.9	859.82
4	OTHER	126.00	28.3997	.	.	5082.8	.
						=======	=======
						12532.3	2235.03

Table D. 2. 1985 Farm Bill System With Support Price of $12.60/cwt

1985 FARM BILL 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	140.705	29.096		.	.	F1	160.1	11.1826
2	2EN	A2	137.094	30.098	B2	126	7.4830	F2	152.4	11.2665
3	3WN	A3	135.342	14.512	B3	126	8.3035	F3	149.8	4.5739
4	4SA	A4	151.024	6.041		.	.	F4	170.4	7.3172
5	5ES	A5	143.184	3.802	B5	126	0.8971	F5	161.5	1.6010
6	6WS	A6	147.422	7.316	B6	126	0.2070	F6	164.9	5.5952
7	7MN	A7	140.460	5.274	B7	126	1.6550	F7	153.1	2.8096
8	8SW	A8	134.365	13.882	B8	126	0.5790	F8	145.2	6.0490
9	9NW	A9	135.717	4.324	B9	126	0.1389	F9	149.3	1.7970
				=======			=======			=======
				114.344			19.2635			52.1920

GRADE A, GRADE B AND FLUID MILK MARKET 2

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2738.3	0.00	2738.3	7129.7	9868.0
2	2EN	2488.7	568.69	3057.4	7152.6	10210.0
3	3WN	1482.3	789.61	2271.9	2791.0	5062.9
4	4SA	536.7	0.00	536.7	3173.0	3709.8
5	5ES	274.2	56.94	331.1	735.5	1066.6
6	6WS	652.0	15.77	667.8	2570.9	3238.7
7	7MN	501.1	141.09	642.2	1772.6	2414.9
8	8SW	1526.4	59.70	1586.1	3818.8	5404.8
9	9NW	412.0	12.29	424.3	1048.0	1472.3
		=======	=======	=======	=======	=======
		10611.8	1644.10	12255.9	30192.2	42448.1

SHIPMENT 3

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.1752
2	2EN	A25	3.2977
3	3WN	A36	2.8410
4	5ES	A54	3.7772
			=======
			13.0911

MANUFACTURED MILK MARKET 4

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.0240	3.82025	.	3017.1	549.73
2	CHEESE	134.65	20.6395	6.13053	.	4186.5	825.48
3	NONFAT	90.69	4.4771	9.48086	.	245.9	859.82
4	OTHER	126.00	28.3997	.	.	5082.8	.
						=======	=======
						12532.3	2235.03

Table D. 3. 1982 System With Support Price of $11.60/cwt, Option 1

82BASE WITH 0% FOR BUTTER AND 100% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	130.195	28.000		.	.	F1	147.2	11.2957
2	2EN	A2	126.961	28.615	B2	116	7.0868	F2	140.1	11.3756
3	3WN	A3	124.409	14.120	B3	116	8.0832	F3	137.9	4.6185
4	4SA	A4	140.891	5.755		.	.	F4	152.0	7.4725
5	5ES	A5	133.051	3.536	B5	116	0.8269	F5	144.6	1.6304
6	6WS	A6	136.489	6.956	B6	116	0.1961	F6	145.9	5.7109
7	7MN	A7	130.287	5.088	B7	116	1.5909	F7	141.6	2.8352
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				109.911			18.4865			52.8481

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2438.35	0.00	2438.3	7274.7	9713.0
2	2EN	2191.20	495.82	2687.0	7291.9	9978.9
3	3WN	1325.76	707.66	2033.4	2845.7	4879.1
4	4SA	476.85	0.00	476.8	3309.1	3785.9
5	5ES	237.00	48.32	285.3	762.8	1048.1
6	6WS	573.95	13.75	587.7	2678.3	3266.0
7	7MN	448.44	124.86	573.3	1805.1	2378.4
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9454.21	1455.29	10909.5	30913.1	41822.6

SHIPMENT 23:07 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.18046
2	2EN	A25	1.09051
3	3WN	A36	1.37620
4	5ES	A54	1.88087
			=======
			7.52804

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.1855	.	0.09877	3157.5	.
2	CHEESE	124.75	21.3319	7.97206	.	4472.1	994.51
3	NONFAT	78.39	5.0253	4.23012	.	309.8	331.60
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13310.1	1326.11

Table D. 4. 1982 System With Support Price of $10.60/cwt, Option 1

82BASE WITH 0% FOR BUTTER AND 100% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	120.491	26.946		.	.	F1	137.2	11.3834
2	2EN	A2	117.866	27.249	B2	106	6.6786	F2	130.1	11.4643
3	3WN	A3	114.882	13.759	B3	106	7.8498	F3	127.9	4.6560
4	4SA	A4	131.796	5.492		.	.	F4	142.0	7.5568
5	5ES	A5	123.956	3.298	B5	106	0.7566	F5	134.6	1.6478
6	6WS	A6	126.962	6.635	B6	106	0.1849	F6	135.9	5.7718
7	7MN	A7	120.921	4.909	B7	106	1.5238	F7	131.6	2.8575
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				105.746			17.6800			53.3103

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2171.55	0.00	2171.55	7388.1	9559.6
2	2EN	1937.06	426.97	2364.03	7406.1	9770.1
3	3WN	1192.94	627.97	1820.92	2892.1	4713.0
4	4SA	425.67	0.00	425.67	3384.2	3809.8
5	5ES	205.89	40.40	246.29	779.2	1025.5
6	6WS	509.19	11.85	521.04	2735.8	3256.8
7	7MN	401.61	109.28	510.89	1833.6	2344.5
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8434.90	1274.42	9709.32	31443.9	41153.3

SHIPMENT 23:09 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.44597
2	2EN	A25	1.95276
3	3WN	A36	1.59550
4	5ES	A54	2.61614
			=======
			8.61037

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.3471	.	3.04997	3301.1	.
2	CHEESE	114.85	22.0244	7.27963	.	4767.2	836.066
3	NONFAT	66.09	5.5722	0.19185	.	380.9	12.679
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14115.8	848.745

Table D.5. 1982 System With Support Price of $9.60/cwt, Option 1

82BASE WITH 0% FOR BUTTER AND 100% FOR POWDER 1
GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	111.225	25.899		.	.	F1	127.2	11.4711
2	2EN	A2	108.600	25.820	B2	96	6.2572	F2	120.1	11.5531
3	3WN	A3	105.380	13.378	B3	96	7.6011	F3	117.9	4.6934
4	4SA	A4	122.530	5.219		.	.	F4	132.0	7.6412
5	5ES	A5	114.690	3.055	B5	96	0.6862	F5	124.6	1.6653
6	6WS	A6	117.460	6.306	B6	96	0.1733	F6	125.9	5.8327
7	7MN	A7	111.622	4.725	B7	96	1.4533	F7	121.6	2.8798
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				101.455			16.8401			53.7725

82BASE WITH 0% FOR BUTTER AND 100% FOR POWDER 2
GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1926.72	0.00	1926.72	7502.4	9429.1
2	2EN	1691.19	362.32	2053.51	7521.1	9574.7
3	3WN	1064.01	550.72	1614.73	2938.8	4553.5
4	4SA	376.00	0.00	376.00	3460.2	3836.2
5	5ES	176.46	33.18	209.65	795.8	1005.4
6	6WS	447.77	10.06	457.82	2793.7	3251.6
7	7MN	356.81	94.39	451.20	1862.3	2313.5
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7462.56	1101.84	8564.40	31979.3	40543.6

SHIPMENT 23:11 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.39942
2	2EN	A25	2.25982
3	3WN	A36	1.81982
4	5ES	A54	2.75760
			=======
			9.23666

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.5086	.	6.07270	3447.9	.
2	CHEESE	104.95	22.7167	6.58731	.	5071.7	691.338
3	NONFAT	53.79	6.1195	.	3.93634	459.4	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						14949.4	691.338

Table D. 6. 1982 System With Support Price of $11.60/cwt, Option 2

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 1
GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	130.195	28.000		.	.	F1	147.2	11.2957
2	2EN	A2	126.961	28.615	B2	116	7.0868	F2	140.1	11.3756
3	3WN	A3	124.409	14.120	B3	116	8.0832	F3	137.9	4.6185
4	4SA	A4	140.891	5.755		.	.	F4	152.0	7.4725
5	5ES	A5	133.051	3.536	B5	116	0.8269	F5	144.6	1.6304
6	6WS	A6	136.489	6.956	B6	116	0.1961	F6	145.9	5.7109
7	7MN	A7	130.287	5.088	B7	116	1.5909	F7	141.6	2.8352
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				109.911			18.4865			52.8481

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 2
GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2438.35	0.00	2438.3	7274.7	9713.0
2	2EN	2191.20	495.82	2687.0	7291.9	9978.9
3	3WN	1325.76	707.66	2033.4	2845.7	4879.1
4	4SA	476.85	0.00	476.8	3309.1	3785.9
5	5ES	237.00	48.32	285.3	762.8	1048.1
6	6WS	573.95	13.75	587.7	2678.3	3266.0
7	7MN	448.44	124.86	573.3	1805.1	2378.4
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9454.21	1455.29	10909.5	30913.1	41822.6

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 3
SHIPMENT

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.18046
2	2EN	A25	1.09051
3	3WN	A36	1.37620
4	5ES	A54	1.88087
			=======
			7.52804

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 4
MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	132.74	7.3150	.	0.22828	3272.3	.
2	CHEESE	124.75	21.6229	7.68105	.	4595.0	958.21
3	NONFAT	84.54	4.7441	4.51131	.	276.1	381.39
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13514.1	1339.60

Table D.7. 1982 System With Support Price of $10.60/cwt, Option 2

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 1
GRADE A, GRADE B AND FLUID MILK MARKET
21:22 MONDAY, JULY 6, 1987

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	120.491	26.946		.	.	F1	137.2	11.3834
2	2EN	A2	117.866	27.249	B2	106	6.6786	F2	130.1	11.4643
3	3WN	A3	114.882	13.759	B3	106	7.8498	F3	127.9	4.6560
4	4SA	A4	131.796	5.492		.	.	F4	142.0	7.5568
5	5ES	A5	123.956	3.298	B5	106	0.7566	F5	134.6	1.6478
6	6WS	A6	126.962	6.635	B6	106	0.1849	F6	135.9	5.7718
7	7MN	A7	120.921	4.909	B7	106	1.5238	F7	131.6	2.8575
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				105.746			17.6800			53.3103

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 2
GRADE A, GRADE B AND FLUID MILK MARKET
21:22 MONDAY, JULY 6, 1987

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2171.55	0.00	2171.55	7388.1	9559.6
2	2EN	1937.06	426.97	2364.03	7406.1	9770.1
3	3WN	1192.94	627.97	1820.92	2892.1	4713.0
4	4SA	425.67	0.00	425.67	3384.2	3809.8
5	5ES	205.89	40.40	246.29	779.2	1025.5
6	6WS	509.19	11.85	521.04	2735.8	3256.8
7	7MN	401.61	109.28	510.89	1833.6	2344.5
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8434.90	1274.42	9709.32	31443.9	41153.3

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 3
SHIPMENT 21:22 MONDAY, JULY 6, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.44597
2	2EN	A25	1.95276
3	3WN	A36	1.59550
4	5ES	A54	2.61614
			=======
			8.61037

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 4
MANUFACTURED MILK MARKET
21:22 MONDAY, JULY 6, 1987

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	121.58	7.6060	.	2.21596	3537.9	.
2	CHEESE	114.85	22.6063	4.2337	.	5022.4	486.240
3	NONFAT	78.39	5.0102	2.1217	.	308.0	166.320
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14534.9	652.561

Table D.8. 1982 System With Support Price of $9.60/cwt, Option 2

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	111.023	25.876		.	.	F1	127.2	11.4711
2	2EN	A2	108.699	25.836	B2	96	6.2572	F2	120.1	11.5531
3	3WN	A3	105.380	13.378	B3	96	7.6011	F3	117.9	4.6934
4	4SA	A4	122.629	5.222		.	.	F4	132.0	7.6412
5	5ES	A5	114.789	3.058	B5	96	0.6862	F5	124.6	1.6653
6	6WS	A6	117.460	6.306	B6	96	0.1733	F6	125.9	5.8327
7	7MN	A7	111.622	4.725	B7	96	1.4533	F7	121.6	2.8798
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				101.453			16.8401			53.7725

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 2

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1921.47	0.00	1921.47	7502.4	9423.8
2	2EN	1693.77	362.32	2056.08	7521.1	9577.2
3	3WN	1064.01	550.72	1614.73	2938.8	4553.5
4	4SA	376.52	0.00	376.52	3460.2	3836.7
5	5ES	176.77	33.18	209.95	795.8	1005.7
6	6WS	447.77	10.06	457.82	2793.7	3251.6
7	7MN	356.81	94.39	451.20	1862.3	2313.5
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7460.71	1101.84	8562.55	31979.3	40541.8

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 3

SHIPMENT

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.05812
2	2EN	A25	2.54374
3	3WN	A36	1.81982
4	5ES	A54	3.05765
			=======
			9.47933

82BASE WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER (RB=0.5) 4

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	110.42	7.8971	.	5.36921	3813.8	.
2	CHEESE	104.95	23.5898	3.25022	.	5468.9	341.111
3	NONFAT	72.24	5.2763	.	1.72656	341.5	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						15594.8	341.111

Table D.9. 1982 System With Support Price of $11.60/cwt, Option 3

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 1
GRADE A, GRADE B AND FLUID MILK MARKET
22:11 MONDAY, JULY 20, 1987

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	130.195	28.000		.	.	F1	147.2	11.2957
2	2EN	A2	126.961	28.615	B2	116	7.0868	F2	140.1	11.3756
3	3WN	A3	124.409	14.120	B3	116	8.0832	F3	137.9	4.6185
4	4SA	A4	140.891	5.755		.	.	F4	152.0	7.4725
5	5ES	A5	133.051	3.536	B5	116	0.8269	F5	144.6	1.6304
6	6WS	A6	136.489	6.956	B6	116	0.1961	F6	145.9	5.7109
7	7MN	A7	130.287	5.088	B7	116	1.5909	F7	141.6	2.8352
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				109.911			18.4865			52.8481

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 2
GRADE A, GRADE B AND FLUID MILK MARKET
22:11 MONDAY, JULY 20, 1987

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2438.35	0.00	2438.3	7274.7	9713.0
2	2EN	2191.20	495.82	2687.0	7291.9	9978.9
3	3WN	1325.76	707.66	2033.4	2845.7	4879.1
4	4SA	476.85	0.00	476.8	3309.1	3785.9
5	5ES	237.00	48.32	285.3	762.8	1048.1
6	6WS	573.95	13.75	587.7	2678.3	3266.0
7	7MN	448.44	124.86	573.3	1805.1	2378.4
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9454.21	1455.29	10909.5	30913.1	41822.6

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 3
SHIPMENT 22:11 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.18046
2	2EN	A25	1.09051
3	3WN	A36	1.37620
4	5ES	A54	1.88087
			=======
			7.52804

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 4
MANUFACTURED MILK MARKET
22:11 MONDAY, JULY 20, 1987

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	140.33	7.2270	.	0.14022	3194.0	.
2	CHEESE	124.75	21.4250	7.87896	.	4511.3	982.90
3	NONFAT	80.36	4.9352	4.32018	.	298.8	347.17
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13374.8	1330.07

Table D. 10. 1982 System With Support Price of $10.60/cwt, Option 3

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 1
GRADE A, GRADE B AND FLUID MILK MARKET
22:15 MONDAY, JULY 20, 1987

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	120.491	26.946		.	.	F1	137.2	11.3834
2	2EN	A2	117.866	27.249	B2	106	6.6786	F2	130.1	11.4643
3	3WN	A3	114.882	13.759	B3	106	7.8498	F3	127.9	4.6560
4	4SA	A4	131.796	5.492		.	.	F4	142.0	7.5568
5	5ES	A5	123.956	3.298	B5	106	0.7566	F5	134.6	1.6478
6	6WS	A6	126.962	6.635	B6	106	0.1849	F6	135.9	5.7718
7	7MN	A7	120.921	4.909	B7	106	1.5238	F7	131.6	2.8575
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				105.746			17.6800			53.3103

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 2
GRADE A, GRADE B AND FLUID MILK MARKET
22:15 MONDAY, JULY 20, 1987

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2171.55	0.00	2171.55	7388.1	9559.6
2	2EN	1937.06	426.97	2364.03	7406.1	9770.1
3	3WN	1192.94	627.97	1820.92	2892.1	4713.0
4	4SA	425.67	0.00	425.67	3384.2	3809.8
5	5ES	205.89	40.40	246.29	779.2	1025.5
6	6WS	509.19	11.85	521.04	2735.8	3256.8
7	7MN	401.61	109.28	510.89	1833.6	2344.5
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8434.90	1274.42	9709.32	31443.9	41153.3

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 3
SHIPMENT 22:15 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.44597
2	2EN	A25	1.95276
3	3WN	A36	1.59550
4	5ES	A54	2.61614
			=======
			8.61037

82BASE WITH 16% FOR BUTTER AND 84% FOR POWDER 4
MANUFACTURED MILK MARKET
22:15 MONDAY, JULY 20, 1987

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	136.76	7.5168	.	3.2197	3455.4	.
2	CHEESE	114.85	22.3515	6.95254	.	4909.8	798.499
3	NONFAT	70.03	5.4104	0.35364	.	359.1	24.765
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14390.9	823.265

Table D.11. 1982 System With Support Price of $9.60/cwt, Option 3

82BASE WITH 16% FOR BUTTER AND 84 % FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	111.023	25.876		.	.	F1	127.2	11.4711
2	2EN	A2	108.699	25.836	B2	96	6.2572	F2	120.1	11.5531
3	3WN	A3	105.380	13.378	B3	96	7.6011	F3	117.9	4.6934
4	4SA	A4	122.629	5.222		.	.	F4	132.0	7.6412
5	5ES	A5	114.789	3.058	B5	96	0.6862	F5	124.6	1.6653
6	6WS	A6	117.460	6.306	B6	96	0.1733	F6	125.9	5.8327
7	7MN	A7	111.622	4.725	B7	96	1.4533	F7	121.6	2.8798
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				101.453			16.8401			53.7725

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1921.47	0.00	1921.47	7502.4	9423.8
2	2EN	1693.77	362.32	2056.08	7521.1	9577.2
3	3WN	1064.01	550.72	1614.73	2938.8	4553.5
4	4SA	376.52	0.00	376.52	3460.2	3836.7
5	5ES	176.77	33.18	209.95	795.8	1005.7
6	6WS	447.77	10.06	457.82	2793.7	3251.6
7	7MN	356.81	94.39	451.20	1862.3	2313.5
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7460.71	1101.84	8562.55	31979.3	40541.8

SHIPMENT 22:13 MONDAY, JULY 20, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.05812
2	2EN	A25	2.54374
3	3WN	A36	1.81982
4	5ES	A54	3.05765
			=======
			9.47933

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	133.19	7.6329	.	6.19799	3562.9	.
2	CHEESE	104.95	22.9960	6.30798	.	5197.1	662.023
3	NONFAT	59.69	5.8497	.	3.66782	419.8	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						15150.3	662.023

Table D. 12. 1985 Farm Bill System With Support Price of $11.60/cwt, Option 1

85 FARM BILL WITH 0% FOR BUTTER AND 100% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	131.283	28.115		.	.	F1	150.1	11.2703
2	2EN	A2	128.675	28.868	B2	116	7.0868	F2	142.4	11.3552
3	3WN	A3	126.193	14.186	B3	116	8.0832	F3	139.8	4.6113
4	4SA	A4	142.605	5.804		.	.	F4	160.4	7.4016
5	5ES	A5	134.765	3.581	B5	116	0.8269	F5	151.5	1.6184
6	6WS	A6	138.273	7.016	B6	116	0.1961	F6	154.9	5.6561
7	7MN	A7	131.064	5.102	B7	116	1.5909	F7	143.1	2.8319
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				110.513			18.4865			52.6541

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2468.72	0.00	2468.7	7242.0	9710.7
2	2EN	2240.45	495.82	2736.3	7265.7	10002.0
3	3WN	1351.03	707.66	2058.7	2836.9	4895.6
4	4SA	486.90	0.00	486.9	3246.6	3733.5
5	5ES	243.07	48.32	291.4	751.6	1043.0
6	6WS	586.40	13.75	600.2	2627.2	3227.3
7	7MN	452.38	124.86	577.2	1800.9	2378.1
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9591.63	1455.29	11046.9	30716.4	41763.3

SHIPMENT 0:16 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.9773
2	2EN	A25	3.0745
3	3WN	A36	2.8602
4	5ES	A54	3.5812
			=======
			12.4932

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.1855	0.25787	.	3157.5	37.11
2	CHEESE	124.75	21.3319	7.97206	.	4472.1	994.51
3	NONFAT	78.39	5.0253	4.67647	.	309.8	366.59
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13310.1	1398.21

Table D. 13. 1985 Farm Bill System With Support Price of $10.60/cwt, Option 1

85 FARM BILL WITH 0% FOR BUTTER AND 100% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	122.269	27.142		.	.	F1	140.1	11.3580
2	2EN	A2	119.308	27.468	B2	106	6.6786	F2	132.4	11.4439
3	3WN	A3	116.700	13.830	B3	106	7.8498	F3	129.8	4.6488
4	4SA	A4	133.238	5.534		.	.	F4	150.4	7.4860
5	5ES	A5	125.398	3.336	B5	106	0.7566	F5	141.5	1.6358
6	6WS	A6	128.780	6.697	B6	106	0.1849	F6	144.9	5.7170
7	7MN	A7	121.727	4.925	B7	106	1.5238	F7	133.1	2.8542
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				106.391			17.6800			53.1163

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2219.70	0.00	2219.70	7355.1	9574.8
2	2EN	1976.69	426.97	2403.66	7379.7	9783.4
3	3WN	1218.04	627.97	1846.02	2883.2	4729.2
4	4SA	433.75	0.00	433.75	3321.0	3754.7
5	5ES	210.69	40.40	251.09	767.9	1019.0
6	6WS	521.40	11.85	533.25	2684.1	3217.3
7	7MN	405.57	109.28	514.85	1829.3	2344.1
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8576.84	1274.42	9851.26	31245.3	41096.5

SHIPMENT 0:19 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.3415
2	2EN	A25	3.0049
3	3WN	A36	3.0630
4	5ES	A54	3.3359
			=======
			12.7452

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.3471	.	2.67437	3301.1	.
2	CHEESE	114.85	22.0244	7.27963	.	4767.2	836.066
3	NONFAT	66.09	5.5722	0.66193	.	380.9	43.747
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14115.8	879.812

Table D. 14. 1985 Farm Bill System With Support Price of $9.60/cwt, Option 1

85 FARM BILL WITH 0% FOR BUTTER AND 100 % FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	113.388	26.147		.	.	F1	130.1	11.4457
2	2EN	A2	109.966	26.034	B2	96	6.2572	F2	122.4	11.5326
3	3WN	A3	107.231	13.454	B3	96	7.6011	F3	119.8	4.6863
4	4SA	A4	123.896	5.260		.	.	F4	140.4	7.5703
5	5ES	A5	116.056	3.091	B5	96	0.6862	F5	131.5	1.6532
6	6WS	A6	119.311	6.371	B6	96	0.1733	F6	134.9	5.7779
7	7MN	A7	112.459	4.742	B7	96	1.4533	F7	123.1	2.8764
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				102.151			16.8401			53.5785

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1982.99	0.00	1982.99	7469.1	9452.1
2	2EN	1726.73	362.32	2089.04	7494.6	9583.7
3	3WN	1088.83	550.72	1639.55	2929.9	4569.4
4	4SA	383.24	0.00	383.24	3396.3	3779.5
5	5ES	180.68	33.18	213.86	784.3	998.2
6	6WS	459.47	10.06	469.52	2741.5	3211.0
7	7MN	360.77	94.39	455.17	1857.9	2313.1
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7606.31	1101.84	8708.15	31778.7	40486.9

SHIPMENT 0:21 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.7077
2	2EN	A25	2.9371
3	3WN	A36	3.2696
4	5ES	A54	3.0909
			=======
			13.0053

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	143.90	7.5086	.	5.67406	3447.9	.
2	CHEESE	104.95	22.7167	6.58731	.	5071.7	691.338
3	NONFAT	53.79	6.1195	.	3.43742	459.4	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						14949.4	691.338

Table D. 15. 1985 Farm Bill System With Support Price of $11.60/cwt, Option 2

85 FARM BILL WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	131.283	28.115		.	.	F1	150.1	11.2703
2	2EN	A2	128.675	28.868	B2	116	7.0868	F2	142.4	11.3552
3	3WN	A3	126.193	14.186	B3	116	8.0832	F3	139.8	4.6113
4	4SA	A4	142.605	5.804		.	.	F4	160.4	7.4016
5	5ES	A5	134.765	3.581	B5	116	0.8269	F5	151.5	1.6184
6	6WS	A6	138.273	7.016	B6	116	0.1961	F6	154.9	5.6561
7	7MN	A7	131.064	5.102	B7	116	1.5909	F7	143.1	2.8319
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				110.513			18.4865			52.6541

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2468.72	0.00	2468.7	7242.0	9710.7
2	2EN	2240.45	495.82	2736.3	7265.7	10002.0
3	3WN	1351.03	707.66	2058.7	2836.9	4895.6
4	4SA	486.90	0.00	486.9	3246.6	3733.5
5	5ES	243.07	48.32	291.4	751.6	1043.0
6	6WS	586.40	13.75	600.2	2627.2	3227.3
7	7MN	452.38	124.86	577.2	1800.9	2378.1
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9591.63	1455.29	11046.9	30716.4	41763.3

SHIPMENT 1:16 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.9773
2	2EN	A25	3.0745
3	3WN	A36	2.8602
4	5ES	A54	3.5812
			=======
			12.4932

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	132.74	7.3150	0.12837	.	3272.3	17.04
2	CHEESE	124.75	21.6229	7.68105	.	4595.0	958.21
3	NONFAT	84.54	4.7441	4.95767	.	276.1	419.12
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13514.1	1394.37

Table D. 16. 1985 Farm Bill System With Support Price of $10.60/cwt, Option 2

85 FARM BILL WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	122.269	27.142		.	.	F1	140.1	11.3580
2	2EN	A2	119.308	27.468	B2	106	6.6786	F2	132.4	11.4439
3	3WN	A3	116.700	13.830	B3	106	7.8498	F3	129.8	4.6488
4	4SA	A4	133.238	5.534		.	.	F4	150.4	7.4860
5	5ES	A5	125.398	3.336	B5	106	0.7566	F5	141.5	1.6358
6	6WS	A6	128.780	6.697	B6	106	0.1849	F6	144.9	5.7170
7	7MN	A7	121.727	4.925	B7	106	1.5238	F7	133.1	2.8542
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				106.391			17.6800			53.1163

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2219.70	0.00	2219.70	7355.1	9574.8
2	2EN	1976.69	426.97	2403.66	7379.7	9783.4
3	3WN	1218.04	627.97	1846.02	2883.2	4729.2
4	4SA	433.75	0.00	433.75	3321.0	3754.7
5	5ES	210.69	40.40	251.09	767.9	1019.0
6	6WS	521.40	11.85	533.25	2684.1	3217.3
7	7MN	405.57	109.28	514.85	1829.3	2344.1
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8576.84	1274.42	9851.26	31245.3	41096.5

SHIPMENT 1:14 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.3415
2	2EN	A25	3.0049
3	3WN	A36	3.0630
4	5ES	A54	3.3359
			=======
			12.7452

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	121.58	7.6060	.	2.9333	3537.9	.
2	CHEESE	114.85	22.6063	6.69770	.	5022.4	769.231
3	NONFAT	78.39	5.0102	1.22392	.	308.0	95.943
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14534.9	865.174

Table D. 17. 1985 Farm Bill System With Support Price of $9.60/cwt, Option 2

85 FARM BILL WITH EQUAL SPLIT BETEEEN BUTTER AND POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	113.388	26.147		.	.	F1	130.1	11.4457
2	2EN	A2	109.966	26.034	B2	96	6.2572	F2	122.4	11.5326
3	3WN	A3	107.231	13.454	B3	96	7.6011	F3	119.8	4.6863
4	4SA	A4	123.896	5.260		.	.	F4	140.4	7.5703
5	5ES	A5	116.056	3.091	B5	96	0.6862	F5	131.5	1.6532
6	6WS	A6	119.311	6.371	B6	96	0.1733	F6	134.9	5.7779
7	7MN	A7	112.459	4.742	B7	96	1.4533	F7	123.1	2.8764
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				102.151			16.8401			53.5785

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1982.99	0.00	1982.99	7469.1	9452.1
2	2EN	1726.73	362.32	2089.04	7494.6	9583.7
3	3WN	1088.83	550.72	1639.55	2929.9	4569.4
4	4SA	383.24	0.00	383.24	3396.3	3779.5
5	5ES	180.68	33.18	213.86	784.3	998.2
6	6WS	459.47	10.06	469.52	2741.5	3211.0
7	7MN	360.77	94.39	455.17	1857.9	2313.1
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7606.31	1101.84	8708.15	31778.7	40486.9

SHIPMENT 1:12 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.7077
2	2EN	A25	2.9371
3	3WN	A36	3.2696
4	5ES	A54	3.0909
			=======
			13.0053

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	110.42	7.8971	.	6.06249	3813.8	.
2	CHEESE	104.95	23.5898	5.71422	.	5468.9	599.707
3	NONFAT	72.24	5.2763	.	2.59424	341.5	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						15594.8	599.707

Table D. 18. 1985 Farm Bill System With Support Price of $11.60/cwt, Option 3

85 FARM BILL WITH 16% FOR BUTTER AND 84% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	131.283	28.115		.	.	F1	150.1	11.2703
2	2EN	A2	128.675	28.868	B2	116	7.0868	F2	142.4	11.3552
3	3WN	A3	126.193	14.186	B3	116	8.0832	F3	139.8	4.6113
4	4SA	A4	142.605	5.804		.	.	F4	160.4	7.4016
5	5ES	A5	134.765	3.581	B5	116	0.8269	F5	151.5	1.6184
6	6WS	A6	138.273	7.016	B6	116	0.1961	F6	154.9	5.6561
7	7MN	A7	131.064	5.102	B7	116	1.5909	F7	143.1	2.8319
8	8SW	A8	124.574	13.650	B8	116	0.5685	F8	135.2	6.0969
9	9NW	A9	126.108	4.191	B9	116	0.1342	F9	139.3	1.8124
				=======			=======			=======
				110.513			18.4865			52.6541

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2468.72	0.00	2468.7	7242.0	9710.7
2	2EN	2240.45	495.82	2736.3	7265.7	10002.0
3	3WN	1351.03	707.66	2058.7	2836.9	4895.6
4	4SA	486.90	0.00	486.9	3246.6	3733.5
5	5ES	243.07	48.32	291.4	751.6	1043.0
6	6WS	586.40	13.75	600.2	2627.2	3227.3
7	7MN	452.38	124.86	577.2	1800.9	2378.1
8	8SW	1391.56	53.97	1445.5	3879.5	5325.0
9	9NW	371.11	10.93	382.0	1066.1	1448.1
		=======	=======	=======	=======	=======
		9591.63	1455.29	11046.9	30716.4	41763.3

SHIPMENT 1:54 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.9773
2	2EN	A25	3.0745
3	3WN	A36	2.8602
4	5ES	A54	3.5812
			=======
			12.4932

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	140.33	7.2270	0.21642	.	3194.0	30.37
2	CHEESE	124.75	21.4250	7.87896	.	4511.3	982.90
3	NONFAT	80.36	4.9352	4.76653	.	298.8	383.04
4	OTHER	116.00	29.1931	.	.	5370.7	.
						=======	=======
						13374.8	1396.31

Table D. 19. 1985 Farm Bill System With Support Price of $10.60/cwt, Option 3

85 FARM BILL WITH 16% FOR BUTTER AND 84% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	122.269	27.142		.	.	F1	140.1	11.3580
2	2EN	A2	119.308	27.468	B2	106	6.6786	F2	132.4	11.4439
3	3WN	A3	116.700	13.830	B3	106	7.8498	F3	129.8	4.6488
4	4SA	A4	133.238	5.534		.	.	F4	150.4	7.4860
5	5ES	A5	125.398	3.336	B5	106	0.7566	F5	141.5	1.6358
6	6WS	A6	128.780	6.697	B6	106	0.1849	F6	144.9	5.7170
7	7MN	A7	121.727	4.925	B7	106	1.5238	F7	133.1	2.8542
8	8SW	A8	114.800	13.405	B8	106	0.5572	F8	125.2	6.1448
9	9NW	A9	116.538	4.053	B9	106	0.1291	F9	129.3	1.8278
				=======			=======			=======
				106.391			17.6800			53.1163

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2219.70	0.00	2219.70	7355.1	9574.8
2	2EN	1976.69	426.97	2403.66	7379.7	9783.4
3	3WN	1218.04	627.97	1846.02	2883.2	4729.2
4	4SA	433.75	0.00	433.75	3321.0	3754.7
5	5ES	210.69	40.40	251.09	767.9	1019.0
6	6WS	521.40	11.85	533.25	2684.1	3217.3
7	7MN	405.57	109.28	514.85	1829.3	2344.1
8	8SW	1259.33	48.34	1307.67	3940.7	5248.4
9	9NW	331.66	9.61	341.27	1084.3	1425.5
		=======	=======	=======	=======	=======
		8576.84	1274.42	9851.26	31245.3	41096.5

SHIPMENT 1:56 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.3415
2	2EN	A25	3.0049
3	3WN	A36	3.0630
4	5ES	A54	3.3359
			=======
			12.7452

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	136.76	7.4299	.	2.75719	3375.9	.
2	CHEESE	114.85	22.2106	7.09342	.	4848.2	814.679
3	NONFAT	70.03	5.3925	0.84165	.	356.7	58.941
4	OTHER	106.00	29.9865	.	.	5666.6	.
						=======	=======
						14247.5	873.620

Table D. 20. 1985 Farm Bill System With Support Price of $9.60/cwt, Option 3

85 FARM BILL WITH 16% FOR BUTTER AND 84% FOR POWDER 1

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	113.388	26.147		.	.	F1	130.1	11.4457
2	2EN	A2	109.966	26.034	B2	96	6.2572	F2	122.4	11.5326
3	3WN	A3	107.231	13.454	B3	96	7.6011	F3	119.8	4.6863
4	4SA	A4	123.896	5.260		.	.	F4	140.4	7.5703
5	5ES	A5	116.056	3.091	B5	96	0.6862	F5	131.5	1.6532
6	6WS	A6	119.311	6.371	B6	96	0.1733	F6	134.9	5.7779
7	7MN	A7	112.459	4.742	B7	96	1.4533	F7	123.1	2.8764
8	8SW	A8	105.044	13.144	B8	96	0.5451	F8	115.2	6.1927
9	9NW	A9	107.016	3.909	B9	96	0.1238	F9	119.3	1.8432
				=======			=======			=======
				102.151			16.8401			53.5785

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	1982.99	0.00	1982.99	7469.1	9452.1
2	2EN	1726.73	362.32	2089.04	7494.6	9583.7
3	3WN	1088.83	550.72	1639.55	2929.9	4569.4
4	4SA	383.24	0.00	383.24	3396.3	3779.5
5	5ES	180.68	33.18	213.86	784.3	998.2
6	6WS	459.47	10.06	469.52	2741.5	3211.0
7	7MN	360.77	94.39	455.17	1857.9	2313.1
8	8SW	1129.85	42.82	1172.68	4002.4	5175.1
9	9NW	293.74	8.35	302.09	1102.6	1404.7
		=======	=======	=======	=======	=======
		7606.31	1101.84	8708.15	31778.7	40486.9

SHIPMENT 1:58 TUESDAY, JULY 21, 1987

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	3.7077
2	2EN	A25	2.9371
3	3WN	A36	3.2696
4	5ES	A54	3.0909
			=======
			13.0053

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	133.19	7.6329	.	5.79833	3562.9	.
2	CHEESE	104.95	22.9960	6.30798	.	5197.1	662.023
3	NONFAT	59.69	5.8497	.	3.16763	419.8	.
4	OTHER	96.00	30.7799	.	.	5970.5	.
						=======	=======
						15150.3	662.023

Table D.21. Zero CCC Purchase Levels of Butter and Nonfat Dry Milk : 1982 System

82BASE ZERO CCC PURCHASE BUTTER AND POWDER

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	122.790	27.200		.	.	F1	139.7	11.3615
2	2EN	A2	119.579	27.509	B2	108.5	6.7819	F2	132.6	11.4421
3	3WN	A3	117.262	13.851	B3	108.5	7.9095	F3	130.4	4.6466
4	4SA	A4	133.509	5.542		.	.	F4	144.5	7.5357
5	5ES	A5	125.669	3.343	B5	108.5	0.7742	F5	137.1	1.6435
6	6WS	A6	129.342	6.716	B6	108.5	0.1877	F6	138.4	5.7566
7	7MN	A7	123.256	4.954	B7	108.5	1.5409	F7	134.1	2.8519
8	8SW	A8	117.241	13.468	B8	108.5	0.5601	F8	127.7	6.1328
9	9NW	A9	118.925	4.088	B9	108.5	0.1304	F9	131.8	1.8240
				=======			=======			=======
				106.673			17.8847			53.1948

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2233.96	0.00	2233.96	7359.7	9593.6
2	2EN	1984.16	443.81	2427.97	7377.4	9805.4
3	3WN	1225.82	647.68	1873.50	2880.4	4753.9
4	4SA	435.28	0.00	435.28	3365.4	3800.6
5	5ES	211.61	42.31	253.92	775.1	1029.0
6	6WS	525.18	12.31	537.50	2721.3	3258.8
7	7MN	413.16	113.11	526.27	1826.4	2352.7
8	8SW	1292.16	49.73	1341.89	3925.4	5267.2
9	9NW	341.41	9.94	351.35	1079.7	1431.0
		=======	=======	=======	=======	=======
		8662.73	1318.89	9981.62	31310.8	41292.4

SHIPMENT

21:44 TUESDAY, AUGUST 18, 1987

1	1NE	A14	2.40069
2	2EN	A25	2.31858
3	3WN	A36	1.54039
4	5ES	A54	2.91316
			=======
			9.17282

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	260.60	6.0698	.	0.00133	2246.8	.
2	CHEESE	117.40	21.5171	5.25286	.	4550.1	616.686
3	NONFAT	4.67	7.9835	.	0.00254	782.0	.
4	OTHER	108.50	29.7882	.	.	5591.9	.
						=======	=======
						13170.9	616.686

Table D. 22. Zero CCC Purchase Levels of Butter and Nonfat Dry Milk : New Quota System

NEWQUOTA (10% PRIVATE DEMAND) ZERO CCC PURCHASE BUTTER AND POWDER

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	QA1	PA	QA	QB1	PB	QB	QF1	PF	QF
1	1NE	A1	120.913	26.993		.	.	F1	137.8	11.3782
2	2EN	A2	117.860	27.248	B2	106.6	6.7035	F2	130.7	11.4590
3	3WN	A3	115.453	13.781	B3	106.6	7.8642	F3	128.5	4.6537
4	4SA	A4	131.790	5.492		.	.	F4	142.6	7.5518
5	5ES	A5	123.950	3.298	B5	106.6	0.7608	F5	135.2	1.6468
6	6WS	A6	127.533	6.654	B6	106.6	0.1855	F6	136.5	5.7681
7	7MN	A7	121.481	4.920	B7	106.6	1.5279	F7	132.2	2.8562
8	8SW	A8	115.385	13.420	B8	106.6	0.5579	F8	125.8	6.1419
9	9NW	A9	117.111	4.062	B9	106.6	0.1294	F9	129.9	1.8269
				=======			=======			=======
				105.868			17.7294			53.2826

GRADE A, GRADE B AND FLUID MILK MARKET

OBS	REGION	PSA	PSB	PSSUM	CSF	SURPLUS
1	1NE	2182.92	0.00	2182.92	7381.3	9564.2
2	2EN	1936.91	430.99	2367.89	7399.2	9767.1
3	3WN	1200.80	632.69	1833.49	2889.3	4722.7
4	4SA	425.64	0.00	425.64	3379.6	3805.3
5	5ES	205.87	40.85	246.73	778.2	1025.0
6	6WS	513.00	11.96	524.96	2732.3	3257.2
7	7MN	404.36	110.20	514.56	1831.9	2346.4
8	8SW	1267.17	48.67	1315.85	3937.0	5252.9
9	9NW	333.98	9.69	343.67	1083.2	1426.8
		=======	=======	=======	=======	=======
		8470.66	1285.05	9755.71	31412.0	41167.7

SHIPMENT

OBS	REGION	CODE	SHIPMENT
1	1NE	A14	2.19692
2	2EN	A25	2.53819
3	3WN	A36	1.58231
4	5ES	A54	3.11130
			=======
			9.42872

MANUFACTURED MILK MARKET

OBS	ITEM	PM	QM	QGD	QGS	SURPLUS	PROGCOST
1	BUTTER	244.26	6.2034	.	0.00003	2353.3	.
2	CHEESE	115.59	21.6092	7.04479	.	4589.1	814.307
3	NONFAT	10.71	7.7374	.	0.00059	734.5	.
4	OTHER	106.60	29.9389	.	.	5648.6	.
						=======	=======
						13325.5	814.307

APPENDIX E

MATRIX GENERATING FORTRAN PROGRAM , INPUT DATA AND OUTPUT (MPS INPUT) FILES

E.1. Introduction

The Interregional Dairy Model, known as INTRDAR is a computer software package designed to model the dairy industry in such a way that facilitates certain economic analysis of the industry. The program is specifically designed to aid in evaluating changes in the dairy support price and changes in the minimum prices for milk in fluid use, upon regional milk quantities demanded and supplied, government purchases, and upon the interregional flow of milk.

The program allows the user to specify an economic model of the dairy industry as a nonlinear programming model, and for the solution to be closely approximated by a separable linear programming problem. Using parameters specifying the nonlinear problem as an input data file, the program generates an output file that is in turn, an input file for a standard linear programming software package.

INTRDAR is designed for users who are familiar with FORTRAN run under the CMS (Conversational Monitor System) and MVS (Multiple Virtual Storage) systems. Both systems are available on the IBM computer system at Virginia Tech. Those who need more information on both systems should refer to Virginia Tech Computing Center User's Guide. The program operates in conjunction with mathematical programming system, MPS, a system of computer programs that solves linear programming (LP) models.

As shown in figure IV-2, a linear programming model of the dairy industry may be viewed as being composed of two parts, a nonaugmented and an augmented section. The nonaugmented portion is the standard part of traditional linear programming problems. A problem of this nature simply requires the specification of the problem in terms of the activities, the coefficients, and the right-hand-side (RHS) parameters. Therefore in this respect, INTRDAR is simply a means of entering the data for a linear programming problem, which is the linear portion of a nonlinear programming problem. This specification is referred to as the nonaugmented problem, because it has not been augmented to include a nonlinear function.

The augmented portion of the matrix is that portion generated by the FORTRAN program from input data in non-linear functional form. The principle involved is that a nonlinear function may be approximated by a number of linear steps each of which is a separate linear programming activity. Hence, this technique is also known as separable programming. As the number of steps increases the loss in accuracy decreases. The solution procedure first requires that the parameters specifying the nonlinear objective function, and the constraints, be entered as input data for the matrix generator, INTRDAR. INTRDAR then defines discrete linear programming activities with the appropriate objective function and constraint activities according to the instructions provided by the user. The augmented portion of the matrix is also referred to as the extended portion of the matrix.

In specifying problems with both nonaugmented and augmented matrices, the user is advised to design the matrices such that the nonaugmented portion of the matrix is in the upper left hand portion of the matrix and linear approximations of nonlinear functions is on the upper right hand side (see figure IV-2). This method of specification is required for the program's data input format.

E.2. Data Enrty

In this section, data entry procedures for INTRDAR are illustrated. Readers should refer to the FORTRAN program in the following section (section E.2.2). Each step is numbered and boxed in the program.

E.2.1. Card Format

1. Read in the cloumn and row numbers in the nonaugmented matrix.

```
        READ (5, 4200) COL, ROW
   4200 FORMAT (2X, 2(1X, I3))
```

COL : Number of columns in the nonaugmented matrix.

ROW : Number of rows in the nonaugmented matrix.

2. Read in the title of the matrix (eg. BASE82)

```
        READ (5, 4100) (TITLE (IA), IA = 1, 2)
    100 FORMAT (16A4)
```

3. Read in the nonaugmented or traditional linear programming (L.P.) activities.

```
        READ (5, 4101) (ACT (IA), IA = KK1, KK2)
   4101 FORMAT (14, (1X, A4))
```

ACT (IA) : Activity names.

4. Read in the nonzero coefficients of the objective function of the nonaugmented matrix. Activities such as transfer columns having no objective function value need not be entered.

```
READ (5,4600) (ICOL (KB), SIGN (KB), COEF (KB), KB = JB, JB4)
4600 FORMAT (5 (I4, 1X, A1, F8.2, 1X))
```

ICOL (KB) : The integer number of the activity, ACT (IA) for which an objective function value is entered. Numbers begin with the left hand side of the matrix with 1, and run consecutively up through the number of columns in the nonaugmented matrix (COL).

SIGN (IB) : The sign, + or -, of the objective function coefficient.

COEF (IB) : The value of the objective function coefficient.

Note that up to five such entries may be entered on each card.

FLAG : Once all objective function values are read in, or if there are no nonzero values associated with the nonaugmented matrix, then ICOL = -999. So at least one card, with entry -999 in the first four columns is necessary if any nonaugmented activities are entered.

5. Read in the constraints for the nonaugmented matrix.

```
READ (5, 4601) (ICOL (MC), SIGN (MC), COEF (MC), MC = KC, KC4)
4601 FORMAT (5 (I4, 1X, A1, F8.2, 2X)
```

As in the case of the objective function, only the nonzero coefficients need be entered. In order to signify the completion of input for each constraint, three possible values may be assigned to ICOL. These values coincide with the nature of the constraints.

ICOL = -100 then RHS constraint $\geq$ 0,

ICOL = -200 then RHS constraint = 0, and

ICOL = -300 then RHS constraint $\leq$ 0.

Just as in the case of the column coefficients, the right hand side parameter is entered with SIGN and COEF along with the appropriate ICOL value. No other indicator is necessary to signify the completion of constraint input.

6. Read in information for extended functions from which the augumented portion of the matrix is composed. This section is characterized by generating linear activities from a single nonlinear function, such as a supply and demand function.

```
      READ (5, 4602, END = 800) EID (JA), RM (JA), IDPV (JA), VAL (JA), DIFF (JA)
 4602 FORMAT (I5, F10.2, I5, F5.2, F5.2)
```

IDPV : Flag for single or multiple variable function. If IDPV = 0 then it is a single variable function, and if IDPV $\neq$ 0 then it is a multiple variable function.

VAL : Flag for subroutine 'MLTLON' which generates both price and quantity constraint rows for a supply or demand function of a single variable. If VAL = 0, do not call 'MLTCON' and if VAL $\neq$ 0, then call 'MLTCON'.

EID, for IDPV = 0, denotes the number of nonzero coefficients for activities in the nonaugmented matrix in the same row as the generated activities; for IDPV $\neq$ 0, EID = 2 denoting the number of rows necessary for the exponential function, one row each for demand, and supply; for VAL $\neq$ 0, EID = 3, denoting the number of rows necessary to generate price and quantity constraints for supply and demand functions and convexity constraints for the extended row, and

RM, the right hand side value for the extended row. For each set of activities generated, a convexity constraint is generated having a RHS value of 1.0.

DIFF : Flag used in 'MLTCON'. If DIFF > 0, then calculate blend price constraints. The value of DIFF is the value of the class I differential. If DIFF ≤ 0, then do not calculate blend price constraints. Normally DIFF = 0 with normal supply or demand functions, and price steps in constraints will have negative signs. If DIFF = -1.0, then price constraints will have positive signs on all price steps.

7. Set up quantity and price constraints (MLTCON). Read in information for quantity constraint first, then price constraint.

```
      READ (5.507) IEID (I3)
507 FORMAT (I5)
      READ (5,506) (ICOLX (I1), SINXT (I1), COFX (I1), I1 = IALEN, MIEIDI)
```

IEID (I3) : The number of coefficients in the row in the augmented portion of the matrix.

ICOLX (I1) : The integer number of the activity in the left hand side LHS of the augmented portion of the matrix.

SINXT (I1) and COFX (I1) : Sign and value for the activity, ACT (ICOLX (I2)) in the left hand side (LHS) of the augumented portion of the matrix.

IALEN : Starting value of array.

MIEIDI : Ending value of array.

8. Read in the integrated supply and demand functions.

```
      READ (5, 507) IJ
507 FORMAT (I5)
      READ (5, 508) (CC (IK), IEXP (IK), IK = 1, IJ)
508 FORMAT (3(E12.6, F5.4))
```

IJ : Number of terms in the function.

CC (IK) : Multiplicative coefficient.

IEXP (IK) : Exponential.

9. Read in step information.

```
      READ (5, 509) Q(1), DELTAQ, STEP
509 FORMAT (2F10.4, I5)
```

Q(1) : Initial value.

DELTAQ : Change of increment.

STEP : Number of steps.

10. From step 8 and 9, calculate price, quantity, and area under supply or demand curve.

```
READ (5, 507) IJ
READ (5, 508) (CC (IK), IEXP (IK), IK = 1, IJ)
READ (5, 509) Q(1), DELTAQ; STEP
```

IK = i = 1, 2 ..n, CC (IK) = ai, and IEXP (IK) = γ_i, as read in the functional form of supply and demand curve. Area and price are defined as follows:

$$W = \int pdQ = \int f(Q)dQ = \sum_{i=1}^{n}(ai)(Qi^{(\gamma i)}) \text{ and } P = \sum_{i=1}^{n} \frac{(\gamma i)(ai)(Qi)^{(\gamma i)}}{Qi}.$$

```
    DO 300 IL = 1, STEP
    W (IL) = 0
    P (IL) = 0
    DO 301 IM = 1, IJ
    W (IL) = W (IL) + CC (IM) * Q (IL) ** IEXP (IM)
    P (IL) = P (IL) + IEXP (IM) * (CC (IM) * Q (IL) ** IEXP (IM)/Q (IL)
301 CONTINUE
    Q (IL + 1) = Q (IL) + DELTAQ
```

11. Calculate blend price constraint.

```
    IF (DIFF (JA) .GT. 0.0) go to 302
    READ (5, 507) N
    READ (5, 508) (PC (IK), PEXP (IK), IK = I, N)
```

Read in the demand function where $W = \int pdQ = \int f(p)dQ = \sum_{i=1}^{n}(bi)(Qi)^{(\beta i)}$. Suppose the demand function is formed as p = k - (1 Q). Then Q is an inverse function of p such that $Q = \frac{k}{1} - \frac{1}{1}p = u - vp$. Define QIM = u. PC(IM) = -v, and PIM = p. Then read:

PIIE = VAL (JA) : the support price level for manufactured milk products.

PIM = PIIE + DIFF : which is the minimum Federal Marketing Order price.

QIM = 0.0 + PC (1) : sets minimum quantity level.

```
    DO 303 IM = 2, N
    QIM = QIM + PC (IM) * PIM ** PEXP (IM)
```

```
303 CONTINUE
```

12. Calculate the area under blend price curve and price level. Area under a blend price curve will not be counted in the objective function.

```
    DO 400 IL = 1, STEP
    P (IL) = 0.0
    PI (IL) = 0.0
    W (IL) = 0.0
    DO 401 IM = 1, IJ
    W (IL) = W (IL) + cc (IM) * 2 (IL) ** IEXP (IM)
    PI (IL) = PI (IL) + IEXP (IM) * (CC (IM) * 2 (IL) ** IEXP (IM)/Q (IL)
    W (IL) = 0.0
401 CONTINUE
```

13. If there is excess demand in the fluid milk market, blend price (P) is set to equal to fluid demand price (PI). In this particular situation the fluid market equilibrium price should be greater than, or at least equal to the minimum Class I price (PIM).

```
    IF (PI (IL) .GE. PIM) GO TO 402
    QII = (Q (IL) - (QIM)
    P (IC) = (PIM * QIM + PIIE * QII)/Q (IL)
    GO TO 403
402 CONTINUE
    P (IL) = PI (IL)
403 CONTINUE
    Q (IL + 1) = Q (IL) + DELTAQ
```

E.2.2. FORTRAN Matrix Generating Program

```
C **********
C **
C ** PROGRAM TO CREATE A MATRIX FORM A SUPPLY/DEMAND FUNCTION TO BE USED
C ** BY A LINEAR PROGRAMING PACKAGE TO SOLVE FOR MAX/MIN.
C **
C ** THE ORIGINAL SUPPLY/DEMAND FUNCTION WILL BE NON-LINEAR IN NATURE.
C ** THE PROGRAM WILL PRODUCE LINEAR APPROXIMATIONS TO THE NON-LINEAR
C ** FUNCTION AT VARIOUS POINTS ALONG THE FUNTION. THESE LINEAR APPROX-
C ** IMATIONS WILL BE USED WHEN THE OUTPUT FROM THIS PROGRAM IS SUBMITED
C ** TO THEN LINEAR PROGRAMING PACKAGE
C **
C **********
C
C ********** DEFINE VARIABLES USED IN PROGRAM
C **********
CCC DELTAQ  : CHANGE OF INCREMENT
CCC COL     : NUMBER OF COLUMNS OF NONAUGMENTED MATRIX
CCC ROW     : NUMBER OF ROWS OF NONAUGMENTED MATRIX
CCC EID     : NUMBER OF ROWS IN THE NONAUGMENTED PORTION OF THE
CCC         MATRIX ASSOCIATED WITH EACH GENERATED ACTIVITY (Y)
CCC         IN THE AUGMENTED PORTION OF THE MATRIX
CCC IJ      : NUMBER OF TERMS IN THE FUNCTION
CCC NOOB    : ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY VARIABLE
CCC         : WHOSE VALUE IS -999
CCC VAL     : FLAG FOR SUBROUTINE 'MLTCON'
CCC DIFF    : FLAG FOR BLEND CALCULATION IN 'MLTCON'
CCC RM      : RHS VALUE FOR THE EXTENDED ROW
CCC GEL     : SEE 'DATA GEL'
CCC ACT     : ACTIVITY VARIABLE
CCC ACTT    : NEW ACTIVITY VARIABLES
CCC ICOL    : INDEX NUMBER OF COLUMN ACTIVITIES
CCC SIGN    : SIGN OF COEFFICIENT VALUES CORRESPONDING TO COLUMN
CCC         ACTIVITIES
CCC XSIGN   : MINUS (-) SIGN
CCC YSIGN   : PLUS (+) SIGN
CCC ZERO    : ZERO (0) VALUE
CCC JA      : ARRAY FOR READING/WRITING TO GENERATE AUGMENTED SUBMATRIX
CCC JB      : BASE FOR ARRAYS, READING/TESTING UP TO 5 'RECORDS' AT
CCC         ONCE TO GENERATE OBJECTIVE PORTION IN NONAUGMENTED
CCC         SUBMATRIX
CCC JC      : BASE FOR ARRAYS, READING/TESTING UP TO 5 ;RECORDS' AT
CCC         ONCE TO GENERATE CONSTRAINT PORTION IN NONAUGMENTED
CCC         SUBMATRIX
CCC STEP    : NUMBER OF INCREMENT STEP, RELATED TO 'DELTAQ'
CCC TOTARA  : LENGTH OF USED PORTION OF 'ICOL', 'SIGN', AND 'COEF'
CCC         ARRAYS, EQUIVALENT TO 'NC', SEE 'NC'
CCC NAROWS  : ARRAY NUMBER OF ROWS WRITTEN TO NONAUGMENTED SUBMATRIX
CCC SAVROW  : NUMBER OF ROWS IN NONAUGMENTED SUBMATRIX, EQUIVALENT TO
CCC         'ROW', SEE 'ROW'
CCC ICOLX   : INDEX NUMBER OF COLUMN ACTIVITY
CCC COFX    : COEFFICIENT VALUE OF CONSTRAINT CORRESPONDING TO COLUMN
CCC         ACTIVITY
CCC SINXT   : SIGN OF 'COFX' VALUE
CCC ONER    : VALUE OF ONE, RHS VALUE OF CONVEXITY ROW
CCC MPSX    : 'NAME' OR 'ROW' & 'COLUMN' OR ACTIVITY VARIABLE NAMES
CCC         IN MPS INPUT FILE
CCC MPSY    : ROW NUMBER OF  NONAUGMENTED PORTION IN MPS INPUT FILE
CCC MPSX1   : EQUALITY OR INEQUALITY OF EACH CONTRAINT ROW  OF
CCC         NONAUGMENTED PORTION IN MPS INPUT FILE
CCC XSINXT  : SIGN OF COEFFICIENT
CCC SIGNQ   : SIGN OF Q IN FILE 4
CCC SIGNP   : SIGN OF P IN FILE 4
CCC Y       : ACTIVITY VARIABLE IN AUGMENTED SUBMATRIX, SEE 'DATA YXX'
CCC ROWS    : ROW NUMBER IN THE MATRIX, SEE 'DATA ROWS'
CCC GEL     : SEE 'DATA GEL'
CCC MPSINS  : SEE 'DATA MPSINS'
CCC MPSCT   : SEE 'DATA MPSCT'
CCC Q       : QUANTITY VALUE OF THE FUNCTION (E.G. SUPPLY OR DEMAND)
CCC W       : AREA UNDER CURVE (E.G. SUPPLY CURVE)
CCC CC      : MULTIPLICATIVE COEFFICIENT OF THE FUNCTION
CCC IEXP    : EXPONENT OF THE FUNCTION
CCC WSIGN   : SIGN OF AREA UNDER CURVE
CCC PSIGN   : SIGN OF PRICE VALUE
CCC P       : PRICE VALUE
CCC PI      : SPECIAL PRICE VALUE SUCH AS FLUID DEMAND PRICE
CCC PC      : MULTIPLICATIVE COEFFICIENT OF THE FUNCTION
CCC PEXP    : EXPONENT OF THE FUNCTION
CCC VARS    : SEE 'VARS'
CCC NSTEP   : EQUIVALENT TO 'STEP', SEE 'STEP'
CCC NOCO    : ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY VARIABLE
CCC         WHOSE VALUE IS -999, SEE 'NOOB' OR 'NOCIEW'
CCC NROW    : EQUIVALENT TO 'ROW', SEE 'ROW'
CCC NCOL    : EQUIVALENT TO 'COL', SEE 'COL'
CCC NEID    : EQUIVALENT TO 'EID', SEE 'EID'
CCC IDPV    : GLAG FOR MULTIPLE VARIABLE FUNCTION
CCC KEND    : LAST NUMBER OF THE ROW OF THE ACTIVITY VARIABLE INPUT
CCC         PORTION OF THE INPUT FILE PLUS 1
CCC KK1     : FIRST ORDERED NUMBER OF THE ACTIVITY VARIABLE IN EACH
CCC         LINE IN THE INPUT FILE
CCC KK2     : LAST ORDERED NUMBER OF THE ACTIVITY VARIABLE IN EACH
CCC         LINE IN THE INPUT FILE
CCC IBEND   : LAST NUMBER OF THE ROW OF THE INDEX NUMBERED ACTIVITY
```

```
CCC          VARIABLES AND VALUES OF COEFFICIENTS PORTION IN THE
CCC          INPUT FILE PLUS 1
CCC JB       : FIRST ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY
CCC          VARIABLES AND VALUES OF COEFFICIENTS OF THE OBJECTIVE
CCC          FUNCTION PORTION IN EACH LINE IN THE INPUT FILE,
CCC          SEE ANOTHER DEFINITION OF 'JB'
CCC JB4      : LAST ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY
CCC          VARIABLES AND VALUES OF COEFFICIENTS OF THE OBJECTIVE
CCC          FUNCTION PORTION IN EACH LINE IN THE INPUT FILE
CCC NOCIEW   : EQUIVALENT TO ½NOOB', SEE 'NOOB'
CCC JCEND    : EQUIVALENT TO 'IBEND', SEE 'IBEND'
CCC KC       : FIRST ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY
CCC          VARIABLES AND VALUES OF COEFFICIENTS OF CONSTRAINTS
CCC          PORTION IN EACH LINE IN THE INPUT FILE
CCC KC4      : LAST ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY
CCC          VARIABLES AND VALUES OF COEFFICIENTS OF CONSTRAINTS
CCC          PORTION IN EACH LINE IN THE INPUT FILE
CCC IEW      : ARRAY FOR 'NOCO', STARTING FROM 1, SEE 'NOCO'
CCC NOCO(IEW): ORDERED NUMBER OF THE INDEX NUMBERED ACTIVITY VARIABLES
CCC          WHOSE VALUE IS NEGATIVE (ICOL(NC)<0). THE VALUE OF
CCC          NOCO (IEW) IS SAME REGARDLESS THE VALUE OF IEW.
CCC          SEE 'NOOB' AND 'NOCIEW'
CCC IGEL     : FLAG VALUE FOR LESS THAN, GREATER THAN OR EQUIVALENT TO
CCC IC       : ORDERED NUMBER OF CONSTRAINT ROWS IN NONAUGMENTED
CCC          SUBMATRIX LESS 1
CCC IC1      : ORDERED NUMBER OF CONSTRAINT ROWS IN NONAUGMENTED
CCC          SUBMATRIX, IC1=IC+1
CCC IROWX    : ORDERED NUMBER OF THE FIRST CONSTRAINT ROW IN
CCC          AUGMENTED SUBMATRIX LESS 1
CCC IALEN    : EQUIVALENT TO THE VALUE OF 'NOCIEW', SEE 'NOOB' OR
CCC          'NOCIEW'
CCC KD       : ARRAY NUMBER FOR THE INDEX NUMBERED ACTIVITY VARIABLES
CCC          (ICOL), STARTING FROM 1
CCC JA       : ARRAY NUMBER FOR INPUT INFORMATION FOR LINEARIZING
CCC          PROGRAMMING, STARTING FROM 1, SEE ANOTHER DEF. OF 'JA'
CCC IG       : ORDERED NUMBER OF EACH STEP OF SEPARABLE LINEARIZING
CCC          APPROXIMATIONS OF GIVEN FUNCTIONS
CCC IGCOL    : ARRAY NUMBER OF GENERATED ACTIVITY VARIABLES IN
CCC          AUGMENTED SUBMATRIX
CCC LEID     : EQUIVALENT TO 'EID', SEE 'EID'
CCC MIEID    : NUMBER OF NONZERO COEFFICIENTS IN EACH CONSTRAINT
CCC          ROW IN AUGMENTED SUBMATRIX. EQUIVALENT TO 'IEID',
CCC          SEE 'IEID'
CCC MIEID1   : MIEID+IALEN+1
CCC ICOL1    : ARRAY COLUMN NUMBER OF THE FIRST GENERATED ACTIVITY
CCC          VARIABLES FOR A SPECIFIC FUNCTION AND REGION IN THE
CCC          AUGMENTED SUBMATRIX
CCC ICOLST   : ARRAY COLUMN NUMBER OF THE LAST GENERATED ACTIVITY
CCC          VARIABLE FOR A SPECIFIC FUNCTION AND REGION IN THE
CCC          AUGMENTED SUBMATRIX
CCC NSTPJA   : EQUIVALENT TO THE VALUE OF THE STEP FOR EACH SPECIFIC
CCC          FUNCTION IN THE REGION, NSTPJA=NSTEP(JA)
CCC IENDK    : REFER TO 'KEND'
C************************ END OF DEF ******************************
CCC
CCC
C > > DECLARE AND INITIALIZE VARIABLES
C

      BLOCK DATA
      COMMON /T112/DELTAQ,COL,ROW,EID(50),STEP,IJ,NOOB,
     * VAL(50),DIFF(50),RM(50)
      COMMON  /T120/XSIGN,YSIGN,ZERO,JA,JB,JC
      COMMON /T125/ICOLX(1300),SINXT(1300),COFX(1300),IALEN
      INTEGER  COL, ROW, EID, STEP
      DATA  ZERO,EID/0.0,50*-1/
      DATA XSIGN,YSIGN/'-','+'/
      DATA SINXT/1300*'-'/
      DATA JA,JB,JC/0,0,1/
      END

      INTEGER  COL, ROW, EID, STEP
      INTEGER  NAROWS, SAVROW

      DATA ONER/1.0/
      DATA MPSX,MPSY/2*'    '/
      DATA MPSX1,XSINXT,SIGNQ,SIGNP/4*' '/
      DATA DEMC,AP/'DEMC','AP'/
CC** ACTUAL USED DIMENSIONS FOR Y AND ROWS ARE:(1)NUMBER OF FUNCTIONS
CC** TIMES NUMBER OF REGIONS, I.E.,3 FUNCTIONS(SUPPLY,DEMAND,BLEND)X
CC** 8 REGIONS=24;(2)NUMBER OF ROWS IN NONAUGMENTED AND AUGMENTED
CC** MATRICES, ALWAYS NEED TO REFER TO L.P. MATRIX TABLEAU

CC** DIMENSION FOR EACH Y DEPENDS ON NUMBER OF INCREMENT STEPS

      DIMENSION Y(38,50),GEL(3),ROWS(218),
     *MPSINS(2,5), MPSCT(4)

      DIMENSION Y1(50),Y2(50),Y3(50),Y4(50),Y5(50),Y6(50),Y7(50),
     *Y8(50),Y9(50),Y10(50),Y11(50),Y12(50),Y13(50),Y14(50),
     *Y15(50),Y16(50),Y17(50),Y18(50),Y19(50),Y20(50),Y21(50),
     *Y22(50),Y23(50),Y24(50),
     *Y25(50),Y26(50),Y27(50),Y28(50),Y29(50),Y30(50),Y31(50),
     *Y32(50),Y33(50),Y34(50),Y35(50),Y36(50),Y37(50),Y38(50)

      DATA MPSINS/'NAME',' ','ROWS','    ','COLU','MNS ',
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     *'RHS ',' ', 'ENDA','TA '/
      DATA MPSCT/'L', 'E', 'G', 'N'/

CC** TOTAL NUMBER OF ROWS ARE TO BE SET UP ACCORDING TO THE SIZE
CC** OF DIMENSION OF THE WHOLE (NONAUGMENTED AND AUGMENTED) L.P.
CC** MATRIX TABLE. THE FIRST ROWS IS 'FUNC' FOR OBJECTIVE ROW
CC** SO ARRAY NUMBER FOR EACH ROW IS ALWAYS RUNNING AHEAD BY 1
CC** IN THE ALGORITHM.
      DATA ROWS/ 'OBJ','001','002','003','004','005','006','007','008',
     *'009','010','011','012','013','014','015','016','017','018','019',
     *'020','021','022','023','024','025','026','027','028','029','030',
     *'031','032','033','034','035','036','037','038','039','040','041',
     *'042','043','044','045','046','047','048','049','050','051','052',
     *'053','054','055','056','057','058','059','060','061','062','063',
     *'064','065','066','067','068','069','070','071','072','073','074',
     *'075','076','077','078','079','080','081','082','083','084','085',
     *'086','087','088','089','090','091','092','093','094','095','096',
     *'097','098','099','100','101','102','103','104','105','106','107',
     *'108','109','110','111','112','113','114','115','116','117','118',
     *'119','120','121','122','123','124','125','126','127','128','129',
     *'130','131','132','133','134','135','136','137','138','139','140',
     *'141','142','143','144','145','146','147','148','149','150','151',
     *'152','153','154','155','156','157','158','159','160','161','162',
     *'163','164','165','166','167','168','169','170','171','172','173',
     *'174','175','176','177','178','179','180','181','182','183','184',
     *'185','186','187','188','189','190','191','192','193','194','195',
     *'196','197','198','199','200','201','202','203','204','205','206',
     *'207','208','209','210','211','212','213','214','215','216','217'/
CC** TOTAL NUMBER OF Y DEPENDS ON THREE INFORMATION:
CC** (1) NUMBER OF REGIONS IN THE MODEL
CC** (2) NUMBER OF FUNCTIONS FOR EACH REGION
CC** (3) NUMBER OF INCREMENT STEPS
CC** FOR EXAMPLE 3 FUNCTIONS (SUPPY OF GRADE A MILK, DEMAND FOR FLUID
CC** MILK, BLEND FOR POOLING) ,8 REGIONS AND 10 STEPS NEED Y(24,10).
      DATA Y1/                   'YA01',  'YA02',  'YA03',  'YA04',
     *    'YA05',  'YA06',  'YA07',  'YA08',  'YA09',  'YA10',
     *    'YA11',  'YA12',  'YA13',  'YA14',  'YA15',  'YA16',
     *    'YA17',  'YA18',  'YA19',  'YA20',  'YA21',  'YA22',
     *    'YA23',  'YA24',  'YA25',  'YA26',  'YA27',  'YA28',
     *    'YA29',  'YA30',  'YA31',  'YA32',  'YA33',  'YA34',
     *    'YA35',  'YA36',  'YA37',  'YA38',  'YA39',  'YA40',
     *    'YA41',  'YA42',  'YA43',  'YA44',  'YA45',  'YA46',
     *    'YA47',  'YA48',  'YA49',  'YA50'/
C    *    'YA53',  'YA54',  'YA55',  'YA56',  'YA57',  'YA58',
C    *    'YA59',  'YA60',  'YA61',  'YA62',  'YA63',  'YA64',
C    *    'YA65',  'YA66',  'YA67',  'YA68',  'YA69',  'YA70',
C    *    'YA71',  'YA72',  'YA73',  'YA74',  'YA75',  'YA76',
C    *    'YA77',  'YA78',  'YA79',  'YA80',  'YA81',  'YA82',
C    *    'YA83',  'YA84',  'YA85',  'YA86',  'YA87',  'YA88',
C    *    'YA89',  'YA90',  'YA91',  'YA92',  'YA93',  'YA94',
C    *    'YA95',  'YA96',  'YA97',  'YA98',  'YA99',  'YA00'/
      DATA Y2/                   'YB01',  'YB02',  'YB03',  'YB04',
     *    'YB05',  'YB06',  'YB07',  'YB08',  'YB09',  'YB10',
     *    'YB11',  'YB12',  'YB13',  'YB14',  'YB15',  'YB16',
     *    'YB17',  'YB18',  'YB19',  'YB20',  'YB21',  'YB22',
     *    'YB23',  'YB24',  'YB25',  'YB26',  'YB27',  'YB28',
     *    'YB29',  'YB30',  'YB31',  'YB32',  'YB33',  'YB34',
     *    'YB35',  'YB36',  'YB37',  'YB38',  'YB39',  'YB40',
     *    'YB41',  'YB42',  'YB43',  'YB44',  'YB45',  'YB46',
     *    'YB47',  'YB48',  'YB49',  'YB50'/
C    *    'YB53',  'YB54',  'YB55',  'YB56',  'YB57',  'YB58',
C    *    'YB59',  'YB60',  'YB61',  'YB62',  'YB63',  'YB64',
C    *    'YB65',  'YB66',  'YB67',  'YB68',  'YB69',  'YB70',
C    *    'YB71',  'YB72',  'YB73',  'YB74',  'YB75',  'YB76',
C    *    'YB77',  'YB78',  'YB79',  'YB80',  'YB81',  'YB82',
C    *    'YB83',  'YB84',  'YB85',  'YB86',  'YB87',  'YB88',
C    *    'YB89',  'YB90',  'YB91',  'YB92',  'YB93',  'YB94',
C    *    'YB95',  'YB96',  'YB97',  'YB98',  'YB99',  'YB00'/
      DATA Y3/                   'YC01',  'YC02',  'YC03',  'YC04',
     *    'YC05',  'YC06',  'YC07',  'YC08',  'YC09',  'YC10',
     *    'YC11',  'YC12',  'YC13',  'YC14',  'YC15',  'YC16',
     *    'YC17',  'YC18',  'YC19',  'YC20',  'YC21',  'YC22',
     *    'YC23',  'YC24',  'YC25',  'YC26',  'YC27',  'YC28',
     *    'YC29',  'YC30',  'YC31',  'YC32',  'YC33',  'YC34',
     *    'YC35',  'YC36',  'YC37',  'YC38',  'YC39',  'YC40',
     *    'YC41',  'YC42',  'YC43',  'YC44',  'YC45',  'YC46',
     *    'YC47',  'YC48',  'YC49',  'YC50'/
C    *    'YC53',  'YC54',  'YC55',  'YC56',  'YC57',  'YC58',
C    *    'YC59',  'YC60',  'YC61',  'YC62',  'YC63',  'YC64',
C    *    'YC65',  'YC66',  'YC67',  'YC68',  'YC69',  'YC70',
C    *    'YC71',  'YC72',  'YC73',  'YC74',  'YC75',  'YC76',
C    *    'YC77',  'YC78',  'YC79',  'YC80',  'YC81',  'YC82',
C    *    'YC83',  'YC84',  'YC85',  'YC86',  'YC87',  'YC88',
C    *    'YC89',  'YC90',  'YC91',  'YC92',  'YC93',  'YC94',
C    *    'YC95',  'YC96',  'YC97',  'YC98',  'YC99',  'YC00'/
      DATA Y4/                   'YD01',  'YD02',  'YD03',  'YD04',
     *    'YD05',  'YD06',  'YD07',  'YD08',  'YD09',  'YD10',
     *    'YD11',  'YD12',  'YD13',  'YD14',  'YD15',  'YD16',
     *    'YD17',  'YD18',  'YD19',  'YD20',  'YD21',  'YD22',
     *    'YD23',  'YD24',  'YD25',  'YD26',  'YD27',  'YD28',
     *    'YD29',  'YD30',  'YD31',  'YD32',  'YD33',  'YD34',
     *    'YD35',  'YD36',  'YD37',  'YD38',  'YD39',  'YD40',
     *    'YD41',  'YD42',  'YD43',  'YD44',  'YD45',  'YD46',
     *    'YD47',  'YD48',  'YD49',  'YD50'/
C    *    'YD53',  'YD54',  'YD55',  'YD56',  'YD57',  'YD58',
C    *    'YD59',  'YD60',  'YD61',  'YD62',  'YD63',  'YD64',
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C  *   'YD65', 'YD66', 'YD67', 'YD68', 'YD69', 'YD70',
C  *   'YD71', 'YD72', 'YD73', 'YD74', 'YD75', 'YD76',
C  *   'YD77', 'YD78', 'YD79', 'YD80', 'YD81', 'YD82',
C  *   'YD83', 'YD84', 'YD85', 'YD86', 'YD87', 'YD88',
C  *   'YD89', 'YD90', 'YD91', 'YD92', 'YD93', 'YD94',
C  *   'YD95', 'YD96', 'YD97', 'YD98', 'YD99', 'YD00'/
    DATA Y5/               'YE01', 'YE02', 'YE03', 'YE04',
     *  'YE05', 'YE06', 'YE07', 'YE08', 'YE09', 'YE10',
     *  'YE11', 'YE12', 'YE13', 'YE14', 'YE15', 'YE16',
     *  'YE17', 'YE18', 'YE19', 'YE20', 'YE21', 'YE22',
     *  'YE23', 'YE24', 'YE25', 'YE26', 'YE27', 'YE28',
     *  'YE29', 'YE30', 'YE31', 'YE32', 'YE33', 'YE34',
     *  'YE35', 'YE36', 'YE37', 'YE38', 'YE39', 'YE40',
     *  'YE41', 'YE42', 'YE43', 'YE44', 'YE45', 'YE46',
     *  'YE47', 'YE48', 'YE49', 'YE50'/
C    *  'YE53', 'YE54', 'YE55', 'YE56', 'YE57', 'YE58',
C    *  'YE59', 'YE60', 'YE61', 'YE62', 'YE63', 'YE64',
C    *  'YE65', 'YE66', 'YE67', 'YE68', 'YE69', 'YE70',
C    *  'YE71', 'YE72', 'YE73', 'YE74', 'YE75', 'YE76',
C    *  'YE77', 'YE78', 'YE79', 'YE80', 'YE81', 'YE82',
C    *  'YE83', 'YE84', 'YE85', 'YE86', 'YE87', 'YE88',
C    *  'YE89', 'YE90', 'YE91', 'YE92', 'YE93', 'YE94',
C    *  'YE95', 'YE96', 'YE97', 'YE98', 'YE99', 'YE00'/
    DATA Y6/               'YF01', 'YF02', 'YF03', 'YF04',
     *  'YF05', 'YF06', 'YF07', 'YF08', 'YF09', 'YF10',
     *  'YF11', 'YF12', 'YF13', 'YF14', 'YF15', 'YF16',
     *  'YF17', 'YF18', 'YF19', 'YF20', 'YF21', 'YF22',
     *  'YF23', 'YF24', 'YF25', 'YF26', 'YF27', 'YF28',
     *  'YF29', 'YF30', 'YF31', 'YF32', 'YF33', 'YF34',
     *  'YF35', 'YF36', 'YF37', 'YF38', 'YF39', 'YF40',
     *  'YF41', 'YF42', 'YF43', 'YF44', 'YF45', 'YF46',
     *  'YF47', 'YF48', 'YF49', 'YF50'/
C    *  'YF53', 'YF54', 'YF55', 'YF56', 'YF57', 'YF58',
C    *  'YF59', 'YF60', 'YF61', 'YF62', 'YF63', 'YF64',
C    *  'YF65', 'YF66', 'YF67', 'YF68', 'YF69', 'YF70',
C    *  'YF71', 'YF72', 'YF73', 'YF74', 'YF75', 'YF76',
C    *  'YF77', 'YF78', 'YF79', 'YF80', 'YF81', 'YF82',
C    *  'YF83', 'YF84', 'YF85', 'YF86', 'YF87', 'YF88',
CC   *  'YF89', 'YF90', 'YF91', 'YF92', 'YF93', 'YF94',
C    *  'YF95', 'YF96', 'YF97', 'YF98', 'YF99', 'YF00'/
    DATA Y7/               'YG01', 'YG02', 'YG03', 'YG04',
     *  'YG05', 'YG06', 'YG07', 'YG08', 'YG09', 'YG10',
     *  'YG11', 'YG12', 'YG13', 'YG14', 'YG15', 'YG16',
     *  'YG17', 'YG18', 'YG19', 'YG20', 'YG21', 'YG22',
     *  'YG23', 'YG24', 'YG25', 'YG26', 'YG27', 'YG28',
     *  'YG29', 'YG30', 'YG31', 'YG32', 'YG33', 'YG34',
     *  'YG35', 'YG36', 'YG37', 'YG38', 'YG39', 'YG40',
     *  'YG41', 'YG42', 'YG43', 'YG44', 'YG45', 'YG46',
     *  'YG47', 'YG48', 'YG49', 'YG50'/
C    *  'YG53', 'YG54', 'YG55', 'YG56', 'YG57', 'YG58',
C    *  'YG59', 'YG60', 'YG61', 'YG62', 'YG63', 'YG64',
C    *  'YG65', 'YG66', 'YG67', 'YG68', 'YG69', 'YG70',
C    *  'YG71', 'YG72', 'YG73', 'YG74', 'YG75', 'YG76',
C    *  'YG77', 'YG78', 'YG79', 'YG80', 'YG81', 'YG82',
C    *  'YG83', 'YG84', 'YG85', 'YG86', 'YG87', 'YG88',
C    *  'YG89', 'YG90', 'YG91', 'YG92', 'YG93', 'YG94',
C    *  'YG95', 'YG96', 'YG97', 'YG98', 'YG99', 'YG00'/
    DATA Y8/               'YH01', 'YH02', 'YH03', 'YH04',
     *  'YH05', 'YH06', 'YH07', 'YH08', 'YH09', 'YH10',
     *  'YH11', 'YH12', 'YH13', 'YH14', 'YH15', 'YH16',
     *  'YH17', 'YH18', 'YH19', 'YH20', 'YH21', 'YH22',
     *  'YH23', 'YH24', 'YH25', 'YH26', 'YH27', 'YH28',
     *  'YH29', 'YH30', 'YH31', 'YH32', 'YH33', 'YH34',
     *  'YH35', 'YH36', 'YH37', 'YH38', 'YH39', 'YH40',
     *  'YH41', 'YH42', 'YH43', 'YH44', 'YH45', 'YH46',
     *  'YH47', 'YH48', 'YH49', 'YH50'/
C    *  'YH53', 'YH54', 'YH55', 'YH56', 'YH57', 'YH58',
C    *  'YH59', 'YH60', 'YH61', 'YH62', 'YH63', 'YH64',
C    *  'YH65', 'YH66', 'YH67', 'YH68', 'YH69', 'YH70',
C    *  'YH71', 'YH72', 'YH73', 'YH74', 'YH75', 'YH76',
C    *  'YH77', 'YH78', 'YH79', 'YH80', 'YH81', 'YH82',
C    *  'YH83', 'YH84', 'YH85', 'YH86', 'YH87', 'YH88',
C    *  'YH89', 'YH90', 'YH91', 'YH92', 'YH93', 'YH94',
C    *  'YH95', 'YH96', 'YH97', 'YH98', 'YH99', 'YH00'/
    DATA Y9/               'YI01', 'YI02', 'YI03', 'YI04',
     *  'YI05', 'YI06', 'YI07', 'YI08', 'YI09', 'YI10',
     *  'YI11', 'YI12', 'YI13', 'YI14', 'YI15', 'YI16',
     *  'YI17', 'YI18', 'YI19', 'YI20', 'YI21', 'YI22',
     *  'YI23', 'YI24', 'YI25', 'YI26', 'YI27', 'YI28',
     *  'YI29', 'YI30', 'YI31', 'YI32', 'YI33', 'YI34',
     *  'YI35', 'YI36', 'YI37', 'YI38', 'YI39', 'YI40',
     *  'YI41', 'YI42', 'YI43', 'YI44', 'YI45', 'YI46',
     *  'YI47', 'YI48', 'YI49', 'YI50'/
C    *  'YI53', 'YI54', 'YI55', 'YI56', 'YI57', 'YI58',
C    *  'YI59', 'YI60', 'YI61', 'YI62', 'YI63', 'YI64',
C    *  'YI65', 'YI66', 'YI67', 'YI68', 'YI69', 'YI70',
C    *  'YI71', 'YI72', 'YI73', 'YI74', 'YI75', 'YI76',
C    *  'YI77', 'YI78', 'YI79', 'YI80', 'YI81', 'YI82',
C    *  'YI83', 'YI84', 'YI85', 'YI86', 'YI87', 'YI88',
C    *  'YI89', 'YI90', 'YI91', 'YI92', 'YI93', 'YI94',
C    *  'YI95', 'YI96', 'YI97', 'YI98', 'YI99', 'YI00'/
    DATA Y10/              'YJ01', 'YJ02', 'YJ03', 'YJ04',
     *  'YJ05', 'YJ06', 'YJ07', 'YJ08', 'YJ09', 'YJ10',
     *  'YJ11', 'YJ12', 'YJ13', 'YJ14', 'YJ15', 'YJ16',
     *  'YJ17', 'YJ18', 'YJ19', 'YJ20', 'YJ21', 'YJ22',
     *  'YJ23', 'YJ24', 'YJ25', 'YJ26', 'YJ27', 'YJ28',
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     * 'YJ29', 'YJ30', 'YJ31', 'YJ32', 'YJ33', 'YJ34',
     * 'YJ35', 'YJ36', 'YJ37', 'YJ38', 'YJ39', 'YJ40',
     * 'YJ41', 'YJ42', 'YJ43', 'YJ44', 'YJ45', 'YJ46',
     * 'YJ47', 'YJ48', 'YJ49', 'YJ50'/
C    * 'YJ53', 'YJ54', 'YJ55', 'YJ56', 'YJ57', 'YJ58',
C    * 'YJ59', 'YJ60', 'YJ61', 'YJ62', 'YJ63', 'YJ64',
C    * 'YJ65', 'YJ66', 'YJ67', 'YJ68', 'YJ69', 'YJ70',
C    * 'YJ71', 'YJ72', 'YJ73', 'YJ74', 'YJ75', 'YJ76',
C    * 'YJ77', 'YJ78', 'YJ79', 'YJ80', 'YJ81', 'YJ82',
C    * 'YJ83', 'YJ84', 'YJ85', 'YJ86', 'YJ87', 'YJ88',
C    * 'YJ89', 'YJ90', 'YJ91', 'YJ92', 'YJ93', 'YJ94',
C    * 'YJ95', 'YJ96', 'YJ97', 'YJ98', 'YJ99', 'YJ00'/
      DATA Y11/               'YK01', 'YK02', 'YK03', 'YK04',
     * 'YK05', 'YK06', 'YK07', 'YK08', 'YK09', 'YK10',
     * 'YK11', 'YK12', 'YK13', 'YK14', 'YK15', 'YK16',
     * 'YK17', 'YK18', 'YK19', 'YK20', 'YK21', 'YK22',
     * 'YK23', 'YK24', 'YK25', 'YK26', 'YK27', 'YK28',
     * 'YK29', 'YK30', 'YK31', 'YK32', 'YK33', 'YK34',
     * 'YK35', 'YK36', 'YK37', 'YK38', 'YK39', 'YK40',
     * 'YK41', 'YK42', 'YK43', 'YK44', 'YK45', 'YK46',
     * 'YK47', 'YK48', 'YK49', 'YK50'/
C    * 'YK53', 'YK54', 'YK55', 'YK56', 'YK57', 'YK58',
C    * 'YK59', 'YK60', 'YK61', 'YK62', 'YK63', 'YK64',
C    * 'YK65', 'YK66', 'YK67', 'YK68', 'YK69', 'YK70',
C    * 'YK71', 'YK72', 'YK73', 'YK74', 'YK75', 'YK76',
C    * 'YK77', 'YK78', 'YK79', 'YK80', 'YK81', 'YK82',
C    * 'YK83', 'YK84', 'YK85', 'YK86', 'YK87', 'YK88',
C    * 'YK89', 'YK90', 'YK91', 'YK92', 'YK93', 'YK94',
C    * 'YK95', 'YK96', 'YK97', 'YK98', 'YK99', 'YK00'/
      DATA Y12/               'YL01', 'YL02', 'YL03', 'YL04',
     * 'YL05', 'YL06', 'YL07', 'YL08', 'YL09', 'YL10',
     * 'YL11', 'YL12', 'YL13', 'YL14', 'YL15', 'YL16',
     * 'YL17', 'YL18', 'YL19', 'YL20', 'YL21', 'YL22',
     * 'YL23', 'YL24', 'YL25', 'YL26', 'YL27', 'YL28',
     * 'YL29', 'YL30', 'YL31', 'YL32', 'YL33', 'YL34',
     * 'YL35', 'YL36', 'YL37', 'YL38', 'YL39', 'YL40',
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*       'ZK29', 'ZK30', 'ZK31', 'ZK32', 'ZK33', 'ZK34',
*       'ZK35', 'ZK36', 'ZK37', 'ZK38', 'ZK39', 'ZK40',
*       'ZK41', 'ZK42', 'ZK43', 'ZK44', 'ZK45', 'ZK46',
*       'ZK47', 'ZK48', 'ZK49', 'ZK50'/
      DATA Y38/               'ZL01', 'ZL02', 'ZL03', 'ZL04',
*       'ZL05', 'ZL06', 'ZL07', 'ZL08', 'ZL09', 'ZL10',
*       'ZL11', 'ZL12', 'ZL13', 'ZL14', 'ZL15', 'ZL16',
*       'ZL17', 'ZL18', 'ZL19', 'ZL20', 'ZL21', 'ZL22',
*       'ZL23', 'ZL24', 'ZL25', 'ZL26', 'ZL27', 'ZL28',
*       'ZL29', 'ZL30', 'ZL31', 'ZL32', 'ZL33', 'ZL34',
*       'ZL35', 'ZL36', 'ZL37', 'ZL38', 'ZL39', 'ZL40',
*       'ZL41', 'ZL42', 'ZL43', 'ZL44', 'ZL45', 'ZL46',
*       'ZL47', 'ZL48', 'ZL49', 'ZL50'/

      COMMON /T111/Q(1000),W(1000),CC(10),IEXP(10) ,WSIGN(1000),
     * PSIGN(1000),P(1000),PI(50),PC(10),PEXP(10)
      COMMON /T112/DELTAQ,COL,ROW,EID(50),STEP,IJ,NOOB,
     * VAL(50),DIFF(50),RM(50)
      COMMON  /T113/TITLE(16),GEL,ACT(1500),ICOL(1300),SIGN(1300),
     *       COEF(1300),VARS(3,26),ACTT(1300)
      COMMON  /T115/NSTEP(50),NOCO(500),NROW(50),NCOL(50),NEID(50)
      COMMON   /T118/IDPV(50)
      COMMON   /T119/IEID(50)
      COMMON   /T120/XSIGN,YSIGN,ZERO,JA,JB,JC
      COMMON /T125/ICOLX(1300),SINXT(1300),COFX(1300),IALEN
C
C **  SET UP Y ARRAY WITH Y1,Y2,...
C
CCC** NUMBER OF Y'S HAS TO BE CONSISTENT WITH "DATA" Y'S: FOR EXAMPLE
CCC** 3 FUNCTIONS (SUPPLY, DEMAND, BLEND) TIMES 8 REGIONS EQUALS
CCC** 24 Y'S AND ACTUAL ARRAY I IS THE NUMBER OF STEPS.
      DO 1 I= 1, 50
        Y(1,I) = Y1(I)
        Y(2,I) = Y2(I)
        Y(3,I) = Y3(I)
        Y(4,I) = Y4(I)
        Y(5,I) = Y5(I)
        Y(6,I) = Y6(I)
        Y(7,I) = Y7(I)
        Y(8,I) = Y8(I)
        Y(9,I) = Y9(I)
       Y(10,I) = Y10(I)
       Y(11,I) = Y11(I)
       Y(12,I) = Y12(I)
       Y(13,I) = Y13(I)
       Y(14,I) = Y14(I)
       Y(15,I) = Y15(I)
       Y(16,I) = Y16(I)
       Y(17,I) = Y17(I)
       Y(18,I) = Y18(I)
       Y(19,I) = Y19(I)
       Y(20,I) = Y20(I)
       Y(21,I) = Y21(I)
       Y(22,I) = Y22(I)
       Y(23,I) = Y23(I)
       Y(24,I) = Y24(I)
       Y(25,I) = Y25(I)
       Y(26,I) = Y26(I)
       Y(27,I) = Y27(I)
       Y(28,I) = Y28(I)
       Y(29,I) = Y29(I)
       Y(30,I) = Y30(I)
       Y(31,I) = Y31(I)
       Y(32,I) = Y32(I)
       Y(33,I) = Y33(I)
       Y(34,I) = Y34(I)
       Y(35,I) = Y35(I)
       Y(36,I) = Y36(I)
       Y(37,I) = Y37(I)
    1  Y(38,I) = Y38(I)

C *** INPUT THE ROW AND COLUMN DIMENSION FOR NON-AUGMENTED MATRIX
C
      READ(5,4200) COL, ROW
      WRITE(11,4200) COL, ROW                                      1

      SAVROW = ROW
C ** INPUT THE TITLE OF THE PROBLEM
C
      READ(5,4100) (TITLE(IA),IA = 1,2)
      WRITE(11,4100) (TITLE(IA),IA = 1,2)                          2
```

```
C ** WRITE TITLE AND 'ROWS' INSTRUCTION TO NONAUG FILE (FILE 1)
C
     WRITE(1,4151) MPSINS(1,1), (TITLE(IA2),IA2 = 1,2)
     WRITE(1,4152) MPSINS(1,2), MPSCT(4), ROWS(1)
C ** WRITE TO TERM TO SHOW STATUS (FILE 6)
C
     WRITE(6,4151) MPSINS(1,1), (TITLE(IA2),IA2 = 1,2)
     WRITE(6,4152) MPSINS(1,2), MPSCT(4), ROWS(1)

C ** INPUT VARIABLE (ACTIVITY) NAMES
C
     KEND = ((COL-1)/11) + 1
     DO 2 K = 1,KEND
      KK1 = ((K-1)*11) + 1
      KK2 = KK1 + 10

     READ(5,4101) (ACT(IA), IA = KK1,KK2)
     WRITE(11,4101) (ACT(IA), IA = KK1,KK2)                     3

   2 CONTINUE
C
C > > INPUT VARIABLE (ACTIVITY) VALUES
C ** INPUT VARIABLE (ACTIVITY) VALUES = COEFFICIENTS OF OBJECT FUNCTION
C .. VAR IBEND IS MOST NUMBER OF COLUMNS WILL HAVE TO READ FROM DATA
C  . FILE, READING UP TO FIVE COLUMNS PER LINE.
C
     IBEND = (COL / 5) + 1
     DO 10 IB = 1, IBEND
C     ** JB = BASE FOR ARRAYX, READING/TESTING UP TO 5 'RECORDS' AT ONCE
       JB = ((IB - 1) * 5) + 1
       JB4 = JB + 4

       READ (5,4600) (ICOL(KB), SIGN(KB), COEF(KB), KB = JB, JB4)
       WRITE (11,4600) (ICOL(KB), SIGN(KB), COEF(KB), KB = JB, JB4)     4

       DO 10 LB = JB, JB4
C       ** ICOL(LB) = -999 --> SIGNALS END OF VALUES
C ..    WHEN -999 REACHED LB WILL BE NUMBER OF NON-ZERO COLUMNS IN
C .     OBJECTIVE FUNCTION ROW PLUS ONE.
         IF (ICOL(LB) .EQ. -999) GOTO 11
  10 CONTINUE
  11 CONTINUE
     NOOB = LB


C ** TEST IF NO CONSTRAINTS IN NON-AUGMENTED MATRIX
C **** ROW IS EQUAL TO THE NUMBER OF CONSTRAINT EQUATIONS
C ***** IN NONAUGMENTED MATRIX
C
     IF (ROW .EQ. 0) GOTO 99

C ** INPUT COEFFICIENTS OF CONSTRAINTS IN NONAUGMENTED MATRIX
C
     IEW = 0
C *** RECALL NOOB = LB
     NOCIEW = NOOB

C ** READ NON-ZERO COLUMNS FOR EACH NONAUG ROW
C
     DO 45 IC = 1, ROW
       JCEND = (COL / 5) + 1
       DO 20 JC = 1, JCEND
C       ** KC = BASE FOR ARRAYX, READING/TESTING UP TO 5 'RECORDS'
         KC = ((JC - 1) * 5) + 1 + NOCIEW
         KC4 = KC + 4

         READ(5,4601) (ICOL(MC), SIGN(MC), COEF(MC), MC = KC, KC4)
         WRITE(11,4601) (ICOL(MC), SIGN(MC), COEF(MC), MC = KC, KC4)     5

         DO 20 NC = KC, KC4
           IF (ICOL(NC) .LT. 0) GOTO 21
  20   CONTINUE
  21   CONTINUE
C **** NOCO OR NOCIEW CONTAINS THE NO. OF NON-ZERO COEF. OF CONSTRAINT
       IEW = IEW + 1
       NOCO(IEW) = NC
       NOCIEW = NOCO(IEW)
       IGEL = ICOL(NC) / (-100)

C **** WRITE THE 'ROWS' PORTION OF THE NON-AUGMENTED MATRIX TO FILE
C **** (FILES 1 & 6)
C
       IC1 = IC + 1
       WRITE(1,4153) MPSCT(IGEL), ROWS(IC1)
C **** ECHO TO TERM TO SHOW STATUS
C
       WRITE(6,4153) MPSCT(IGEL), ROWS(IC1)

  45 CONTINUE
     IROWX = ROW + 1
C
C ... PULL STUFF OUT OF ICOL,SIGN,COEF ARRAYS INTO ICOLX,SINXT,COEFX
C     ARRAYS FOR NON-AUG MATRIX (WILL BE CHECKED IN FILE 2)
C
```

```
      DO 533 II=1,NOCIEW
        ICOLX(II)=ICOL(II)
        SINXT(II)=SIGN(II)
        COFX(II) =COEF(II)
 533  CONTINUE

C ** WRITE THE 'COLUMNS' PORTIONS OF THE NON-AUGMENTED MATRIX TO FILE
C *** (FILES 1 & 6)
C
      WRITE(1,4154)(MPSINS(ID,3),ID=1,2)
C ** ECHO TO TERM
C
      WRITE(6,4154)(MPSINS(ID,3),ID=1,2)
C .. NAROWS IS NUMBER OF ROWS WRITTEN TO NON-AUG FILE
      NAROWS=0
C .. IALEN IS LENGTH OF USED PORTION OF ICOL, SIGN, AND COEF ARRAYX
C  . IS USED IN CONJUNCTION WITH KD TO SCAN WHOLE ARRAY FOR EACH COL
      IALEN = NC
      DO 49 JD = 1, COL
       KD = 0
       IROW = 1
  46   KD = KD + 1
        IF(ICOL(KD).GT.0) GOTO 48
         IROW = IROW + 1
  47      KD = KD + 1
         IF(ICOL(KD).EQ.0) GOTO 47
  48    IF(ICOL(KD).EQ.JD) WRITE(1,4551) ACT(JD), ROWS(IROW), SIGN(KD)
     *                ,COEF(KD)
        IF(ICOL(KD).EQ.JD) WRITE(6,4551) ACT(JD), ROWS(IROW), SIGN(KD)
     *                ,COEF(KD)
        IF(ICOL(KD).EQ.JD) NAROWS=NAROWS+1
       IF(KD.LE.IALEN) GOTO 46
  49  CONTINUE
  50  CONTINUE
C ** WRITE 'RHS' PART OF NON-AUG. MAT TO FILE (FILES 1 & 6)
C
      WRITE(1,4155) MPSINS(1,4)
      WRITE(6,4155) MPSINS(1,4)

      IROW = 1
      DO 60 IE=1, IALEN
       IF(ICOL(IE).GE.0)     GOTO 60
       IF(ICOL(IE).EQ.(-999)) GOTO 60
        IROW = IROW + 1
        WRITE(1,4552) DEMC,AP,ROWS(IROW), SIGN(IE), COEF(IE)
        WRITE(6,4552) DEMC,AP,ROWS(IROW), SIGN(IE), COEF(IE)
  60  CONTINUE
  99  CONTINUE

C ** WRITE ENDATA TO SHOW END OF NONAUG INFO
C
      WRITE(1,4199) (MPSINS(IZ,5),IZ=1,2)
C ** ECHO TO TERM
C
      WRITE(6,4199) (MPSINS(IZ,5),IZ=1,2)

C
C > >  GENERATE AUGMENTED SUBMATRIX  USING VALUES AND EQUATIONS FROM NON-
C   AUGMENTED SUBMATRIX
C ** AUGMENTED SUBMATRIX IS LINEAR 'EQUIVALANT' OF NON-LINEAR PROBLEM IN
C   NON-AUGMENTED SUBMATRIX
C

C ... TEST IF THE PROBLEM NEEDS TO BE EXTENDED (CHECK EOF)
 100  CONTINUE
      JA = JA + 1

      READ(5,4602,END=800) EID(JA), RM(JA), IDPV(JA), VAL(JA), DIFF(JA)
      WRITE(11,4602) EID(JA), RM(JA), IDPV(JA), VAL(JA), DIFF(JA)          6

 102  CONTINUE

      IF (IDPV(JA) .EQ. 0) GOTO 103
      GOTO 125
 103  CONTINUE


C *** NOW CALL MLTCON
      CALL MLTCON
      GOTO 125

C ... SET UP NEW ACTIVITIES ,Y'S, FOR AUGMENTED MATRIX
 125  CONTINUE
      DO 126 IG=1,STEP
       IGCOL=IG+COL
       ACT(IGCOL) = Y(JA,IG)
 126  CONTINUE

C ... EXTENDING THE OBJECT FUNCTION
C *** THIS CASE NONZERO COEFFICIENT IN OBJ. FN.

      IQ   = 1
      ICOL1 = COL + 1
      ICOLST= COL + STEP
      DO 135 IP = ICOL1, ICOLST
       IPP=IP-COL
```

```
      SIGN(IP) = WSIGN(IPP)
      IF(COEF(IP).LT.0.0) SIGN(IP) = XSIGN
      COEF(IP) = ABS(W(IQ))
      ICOL(IP) = COL + IQ
      IQ = IQ + 1
  135 CONTINUE

C ... STORE THE VALUES OF ROW, COL,STEPS AND EID (# OF ROWS NEEDED FOR
C ... FOR EACH STEP)
     NROW(JA) = ROW
     NCOL(JA) = COL
     NSTEP(JA) = STEP
     NEID(JA) = EID(JA)

C ... EXTENDING THE CONSTRAINTS
     IF (IDPV(JA) .NE. 0) GOTO 160
     IF (VAL(JA) .NE. 0) GOTO 160
     NSTPJA = NSTEP(JA)
     WRITE (3,4450) (Q(II),II = 1,NSTPJA)

C ... UPDATE THE VALUES OF COL AND ROW
  160 CONTINUE
     COL = COL + STEP
     IF (IDPV(JA) .NE. 0) ROW = ROW + 4
     IF (VAL(JA) .NE. 0) ROW = ROW + 3
     GOTO 100

C > > OUTPUT REMAINDER OF MATRIX IN MPS FORMAT
C
  800 CONTINUE
C ... DUMP TO JUNK FILE FOR TEST (FILE 7)
C
     JAM1 = JA-1
     DO 500 III = 1, JAM1
      WRITE(7,2000) III,NROW(III),NCOL(III),NSTEP(III),NEID(III)
 2000 FORMAT(' FOR JA=',I3,' : '/4I4)
      NCOL1 = NCOL(III)+1
      NCOLST= NCOL(III) + NSTEP(III)
      DO 450 JJJ = NCOL1, NCOLST
       WRITE (7,2001) COEF(JJJ),ICOL(JJJ)
 2001 FORMAT('   COEF=',E12.6,'   COL=',I4)
  450   CONTINUE
  500 CONTINUE
C ... REWIND ALL THE FILES AND SHLEP IT ALL BACK TOGETHER
C
     REWIND 1
     REWIND 3
     REWIND 4

C .. READ THE FIRST FEW LINES FROM THE NON-AUG FILE(FILE 1) AND DUMP IT
C  . TO FINAL OUTPUT FILE(FILE 10).
C
CC** START WRITING "ROWS" SECTION OF MPS INPUT FILE
CC** NOW BEGINS WITH NONAUGMENTED PORTION
CC**
     READ(1,4151) MPSX, (TITLE(IK),IK = 1,2)
     WRITE(10,4151) MPSX, (TITLE(IK),IK = 1,2)
     READ(1,4152) MPSX, MPSX1, MPSY
     WRITE(10,4152) MPSX, MPSX1, MPSY
C .. READ AS MANY ROWS AS THERE ARE IN NON-AUG ARRAY (SAVROW)
     DO 513 IX = 1, SAVROW
  510 READ(1,4153) MPSX1, MPSY
  511 WRITE(10,4153) MPSX1, MPSY
  513 CONTINUE

CC** THIS TIME WRITES LHS OF AUGMENTED PORTION
C
CC** STILL WRITING "ROWS" SECTION OF MPS INPUT FILE
C ** READSTUFF FOR ROWS FOR AUGMENTED MATRIX
C .. IRO IS THE CURRENT AUGMENTED ROW
     IRO = NROW(1)
     IRO = IRO + 1

C .. NUM IS THE NUMBER OF GIVEN COEFICIENTS FOR LOWER LEFT PART OF ARRAY
C  . NUM1 IS THE RELATIONSHIP (IN ICOL) AND RHS. WE WANT THE
C  . THE RELATIONSHIP (LE,EQ,GE) FOR NOW.
C
  514 READ(3,5514,END=525) VALUE, DIF
 5514 FORMAT(F5.1,F5.2)
  515 READ(3,516,END=525) NUM
     ISTART = IALEN + 1
     NUM1 = NUM + ISTART
  516 FORMAT(I5)
CCC** READ & WRITE FIRST ROW FOR QUANTITY OF EACH REGION, STEP
     READ(3,517) (ICOLX(JK), SINXT(JK), COFX(JK), JK = ISTART,NUM1)
  517 FORMAT(I4,A1,E11.6)
     IGEL = ICOLX(NUM1)/(-100)
     IRO = IRO + 1
     WRITE(10,4153) MPSCT(IGEL), ROWS(IRO)
CCC** READ & WRITE SECOND ROW FOR PRICE OF EACH REGION, STEP
     READ(3,516,END=525) NUM
     NUM1 = NUM + ISTART
     READ(3,517) (ICOLX(JK), SINXT(JK), COFX(JK),JK = ISTART,NUM1)
     IGEL = ICOLX(NUM1)/(-100)
     IRO = IRO + 1
```

```
      WRITE(10,4153) MPSCT(IGEL), ROWS(IRO)
CCC** READ & WRITE THIRD ROW FOR CONVEXITY CONSTRAINT OF EACH REGION,
CCC** STEP
      IRO=IRO+1
C *** WRITE CONSTRAINT SIGNS
C *** WRITE "E" FOR BLEND CASE, OTHERWISE "L" THIS CASE
      IF (DIF .GT. 0) GOTO 519
C *** WRITE "L" FOR LESS THAN OR EQUAL
      WRITE(10,4153) MPSCT(1), ROWS(IRO)
      GOTO 514
C *** WRITE "G" FOR GREATER THAN OR EQUAL
C *** WRITE "E" FOR EQUALITY
519   WRITE(10,4153) MPSCT(2), ROWS(IRO)
      GOTO 514
525   CONTINUE
C ... COLLECT STUFF FOR COLUMNS READ TO GET NEXT LINE
C
      WRITE(10,4154) (MPSINS(KK,3),KK=1,2)
      READ(1,4154) MPSX, MPSY
      DO 530 I=1,NAROWS
 526  READ(1,4551) MPSX, MPSY, XSINXT, COEFZ
 530  CONTINUE

C **  REREAD ACTIVITY NAMES FROM DATA FILE (FILE 11)
C *** REWIND FILE 11 HERE
C
      REWIND 11
      READ(11,4200) COL, ROW
      READ(11,4100) (TITLE(IA),IA=1,2)
      IENDK = (COL/11) + 1
      DO 534 K=1,IENDK
       KK1=((K-1)*11)+1
       KK2=KK1+10
       READ(11,4101) (ACTT(IA),IA=KK1,KK2)
 534  CONTINUE

550   CONTINUE

C *** CHECK ICOLX AND IALEN ARRAY & WRITE TO FILE 2
      WRITE (2,4653) (ICOLX(I),SINXT(I),COFX(I),I=1,IALEN)
 4653 FORMAT(I4,A1,E11.6,I4)
C ***  REWIND FILE2 HERE AND REREAD ALL ICOLX INFORMATION FROM FILE 2
      REWIND 2
      READ(2,4653) (ICOLX(J),SINXT(J),COFX(J),K J=1,IALEN)
C

CC**   STARTS WRITING "COLUMNS" SECTION OF MPS INPUT FILE
CC**   NOW BEGINS WITH NONAUGMENTED PORTION THEN LHS AUGMENTED PORTION
CC**   NOTE:NONAUGMENTED PORTION OF OBJECTIVE FUNCTION IS INCLUDED HERE

C ... WRITE OUT INFO IN ICOLX, SINXT, COFX IN ORDER OF COLUMNS (FILE 10)
C     (DONE LIKE SECTION FROM LINE NUMBERS 45-50).

      DO 554 JT=1,COL
       KT=0
       IROW=1
 551   KT=KT+1
        IF(ICOLX(KT).GT.0) GOTO 553
         IROW=IROW+1
 552       KT=KT+1
        IF(ICOLX(KT).EQ.0) GOTO 552
 553    IF(ICOLX(KT).EQ.JT) WRITE(10,4551) ACTT(JT),ROWS(IROW),
     *        SINXT(KT), COFX(KT)
       IF(KT.LE.IALEN) GOTO 551
 554  CONTINUE

C ** READ FILE GENERATED BY MLTCON.  NOTICE LINE WRITING ONE AFTER Q AND
C    P.  THIS IS TO ACCOMIDATE MLTCON.  AGAIN, TESTING SHOULD BE DONE
C    AFTER OTHER ROUTINES ARE ADDED.
C
C .. ICOL IS THE CURRENT COLUMN (ACTIVITY).  WILL WRITE ALL AUGMENTED
C    INFO FOR THIS COLUMN TOGETHER.
C .. IRO, IRO1, AND IRO2 ARE THE ROWS (IN ADDITION TO THE OBJECTIVE
C    FUNCTION ROW) THAT INFORMATION IS NEED FOR.
C
      ICO=NCOL(1)
      ICO=ICO+1
      IRO=NROW(1)
      IRO=IRO+1+1
      IRO1=IRO+1
      IRO2=IRO+2
      IX=0
 555  IX=IX+1
      STEP=NSTEP(IX)
      ICEND=ICO+STEP-1

C **  READ INFORMATION ONLY FOR THE NUMBER OF COLUMNS GENERATED BY A
C     PARTICULAR CALL TO MLTCON.
CC**  THIS TIME AUGMENTED PORTION OF OBJECTIVE FUNCTION AND RHS
CC**  AUGMENTED PORTION
      DO 570 IL=ICO,ICEND

C ** WRITE OBJECTIVE FUNCTION CELL FOR THIS COLUMN (FILE 10)
       WRITE(10,4551) ACT(IL), ROWS(1), SIGN(IL), COEF(IL)

C ** READ STUFF GENERATED BY MLTCON (FROM FILE 4 TO FILE 10)
```

```
      READ(4,556) SIGNQ, COEFQ, SIGNP, COEFP
  556  FORMAT(2(A1,F15.6))
      WRITE(10,4551) ACT(IL), ROWS(IRO), SIGNQ, COEFQ
      WRITE(10,4551) ACT(IL), ROWS(IRO1), SIGNP, COEFP
      WRITE(10,4551) ACT(IL), ROWS(IRO2), YSIGN, ONER
  570 CONTINUE

C ** NCOL(JAM1) IS THE TOTAL NUMBER OF COLUMNS PROCESSED BY THE PROGRAM
C    IF ICEND IS GREATER THAN THIS, WE'VE PROCESSED ALL COLUMNS SO LEAVE
C    LOOP, ELSE UPDATE ICO AND IRO VALUES AND GO TO TOP OF LOOP
C
      IF(ICEND.GT.NCOL(JAM1)) GOTO 575
      ICO=ICEND+1
      IRO=IRO+3
      IRO1=IRO+1
      IRO2=IRO+2
      GOTO 555
  575 CONTINUE

C ... WRITE THE " RHS" PART OUT INCLUDING CONVEXITY ROW OF ONE (FILE 10)
C
      WRITE(10,4155) MPSINS(1,4)
      READ(1,4155) MPSX
      DO 580 IXX=1, SAVROW
CC**  NONAUGMENTED PORTION OF THE MATRIX
CC**
  576 READ(1,4552,END=581) DEMCX,APX,MPSX, SINXT(1), COFX(1)
      WRITE(10,4552) DEMCX,APX,MPSX, SINXT(1), COFX(1)
  580 CONTINUE
  581 CONTINUE

C *** REWIND FILE 3 AGAIN
  582 REWIND 3
      IRO=NROW(1)
      IRO=IRO+1
CC**  AUGMENTED PORTION OF THE MATRIX
CC**
  585 READ(3,5514,END=600) VALUE,DIF
      READ(3,516,END=600) NUM
      NUM1=NUM+1
      READ(3,517) (ICOLX(JK), SINXT(JK), COFX(JK), JK=1,NUM1)
      IRO=IRO+1
      WRITE(10,4552) DEMC,AP,ROWS(IRO), SINXT(NUM1), COFX(NUM1)
      READ(3,516,END=600) NUM
      NUM1=NUM+1
      READ(3,517) (ICOLX(JK), SINXT(JK), COFX(JK),JK=1,NUM1)
      IRO=IRO+1
      WRITE(10,4552) DEMC,AP,ROWS(IRO), SINXT(NUM1), COFX(NUM1)
      IRO=IRO+1
      WRITE(10,4552) DEMC,AP,ROWS(IRO), YSIGN, ONER
      GOTO 585
  600 CONTINUE

C ** WRITE 'ENDATA' TO SHOW MPS END OF DATA (FILE 10)
C
      WRITE(10,4199) (MPSINS(IX,5), IX=1,2)
      STOP
C ** FORMATS GALORE
C **** FORMAT STATEMENTS ARE NUMBERED IN THE FORM [4XYY], WHERE:
C     X = 1 FOR ALL CHAR.;        X = 2 FOR ALL INT.;
C     X = 3 FOR MIXED CHAR, INT.;  X = 4 FOR ALL REAL;
C     X = 5 FOR MIXED CHAR, REAL;  X = 6 FOR MIXED INT., REAL;
C     X = 7 FOR MIXED CHAR, INT, REAL
C     YY < 50  FOR INPUT;        YY > = 50  FOR OUTPUT;
 4100 FORMAT (2A4)
 4101 FORMAT (3X, 11A7)
 4150 FORMAT (2A4/3A4/16A4)
 4151 FORMAT (A4,10X,2A4)
 4152 FORMAT (A4/1X,A1,2X,A4)
 4153 FORMAT (1X,A1,2X,A4)
 4154 FORMAT (A4,A3)
 4155 FORMAT (A3)
 4156 FORMAT (10(A4,2X))
 4199 FORMAT (A4,A2)
 4200 FORMAT (1X,2X,2I5)
 4450 FORMAT (5(E12.6))
 4550 FORMAT (A8,F16.5)
 4551 FORMAT (4X,A4,6X,A4,6X,A1,E11.6)
 4552 FORMAT (4X,A4,A2,4X,A4,6X,A1,E11.6)
 4600 FORMAT (5(I4,A1,F11.2))
 4601 FORMAT (5(I4,A1,F11.2))
 4602 FORMAT (I5,F10.2,I5,F5.1,F5.2)
 4603 FORMAT (5(I4,1X,F9.2,1X))
 4604 FORMAT (I5,5(F9.2,F5.4))
 4605 FORMAT (2F9.2,I4)
 4650 FORMAT (5(F10.2,I4))
 4651 FORMAT (5(F10.5,I4))
 4652 FORMAT (I4,A1,E11.6)
      END


      SUBROUTINE MLTCON
C *** CALCULATES MULTIPLE CONSTRAINTS AND OBJECTIVE FUNCTION ,E.G. W,Q,
C **  AND P
```

```
      INTEGER COL,ROW,EID,STEP
      REAL IEXP,DIFF,VAL,PIIE,PIM,QIM,QII,PEXP
C *** MAKE SURE MAIN PROGRAM  HAS THESE COMMONS
C
      COMMON /T111/Q(1000),W(1000),CC(10),IEXP(10),WSIGN(1000),
     *    PSIGN(1000),P(1000),PI(50),PC(10),PEXP(10)
      COMMON /T112/DELTAQ,COL,ROW,EID(50),STEP,IJ,NOOB,
     *VAL(50),DIFF(50),RM(50)
      COMMON /T119/IEID(50)
      COMMON  /T120/XSIGN,YSIGN,ZERO,JA,JB,JC
      COMMON /T125/ICOLX(1300),SINXT(1300),COFX(1300),IALEN
C *** THIS MLTCON LOOP READS CONSTRAINTS FOR ROWS FOR AUGMENTED MATRIX
C
C *** LEID+1 IS NUMBER OF ROWS NEEDED FOR EACH REGION AND FUNCTIONS
C **  (USUALLY 2 FOR QUANTITY AND PRICE FUNCTIONS AND 1 FOR CONVEXITY
C *   CONSTRAINT, HENCE LEID+1=3)

      LEID = EID(JA)
      WRITE (3,99) VAL(JA), DIFF(JA)
 99   FORMAT(F5.1,F5.2)
      DO 200 I3=1,LEID

       READ(5,507) IEID(I3)
       MIEID = IEID(I3)
       MIEID1= MIEID + 1 + IALEN                                    7
       IALEN= IALEN + 1
       READ(5,506) (ICOLX(I1),SINXT(I1),COFX(I1),I1=IALEN,MIEID1)

 101   CONTINUE
C*** WRITE OUT TO PERMANENT FILE (TAPE3)
       WRITE (3,507) IEID(I3)
       WRITE (3,516) (ICOLX(I1),SINXT(I1),COFX(I1),I1=IALEN,MIEID1)

       IALEN = IALEN + MIEID
C *** CREATE DUMMY FOR CONVEXITY ROW AFTER READING LAST FUNCTION (SUCH
C **  AS PRICE) ROW FOR EVERY REGION
C *   CHECK LAST ARRAY (I3) IS EQUAL TO LEID AND IF LAST THEN COPY
C **  LAST (POSITIVE) ICOLX SETTING ZERO COEFFICIENT

      IF (I3 .NE. LEID) GO TO 200
      MM1=MIEID1+1
      MMM=MIEID1-1
      ICOLX(MM1)=ICOLX(MMM)
      SINXT(MM1)=SINXT(MMM)
      COFX(MM1)=0.0
C *** THIS TIME COPY LAST (NEGATIVE) ICOLX SETTING ZERO COEFFICIENT
C **  SEE OUTPUT FILE 2 FOR CHECKING
      MM2=MIEID1+2
      ICOLX(MM2)=ICOLX(MIEID1)
      SINXT(MM2)=SINXT(MIEID1)
      COFX(MM2)=0.0
C**** SINCE WE ADD TWO DUMMY ICOLX'S IALEN IS ADDED BY 2 NOW
       IALEN=IALEN+2


 200  CONTINUE

C  ** READ INTEGRATED FUNCTION FOR OBJECTIVE
C
C *** NEXT READ AND WRITE IS DEPENDING ON INPUT DATA FORMATTING

      READ(5,598) IJ, (CC(IK), IEXP(IK), IK=1,IJ)
      WRITE(7,*) (IJ,CC(IK),IEXP(IK),IK=1,IJ)                       8

C*** PROCESS THE EXTENDING PROCEDURE

      READ (5,509) Q(1),DELTAQ,STEP                                 9
      WRITE(7,*) Q(1), DELTAQ, STEP
C
C *** STARTS CALCULATING AREA(W), Q AND P FOR EACH INCREMENT STEP
C **  IF DIFF > 0 THEN CALCULATE "BLEND" STUFF

      IF ( DIFF(JA) .GT. 0.0 ) GO TO 302
      DO 300 IL=1,STEP
       W(IL)=0.0
       P(IL)=0.0
       DO 301 IM=1,IJ                                               10
        W(IL)=W(IL)+CC(IM)*Q(IL)**IEXP(IM)
        P(IL)=P(IL)+IEXP(IM)*(CC(IM)*Q(IL)**IEXP(IM))/Q(IL)
 301   CONTINUE
       Q(IL+1)=Q(IL)+DELTAQ

 300  CONTINUE
      WRITE (7,2100) EID(JA), RM(JA), VAL(JA), DIFF(JA)
      WRITE (7,2101) (Q(III),W(III),PI(III),P(III),III=1,STEP)
2100  FORMAT(I5,F10.2,F5.1,F5.2)
2101  FORMAT(4(E12.6,2X))
       GO TO 500
 302  CONTINUE
C:::::CALCULATE POOL PRICE-PIIE=VAL=EST CLASS II P,PIM=MIN CLS I P

      READ (5,508) N, (PC(IK),PEXP(IK),IK=1,N)
      WRITE (7,*) N,(PC(IK),PEXP(IK),IK=1,N)
      PIIE=VAL(JA)                                                  11
      PIM=PIIE+DIFF(JA)
      QIM=0.0+PC(1)
```

```
      DO 303 IM = 2,N                                                    11
        QIM = QIM + PC(IM)*PIM**PEXP(IM)
  303 CONTINUE

      DO 400 IL = 1,STEP
       P(IL) = 0.0
       PI(IL) = 0.0
       W(IL) = 0.0                                                       12
       DO 401 IM = 1,IJ
        W(IL) = W(IL) + CC(IM)*Q(IL)**IEXP(IM)
        PI(IL) = PI(IL) + IEXP(IM)*(CC(IM)*Q(IL)**IEXP(IM))/Q(IL)
        W(IL) = 0.0
  401  CONTINUE

C
C *** IF DEMAND (FLUID) PRICE IS LOWER THAN MARKETING ORDER MINIMUM
C **  CLASS I PRICE, THEN BLEND PRICE (P) = (PI*QI + PII*QII)/QA, WHERE
C *   QA = QI + QII
C
       IF (PI(IL) .GE. PIM) GO TO 402
        QII = (Q(IL)-QIM)
        P(IL) = (PIM*QIM + PIIE*QII)/Q(IL)
        GO TO 403                                                        13
  402  CONTINUE
       P(IL) = PI(IL)
  403  CONTINUE
       Q(IL + 1) = Q(IL) + DELTAQ

  400 CONTINUE
      WRITE(7,2100) EID(JA),RM(JA),VAL(JA),DIFF(JA)
      WRITE(7,2101) (Q(III),W(III),PI(III),P(III),III = 1,STEP)
  500 CONTINUE
C *** DEFINE SIGNS OF W ,Q, AND P
C
      DO 501 IN = 1,STEP
       WSIGN(IN) = YSIGN
       IF(W(IN).GE.0.0) GO TO 502
        WSIGN(IN) = XSIGN
  502  CONTINUE
       Q(IN) = ABS(Q(IN))
       P(IN) = ABS(P(IN))
  501 CONTINUE
C
C *** IF WE DEAL WITH DEMAND FUNCTION (DIFF = -1) THEN COEFFICIENT
C **  OF PRICE SHOULD BE POSITIVE (REFER TO MATRIX TABLEAU)
      IF (DIFF(JA) .EQ. -1.0) GO TO 503
      WRITE (4,599) (XSIGN, Q(IL), XSIGN, P(IL), IL = 1,STEP)
      GO TO 504
  503 WRITE (4,599) (XSIGN, Q(IL), YSIGN, P(IL), IL = 1,STEP)

  504 CONTINUE
C *** FORMATS CAN BE MODIFIED DEPENDING ON DATA STRUCTURE
C
  507 FORMAT (I5)
  506 FORMAT (5(I4,A1,F11.2))
  516 FORMAT (I4,A1,E11.6)
  508 FORMAT (I5, 5(F10.4,F5.2))
  598 FORMAT (I5, 4(F15.10,F5.2))
  509 FORMAT (2F10.4,I5)
  599 FORMAT (2(A1,F15.6))
      RETURN
      END
```

E.2.3. Matrix Generator Input Explanation

Data input for the 1982 analysis is illustrated in this section. Each line corresponds to a line on the monitor. Readers should refer to a linear programming model specification in the section 3.2 in Chapter IV and sections 2.1 and 2.2 in this appendix for data entry and format information. The matrix generator input file is structured as follows. Each step is in a numbered box in the following pages (see the section 2.4 in this appendix). Steps up to numbered box 5 are explained in general and steps after numbered box 5 are explained in detail for the Northeast (first region in the program) region.

<u>1982 Input Data</u>

1. 156 columns and 83 rows in the nonaugmented matrix.

2. Title.

3. Variable (activity) names. Activity variable names were defined as follows:

Ai represents the quantity of Grade A milk produced in region i;
Bi represents the quantity of Grade B milk produced in region i;
Fj represents the quantity of fluid milk demanded in region j;
PAi represents Grade A milk supply price in region i;
PBi represents Grade B milk supply price in region i;
PFj represents fluid milk demand price in region j;
PM represents raw milk demand price for manufactured milk;
Aij represents the quantity of Grade A milk shipped from region i to region j;
AiM represents the quantity of Class II Grade A milk demanded in region i;
BiM represents the quantity of Grade B milk demanded in region i;
M12 represents the quantity of raw milk used for butter-powder production;
M3 represents the quantity of raw milk used for cheese production;
YB represents the quantity of commercial demand for butter;
YN represents the quantity of commercial demand for nonfat dry milk;
YC represents the quantity of commercial demand for cheese;
PYB represents butter market price;
PYN represents nonfat dry milk market price;
PYC represents cheese market price;
GDB represents the quantity of government purchases of butter;
GDN represents the quantity of government purchases of nonfat dry milk;
GDC represents the quantity of government purchases of cheese;
GSB represents the quantity of government sales of butter;
GSN represents the quantity of government sales of nonfat dry milk;
GSC represents the quantity of government sales of cheese;
BSB represents the quantity of beginning stocks of butter;
BSN represents the quantity of beginning stocks of nonfat dry milk;
BSC represents the quantity of beginning stocks of cheese;
ESB represents the quantity of ending stocks of butter;
ESN represents the quantity of ending stocks of nonfat dry milk;

ESC represents the quantity of ending stocks of cheese;
IMB represents the quantity of imports of butter;
IMN represents the quantity of imports of nonfat dry milk;
IMC represents the quantity of imports of cheese;and
M4 represents the quantity of other milk products demanded.

4. Nonaugmented portion of objective function (second line in equation (IV-39)). Transportation costs, processing costs of butter-powder and cheese, and government expenditures are included.

5. Coeffients by columns, constraint types, and RHS values for linear institutional constraints as specified in equation (IV-39) and explained in step 5 in the section E.2.1.

a. Fluid demand price constraints associated with $\lambda 6$ in equation (IV-39). First line is for the Northeast region and implies PF1 - PM $\geq$ 31.2 where PI^{o} = PM + 31.2.

b. Raw milk price constraints in manufactured use associated with $\lambda 10$ in equation (IV-39). First line is for the East Northcentral region and implies PB2 - PM = 0.

c. Support and Purchase prices are exogenously given. PYB = 143.90, PYN = 90.69, PYC = 134.65 and PM = 126.0.

d. Blend price alignment constraints associated with $\lambda 9$ in equation (IV-39). First line is for the Northeast region and implies PA4 - PA1 $\leq$ 11.80.

e. Grade A milk suppy constraints associated with $\lambda 1$ in equation (IV-39). First two lines are for the Northeast region and implies 1A1 - 1A11 - 1A12 - 1A14 + 1A1M $\geq$ 0.

f. Grade B milk suppy constraints associated with $\lambda 2$ in equation (IV-39). First line is for the Northeast region and implies 1B2 - 1B2M $\geq$ 0.

g and h. Quantity balance constraints for fluid milk use associated with $\lambda 3$ in equation (IV-39). First two lines in g and h are for the Northeast region and implies (1) 1F1 + 1A1M - 1A11 - 1A21 - 1A31 $\leq$ 0 and (2) 1.2F - 1A11 - 1A21 -1A31 $\leq$ 0.

i. Quantity balance constraints for manufactured milk associated with $\lambda 4$ in equation (IV-39). 1M12 + 1M3 + 1M4 - $\sum_i 1AiM - \sum_i 1Bi \leq 0$.

j. Quantity balance constraints for butter, nonfat dry milk and cheese associated with $\lambda 5$ in equation (IV-39). 1ESB + 1GDB + 1YB - (.448)M12 - 1BSB - 1GSB - 1IMB $\leq$ 0 for butter..

k. Capacity constraints of butter-powder and cheese plants associated with $\lambda 7$ and $\lambda 8$ in equation (IV-39). (.448)M12 $\leq$ 12.57 for butter.

l. Quantity balance constraints for beginning and ending stocks, imports and export, and government purchases of butter, nonfat dry milk, and cheese associated with $\lambda 5$ in equation (IV-39). These values are exogenously given. BSB = 4.290, BSN = 8.900, and BSC = 8.890; ESB = 4.670, ESN = 8.972, and ESC = 9.820; IMB = 0.030, IMN = 0.020, and IMC = 0.180; GDB $\leq$900.0, GDN $\leq$ 900.0, and GDC $\leq$ 900; and GSB $\leq$900.0, GSN $\leq$ 900.0, and GSC $\leq$.

6. Grade A and Grade B milk supply information. Explanation for each coefficient is based on information for the Northeast region.

a. Number of rows in the LHS augmented portion of the matrix associated with each generated activity in the RHS augmented portion of the matrix (EID=2), the right hand side value for the extended (convexity) row (RM=0), single dependent variable function (IDPV=0), flag for 'MLTCON' subroutine (VAL=1.00), and flag for not calculating 'blend' price (DIFF=0).

b. Number of nonzero coefficients in the LHS augmented portion of the matrix (IEID = 1).

c. Column (ICOL = 1), sign (SINXT = '+'), value (COFX = 1), of nonzero coefficients of the LHS augmented portion of the matrix and constraint type (ILOL = -200) and RHS Value (SINXT = '+', COFX = 0).

d. Number of nonzero coefficients in the LHS augmented portion of the matrix (IEID = 1).

e. Column (ILOL = 31), sign (SINXT = '+'), value (COFX = 1) of nonzero coefficient of the LHS augmented portion of the matrix, constraint type (ICOL = -200) and RHS value (SINXT = '+', COFX = 0).

f. Number of terms in the supply function (IJ = 1).

g. Integrated supply function,

$$\int pdQ = \int (.155359083)Q^{2.020} = (.0514434057)Q^{3.020}.$$

h. Step information of supply function initial value for Q (Q(1) = 24.0), increment of Q (DELTAQ = .40), and number of increment steps (STEP = 20).

7. Fluid milk demand information. Explanation for each coefficient is based on information for the Northeast region.

a. Number of rows in the LHS augmented portion of the matrix associated with each generated activity in the RHS augmented portion of the matrix (EID = 2), the RHS value for the convexity row (RM = 0), single dependent variable function (IDPV = 0), flag for 'MLTCON' subroutine (VAL = 1.00), and flag for not calculating 'blend' price (DIFF = -1.0).

b. Number of nonzero coefficients (IEID = 1), in the LHS augmented portion of the matrix.

c. Column (ICOL = 19), sign (SINXT = '+'), value (COFX = 1) of nonzero coefficients of the LHS augmented portion of the matrix, constraint type (ICOL = -200) and RHS value (SINXT = '+').

d. Number of nonzero coefficients (IEID = 1) in the LHS augmented portion of the matrix.

e. Column (ICOL = 41), sign (SINXT = '-'), value (COFX = 1) of nonzero coefficients of the LHS augmented portion of the matrix, constraint type (ICOL = -200) and RHS value (SINXT = '+', COFX = 0).

f. Number of terms in the demand function (IJ = 2).

g. Integrated demand function,

$$\int pdQ = \int [1435.25 - (114.03)Q]dQ = 1435.25Q - (114.03)Q^2.$$

h. Step information of demand function initial value for Q (Q(1) = 11.0), increment of Q (DELTAQ = .045), and number of increment steps (STEP = 20).

8. Information for a blend price constraint. Explanation for each coefficient is based on information for the Northeast region.

a. Number of rows in the LHS augmented portion of the matrix associated with each generated activity in the RHS augmented portion of the matrix (EID = 2), the RHS value for the convexity rows (RM = 0), single dependent variable function (IDPV = 0), flag for 'MLTCON' subroutine (VAL = 126.0), and flag for calculating blend' price (DIFF = 31.2).

b. Number of nonzero coefficients in the LHS augmented portion of the matrix (IEID = 3).

c. Columns (ICOL = 51,56,63), signs (SINXT = '+'), and values (COFX = 1) of nonzero coefficients of the LHS augmented portion of the matrix, constraint type (ICOL = -200) and RHS value (SINXT = '+', COFX = 0).

d. Number of nonzero coefficients in the LHS augmented portion of the matrix (IEID = 2).

e. Column (ICOL = 31,51) sign (SINXT = '+'), and value (COFX = 1), of nonzero coefficients of the LHS augmented portion of the matrix, constraint type (ICOL = -200) and RHS value (SINXT = '+', COFX = 0).

f. Number of terms in the demand function, (IJ = 2).

g. Integrated demand function,

$$\int p dQ = 1435.25Q - (57.015)Q^2$$

h. Step information of the demand function, initial value for Q (Q(1) = 22.0), increment of Q (DELTAQ = .5), and number of increment steps (STEP = 21).

i. Number of terms in the inverse function of demand (IJ = 2).

j. Inverse demand function,

$$P = 1435.25 - (114.03)Q, \; Q = \frac{1435.25 - P}{(114.03)} = 12.5866 - .0088P.$$

E.2.4. Matrix Generator Input File (1982 Analysis)

```
011 156 83                                                                    1
BASE82A                                                                       2
   A1   A2   A3   A4   A5   A6   A7   A8   A9   B2   B3
   B5   B6   B7   B8   B9   SB   IM   F1   F2   F3   F4
   F5   F6   F7   F8   F9   M    GD   ES   PA1  PA2  PA3
   PA4  PA5  PA6  PA7  PA8  PA9  PB   PF1  PF2  PF3  PF4
   PF5  PF6  PF7  PF8  PF9  PM   A11  A12  A14  A15  A1M
   A21  A22  A24  A25  A23  A27  A2M  A31  A32  A33  A34
   A35  A36  A37  A3M  A44  A46  A4M  A54  A55  A57  A5M
   A65  A66  A67  A68  A6M  A79  A77  A7M  A88  A89  A8M
   A97  A98  A99  A9M  B2M  B3M  B5M  B6M  B7M  B8M  B9M                     3
   SBT  IMT  PB2  PB3  PB5  PB6  PB7  PB8  PB9  A56  A76
   GS   M12  M3   Y1   Y2   Y3   PY1  PY2  PY3  YB   YN
   YC   PYB  PYN  PYC  GD1  GD2  GD3  GS1  GS2  GS3  BS1
   BS2  BS3  IM1  IM2  IM3  GDB  GDN  GDC  GSB  GSN  GSC
   BSB  BSN  BSC  ESB  ESN  ESC  IMB  IMN  IMC  ES1  ES2
   ES3  M4
51-     0.0 52-     12.15 53-    11.80 54-    16.84 55-     0.0
56-    12.15 57-     0.0 58-     16.91 59-     6.09 60-    16.77
61-    999.9 62-     0.0 63-     999.9 64-    16.77 65-     0.0
66-    19.78 67-    16.87 68-    12.08 69-    999.9 70-     0.0
71-     0.0 72-     13.97 73-     0.0 74-      7.84 75-     0.0
76-    999.9 77-     0.0 78-     16.66 79-     0.0 80-    999.0              4
81-    999.9 82-     0.0 83-     13.16 84-     0.0 85-     0.0
86-     0.0 87-     12.08 88-     0.0 89-     13.16 90-    12.08
91-     0.0 92-     0.0 93-      0.0 94-      0.0 95-     0.0
96-     0.0 97-     0.0 98-      0.0 99-      0.0 109-    14.49
110-   12.60 138+   143.90 139+   90.69 140+   134.65 141-   143.90
142-   90.69 143-   134.65 112-   10.962 113-   7.595-999
41+    1.0 50-    1.0-300+   31.2
42+    1.0 50-    1.0-300+   24.1
43+    1.0 50-    1.0-300+   21.9
44+    1.0 50-    1.0-300+   36.0          a
45+    1.0 50-    1.0-300+   28.6
46+    1.0 50-    1.0-300+   29.9
47+    1.0 50-    1.0-300+   25.6
48+    1.0 50-    1.0-300+   19.2
49+    1.0 50-    1.0-300+   23.3
102+   1.0 50-    1.0-200+   0.0
103+   1.0 50-    1.0-200-   0.0
104+   1.0 50-    1.0-200-   0.0          b
105+   1.0 50-    1.0-200-   0.0
106+   1.0 50-    1.0-200-   0.0
107+   1.0 50-    1.0-200-   0.0
108+   1.0 50-    1.0-200-   0.0
123+   1.0-200+   143.90
124+   1.0-200+   90.69
125+   1.0-200+   134.65                  c
50+    1.0-200+   126.0
34+    1.0 31-    1.0-100+   11.80
35+    1.0 32-    1.0-100+   6.09
36+    1.0 33-    1.0-100+   12.08        d                                   5
34+    1.0 35-    1.0-100+   7.84
36+    1.0 35-    1.0-100+   14.49
36+    1.0 37-    1.0-100+   12.60
1-     1.0 51+    1.0 52+    1.0 53+    1.0 54+    1.0
-100+  0.0
2-     1.0 57+    1.0 56+    1.0 58+    1.0 59+    1.0
60+    1.0 61+    1.0-100+   0.0
3-     1.0 65+    1.0 63+    1.0 64+    1.0 66+    1.0
67+    1.0 68+    1.0 69+    1.0-100+   0.0                   e
4-     1.0 72+    1.0 71+    1.0-100+   0.0
5-     1.0 75+    1.0 74+    1.0 109+   1.0-100+   0.0
6-     1.0 78+    1.0 79+    1.0 80+    1.0 81+    1.0
-100+  0.0
7-     1.0 83+    1.0 84+    1.0 110+   1.0-100+   0.0
8-     1.0 86+    1.0 87+    1.0-100+   0.0
9-     1.0 89+    1.0 90+    1.0 91+    1.0-100+   0.0
10-    1.0 93+    1.0-100+   0.0
11-    1.0 94+    1.0-100+   0.0
12-    1.0 95+    1.0-100+   0.0
13-    1.0 96+    1.0-100+   0.0             f
14-    1.0 97+    1.0-100+   0.0
15-    1.0 98+    1.0-100+   0.0
16-    1.0 99+    1.0-100+   0.0
19+    1.0 51-    1.0 56-    1.0 55+    1.0 63-    1.0
-100+  0.0
20+    1.0 52-    1.0 64-    1.0 62+    1.0 57-    1.0
-100+  0.0
21+    1.0 65-    1.0 60-    1.0 70+    1.0-100+   0.0
22+    1.0 53-    1.0 58-    1.0 66-    1.0 71-    1.0
74-    1.0 73+    1.0-100+   0.0
23+    1.0 54-    1.0 59-    1.0 67-    1.0 72-    0.0                  g
78-    1.0 77+    1.0 75-    1.0-100+   0.0
24+    1.0 109-   1.0 110-   1.0 79-    1.0 82+    1.0
68-    1.0 72-    1.0-100+   0.0
25+    1.0 84-    1.0 89-    1.0 85+    1.0 69-    1.0
61-    1.0 80-    1.0-100+   0.0
```

```
26+     1.0  88+    1.0  86-    1.0  90-    1.0  81-    1.0
-100+   0.0                                                  g
27+     1.0  83-    1.0  91-    1.0  87-    1.0  92+    1.0
-100+   0.0
19+     1.20  51-   1.0  56-    1.0  55+    0.0  63+    1.0
-------------------------------------------------------------
-100+   0.0
20+     1.20  52-   1.0  64-    1.0  62+    0.0  57-    1.0
-100+   0.0
21+     1.20  65-   1.0  60-    1.0  70+    0.0-100+    0.0
22+     1.20  53-   1.0  58-    1.0  66-    1.0  71-    1.0
74-     1.0  73+    0.0-100+    0.0
23+     1.20  54-   1.0  59-    1.0  67-    1.0  72-    0.0      h
78-     1.0  77+    0.0  75-    1.0-100+    0.0
24+     1.20 109-   1.0 110-    1.0  79-    1.0  82+    0.0
68-     1.0  72-    1.0-100+    0.0
25+     1.20  84-   1.0  89-    1.0  85+    0.0  69-    1.0
61-     1.0  80-    1.0-100+    0.0
26+     1.20  88+   0.0  86-    1.0  90-    1.0  81-    1.0      5
-100+   0.0
27+     1.20  83-   1.0  91-    1.0  87-    1.0  92+    0.0
-100+   0.0
-------------------------------------------------------------
112+    1.0 113+    1.0 156+    1.0  55-    1.0  62-    1.0
70-     1.0  73-    1.0  77-    1.0  82-    1.0  85-    1.0      i
88-     1.0  92-    1.0  93-    1.0  94-    1.0  95-    1.0
96-     1.0  97-    1.0  98-    1.0  99-    1.0-100+    0.0
-------------------------------------------------------------
112-    .44800 144- 1.0 141-    1.0 150-    1.0 147+    1.0
138+    1.0 120+    1.0-100+    0.0
112-    .56069 145- 1.0 142-    1.0 151-    1.0 148+    1.0      j
139+    1.0 121+    1.0-100+    0.0
113-    1.0100 146- 1.0 143-    1.0 152-    1.0 149+    1.0
-------------------------------------------------------------
140+    1.0 122+    1.0-100+    0.0
112+    .44800-100+ 12.57
112+    .56069-100+ 14.01                                        k
113+    1.0100-100+ 27.52
-------------------------------------------------------------
156+    1.0-100+    999.00
144+    1.0-200+    4.290
150+    1.0-200+    0.030
147+    1.0-200+    4.670
145+    1.0-200+    8.900
151+    1.0-200+    0.020
148+    1.0-200+    8.972
146+    1.0-200+    8.890                                        l
152+    1.0-200+    0.180
149+    1.0-200+    9.820
138+    1.0-100+    900.0
139+    1.0-100+    900.0
140+    1.0-100+    900.0
141+    1.0-100+    900.0
142+    1.0-100+    900.0
143+    1.0-100+    900.0
=============================================================
a  2              1.0  0.0
b  1
c  1+        1.0-200       0.0
d  1                              Northeast (Grade A)
e  31+       1.0-200       0.0
f  1-.0514434057  3.020
g  24.0      .40   20
-------------------------------------------------------------
2              1.0  0.0
1                                 East Northcentral
2+        1.0-200       0.0
1                                 (Grade A)
32+       1.0-200       0.0
1-.3077799674  2.520
23.0      0.5   20
-------------------------------------------------------------
2              1.0  0.0
1                                 West Northcentral
3+        1.0-200       0.0
1                                 (Grade A)                      6
33+       1.0-200       0.0
1-.0088400692  4.077
12.4      0.12  20
-------------------------------------------------------------
2              1.0  0.0
1                                 South Atlantic
4+        1.0-200       0.0
1                                 (Grade A)
34+       1.0-200       0.0
1-4.7572613204  2.429
3.3       .25   20
-------------------------------------------------------------
2              1.0  0.0
1                                 East Southcentral
5+        1.0-200       0.0
1                                 (Grade A)
35+       1.0-200       0.0
1-18.3214280306  2.015
2.9       .09   20
-------------------------------------------------------------
2              1.0  0.0
1                                 West Southcentral
6+        1.0-200       0.0
1                                 (Grade A)
36+       1.0-200       0.0
1-2.7804342768  2.529
5.0       .19   20
-------------------------------------------------------------
2              1.0  0.0
1                                 Mountain
```

```
7+          1.0-200      0.0
1
37+          1.0-200      0.0
 1-1.4015570673  3.092
   4.3       .095   20
```

(Grade A)

```
2                  1.0  0.0
1
8+          1.0-200      0.0
1
38+          1.0-200      0.0
 1-.0001740995   5.505
   12.6       .11   20
```

Southwest
(Grade A)

```
2                  1.0  0.0
1
9+          1.0-200      0.0
1
39+          1.0-200      0.0
 1-1.2798730816  3.358
   3.6       .07   20
```

Northwest
(Grade A)

```
2                  1.0  0.0
1
10+          1.0-200      0.0
1
102+          1.0-200      0.0
 1-2.3462055231  2.520
   6.0       .125   20
```

East Northcentral
(Grade B)

6

```
2                  1.0  0.0
1
11+          1.0-200      0.0
1
103+          1.0-200      0.0
 1-.0458629993   4.077
   7.4       .07   20
```

West Northcentral
(Grade B)

```
2                  1.0  0.0
1
12+          1.0-200      0.0
1
104+          1.0-200      0.0
 1-69.8188536382 2.015
   .60       .008   45
```

East Southcentral
(Grade B)

```
2                  1.0  0.0
1
13+          1.0-200      0.0
1
105+          1.0-200      0.0
 1-553.76929849992.529
   .166      .0014   40
```

West Southcentral
(Grade B)

```
2                  1.0  0.0
1
14+          1.0-200      0.0
1
106+          1.0-200      0.0
 1-14.2032619950 3.092
   1.38      .0085   40
```

Mountain
(Grade B)

```
2                  1.0  0.0
1
15+          1.0-200      0.0
1
107+          1.0-200      0.0
 1-268.3288149412 5.505
   .535      .0013   40
```

Southwest
(Grade B)

```
2                  1.0  0.0
1
16+          1.0-200      0.0
1
108+          1.0-200      0.0
 1-3939.280806172 3.358
   .120      .0006   40
```

Northwest
(Grade B)

```
a  2                  1.0 -1.0
b  1
c  19+          1.0-200      0.0
d  1
e  41-        1.0-200      0.0
f  2          1435.25  1.0        -57.015  2.0
g     11.0       .045   20
```

Northeast
(Fluid Milk)

```
2                  1.0 -1.0
1
20+          1.0-200      0.0
1
42-        1.0-200      0.0
2          1422.13  1.0        -56.350  2.0
   10.9       .070   20
```

East Northcentral
(Fluid Milk)

7

```
2                  1.0 -1.0
1
21+          1.0-200      0.0
1
43-        1.0-200      0.0
2          1370.21  1.0        -133.411  2.0
   4.5       .02   20
```

West Northcentral
(Fluid Milk)

```
2                  1.0 -1.0
1
22+          1.0-200      0.0
1
44-        1.0-200      0.0
```

South Atlantic
(Fluid Milk)

```
2      1037.68  1.0       -59.263  2.0
  6.9      .07  20
-----------------------------------------------------------
2               1.0 -1.0
1                                         East Southcentral
23+       1.0-200       0.0
1                                         (Fluid Milk)
45-       1.0-200       0.0
2      1080.35  1.0       -286.965  2.0
  1.59     .007  20
-----------------------------------------------------------
2               1.0 -1,0
1                                         West Southcentral
24+       1.0-200       0.0
1                                         (Fluid Milk)
46-       1.0-200       0.0
2      1083.88  1.0       -82.122  2.0
  5.32     .05  20
-----------------------------------------------------------
2               1.0 -1.0
1                                         Mountain
25+       1.0-200       0.0
1                                         (Fluid Milk)
47-       1.0-200       0.0
2      1414.93  1.0       -224.553  2.0
  2.77     .0085  20
-----------------------------------------------------------
2               1.0 -1.0
1                                         Southwest
26+       1.0-200       0.0
1
48-       1.0-200       0.0               (Fluid Milk)
2      1407.81  1.0       -104.365  2.0
  5.90     .02  20
-----------------------------------------------------------
2               1.0 -1.0
1                                         Northwest
27+       1.0-200       0.0
1
49-       1.0-200       0.0               (Fluid Milk)
2      1315.71  1.0       -324.543  2.0
  1.754    .0065  20
-----------------------------------------------------------
2               1.0  0.0
1
120+      1.0-200       0.0
1                                         Butter
123+      1.0-200       0.0
2      1003.00  1.0       -61.155  2.0
  6.5      .0500  50
-----------------------------------------------------------
2               1.0  0.0
1
121+      1.0-200       0.0
1                                         Nonfat Dry Milk
124+      1.0-200       0.0
2       200.55  1.0       -12.269  2.0
  2.0      .120  50
-----------------------------------------------------------
2               1.0  0.0
1
122+      1.0-200       0.0
1                                         Cheese
125+      1.0-200       0.0
2       540.34  1.0       -9.828  2.0
  15.0     .24  50
-----------------------------------------------------------
2               1.0  0.0
1
156+      1.0-200       0.0
1                                         Other Milk Products
50+       1.0-200       0.0
2       483.95  1.0       -6.302  2.0
  26.0     .24  50                                               7
-----------------------------------------------------------
a 2             126.0 31.2
b 3                                                       Northeast
c 51+     1.0  56+      1.0  63+      1.0-200     0.0
d 2
e 31+     1.0  51+      0.0-200       0.0
f 2    1435.25  1.0     -57.015  2.0                      (Blend)
g   22.0    .500   21
h 2  12.5866     -.0088    1.0
-----------------------------------------------------------
2               126.0 24.1
3                                                         East Northcentral
52+       1.0  64+      1.0  57+      1.0-200     0.0
2
32+       1.0  57+      0.0-200       0.0                 (Blend)
2      1422.13  1.0     -56.350  2.0
  24.0     .400   25
2  12.6189       -.0089    1.0
-----------------------------------------------------------
2               126.0 21.9
2                                                         West Northcentral
60+       1.0  65+      1.0-200       0.0
2
33+       1.0  65+      0.0-200       0.0
2      1370.21  1.0     -133.411  2.0                     (Blend)
  9.5      .150   40
2   5.1353      -.0037    1.0                                       8
-----------------------------------------------------------
2               126.0 36.0
5
53+       1.0  58+      1.0  66+      1.0  71+      1.0  74+   South Atlantic
-200      0.0
2
```

```
34+      1.0  71+      0.0-200      0.0
  2      1037.68  1.0  -59.263  2.0                              (Blend)
   7.0      .20   40
  2   8.7548     -.0084   1.0
------------------------------------------------------------------
  2            126.0 28.6
  6
 54+      1.0  59+      1.0  67+      1.0  72+      0.0  78+     East
 75+      1.0-200+      0.0                                      Southcentral
  2
 35+      1.0  75+      0.0-200      0.0
  2      1080.35  1.0  -286.965  2.0                             (Blend)
   1.5      .10   30
  2   1.8824     -.0017   1.0
------------------------------------------------------------------
  2            126.0 29.9
  5                                                              West
109+      1.0  79+      1.0 110+      1.0  68+      1.0  72+     Southcentral
-200+     0.0
  2
 36+      1.0  79+      0.0-200      0.0
  2      1083.88  1.0  -82.122  2.0                              (Blend)
   5.0      0.19  40
  2   6.5992     -.0061   1.0
------------------------------------------------------------------
  2            126.0 25.6
  5
 84+      1.0  89+      1.0  69+      1.0  61+      1.0  80+     Mountain
-200+     0.0
  2
 37+      1.0  84+      0.0-200      0.0                         (Blend)
  2      1414.93  1.0  -224.553  2.0
   4.3      .095  20
  2   3.1506     -.0022   1.0
------------------------------------------------------------------
  2            126.0 19.2
  2
 86+      1.0  90+      1.0-200      0.0                         Southwest
  2
 38+      1.0  86+      0.0-200      0.0                         (Blend)
  2      1407.81  1.0  -104.365  2.0
  12.6      .11   20
  2   6.7446     -.0048   1.0
------------------------------------------------------------------
  2            126.0 23.3
  3
 83+      1.0  87+      1.0  91+      1.0-200      0.0           Northwest
  2
 39+      1.0  91+      0.0-200      0.0
  2      1315.71  1.0  -324.543  2.0                             (Blend)
   3.6      .07   20
  2   2.0270     -.0015   1.0
------------------------------------------------------------------
```

8

E.3. Mathematical Programming System (MPS) Input File (1982 Analysis)

In this section matrix generator output (MPS input) file for the 1982 analysis is illustrated. Readers should refer to the section 2 in this appendix. Constraint rows up to 83 are nonaugmented portion (see step 5 in E.2.3) and rows after 83 are augmented portion (see steps 6,7, and 8 in E.2.3.).

```
// EXEC LP
//LP.SYSIN DD *
       PROGRAM
       INITIALZ
       TITLE ('PILOT RUN 82DATA')
       MOVE (XDATA,'BASE82A')
       MOVE (XPBNAME,'DATA')
       CONVERT ('CHECK','SUMMARY')
       SETUP('MAX')
       MOVE (XOBJ,'OBJ')
       MOVE (XRHS,'DEMCAP')
       TRANCOL
       VARIFORM
       SOLUTION
       EXIT
       PEND
//GO.SYSIN  DD *
NAME        BASE82A
ROWS
 N  OBJ
 G  001
 G  002
 G  003
 G  004
 G  005
 G  006
 G  007
 G  008
 G  009
 E  010
 E  011
 E  012
 E  013
 E  014
 E  015
 E  016
 E  017
 E  018
 E  019
 E  020
 L  021
 L  022
 L  023
 L  024
 L  025
 L  026
 L  027
 L  028
 L  029
 L  030
 L  031
 L  032
 L  033
 L  034
 L  035
 L  036
 L  037
 L  038
 L  039
 L  040
 L  041
 L  042
 L  043
 L  044
 L  045
 L  046
 L  047
 L  048
 L  049
 L  050
 L  051
 L  052
 L  053
 L  054
 L  055
 L  056
 L  057
 L  058
 L  059
 L  060
 L  061
 L  062
 L  063
 L  064
 L  065
 L  066
 L  067
```

L 068
E 069
E 070
E 071
E 072
E 073
E 074
E 075
E 076
E 077
L 078
L 079
L 080
L 081
L 082
L 083
E 084
E 085
L 086
E 087
E 088
L 089
E 090
E 091
L 092
E 093
E 094
L 095
E 096
E 097
L 098
E 099
E 100
L 101
E 102
E 103
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E 144
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E 148
L 149
E 150
E 151
L 152
E 153
E 154
L 155
E 156
E 157
L 158
E 159
E 160
L 161
E 162
E 163

```
L  164
E  165
E  166
L  167
E  168
E  169
L  170
E  171
E  172
E  173
E  174
E  175
E  176
E  177
E  178
E  179
E  180
E  181
E  182
E  183
E  184
E  185
E  186
E  187
E  188
E  189
E  190
E  191
E  192
E  193
E  194
E  195
E  196
E  197
COLUMNS
    A1     027     -.100000E+01
    A1     084     +.100000E+01
    A2     028     -.100000E+01
    A2     087     +.100000E+01
    A3     029     -.100000E+01
    A3     090     +.100000E+01
    A4     030     -.100000E+01
    A4     093     +.100000E+01
    A5     031     -.100000E+01
    A5     096     +.100000E+01
    A6     032     -.100000E+01
    A6     099     +.100000E+01
    A7     033     -.100000E+01
    A7     102     +.100000E+01
    A8     034     -.100000E+01
    A8     105     +.100000E+01
    A9     035     -.100000E+01
    A9     108     +.100000E+01
    B2     036     -.100000E+01
    B2     111     +.100000E+01
    B3     037     -.100000E+01
    B3     114     +.100000E+01
    B5     038     -.100000E+01
    B5     117     +.100000E+01
    B6     039     -.100000E+01
    B6     120     +.100000E+01
    B7     040     -.100000E+01
    B7     123     +.100000E+01
    B8     041     -.100000E+01
    B8     126     +.100000E+01
    B9     042     -.100000E+01
    B9     129     +.100000E+01
    F1     043     +.100000E+01
    F1     052     +.120000E+01
    F1     132     +.100000E+01
    F2     044     +.100000E+01
    F2     053     +.120000E+01
    F2     135     +.100000E+01
    F3     045     +.100000E+01
    F3     054     +.120000E+01
    F3     138     +.100000E+01
    F4     046     +.100000E+01
    F4     055     +.120000E+01
    F4     141     +.100000E+01
    F5     047     +.100000E+01
    F5     056     +.120000E+01
    F5     144     +.100000E+01
    F6     048     +.100000E+01
    F6     057     +.120000E+01
    F6     147     +.100000E+01
    F7     049     +.100000E+01
    F7     058     +.120000E+01
    F7     150     +.100000E+01
    F8     050     +.100000E+01
    F8     059     +.120000E+01
    F8     153     +.100000E+01
    F9     051     +.100000E+01
    F9     060     +.120000E+01
    F9     156     +.100000E+01
    PA1    021     -.100000E+01
    PA1    085     +.100000E+01
```

PA1	086	+.0
PA1	172	+.100000E+01
PA2	022	-.100000E+01
PA2	088	+.100000E+01
PA2	089	+.0
PA2	175	+.100000E+01
PA3	023	-.100000E+01
PA3	091	+.100000E+01
PA3	092	+.0
PA3	178	+.100000E+01
PA4	021	+.100000E+01
PA4	024	+.100000E+01
PA4	094	+.100000E+01
PA4	095	+.0
PA4	181	+.100000E+01
PA5	022	+.100000E+01
PA5	024	-.100000E+01
PA5	025	-.100000E+01
PA5	097	+.100000E+01
PA5	098	+.0
PA5	184	+.100000E+01
PA6	023	+.100000E+01
PA6	025	+.100000E+01
PA6	026	+.100000E+01
PA6	100	+.100000E+01
PA6	101	+.0
PA6	187	+.100000E+01
PA7	026	-.100000E+01
PA7	103	+.100000E+01
PA7	104	+.0
PA7	190	+.100000E+01
PA8	106	+.100000E+01
PA8	107	+.0
PA8	193	+.100000E+01
PA9	109	+.100000E+01
PA9	110	+.0
PA9	196	+.100000E+01
PA9	198	+.100000E+01
PF1	001	+.100000E+01
PF1	133	-.100000E+01
PF1	134	-.0
PF2	002	+.100000E+01
PF2	136	-.100000E+01
PF2	137	-.0
PF3	003	+.100000E+01
PF3	139	-.100000E+01
PF3	140	-.0
PF4	004	+.100000E+01
PF4	142	-.100000E+01
PF4	143	-.0
PF5	005	+.100000E+01
PF5	145	-.100000E+01
PF5	146	-.0
PF6	006	+.100000E+01
PF6	148	-.100000E+01
PF6	149	-.0
PF7	007	+.100000E+01
PF7	151	-.100000E+01
PF7	152	-.0
PF8	008	+.100000E+01
PF8	154	-.100000E+01
PF8	155	-.0
PF9	009	+.100000E+01
PF9	157	-.100000E+01
PF9	158	-.0
PM	001	-.100000E+01
PM	002	-.100000E+01
PM	003	-.100000E+01
PM	004	-.100000E+01
PM	005	-.100000E+01
PM	006	-.100000E+01
PM	007	-.100000E+01
PM	008	-.100000E+01
PM	009	-.100000E+01
PM	010	-.100000E+01
PM	011	-.100000E+01
PM	012	-.100000E+01
PM	013	-.100000E+01
PM	014	-.100000E+01
PM	015	-.100000E+01
PM	016	-.100000E+01
PM	020	+.100000E+01
PM	169	+.100000E+01
PM	170	+.0
A11	OBJ	-.0
A11	027	+.100000E+01
A11	043	-.100000E+01
A11	052	-.100000E+01
A11	171	+.100000E+01
A11	172	+.0
A11	173	+.0
A12	OBJ	-.121500E+02
A12	027	+.100000E+01
A12	044	-.100000E+01
A12	053	-.100000E+01
A12	174	+.100000E+01

A14	OBJ	-.118000E+02
A14	027	+.100000E+01
A14	046	-.100000E+01
A14	055	-.100000E+01
A14	180	+.100000E+01
A15	OBJ	-.168400E+02
A15	027	+.100000E+01
A15	047	-.100000E+01
A15	056	-.100000E+01
A15	183	+.100000E+01
A1M	OBJ	-.0
A1M	043	+.100000E+01
A1M	052	+.0
A1M	061	-.100000E+01
A21	OBJ	-.121500E+02
A21	028	+.100000E+01
A21	043	-.100000E+01
A21	052	-.100000E+01
A21	171	+.100000E+01
A22	OBJ	-.0
A22	028	+.100000E+01
A22	044	-.100000E+01
A22	053	-.100000E+01
A22	174	+.100000E+01
A22	175	+.0
A22	176	+.0
A24	OBJ	-.169100E+02
A24	028	+.100000E+01
A24	046	-.100000E+01
A24	055	-.100000E+01
A24	180	+.100000E+01
A25	OBJ	-.609000E+01
A25	028	+.100000E+01
A25	047	-.100000E+01
A25	056	-.100000E+01
A25	183	+.100000E+01
A23	OBJ	-.167700E+02
A23	028	+.100000E+01
A23	045	-.100000E+01
A23	054	-.100000E+01
A23	177	+.100000E+01
A27	OBJ	-.999900E+03
A27	028	+.100000E+01
A27	049	-.100000E+01
A27	058	-.100000E+01
A27	189	+.100000E+01
A2M	OBJ	-.0
A2M	044	+.100000E+01
A2M	053	+.0
A2M	061	-.100000E+01
A31	OBJ	-.999900E+03
A31	029	+.100000E+01
A31	043	-.100000E+01
A31	052	+.100000E+01
A31	171	+.100000E+01
A32	OBJ	-.167700E+02
A32	029	+.100000E+01
A32	044	-.100000E+01
A32	053	-.100000E+01
A32	174	+.100000E+01
A33	OBJ	-.0
A33	029	+.100000E+01
A33	045	-.100000E+01
A33	054	-.100000E+01
A33	177	+.100000E+01
A33	178	+.0
A33	179	+.0
A34	OBJ	-.197800E+02
A34	029	+.100000E+01
A34	046	-.100000E+01
A34	055	-.100000E+01
A34	180	+.100000E+01
A35	OBJ	-.168700E+02
A35	029	+.100000E+01
A35	047	-.100000E+01
A35	056	-.100000E+01
A35	183	+.100000E+01
A36	OBJ	-.120800E+02
A36	029	+.100000E+01
A36	048	-.100000E+01
A36	057	-.100000E+01
A36	186	+.100000E+01
A37	OBJ	-.999900E+03
A37	029	+.100000E+01
A37	049	-.100000E+01
A37	058	-.100000E+01
A37	189	+.100000E+01
A3M	OBJ	-.0
A3M	045	+.100000E+01
A3M	054	+.0
A3M	061	-.100000E+01
A44	OBJ	-.0
A44	030	+.100000E+01
A44	046	-.100000E+01
A44	055	-.100000E+01
A44	180	+.100000E+01

A44	181	+.0
A44	182	+.0
A46	OBJ	-.139700E+02
A46	030	+.100000E+01
A46	047	-.0
A46	048	-.100000E+01
A46	056	-.0
A46	057	-.100000E+01
A46	183	+.0
A46	186	+.100000E+01
A4M	OBJ	-.0
A4M	046	+.100000E+01
A4M	055	+.0
A4M	061	-.100000E+01
A54	OBJ	-.784000E+01
A54	031	+.100000E+01
A54	046	-.100000E+01
A54	055	-.100000E+01
A54	180	+.100000E+01
A55	OBJ	-.0
A55	031	+.100000E+01
A55	047	-.100000E+01
A55	056	-.100000E+01
A55	183	+.100000E+01
A55	184	+.0
A55	185	+.0
A57	OBJ	-.999900E+03
A5M	OBJ	-.0
A5M	047	+.100000E+01
A5M	056	+.0
A5M	061	-.100000E+01
A65	OBJ	-.166600E+02
A65	032	+.100000E+01
A65	047	-.100000E+01
A65	056	-.100000E+01
A65	183	+.100000E+01
A66	OBJ	-.0
A66	032	+.100000E+01
A66	048	-.100000E+01
A66	057	-.100000E+01
A66	186	+.100000E+01
A66	187	+.0
A66	188	+.0
A67	OBJ	-.999900E+03
A67	032	+.100000E+01
A67	049	-.100000E+01
A67	058	-.100000E+01
A67	189	+.100000E+01
A68	OBJ	-.999900E+03
A68	032	+.100000E+01
A68	050	-.100000E+01
A68	059	-.100000E+01
A6M	OBJ	-.0
A6M	048	+.100000E+01
A6M	057	+.0
A6M	061	-.100000E+01
A79	OBJ	-.131600E+02
A79	033	+.100000E+01
A79	051	-.100000E+01
A79	060	-.100000E+01
A79	195	+.100000E+01
A77	OBJ	-.0
A77	033	+.100000E+01
A77	049	-.100000E+01
A77	058	-.100000E+01
A77	189	+.100000E+01
A77	190	+.0
A77	191	+.0
A7M	OBJ	-.0
A7M	049	+.100000E+01
A7M	058	+.0
A7M	061	-.100000E+01
A88	OBJ	-.0
A88	034	+.100000E+01
A88	050	-.100000E+01
A88	059	-.100000E+01
A88	192	+.100000E+01
A88	193	+.0
A88	194	+.0
A89	OBJ	-.120800E+02
A89	034	+.100000E+01
A89	051	-.100000E+01
A89	060	-.100000E+01
A89	195	+.100000E+01
A8M	OBJ	-.0
A8M	050	+.100000E+01
A8M	059	+.0
A8M	061	-.100000E+01
A97	OBJ	-.131600E+02
A97	035	+.100000E+01
A97	049	-.100000E+01
A97	058	-.100000E+01
A97	189	+.100000E+01
A98	OBJ	-.120800E+02
A98	035	+.100000E+01
A98	050	-.100000E+01

A98	059	-.100000E+01
A98	192	+.100000E+01
A99	OBJ	-.0
A99	035	+.100000E+01
A99	051	-.100000E+01
A99	060	-.100000E+01
A99	195	+.100000E+01
A99	196	+.0
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A9M	OBJ	-.0
A9M	051	+.100000E+01
A9M	060	+.0
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B2M	OBJ	-.0
B2M	036	+.100000E+01
B2M	061	-.100000E+01
B3M	OBJ	-.0
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B3M	061	-.100000E+01
B5M	OBJ	-.0
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B5M	061	-.100000E+01
B6M	OBJ	-.0
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B6M	061	-.100000E+01
B7M	OBJ	-.0
B7M	040	+.100000E+01
B7M	061	-.100000E+01
B8M	OBJ	-.0
B8M	041	+.100000E+01
B8M	061	-.100000E+01
B9M	OBJ	-.0
B9M	042	+.100000E+01
B9M	061	-.100000E+01
PB2	010	+.100000E+01
PB2	112	+.100000E+01
PB2	113	+.0
PB3	011	+.100000E+01
PB3	115	+.100000E+01
PB3	116	+.0
PB5	012	+.100000E+01
PB5	118	+.100000E+01
PB5	119	+.0
PB6	013	+.100000E+01
PB6	121	+.100000E+01
PB6	122	+.0
PB7	014	+.100000E+01
PB7	124	+.100000E+01
PB7	125	+.0
PB8	015	+.100000E+01
PB8	127	+.100000E+01
PB8	128	+.0
PB9	016	+.100000E+01
PB9	130	+.100000E+01
PB9	131	+.0
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A56	031	+.100000E+01
A56	048	-.100000E+01
A56	057	-.100000E+01
A56	186	+.100000E+01
A76	OBJ	-.126000E+02
A76	033	+.100000E+01
A76	048	-.100000E+01
A76	057	-.100000E+01
A76	186	+.100000E+01
M12	OBJ	-.109620E+02
M12	061	+.100000E+01
M12	062	-.448000E+00
M12	063	-.560690E+00
M12	065	+.448000E+00
M12	066	+.560690E+00
M3	OBJ	-.759500E+01
M3	061	+.100000E+01
M3	064	-.101000E+01
M3	067	+.101000E+01
YB	062	+.100000E+01
YB	159	+.100000E+01
YN	063	+.100000E+01
YN	162	+.100000E+01
YC	064	+.100000E+01
YC	165	+.100000E+01
PYB	017	+.100000E+01
PYB	160	+.100000E+01
PYB	161	+.0
PYN	018	+.100000E+01
PYN	163	+.100000E+01
PYN	164	+.0
PYC	019	+.100000E+01
PYC	166	+.100000E+01
PYC	167	+.0
GDB	OBJ	+.143900E+03
GDB	062	+.100000E+01
GDB	078	+.100000E+01
GDN	OBJ	+.906900E+02
GDN	063	+.100000E+01
GDN	079	+.100000E+01

GDC	OBJ	+.134650E+03
GDC	064	+.100000E+01
GDC	080	+.100000E+01
GSB	OBJ	-.143900E+03
GSB	062	-.100000E+01
GSB	081	+.100000E+01
GSN	OBJ	-.906900E+02
GSN	063	-.100000E+01
GSN	082	+.100000E+01
GSC	OBJ	-.134650E+03
GSC	064	-.100000E+01
GSC	083	+.100000E+01
BSB	062	-.100000E+01
BSB	069	+.100000E+01
BSN	063	-.100000E+01
BSN	072	+.100000E+01
BSC	064	-.100000E+01
BSC	075	+.100000E+01
ESB	062	+.100000E+01
ESB	071	+.100000E+01
ESN	063	+.100000E+01
ESN	074	+.100000E+01
ESC	064	+.100000E+01
ESC	077	+.100000E+01
IMB	062	-.100000E+01
IMB	070	+.100000E+01
IMN	063	-.100000E+01
IMN	073	+.100000E+01
IMC	064	-.100000E+01
IMC	076	+.100000E+01
M4	061	+.100000E+01
M4	068	+.100000E+01
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YA01	OBJ	-.757824E+03
YA01	084	-.240000E+02
YA01	085	-.953595E+02
YA01	086	+.100000E+01
YA02	OBJ	-.796612E+03
YA02	084	-.244000E+02
YA02	085	-.985971E+02
YA02	086	+.100000E+01
YA03	OBJ	-.836707E+03
YA03	084	-.248000E+02
YA03	085	-.101889E+03
YA03	086	+.100000E+01
YA04	OBJ	-.878129E+03
YA04	084	-.252000E+02
YA04	085	-.105236E+03
YA04	086	+.100000E+01
YA05	OBJ	-.920901E+03
YA05	084	-.256000E+02
YA05	085	-.108638E+03
YA05	086	+.100000E+01
YA06	OBJ	-.965044E+03
YA06	084	-.260000E+02
YA06	085	-.112094E+03
YA06	086	+.100000E+01
YA07	OBJ	-.101058E+04
YA07	084	-.264000E+02
YA07	085	-.115605E+03
YA07	086	+.100000E+01
YA08	OBJ	-.105753E+04
YA08	084	-.268000E+02
YA08	085	-.119170E+03
YA08	086	+.100000E+01
YA09	OBJ	-.110593E+04
YA09	084	-.272000E+02
YA09	085	-.122790E+03
YA09	086	+.100000E+01
YA10	OBJ	-.115577E+04
YA10	084	-.275999E+02
YA10	085	-.126465E+03
YA10	086	+.100000E+01
YA11	OBJ	-.120710E+04
YA11	084	-.279999E+02
YA11	085	-.130195E+03
YA11	086	+.100000E+01
YA12	OBJ	-.125994E+04
YA12	084	-.283999E+02
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YA13	OBJ	-.131429E+04
YA13	084	-.287999E+02
YA13	085	-.137818E+03
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YA14	OBJ	-.137019E+04
YA14	084	-.291999E+02
YA14	085	-.141712E+03
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YA15	OBJ	-.142767E+04
YA15	084	-.295999E+02
YA15	085	-.145661E+03
YA15	086	+.100000E+01
YA16	OBJ	-.148673E+04
YA16	084	-.299999E+02
YA16	085	-.149665E+03

YA16	086	+.100000E+01
YA17	OBJ	-.154740E+04
YA17	084	-.303999E+02
YA17	085	-.153723E+03
YA17	086	+.100000E+01
YA18	OBJ	-.160971E+04
YA18	084	-.307999E+02
YA18	085	-.157836E+03
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YA19	OBJ	-.167368E+04
YA19	084	-.311999E+02
YA19	085	-.162004E+03
YA19	086	+.100000E+01
YA20	OBJ	-.173932E+04
YA20	084	-.315999E+02
YA20	085	-.166227E+03
YA20	086	+.100000E+01
YB01	OBJ	-.831371E+03
YB01	087	-.230000E+02
YB01	088	-.910893E+02
YB01	089	+.100000E+01
YB02	OBJ	-.877671E+03
YB02	087	-.235000E+02
YB02	088	-.941163E+02
YB02	089	+.100000E+01
YB03	OBJ	-.925493E+03
YB03	087	-.240000E+02
YB03	088	-.971767E+02
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YB04	OBJ	-.974854E+03
YB04	087	-.245000E+02
YB04	088	-.100271E+03
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YB05	OBJ	-.102577E+04
YB05	087	-.250000E+02
YB05	088	-.103398E+03
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YB06	OBJ	-.107825E+04
YB06	087	-.255000E+02
YB06	088	-.106557E+03
YB06	089	+.100000E+01
YB07	OBJ	-.113233E+04
YB07	087	-.260000E+02
YB07	088	-.109749E+03
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YB08	OBJ	-.118801E+04
YB08	087	-.265000E+02
YB08	088	-.112973E+03
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YB09	OBJ	-.124531E+04
YB09	087	-.270000E+02
YB09	088	-.116229E+03
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YB10	OBJ	-.130425E+04
YB10	087	-.275000E+02
YB10	088	-.119516E+03
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YB11	OBJ	-.136483E+04
YB11	087	-.280000E+02
YB11	088	-.122835E+03
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YB12	OBJ	-.142708E+04
YB12	087	-.285000E+02
YB12	088	-.126184E+03
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YB13	OBJ	-.149102E+04
YB13	087	-.290000E+02
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YB18	087	-.315000E+02
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YB19	087	-.320000E+02
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YB20	OBJ	-.198695E+04
YB20	087	-.325000E+02
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YC01	OBJ	-.253708E+03
YC01	090	-.124000E+02
YC01	091	-.834169E+02
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YC02	OBJ	-.263868E+03
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YC03	OBJ	-.274333E+03
YC03	090	-.126400E+02
YC03	091	-.884852E+02
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YC04	OBJ	-.285107E+03
YC04	090	-.127600E+02
YC04	091	-.910957E+02
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YC05	OBJ	-.296198E+03
YC05	090	-.128800E+02
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YC06	OBJ	-.307611E+03
YC06	090	-.130000E+02
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YC07	OBJ	-.319353E+03
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YC08	OBJ	-.331430E+03
YC08	090	-.132400E+02
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YC09	OBJ	-.343849E+03
YC09	090	-.133600E+02
YC09	091	-.104931E+03
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YC10	OBJ	-.356615E+03
YC10	090	-.134800E+02
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YC11	OBJ	-.369736E+03
YC11	090	-.136000E+02
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YC12	OBJ	-.383219E+03
YC12	090	-.137200E+02
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YC13	OBJ	-.397069E+03
YC13	090	-.138400E+02
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YC15	OBJ	-.425900E+03
YC15	090	-.140800E+02
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YC16	OBJ	-.440893E+03
YC16	090	-.142000E+02
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YC17	090	-.143200E+02
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YC18	OBJ	-.472074E+03
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YC19	OBJ	-.488274E+03
YC19	090	-.145600E+02
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YC20	OBJ	-.504889E+03
YC20	090	-.146800E+02
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YD01	OBJ	-.864623E+02
YD01	093	-.330000E+01
YD01	094	-.636415E+02
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YD02	OBJ	-.103243E+03
YD02	093	-.355000E+01
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YD03	OBJ	-.121801E+03
YD03	093	-.380000E+01
YD03	094	-.778564E+02
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YD04	OBJ	-.142189E+03
YD04	093	-.405000E+01
YD04	094	-.852781E+02

YD04	095	+.100000E+01
YD05	OBJ	-.164456E+03
YD05	093	-.430000E+01
YD05	094	-.928987E+02
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YD06	OBJ	-.188654E+03
YD06	093	-.455000E+01
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YD07	093	-.480000E+01
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YD09	OBJ	-.273289E+03
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YD19	OBJ	-.698642E+03
YD19	093	-.780000E+01
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YD20	OBJ	-.754283E+03
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YE01	OBJ	-.156564E+03
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YE01	098	+.100000E+01
YE02	OBJ	-.166508E+03
YE02	096	-.299000E+01
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YE03	OBJ	-.176762E+03
YE03	096	-.308000E+01
YE03	097	-.115641E+03
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YE04	OBJ	-.187324E+03
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YE04	098	+.100000E+01
YE05	OBJ	-.198194E+03
YE05	096	-.326000E+01
YE05	097	-.122504E+03
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YE06	OBJ	-.209374E+03
YE06	096	-.335000E+01
YE06	097	-.125937E+03
YE06	098	+.100000E+01
YE07	OBJ	-.220863E+03
YE07	096	-.343999E+01
YE07	097	-.129372E+03
YE07	098	+.100000E+01
YE08	OBJ	-.232661E+03
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YE09	OBJ	-.244768E+03
YE09	096	-.361999E+01
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YE10	OBJ	-.257185E+03
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YE11	OBJ	-.269911E+03
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YE12	OBJ	-.282947E+03
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YE12	097	-.146565E+03
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YE13	OBJ	-.296293E+03
YE13	096	-.397999E+01
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YE14	OBJ	-.309948E+03
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YE14	098	+.100000E+01
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YE15	097	-.156896E+03
YE15	098	+.100000E+01
YE16	OBJ	-.338189E+03
YE16	096	-.424999E+01
YE16	097	-.160342E+03
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YE17	OBJ	-.352775E+03
YE17	096	-.433999E+01
YE17	097	-.163789E+03
YE17	098	+.100000E+01
YE18	OBJ	-.367671E+03
YE18	096	-.442999E+01
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YE19	OBJ	-.382878E+03
YE19	096	-.451999E+01
YE19	097	-.170686E+03
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YE20	OBJ	-.398395E+03
YE20	096	-.460998E+01
YE20	097	-.174136E+03
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YF01	OBJ	-.162858E+03
YF01	099	-.500000E+01
YF01	100	-.823733E+02
YF01	101	+.100000E+01
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YF02	099	-.519000E+01
YF02	100	-.872071E+02
YF02	101	+.100000E+01
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YF03	100	-.921355E+02
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YF04	100	-.971569E+02
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YF05	100	-.102270E+03
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YF07	OBJ	-.273772E+03
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YF08	099	-.633000E+01
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YI03	108	-.374000E+01
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YK01	115	-.883949E+02
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YK02	115	-.909933E+02
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YK03	OBJ	-.173182E+03
YK03	114	-.754000E+01
YK03	115	-.936426E+02
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YL02	OBJ	-.256176E+02
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YL03	OBJ	-.263013E+02
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YL10	OBJ	-.313416E+02
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The two page vita has been removed from the scanned document. Page 2 of 2