DAIRY MARKETING AND POLICY ANALYSIS: A CRITICAL REVIEW OF RECENT EMPIRICAL STUDIES

By

ROGER A. DAHLGRAN

Economics Special Report No. 62
Department of Economics and Business
North Carolina State University
Raleigh, North Carolina
March 1981

DAIRY MARKETING AND POLICY ANALYSIS:

A CRITICAL REVIEW OF RECENT EMPIRICAL STUDIES

Roger A. Dahlgran

Economics Special Report No. 62
Department of Economics and Business
North Carolina State University
Raleigh, North Carolina
March 1981

ABSTRACT

This review summarizes recent dairy marketing studies. They have been placed in one of two categories: nonpolicy research and policy research. Nonpolicy research studies are concerned with estimating a specific response. These studies are summarized to facilitate comparisons among models and resulting estimates. Policy research studies are concerned with the effects of altering policy variables or eliminating entire programs. The features of each study are explicitly stated so as to allow comparisons among the various studies.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This report is a contribution to the regional research program under S-104 entitled "Marketing Performance of Selected Milk Pricing Systems for the Southern Region." Financial support provided under research agreements between the North Carolina Agricultural Research Service and the Economics and Statistics Service, U.S. Department of Agriculture, is gratefully acknowledged.

The author was formerly a graduate research assistant at North Carolina State University and is now Assistant Professor in the Department of Economics, Iowa State University.

DAIRY MARKETING AND POLICY ANALYSIS:

A CRITICAL REVIEW OF RECENT EMPIRICAL STUDIES

Roger A. Dahlgran

Introduction

Policy controversy involving the U.S. dairy industry began late in the 1800s over the immunity of dairy cooperatives located in the upper Midwest from prosecution under the Sherman Antitrust Act (Williams et al., 1970, p. 30). Since that time, the U.S. dairy industry has become subject to other regulations, including sanitary requirements, classified pricing and pooling under state and federal regulation, import restrictions, and base plans. The passage of the Agricultural Act of 1949 established the present authority for price supports between 75 and 90 percent of parity and was the last major piece of the current regulatory program. It is not to be inferred that these regulations were created in the absence of research or forethought, but economists' abilities to analyze data and make forecasts have been greatly enhanced by modern electronic computers and modern quantitative techniques, both of which were developed after the bulk of the current dairy market regulation was in place. The studies to be examined in this literature review are recent empirical dairy marketing and policy studies. The term "recent studies" eliminates research done before 1948, while "empirical research" is intended to restrict attention to those studies using multiple regression, simultaneous equation techniques, and/or simulation techniques. Descriptive studies of structure and trends of the U.S. dairy industry, while numerous, are not included in this review.

The studies selected for review are conveniently divided into two categories. Roughly half of the volume of the literature is nonpolicy studies. These are studies where primary emphasis is placed on supply and/or demand parameter estimation. The other half of the volume of the literature is policy studies. Policy studies are those where primary emphasis is placed on the effect of alternative policy decisions on dairy markets and/or the effect of altering the current policy structure.

Since this is a critical review, the basis of criticism will be exposed at the outset. Criticism will be made, when appropriate, based on the economic theory and econometric techniques embodied in the study. The approach used in this review will be to present a study and then to evaluate it. When several similar studies have been discussed, the studies as a group will be compared with each other, and an attempt will be made to summarize the studies as a group.

Nonpolicy Studies

As has already been mentioned, nonpolicy studies are those studies that are primarily concerned with estimating response relationships. These studies can be further subdivided by the response relationships considered. One group of studies considers only supply relationships, another group considers only demand relationships, while still a third group considers both supply and demand relationships.

Supply Studies

An alternative to direct supply response estimation is to estimate the underlying production function. Production function studies as well as direct supply response studies will be considered.

The production function approach to supply response estimation has resulted in several estimates of dairy production functions. Heady et al. (1960); Heady et al. (1964); Hoover et al. (1967); and Paris et al. (1970) have all estimated production functions relating milk per cow to roughage and concentrate consumption as well as environmental variables and cow characteristics. Cow characteristics include such variables as age, weight, maturity, and initial ability. The form of the production function used in all of these studies was a linear plus a quadratic combination of the inputs. Heady et al. (1960) reported on the fit of a log linear production function. In general, the data fit these functional forms fairly well and exhibited R^2's in the 0.70 to 0.90 range.

While pointing out that estimation of production functions provides an alternative to direct supply response estimation, Heady (1961, p. 14) acknowledged that the production function approach encounters difficulties in the presence of uncertainty, lack of knowledge, nonmonetary goals, lumpiness of fixed factors and joint production of agricultural products. Even with estimated production functions and the implied marginal cost curves, difficulties may still exist due to pecuniary externalities which distort the aggregation of the marginal cost curves into a supply function. A final problem with these particular studies in ascertaining a dairy supply response is that these particular studies are incomplete for modeling the dairy industry. Inputs of land, labor, and capital are omitted from these production functions although they are definitely factors of milk production.

Studies estimating the direct supply response of milk have been done by Brandow (1953), Halvorson (1955, 1958), Cochrane (1958), Wipf and Houck (1967), and Chen et al. (1972). Halvorson (1955) presents a summarization of the a priori beliefs about the nature of the milk supply response. First, the milk supply response is believed to be highly price inelastic due to the large fixed investment requirement required for dairying, the lack of good alternatives for labor in many areas where milk production is substantial, the fact that the small or variable output producer is penalized in the marketplace due to pricing arrangements, the time lag required to alter cow herds or equipment, the effect of price and output uncertainty, and the lag time between production and price formation. Second, the supply elasticity is believed to take on differing values depending on the length of run. A third belief is that supply responses are different for summer than for winter. A final belief is that the total production response is composed of responses in cow numbers and in production per cow. Early researchers focused on production per cow while later researchers have focused on total production relationships.

Brandow's (1953) research was exploratory in nature. Using time series data for 1932 to 1951, Brandow formulated one set of input-output relationships and one set of price response relationships for four major dairy states (Pennsylvania, New York, Wisconsin, and Minnesota). The input-output models specified the relation of summer and winter production per cow to pasture conditions and grain fed per cow. The price response models specified the relation of summer and winter production per cow to pasture conditions and the milk-feed price ratio. The results showed that the responsiveness of milk production per cow to grain fed per cow was higher in the winter than in the summer. The comparison of the summer to the winter response of milk per cow to milk-feed price ratio varied by state.

Halvorson (1955) performed four analyses to evaluate the short-run response of milk production per cow to various factors for the summer and winter seasons. Regional as well as aggregate models were fit using logged and differenced time series data for 1931 to 1954. One analysis was an input-output relation of milk per cow per day to grain and concentrates fed per cow, to hay production, to cow numbers and to a constant term which was an indicator of technological change. The conclusion that the response of milk per cow per day to grain fed per cow was higher in the winter than in the summer is in agreement with the results found by Brandow (1953). A second analysis of the response of grain fed per pound of milk produced to the milk-feed price ratio was formulated to capture the farmer's response rather than the cow's response. The results indicate that the farmer's response was inelastic. A third analysis of the response of milk production per cow to the milk-feed price ratio, to hay production and to cow numbers yielded supply elasticity estimates of 0 to 0.25 with winter estimates in the upper end of the range and summer estimates in the lower end of the range. The fourth analysis was designed to test the hypothesis that the farmer's response in terms of grain fed per pound of milk produced to the milk-feed price ratio for price increases was different from that for price decreases. The conclusion was that the farmer's short-run response was more elastic for price increases than for price decreases.

In 1958, Halvorson again analyzed the response of milk production to price. In this analysis, annual time series data for 1927 through 1957 were used in conjunction with the partial adjustment model. Milk production was regressed on the previous year's milk production, the previous year's deflated price, hay supplies, concentrate supplies and the previous year's deflated hog and beef prices. The results of this analysis indicated that the short-run price elasticity of milk production is in the 0.15 to 0.30 range with some evidence that it has increased in later years. The long-run price elasticity of milk production appears to be in the 0.35 to 0.50 range. A final analysis was done to determine if the response of milk production to falling prices differed from the response of milk production to rising prices. The results are not statistically significant but do suggest that the long-run response to falling prices is greater than the long-run response to rising prices.

Cochrane (1958) formulated a milk supply model using quarterly data from 1947 through 1956. Milk production was regressed on average current and lagged wholesale milk prices, average current and lagged dairy ration prices, production per cow and number of cows. This analysis yielded a supply elasticity of 0.30.

Wipf and Houck (1967) used annual U.S. time series data to estimate the response of milk production to milk prices lagged one year, feed inputs, slaughter cow prices and technology. A partial adjustment model was used to estimate the long-run response. The variables were combined in both linear and log linear forms to ascertain the desired supply response parameters. The conclusions of this work were that either the linear or the log linear form could be used. According to this study, the estimate of the short-run supply elasticity was 0.05 to 0.07, while the estimate of the long-run supply elasticity was 0.07 to 0.15.

A final analysis of the milk production response to price was done by Chen et al. (1972). Using quarterly data for 1953 through 1968 for the California dairy industry, two different structures of the effect of lagged price on quantity were tested. The forms of the tested lag structures were the geometric lag and the second order polynomial lag. In addition to lagged price, other independent variables included seasonal shifters and technological trend variables. The findings of this research are that the California dairy industry has a short-run supply elasticity of 0.15 to 0.40 and a long-run supply elasticity of around 2.54.

This concludes the summarization of the studies that are concerned with estimating the direct supply response of milk production to milk prices. These studies are summarized in Table 1. It should be noted that these studies are similar in conceptual approach and data analyzed. As a group, these studies lack an explicit hypothesis of profit maximization to explain producers' behavior. Further, the hypothesis of quantity supplied reacting solely to last period's price is not rational behavior on the part of producers. A more complete model involving lagged prices would have producers reacting to the current period's expected price which is correlated with last period's price. Another criticism of these studies is that they do not isolate the response of grade A milk production from the response of grade B milk production nor do they specify how total production of milk is composed of a mixture of grade A and grade B milk. A final criticism of these studies is that they ignore the simultaneous determination of quantity and price in a market. Demand is the other schedule to be considered. Models of demand for milk and milk products will now be reviewed.

Demand Studies

Several researchers have estimated the demand response for milk and dairy products at the farm and retail levels. The works of Rojko (1957), Nerlove and Addison (1958), Brandow (1961), Raunikar et al. (1969), George and King (1971), and Boehm (1976) will be reviewed here. Rojko (1957), Brandow (1961), and George and King (1971) estimated both farm level and retail level demand responses for milk and dairy products while Nerlove and Addison (1958), Raunikar et al. (1969), and Boehm (1976) furnish analyses of retail demand only. Nerlove and Addison (1958), Brandow (1961), and George and King (1971) are not exclusively devoted to milk and dairy products but consider dairy products as part of a demand system for many foods. The Rojko (1957), Raunikar et al. (1969), and Boehm (1976) articles are totally devoted to milk demand. The Raunikar et al. (1969) [see also Purcell

Table 1. Summary of direct supply response estimation studies

Author and data	Dependent variable	Independent variables	Elasticities with respect to:		
Brandow (1953)	Production/cow	Grain fed/cow	Grain fed/cow		
Semi-annual 1933-51		Pasture or hay available	.03-.82 (winter)		
for PA, NY, WI, MN			.08-.43 (summer)		
	Production/cow	Milk-feed price ratio	Milk price		
		Pasture or hay variable	.04-.18 (winter)		
			.07-.15 (summer)		
Halvorson (1955)	Production/cow/day	Grain fed/cow	Grain fed/cow		
Semi-annual 1931-54		Hay production	.27 (winter)		
Regional		Cow numbers	.10 (summer)		
	Grain fed/lb of milk produced	Milk-feed price ratio	Milk price		
		Hay production	.26 (winter)		
			.51 (summer)		
	Production/cow/day	Milk-feed price ratio	Milk price		
		Hay production	.10-.22 (winter)		
		Cow numbers	.00-.09 (summer)		
	Grain fed/lb of milk produced	Milk-feed price ratio	Milk price:		
		Hay production		Winter	Summer
			Price↑	.611	.411
			Price↓	.468	.023
Halvorson (1958)	Total milk production	Deflated lagged milk price	Milk price		
Annual U.S. 1927-57		Trend	.16-.18 (short run)		
		Total hay supplies	.40-.44 (long run)		
		Total concentrate supplies			
		Deflated lagged beef price			
		Deflated lagged hog price			
		Lagged dependent variable	.29-.39 (coef. of adj.)		

Table 1 (continued)

Author and data	Dependent variable	Independent variables	Elasticities with respect to:
Halvorson (1958) Annual U.S. 1941-57	Total milk production	Same as above	<u>Milk price</u> .29-.31 (short run) .50-.90 (long run) .35-.54 (coef. of adj.)
Annual U.S. 1927-57	Total milk production	Same as above	<u>Milk price</u> <u>SR</u> <u>LR</u> <u>Coeff. adj.</u> Price↑ .13-.27 .29-.31 .42-.48 Price↓ .18-.20 .40-1.8 .11-.47
Cochrane (1958) Quarterly U.S. 1947-1956	Total milk production	Avg. current and lagged milk price Avg. current and lagged dairy ration price Production/cow Number of cows	<u>Milk price</u> 0.03
Wipf and Houck (1967) Annual U.S.1945-64	Total milk production	Lagged milk price Feed grains price index Roughage avaialble index Slaughter cow prices Technology Lagged dependent variable	<u>Milk price</u> .04-.07 (short run) .06-.16 (long run) .41-.66 (coef. of adj.)
Chen et al. (1972) Quarterly California 1953-68	Total milk production	Milk-feed price ratio Seasonal dummies Technology	<u>Milk price</u> <u>SR</u> <u>LR</u> Nerlove model .38 2.54 Almon model .16 2.53

et al., 1968] and Boehm (1976) studies are similar, emphasizing the effect on demand of demographic variables such as age and racial composition of the population.

Rojko (1957) did an extensive analysis of the U.S. dairy industry using annual data from two distinct time periods, 1924 through 1941, and 1947 through 1954. Quantities supplied were assumed to be predetermined each year. Several models were estimated for the different time periods. Single equation models were estimated by ordinary least squares while multi-equation models were estimated using two stage least squares. Some of the relationships estimated include the demand for butter, cheese and fluid milk at retail; the demand for all milk at retail; farm-retail price interrelationships; and the demand for milk at the farm level. Elasticity estimates both at the farm level and the retail level appear to differ in each of the two time periods. Other elasticity results are summarized in Table 2.

Nerlove and Addison (1958) used a partial adjustment model in conjunction with annual time series data covering 1920 to 1938 to differentiate short-run and long-run demand for twelve different commodity groups in the United Kingdom. This study is noteworthy due to the use of the partial adjustment model and the estimation of the short-run and long-run demand elasticity for dairy products. Application of the model to the United Kingdom data weakens the model's applicability for U.S. projections. The model was applied to United Kingdom data because these data were more accessible and the United Kingdom's involvement in international trade tends to make supply functions perfectly elastic. In estimating the demand elasticities, the restrictions implied by neoclassical demand theory (Phlips, 1974, Ch. 2) were ignored. The results of estimating the demand function for dairy products yield short-run price and income inelasticities of -0.32 and 0.09, respectively; long-run price and income elasticities of -1.00 and 0.28, respectively; and an elasticity of adjustment of 0.32.

The Brandow (1961) study was designed to predict long-run farm income and price responses to different forms of supply control in U.S. agriculture. As such, the model used was a demand model for the many commodities marketed in the agricultural sector of the U.S. economy.

Table 2. Summary of Rojko (1957) elasticity estimation results

Milk demand relation considered	Source	Elasticity estimates: Own price	Cross price	Income
1924-41				
Farm level	pp. 64-65	-.50		.50
Fluid milk	pp. 89-91	-.40 to -.50		.20 to .30
Butter	pp. 89-91	-.40 to -.60		.20 to .30
Manufactured products excl. butter	pp. 89-91	-1.1 to -1.6		.80 to 1.2
All dairy products	pp. 89-91	-.80 to -.90		.30 to .50
1947-54				
Fluid milk	Table 24	-.32		.27
Butter	Table 24	-1.37	.55 (margarine)	.36
American cheese	Table 24	-.75	.92 (meat)	-.99
Other products	Table 24	-1.47		3.06
Margarine	Table 24	-.25	1.50 (butter)	-1.81

Demand relationships were formulated for 24 major food items at the retail level using elasticity estimates provided by several previous studies. When unavailable, other elasticity relationships were derived or bounded by neoclassical demand theory. Farm level demands for domestic food use were derived from retail demand relationships by specifying a marketing margin model. These farm level demand estimates suffer from the difficulty that retail products frequently cannot be translated directly in terms of the farm product. The third sector of this model formulated export demands (ceteris paribus export policy) and industrial demands. When the farm level demand for domestic food, export demand and industrial demand are summed, total demands at the farm level and for food and cotton are obtained. The final sector of this model dealt with interrelationships among livestock products, feed concentrates and vegetable oils. These demands were brought together to obtain demands for feed grains and oil seeds. The significance of this study is that retail demand functions for fluid milk, butter, cheese, evaporated and condensed milk, and ice cream are part of the model. A summary of the elasticity estimates used in this model appears in Table 3.

George and King (1971) performed a study similar to the Brandow (1961) study, but at the same time improved on the Brandow study. Whereas Brandow obtained elasticity estimates from other studies, George and King estimated their elasticity responses. This was done because greater consistency of the estimates could be obtained by estimating elasticities from the same time period and observation interval. Second, George and King expanded the number of food items considered, using 49 instead of Brandow's 24. Thus, there was less commodity aggregation. The final feature of the George and King study was that the data used for estimation were more recent than the Brandow data which should allow more accurate forecasts. The data used by George and King consisted of cross-sectional observations for 1955 and 1965 as well as quarterly and annual postwar time series data. The retail demand elasticity matrix generated by George and King conformed to all of the restrictions implied by neoclassical demand theory (Phlips, 1974, Ch. 2). Theoretically, this study has one difficulty in that filling out the elasticity matrix involved specification of one unobservable parameter, money flexibility

Table 3. Summary and comparison of elasticity estimates from Brandow (1961) and George and King (1971) studies

	Brandow			George & King		
	Direct	Cross price (good)	Income	Direct	Cross price (good)	Income
Retail Demand Elasticities						
	(Table 1)			(Table 5)		
Fluid milk & cream	-.29	.01 (evap. & cond. milk)	.16	-.35	.01 (evap. & cond. milk)	.20
Evap. & cond. milk	-.30	.20 (fluid milk)	.00	-.32	.21 (fluid milk)	.00
Cheese	-.70	.05 (total meat)	.45	-.46	.02 (total meat)	.25
Ice cream	-.55		.35	-.53		.33
Butter	-.85	.16 (margarine)	.33	-.65	.16 (margarine)	.32
Margarine	-.80	.40 (butter)	.12	-.85	.42 (butter)	.00
Farm Level Demand Elasticities[a]						
	(Table 12)			(Table 11)		
Fluid milk & cream	-.14	.01 (evap. and cond. milk)		-.32		
Evap. & cond. milk	-.26	.09 (fluid milk)		--	.20 (fluid milk)	
Cheese	-.54	.03 (total meat)		--	.01 (total meat)	

Table 3 (continued)

	Brandow			George & King		
	Direct	Cross price (good)	Income	Direct	Cross price (good)	Income
	Farm Demand Elasticities[a]					
	(Table 12)			(Table 11)		
Ice cream	-.11			-.45		
Butter	-.66			-.46	.13 (margarine)	
Other uses	-.37			--		

[a]Elasticity of the quantity of milk demanded at the farm level with respect to the retail price.

or the elasticity of the marginal utility of income with respect to income. Since this value was unobservable, George and King used the constant value of -0.86, which was the value implied in the earlier study by Brandow (1961). Each estimated demand equation yields a different implicit value of money flexibility. Thus, the model is inconsistent in a theoretical sense in that the cross-price elasticities between foods in a group and foods not in the same group depend on the value of money flexibility used and the way this money flexibility was entered into the system of demand equations. The significance of the George and King study is that it contains estimates of direct, cross-price, and income elasticities for fluid milk, butter, cheese, evaporated and condensed milk, and ice cream in the context of a complete demand system. From these retail demand relationships, farm level demands were also developed. The farm level demands, like Brandow's, suffer from the difficulty that retail products frequently cannot be identified in terms of the farm product. Retail and farm level demand elasticity estimates from this study are also summarized in Table 3.

The Purcell et al. (1968), and Raunikar et al.(1969) studies are closely related. The Purcell et al.(1968, p. 6) study was "concerned primarily with estimating the nature and magnitude of socio-economic variates generally postulated to influence the household demand for fresh fluid milk and its closely related substitutes," using five years of data reported by 160 households in Atlanta, Georgia. Independent variables used in a regression model to explain fluid milk consumption were the price of milk, age groups, annual household income, race, season, time trends and interactions of these effects. The price elasticity of demand at the middle of the price range was found to be -0.72. Raunikar et al.(1969) used these estimated demand relationships to project both per capita and total fluid milk consumption for 1980. Spatial disaggregation allowed these projections to be made for 204 substate markets, 79 primary markets, and 14 regional markets. The projections for 1980 in this study were made by first projecting the number of households by income group, by age composition and by racial composition. Once these demographic projections were made, they were substituted into the demand relationships estimated in the earlier study. A series of adjustments was used to ensure that estimated consumption for current periods corresponded to actual consumption reported in available data. The significance of these two studies was the emphasis on the effect of population age and racial composition as determinants of demand.

Boehm (1976) estimated the demands for fluid milk at retail using quarterly time series data for 1966 through 1975 for 22 Standard Metropolitan Statistical Areas. The demand functions were estimated using a modified generalized least squares procedure. In addition to having quantity demanded as a function of prices and income, the composition of the population and the physical environment were assumed to influence per capita demand for fluid milk. The inclusion of population composition was to test the hypothesis that recent declines in per capita fluid milk consumption were due to the aging of the U. S. population. The data were unable to refute this hypothesis. Using ordinary least squares, own price and income elasticities of -0.12 and 0.07, respectively, were estimated while generalized least squares price and income elasticity estimates were -0.30 and 0.14, respectively.

This concludes the summarization of the demand responses for milk. The assumptions of these demand studies allow the exclusion of the supply side of the model. Rojko (1957) assumed supply to be absolutely inelastic while Nerlove and Addison (1958) assumed supply to be infinitely elastic. Brandow (1961) and George and King (1971) assumed that with the inclusion of all prices and income in their demand systems, any change in a price or quantity must be a supply phenomenon. Hence, their systems were identified. Boehm (1976) and Purcell et al.(1968) implicitly assumed that all factors affecting demand for fluid milk had been captured. Therefore, only supply shifts could cause price or quantity changes so his demand function was identified. When supply is neither absolutely inelastic nor infinitely elastic and a complete system of demand equations is not specified, simultaneous or recursive models are assumed. These models will now be considered.

Supply and Demand Studies

Several researchers have performed dairy market studies incorporating both supply and demand. The Rojko (1969), Wilson and Thompson

(1967), Prato (1973), and Hallberg and Fallert (1976) studies are reviewed.

Rojko (1969) formulated a 37-equation model of the U. S. dairy industry. The parameters of this model were not estimated. The model components include demand equations for fluid milk and cream, cheese, butter, nonfat dry milk, other dairy products, and margarine; supply equations for whole milk and butterfat; quantity and price identities; margin equations; and farm level demand for milk for various purposes.

Wilson and Thompson (1967) formulated and estimated the first simultaneous equations model of the U.S. dairy industry. Their 13-equation model specified simultaneous relationships for the number of milk cows, yield of milk per cow, the demand for fluid milk products, the marketing margin and the butterfat content of milk. Demand relationships for butterfat and nonfat solids in manufactured dairy products were estimated by ordinary least squares under the assumption that the price for manufactured products and hence for milk components was supported by the price support program. The model was estimated using annual time series data for 1947 through 1963. The principal difficulty with this model is that some of the identity relationships are nonlinear functions of the endogenous variables. The estimation of the parameters of this model would require a nonlinear simultaneous equation technique rather than the two-stage least squares procedure used. Some major elasticity estimates from this study are summarized in Table 4.

Prato (1973) measured supply, demand, and price relationships in the U.S. dairy industry using annual time series data from 1950 to 1968. The 13-equation model used in this study was similar to the Wilson and Thompson (1967) model both in terms of endogenous and exogenous variables and in terms of the specified relationships. This study used simultaneous equations techniques to specify cow numbers; yield per cow; farm prices received for milk used in manufactured dairy products; consumer demands for fluid dairy products, for butterfat and for nonfat solids; and farm retail price relationships for fluid milk, for butterfat and for nonfat solids. This model is differentiated from the Wilson-Thompson (1967) model by the inclusion of the partial adjustment hypotheses to account for possible differences in the short- and long-run elasticities of supply and demand. Like the Wilson-Thompson (1967) model, this model

Table 4. Summary and comparison of supply and demand estimates by Wilson-Thompson (1967) and Prato (1973)

Elasticity	With respect to	Estimates	
		Wilson-Thompson	Prato
Milk supplied	Price SR	.003	-.006
	Price LR	.521	.007
Fluid milk demanded	Price SR	-.31	-.11
	Price LR	--	$-\infty$
	Income	.34	--
Milk fat demanded	Price SR	-.43	-.20
	Price LR	--	-.28
	Income	.60	--
Nonfat solids demanded	Price SR	-.19	-.20
	Price LR	--	-.50
	Income	.71	--

contains nonlinear relationships between variables. This problem is resolved by resorting to Kelejian's (1971) argument that consistent estimates can be obtained by approximating the reduced form equations by a polynomial in all exogenous variables. Another problem with this model is that a time trend was included in the demand functions while income was excluded because of high multicollinearity with the trend. The inclusion of the trend was to account for changes in "tastes and preferences" over time. This procedure is not in keeping with economic theory as income is a fundamental determinant of consumption while trend variables represent unidentifiable events. A more appropriate procedure would have been to include income and exclude the trend variable. Since this study is so similar to the Wilson-Thompson (1967) study, it is summarized with the Wilson-Thompson study in Table 4.

Hallberg and Fallert (1976) formulated and estimated a model that was used in subsequent USDA policy studies. Their model of the U. S. dairy industry consists of a 127-equation recursive system. As a recursive system, their model was estimated by ordinary least squares and restricted ordinary least squares using quarterly time series data from 1955 through 1973. This model divides the continental United States into nine supply regions but considers the United States as a whole for demand purposes. This model is also the most comprehensive in terms of the products considered on the demand side, including five fluid and thirteen manufactured products. The model contains equations to predict farm level support prices, producer prices in the Minnesota-Wisconsin region, fluid milk prices, manufacturing milk prices, blend prices, U.S. average milk prices, milk production by region, total milk production, farm-retail price relationships, wholesale butter prices, inventory demands, per capita retail demands, and aggregate demands for all retail products. The model is closed by the use of identities requiring that milk components supplied be equal to milk components demanded.

At Purdue University, Babb et al. developed a computerized simulation model of federal order milk markets (see Babb et al, 1977a; Babb et al., 1977b; Banker et al., 1977; Martella et al.,1977). This model considers 61 supply centers, 45 fluid milk processing centers, 55 milk manufacturing centers, 45 fluid milk consumption centers and

45 manufactured milk consumption centers. The quantity of milk supplied to the federal order markets at each of the 61 supply centers is assumed to be a function of the blend price that prevailed the previous quarter in that market. The price elasticities of these supply functions vary by region from a high of 0.3 in the Southeast and South Central states to a low of 0.1 in the Lake States with an average supply elasticity of 0.217. The quantity of fluid milk demanded at each of the 45 fluid milk demand centers is assumed to be a function of the retail fluid milk price that prevailed in that market in the previous quarter. The average price elasticity of these fluid milk demand functions was -0.174 with a range of from -0.225 in the Southeast to -0.114 in the Lake States. The quantity of class II products demanded at each of the 45 class II product consumption centers is assumed to be a function of the average retail price of these products that prevailed in this center in the previous quarter. In contrast to the milk supply functions and the fluid milk demand functions, all class II product demand functions were assumed to have an average price elasticity of -0.46. All of the elasticities used in this model were derived from previous studies. With production determined by the blend prices in the previous quarter and consumption determined by retail prices in the previous quarter, the next step is the computation of milk flows that minimize assembly, processing, and distribution costs. A capacitated network flow algorithm is used for this minimization due to its cost advantage over a transshipment formulation. Babb and Pratt (1977) performed a study using this model to simulate the dairy industry under alternative pricing policies. Novakovic et al. (see Novakovic et al., 1979; Novakovic and Babb, 1979; and Novakovic et al., 1980) extended this model to include non-federal order milk production and distribution.

As a group, these supply-demand studies have some shortcomings. First, theoretical models are not fully developed. The relationship between the model estimated and the hypothesis of profit maximization by producers and utility maximization by consumers is never displayed. Second, several of the studies are econometrically weak. The Wilson-Thompson (1967) and Prato (1973) models contain several nonlinear relationships, a problem that was only treated lightly. A third problem is the failure to distinguish between grade A and grade B production. With declining class I utilization rates, declining grade B production and relatively constant milk output, it appears that former grade B producers are employing more resources to produce grade A milk that is utilized in manufactured dairy products. This use of grade A milk in manufactured dairy products is an inefficient allocation of resources. A final criticism is provided by Prato (1973, p. 221):

> Regulation of minimum farm prices for fluid and manufactured milk by federal or state market orders complicates the estimation of milk price elasticities. Most dairy sector models, including the present one, implicitly assume free market conditions. Prices in a free market are determined by supply and demand conditions whereas regulated prices are determined by administrative decisions. Consequently the aggregate demand and supply elasticities reported here may be distorted by the discrepancy between model assumptions and actual market conditions.

Prato's criticism is especially true of supply, demand, or supply and demand models that do not explicitly include the effect of regulation on the response that is to be measured. The Hallberg-Fallert and the Babb et al. studies best model the effects of regulation on milk markets.

When estimating the transfers and welfare losses which result from alternative dairy policies, the last two criticisms mentioned above are important. That is, for these welfare loss and transfer calculations, the failure to include the effect on behavioral responses of past regulation is not a minor oversight. Policy studies which estimate transfers and welfare costs due to alternative regulations will be considered next.

Policy Studies

In terms of volume, policy studies comprise roughly one-half of the literature on empirical dairy marketing research. These policy models are typically concerned with the effect of various regulatory programs on resource and income distribution in dairy markets. As such, these policy studies have been divided into three types, each of which corresponds to one feature of the current regulatory structure. The types of studies considered are classified pricing studies, support price studies, and import quota studies.

Classified Pricing Studies

Two methods of measuring the effects of classified pricing have been used. The first measure is expressed in transfers and welfare costs. This is the approach used by Blakley and Riley (1974), Kwoka (1977), and Ippolito and Masson (1978). The second approach is to measure the effect on prices and quantities of alternative classified pricing systems. Dobson and Babb (1970), Riley and Blakley (1975), Dobson and Buxton (1977), Fallert and Buxton (1978), and Hallberg et al. (1978) have all taken this second approach. Kwoka (1977) and Ippolito and Masson (1978) examine the transfers and net social costs due to classified pricing. This concept is distinct from the examination of the equilibrium that will prevail under alternative forms of classified pricing. All studies except the Kwoka (1977) and the Ippolito and Masson (1978) studies examine pricing systems that are alternatives to the current system.

Kwoka (1977) estimated supply and demand responses for a classified pricing and pooling model that was formulated but never estimated by Kessel (1967). The data used by Kwoka (1977) to derive estimates were from 38 federally regulated milk order markets in 1970. Having derived estimates of the supply and demand responses in these federal milk market orders, Kwoka proceeded to estimate the national aggregate transfers from consumers to producers as $750 million and the efficiency losses due to milk market regulation as $179 million for the year 1970. This analysis assumes that the competitive price of fluid grade milk will be above the competitive price of manufacturing grade milk by a constant differential sufficient to cover the added cost of production. Parameters were estimated using cross section price and quantity data from the different (38 and 46) markets for the different years.

Ippolito and Masson, 1978 [see also, Fones, Hall and Masson, 1977; and MacAvoy, 1977] also estimated the transfers and efficiency losses due to milk market regulation. Their analysis extended Kessel's (1967) model and used elasticity estimates from other studies. Applying this model to market conditions for 1973, gross transfers to regulated farmers were estimated to be $210 million per year and dead-weight losses were estimated to be $60 million per year. A sensitivity analysis was performed to examine the effects on these magnitudes as the supply and demand elasticities took on differing values. This sensitivity analysis indicated that the magnitude of the transfers and deadweight losses was not highly sensitive to the differing values of supply and demand elasticities.

The remaining studies of classified pricing are not concerned with classified pricing compared to unregulated markets but are concerned instead with the effects of alternative sets of classified prices. These studies were done by Dobson and Babb (1970), Blakley and Riley (1974), Riley and Blakley (1975), Dobson and Buxton (1977), Fallert and Buxton (1978) and Hallberg et al. (1978).

Dobson and Babb (1970) were the first to study alternative class I pricing systems. They used a recursive model to forecast the effects of a 7.5 percent increase in federal order minimum prices on consumer prices, consumption, location of processing, producer prices, production, processing costs and transportation costs over a four-year period using 1967 as the basis for comparison. Generally, they found that consumer prices would increase by 5 percent while milk consumption declined in the first year only. They also found that the incomes of producers would increase by 8 percent and intermarket milk shipments would increase along with total transportation costs.

Blakley and Riley (1974) point out that when policy changes are under consideration, tradeoffs between groups or regions may be much larger than aggregate changes averaged over all groups. Relative to the existing price structure, they projected changes in producer and consumer surplus in 31 federal order markets under alternative class I prices near the 1973 level and a uniform class I price near the projected support price for class II milk. Under the policy of uniform class I prices, it was found that producers in the upper and central Midwest and consumers in the Northeast would gain the most. Under a policy of uniform class I price near the support price, it was found that all consumers would benefit, but especially those in the Northeast, and all producers would lose, but again, especially those in the Northeast. In another study, Riley and Blakley (1975) examined the regional impacts of the two previous pricing systems plus a third alternative class I pricing system, namely class I price differentials based on feed costs. The results of this second study are examined in terms of producer receipts and consumer expenditures rather than surplus concepts.

Dobson and Buxton (1977) examined the effects of setting the U.S. average differential between class I and manufacturing milk at three different levels. The results show that, if in 1974 the class I-manufacturing price differential had been $1.80 instead of $2.44, there would have been a net social gain of $13.2 million. Likewise, if the differential had been $2.00 instead of $2.44, there would have been a net social gain of $8.6 million. Finally, if the differential had been $2.68, net social welfare would have been reduced by $5.4 million. To the authors, these results suggest (Dobson and Buxton, 1977, p. 33) "...classified pricing under federal orders assumes more importance for transferring income from consumers to producers than as a mechanism which causes net gains or losses to society." The model used was a national model so the estimated efficiency magnitudes are annual, national estimates. No regional allocations of these estimates were given. One difficulty with this model is that the elasticity estimates came from several studies which leaves their comparability open to question. A second difficulty is that milk is marketed in local or subregional markets and a model of a national market will not reveal intermarket income transfers.

Fallert and Buxton (1978) examined the effect of four alternative class I pricing policies. The alternatives were continuing the current policy; increasing class I differentials 45 cents in all regions; decreasing class I differentials 75 cents in all regions; and eliminating minimum class I differentials. The effects of these policy alternatives were examined using the Hallberg-Fallert model described earlier and were reported on a regional basis with projections through 1985. It was found that by eliminating class I differentials, milk production would increase in Minnesota and Wisconsin and remain approximately constant or decrease elsewhere. Pockets of surplus production, in addition to Eau Claire, Wisconsin, would occur in the West and Northeast. Consumer prices would fall for fluid products and rise for manufactured products causing quantities consumed to increase for fluid products and to decrease for manufactured products.

This policy would also have implications for regional dairy incomes, the location of milk production, and the location of manufactured dairy products processing plants (especially the cheese industry). Increases (decreases) in fluid differentials will cause the relevant magnitudes to change in a way opposite to (the same as) that described above.

Hallberg et al. (1978) used elasticity estimates from previous studies to formulate a spatial equilibrium quadratic programming model. This model disaggregated the northeastern region of the United States into states, while considering other regions as distinct markets, and then solved for equilibrium prices and quantities for raw milk, fluid milk, and manufactured milk products under alternative pricing policies. The first policy considered was the current policy and the values of the model variables compared favorably to 1975 actual market values. An interesting result of this solution was that the Northeast, Southeast, and Upper Midwest were all potential export producing regions. This result is similar to the Fallert and Buxton (1978) conclusion. Pooling milk under a national order was the second policy considered. This policy increased consumer expenditures on fluid milk in the Southwest, South Atlantic, Northeast, and Corn Belt. Producer receipts were increased in the Corn Belt, Northeast, and Southwest and decreased in the Plains, Mountains, Northwest, and South Central regions. Altering the fluid differential from 0 to 111 cents per hundredweight was also considered. As the fluid differential increased, consumer expenditure on fluid milk increased in the Corn Belt, Lake States, Northeast, South Atlantic, and South Central regions. Producer receipts also increased in these regions and decreased in the Lake States, Plains, Mountains, and Northeast regions. Regional orders were also studied but did not provide definite answers on distributional issues. The major criticism of this study is that it ignores grade B milk production.

A summarization of classified pricing policy models is contained in Table 5. As a group, they seem to agree on the effects of alternative policies although the measurement of these effects is not always the same. Some researchers consider transfers only; others consider transfers and deadweight losses, and still others use expenditure-receipt measures. Some researchers examine regional effects while

Table 5. Summarization of recent research on the effects of classified pricing

Authors (date)	Policies considered						Market aggregation			Reference year	Magnitudes measured		
	Current differentials	Varying current diffs.	No fluid differentials	Flat class I price	National milk pool	Regional orders	National	Regional	Federal order only		Surplus changes	Welfare costs-transfers	Price, quantity changes
Dobson & Babb (1970)	X	X							X	1967			X
Blakley & Riley (1974)	X		X	X					X	1973	X		
Riley & Blakley (1975)	X	X	X	X					X	1972			X
Kwoka (1977)	X		X				X			1970		X	
Dobson & Buxton (1977)	X	X					X			1974		X	
Ippolito & Masson (1978)	X		X				X			1973		X	
Fallert & Buxton (1978)	X	X	X					X		Through 1985			X
Hallberg <u>et al</u>. (1978)	X	X			X	X		X		1975			X

others examine only aggregate effects. Most researchers use parameter estimates from previous studies that may or may not have been estimated in a consistent framework. This creates one problem. Another problem is the exclusion of grade B milk from some models.

Support Price Studies

Studies of the effect of the price support program have been performed by Buxton and Hammond (1974) and Heien (1977).

Buxton and Hammond (1974) used elasticity estimates derived in previous studies to formulate a model to estimate the annual net social cost of alternative price support levels for 1973. The social cost varied depending on the price support level and the method of disposition of the purchases. If purchases were donated to domestic programs, the cost reached a maximum of $94 million when the support price was set at 90 percent of parity. Alternatively, if purchases were donated to international programs, the net social cost when support price was set at 90 percent of parity was found to be $447 million.

Heien (1977) formulated a 32-equation model of the U.S. dairy industry with three sectors--retail demand equations, retail price formation equations, and farm output and price determination relations. Retail demand equations were specified for fluid milk, butter, cheese, frozen products, nonfat dry milk, and evaporated and condensed milk. This model was estimated by ordinary least squares using annual data from 1950 through 1969. Using these estimates, the total cost of the price support program was found to be $402 million per year and the total cost of the federal milk marketing order system was found to be $175 million per year. One strong point of this model is the use of a production function that specified the effect of dairy cow vintage. Cow productivity varied by vintage. This model suffers from unrealistically large values for some of its long-run elasticity estimates.

Import Quota Studies

A final set of research results to be examined are the results of three studies on the effect of import quotas and the effect of relaxing these quotas. Studies performed by the U.S. Department of Agriculture

(1975), Novakovic and Thompson (1977), and Salathe et al. (1977) all indicate that import quotas are effective in supporting the U.S. dairy prices above world levels. The U. S. Department of Agriculture (1975) study estimated a short-run decline of 18 cents per hundredweight for each additional billion pounds of aggregate dairy imports measured in terms of milk equivalent. The study by Salathe et al. (1977) was most concerned with the Wisconsin dairy economy and projected that, in the short run, Wisconsin farm milk prices would fall about 14 cents per hundredweight for each additional billion pounds of dairy imports. The Novakovic and Thompson (1977) study considered a narrower range of import policy. Their model indicated that the price of raw milk will fall by about 6 cents per hundredweight in the short run for each one billion pounds of milk equivalent imported.

Other Studies

Two other dairy policy studies have been done that deserve mention in this review. These two studies are included in this section because one, a study by Masson and DeBrock (1980), does not fit under any of the above sections, and the other, a study by Dahlgran (1980a and 1980b; 1980b summarizes 1980a), fits under both the supply-demand estimation section and the classified pricing and pooling section.

Using a model of monopolistic competition as a norm, Masson and DeBrock (1980) examined the deadweight losses and transfers due to the minimum retail price provisions of state order markets. These researchers formulated a four-equation model with an equation for a demand relationship, a marketing margin relationship, a market structure relationship, and a supply price relationship for various regulated state markets. Estimates of the parameters for this model were found using 2SLS. Using these parameter estimates, a lower limit on the social costs due to retail price regulation was estimated to be $91.9 million.

The study by Dahlgran (1980a; 1980b) contains a supply-demand response estimation component and a welfare cost-transfer estimation component which enables it to be classified partially as a nonpolicy (supply-demand) study and partially as a policy (classified pricing) study. In this study, a simultaneous supply and demand model was specified for grade A and grade B milk supply and fluid and manufacturing milk demand. This model was then fit to ten years of time series data for fourteen federal order markets. The resulting set of supply and demand response estimates was then used to formulate an interregional model of the U. S. dairy industry. Using the 1976 dairy economy as a base, this interregional model was then used to simulate unregulated dairy market equilibrium. Comparison of the 1976 actual regulated dairy market economy with the 1976 simulated unregulated dairy market economy allowed the computation of deadweight losses and transfers due to regulations. The computed magnitudes were $439 million as transfers from fluid milk consumers to grade A milk producers, $366 million as transfers from grade A milk producers to manufactured product consumers, $200 million as transfers from grade B milk producers to manufactured product consumers and $131 million as the deadweight losses due to dairy market regulation. In this study, dairy market regulation was finally examined in terms of income enhancement and stability objectives. As a means to enhance milk producers' incomes, the current system of dairy market regulation was judged to be ineffective based on the transfers to milk producers relative to deadweight losses. As a means to create retail price stability, the current system of dairy market regulation was again judged to be inefficient since the same level of retail price stability could be achieved at a lower cost. If, however, the current regulatory system does create price stability at the farm level; and if due to risk aversion on the part of producers, the supply function shifts outward; then it was found that a supply curve outward shift of more than 1.54 percent would create consumer surplus gains that would more than offset the measured deadweight losses due to regulation.

Summary

At this point it is useful to offer some generalizations that can be derived from the numerous studies considered. First, the supply side of the dairy industry seems to correspond with Halvorson's (1955) *a priori* beliefs. That is, the dairy supply response appears to be highly price inelastic in the short run. Based on the single equation supply estimation models (Table 1), production per cow has an inelastic supply response that is in most cases less than 0.5. Total milk production is also inelastic with respect to price, with price elasticity estimates ranging from 0.0 to 0.5. Simultaneous supply-demand models do not refute these results. This inelastic supply response is probably due, as Halvorson (1955) suggests, to the large fixed investment required for dairying, the lack of good alternatives for labor in many areas where milk production is substantial, the penalization of the small or variable output milk producer in the market place due to pricing arrangements, the long time lag required to alter cow herds and equipment, the effect of price and output uncertainty, and the time lag between production and price formation. The summary of supply elasticity estimates presented in Table 1 indicates that supply elasticity with respect to price is slightly greater for winter months than for summer months. The evidence is contradictory for the existence of different elasticities of supply for price increases than for price decreases.

The long-run supply elasticity estimates found by Chen et al. (1972), using quarterly California data, and by this author (Dahlgran, 1980a, 1980b) using annual data from a sample of U. S. milk markets are considerably larger than the long-run supply elasticity estimates found by other researchers. Likewise, the long-run supply elasticity estimates found by other researchers are greater than the short-run supply elasticity estimates found by these researchers. Thus, the evidence indicates that the supply response is greater in the long run than in the short run.

On the demand side, dairy marketing models typically consider two demands for raw milk, the demand for milk for fluid uses, and the demand for milk for manufacturing uses. These demands at the farm level are derived from the demand for fluid and manufactured dairy products at retail. At the retail level, Brandow (1961) and George and King (1971) provide the demand elasticity estimates for dairy products that have received the most attention in recent years. Both of these studies suggest that the demand for fluid milk is inelastic in the range of -0.30 to -0.35 and less than the elasticity of demand for manufactured products. The income elasticity of demand for fluid milk is also low, in the range of 0.16 to 0.20. These studies show that manufactured goods display both a greater price and a greater income elasticity than fluid milk. Of the manufactured dairy products, butter has the greatest price elasticity (-0.65 to -0.85) while evaporated and condensed milk have the lowest price elasticity (-0.30 to -0.32). Based on the information contained in these two studies, inferences can be drawn about demand elasticities for fluid and manufacturing milk at the farm level. These inferences are that the demands for fluid and manufacturing milk at the farm level are both price inelastic with the elasticity of demand for manufacturing milk exceeding the demand elasticity for fluid milk. The Wilson-Thompson (1967) and Prato (1973) studies do not refute these inferences. Raunikar et al.(1969), Purcell et al. (1968) and Boehm (1976) show that demographic factors such as age and racial composition of the population have significant effects on fluid milk demand. Boehm (1976) constructed the hypothesis that the aging of the population was responsible for a recent decline in per capita fluid milk consumption in the United States. The data were unable to refute this hypothesis.

The final set of studies dealt with the effect of dairy market regulation in creating gains and losses to producers and consumers. Kwoka (1977) found that for 1970 classified pricing and pooling resulted in annual efficiency losses of $179 million. Ippolito and Masson (1978) found that for 1973 classified pricing and pooling resulted in annual transfers from consumers to producers of $210 million and created annual efficiency losses of $60 million. For the time period of 1950 to 1969, Heien (1977) found the total social cost of the federal milk marketing order system to be $175 million per year. The author's own work (1980a, 1980b) found that for 1976 annual transfers from both fluid and manufactured milk consumers to regulated producers amounted to $73 million. A $200 million annual transfer from unregulated producers to consumers was also found. The annual efficiency losses due to regulation were found to be $131 million which is midway between the Kwoka (1977) and Ippolito and Masson (1978) estimates.

Other researchers found evidence that regulated classified pricing and pooling plans substantially altered the milk price surface from the surface that would have existed without these plans. In particular, the studies of Fallert and Buxton (1978) and Hallberg et al. (1978)

both found that in the absence of classified pricing, the upstate New York, Vermont area; the Western Kentucky-Western Tennessee area; the upper Midwest and the Northwest would all be milk exporting regions.

The social cost of the price support system was found to depend on the level of support and the disposition of the purchases. The cost was estimated to be $402 million per year between 1950 and 1969 by Heien (1977). An alternative estimate of the annual social cost of price supports at 90 percent of parity was found to be $94 million if purchases were donated domestically and $447 million if purchases were donated abroad.

The effect of import restrictions on the manufacturing milk price was estimated. It was estimated that the manufacturing milk price would fall 14 to 18 cents per hundredweight for each additional billion pounds of milk equivalent imported. Six cents per hundredweight was estimated as the short-run effect.

Several major criticisms of the work reviewed in this paper were provided, but only the major criticisms will be mentioned here. Many of the regression models were judged to be inadequate in that they failed to specify a theoretical model of profit or utility maximization. Another criticism of the existing literature is the lack of attention given to the gradual disappearance of Grade B milk production. Very few researchers are using empirical models to explain why, to determine whether this disappearance is policy induced, or to measure the effect of this disappearance in terms of efficiency from the standpoint of resource allocation. Another criticism of some of the studies reviewed is the lack of specification of the regulatory environment. Finally, many of the policy studies have been concerned only with aggregate transfers and welfare costs of regulation. Equally of interest to society is the distribution of these costs and transfers across markets and between categories of producer and consumer groups. Hopefully, research in the future can benefit from a fuller consideration of these issues.

References

Babb, E. M., D. E. Banker, O. Goldman, D. R. Martella, and J. E. Pratt. 1977a. Economic model of Federal Milk Marketing Order Policy Simulator--Model A. Station Bulletin No. 158, Department of Agricultural Economics, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana.

Babb, E. M., D. E. Banker, O. Goldman, D. R. Martella, and J. E. Pratt. 1977b. User's manual for Federal Milk Marketing Order Policy Simulator--Model A. Station Bulletin No. 157, Department of Agricultural Economics, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana.

Babb, E. M., and J. E. Pratt. 1977. Projections of federal milk marketing order performance under alternative pricing and pooling provisions. Station Bulletin No. 171, Department of Agricultural Economics, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana.

Banker, D. E., E. M. Babb, O. Goldman, D. R. Martella, and J. E. Pratt. 1977. Computer program documentation for Federal Milk Marketing Order Policy Simulator--Model A. Station Bulletin No. 164, Department of Agricultural Economics, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana.

Blakley, L. V., and J. B. Riley. 1974. Regional gains and losses for consumers and producers from changes in fluid milk prices. Southern Journal of Agricultural Economics 6(2):1-8.

Boehm, W. T. 1976. The household demands for fluid milk in the United States with regional consumption projections through 1990. Research Division Bulletin 120, Virginia Polytechnic Institute and State University, Blacksburg.

Brandow, G. E. 1953. Changes in milk production in the United States, 1924-51. Progress Report No. 97, Pennsylvania Agricultural Experiment Station, Pennsylvania State University, University Park.

Brandow, G. E. 1961. Interrelations among demand for farm products and implications for control of market supply. Pennsylvania Agricultural Experiment Station Bulletin 680, Pennsylvania State University, University Park.

Buxton, B. M., and J. W. Hammond. 1974. Social cost of alternative dairy price support levels. American Journal of Agricultural Economics 56(2):286-291.

Chen, D., R. Courtney, and A. Schmitz. 1972. A polynomial lag formulation of milk production response. American Journal of Agricultural Economics 54(1):77-83.

Cochrane, W. W. 1958. Farm Prices, Myth and Reality. University of Minnesota Press, Minneapolis.

Dahlgran, R. A. 1980a. Welfare costs and interregional income transfers due to regulation of dairy markets. American Journal of Agricultural Economics 62(2):288-296.

Dahlgran, R. A. 1980b. Welfare costs and interregional income transfers due to regulation of U.S. dairy markets. Unpublished Ph.D. thesis, North Carolina State University, Raleigh.

Dobson, W. D., and E. M. Babb. 1970. An analysis of alternative price structures and intermarket competition in federal order milk markets. Research Bulletin No. 870, Agricultural Experiment Station, Purdue University, Lafayette, Indiana.

Dobson, W. D., and B. M. Buxton. 1977. Analysis of the effects of federal milk orders on the economic performance of U.S. milk markets. Report R2897, Research Division of the College of Agricultural and Life Sciences, University of Wisconsin, Madison.

Fallert, R. F., and B. M. Buxton. 1978. Alternative pricing policies for class I milk under federal marketing orders: Their economic impact. USDA, Agricultural Economics Report 401, Economics, Statistics and Cooperatives Service. U.S. Government Printing Office, Washington, D.C.

Fones, R. W., J. C. Hall, and R. T. Masson. 1977. Milk marketing. Report of the U.S. Department of Justice to the Task Group of Antitrust Immunities. U.S. Government Printing Office, Washington, D.C.

George, P. S., and G. A. King. 1971. Consumer demand for food commodities in the United States with projections for 1980. Giannini Foundation Monograph No. 26, California Agricultural Experiment Station, Berkeley.

Hallberg, M. C., and R. F. Fallert. 1976. Policy stimulation model of the United States dairy industry. Bulletin 805, Agricultural Experiment Station, Pennsylvania State University, University Park.

Hallberg, M. C., D. C. Hahn, R. W. Stammer, G. J. Elterich, and C. L. Fife. 1978. Impact of alternative federal milk marketing order pricing policies on the United States dairy industry. Bulletin 818, Agricultural Experiment Station, Pennsylvania State University, University Park.

Halvorson, H. W. 1955. The supply elasticity for milk in the short run. Journal of Farm Economics 37(5):1186-1197.

Halvorson, H. W. 1958. The response of milk production to price. Journal of Farm Economics 40(5):1101-1113.

Heady, E. O. 1961. Uses and concepts in supply analysis, pp. 1-25. In E. O. Heady, C. B. Baker, H. G. Diesslin, E. Kehrberg, and S. Staniforth (eds.), Agricultural Supply Functions. Iowa State University Press, Ames.

Heady, E. O., N. L. Jacobson, J. A. Schnittker and S. Bloom. 1960. Milk production functions and marginal rates of substitution between forage and grain, pp. 404-451. In E. O. Heady and J. L. Dillon (eds.), Agricultural Production Functions. Iowa State University Press, Ames.

Heady, E. O., J. P. Madden, N. L. Jacobson, and A. E. Freeman. 1964. Milk production functions incorporating variables for cow characteristics and environment. Journal of Farm Economics 46(1):1-19.

Heien, D. 1977. The cost of U.S. dairy price support programs: 1949-74. Review of Economics and Statistics 59(1):1-8.

Hoover, L. M., P. L. Kelley, G. M. Ward, A. M. Feyerherm, and R. Chaddha. 1967. Economic relationships of hay and concentrate consumption to milk production. American Journal of Agricultural Economics 49(1):64-78.

Ippolito, R. A., and R. T. Masson. 1978. The social cost of government regulation of milk. Journal of Law and Economics 21(1):33-65.

Kelejian, H. H. 1971. Two-stage least squares and economic systems linear in parameters but nonlinear in the endogenous variables. Journal of the American Statistical Association 66(334):373-374.

Kessel, R. A. 1967. Economic effects of federal regulation of milk markets. Journal of Law and Economics 10:51-78.

Kwoka, J. E. 1977. Pricing under federal milk market regulation. Economic Inquiry 15(3):367-384.

MacAvoy, P. W. (ed.). 1977. Federal milk marketing orders and price supports. American Enterprise Institute Studies in Government Regulation 176, American Enterprise Institute for Public Policy Research, Washington, D.C.

Martella, D. R., D. E. Banker, E. M. Babb, and J. E. Pratt. 1977. Computer program documentation for Federal Milk Marketing Order Policy Simulator--Model B. Station Bulletin No. 172, Department of Agricultural Economics, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana.

Masson, R. T., and L. M. DeBrock. 1980. The structural effects of State regulation of retail fluid milk prices. Review of Economics and Statistics 52(2):254-262.

Nerlove, M., and W. Addison. 1958. Statistical estimation of long-run elasticities of supply and demand. Journal of Farm Economics 40(4):861-880.

Novakovic, A. M., and E. M. Babb. 1979. An economic analysis of the U. S. dairy price support program and alternative policies. Agricultural Economics Report 79-27, Department of Agricultural Economics, Agricultural Experiment Station, Cornell University, Ithaca, New York.

Novakovic, A. M., E. M. Babb, D. R. Martella, and J. E. Pratt. 1979. A computer documentation of the Dairy Market Policy Simulator (Model A). Agricultural Economics Staff Paper No. 79-4. Department of Agricultural Economics, Agricultural Experiment Station, Cornell University, Ithaca, New York.

Novakovic, A. M., E. M. Babb, D. R. Martella, and J. E. Pratt. 1980. 1976 Base data for the Dairy Market Policy Simulator--Model A. Agricultural Economics Report 80-22, Department of Agricultural Economics, Cornell University, Agricultural Experiment Station, Cornell University, Ithaca, New York.

Novakovic, A., and R. L. Thompson. 1977. The impact of imports of manufactured milk products on the U.S. dairy industry. American Journal of Agricultural Economics 59(3):507-519.

Paris, Q., F. Malossini, A. M. Pilla, and A. Romita. 1970. A note on milk production functions. American Journal of Agricultural Economics 52(4):594-602.

Phlips, L. 1974. Applied Consumption Analysis. American Elsevier Publishing Company, Inc. New York.

Prato, A. A. 1973. Milk demand, supply and price relationships, 1950-1968. American Journal of Agricultural Economics 55(2):217-222.

Purcell, J. C., R. Raunikar, and J. C. Elrod. 1968. Analysis of demand for beverage milk (Atlanta, Georgia consumer panel). Research Bulletin 43, College of Agriculture Experiment Station, University of Georgia, Athens.

Raunikar, R., J. C. Purcell, and J. C. Elrod. 1969. Spatial and temporal aspects of the demand for food in the United States: I. Fluid milk. Research Bulletin 61, College of Agriculture Experiment Stations, University of Georgia, Athens.

Riley, J. B., and L. V. Blakley. 1975. Impact of alternative class I pricing systems on fluid milk prices. American Journal of Agricultural Economics 57(1):67-73.

Rojko, A. S. 1957. The demand and price structure for dairy products. Technical Bulletin 1168, U.S. Department of Agriculture. U.S. Government Printing Office, Washington, D.C.

Rojko, A. S. 1969. What use can we make of measures of demand in analyzing dairy price and income policy? pp. 38-50. In Proceedings of a Seminar in Demand and Supply Tools in Dairy Price and Income Policy. Department of Agricultural Economics, Ohio State University, Columbus.

Salathe, L., W. D. Dobson, and G. A. Peterson. 1977. Analysis of the impact of alternative U.S. dairy import policies. American Journal of Agricultural Economics 59(3):496-501.

U.S. Department of Agriculture. 1975. The impact of dairy imports on the U.S. dairy industry. Agricultural Economics Report No. 278, Economics Research Service. U.S. Government Printing Office, Washington, D.C.

Williams, S. W., D. A. Vose, C. E. French, H. L. Cook, and A. C. Manchester. 1970. Organization and Competition in the Midwest Dairy Industries. Iowa State University Press, Ames.

Wilson, R. R., and R. G. Thompson. 1967. Demand, supply and price relationships for the dairy sector, post-World War II period. American Journal of Agricultural Economics 49(2):360-371.

Wipf, L. J., and J. Houck. 1967. Milk supply responses in the United States, an aggregate analysis. Report No. 532, Department of Agricultural Economics, Institute of Agriculture, University of Minnesota, Minneapolis.

North Carolina Agricultural Research Service

North Carolina State University
at Raleigh

D. F. Bateman, Director of Research