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DISEQUILIBRIUM ANALYSIS FOR FLUID MILK

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I. Introduction

With approximately 95 percent of all milk (meeting fluid use standards) priced under state and/or federal marketing orders, fluid milk markets are subject to more governmental regulation than most other markets in the United States. The traditional justification for these regulatory programs rests on two factors. First, milk is generally accepted as an essential food in the human diet; for this reason there is a need to insure an adequate supply. Second, the unique product characteristics of milk (e.g., high perishability) are believed to promote instability that inherently interferes with the supply process (Clarke, 1955). Thus, in the absence of regulation, it is often claimed that the public could not be confident of dairy product availability at reasonable prices. On the other hand, many consumers and economists who disagree with the second premise have come to view these programs as beneficial only to producers and processors and not to consumers.

Recently, there has been increased interest in evaluating milk marketing programs (Gordon and Hanke, 1978; MacAvoy, 1977). Previous analyses have concentrated typically on measuring the welfare gains associated with deregulation via surplus analysis. Such studies suggest implicitly that observed price is nonmarket clearing due to government intervention and perhaps higher than that which would otherwise prevail as a result of market forces. Surprisingly little attention has been directed at determining quantitatively the actual effect of deregulation on price. One purpose of this paper is to examine this issue. Results show that regulated prices have been set remarkably close to equilibrium and that, on average, regulations have tended to slightly favor consumers rather than producers.

To adequately assess the impact of the suspension of government controls, it is necessary first to identify the demand and supply relationships that exist in the market. Traditional econometric models, which are based on the assumption of market equilibrium, however, are clearly inappropriate in this case. Nevertheless, this point is seldom considered in simultaneous-equation econometric analyses of milk markets (Wilson and Thompson, 1967; Prato, 1973), although the potential importance of the issue is often acknowledged. Fortunately, recent developments in disequilibrium econometrics facilitate appropriate investigation. In particular, the California retail milk market provides an interesting case study since, until recently, this market has been regulated perhaps more than any other. The principal features of this milk stabilization plan are first described in detail below before specifying a model for the analysis.

II. The California Milk Stabilization and Pooling Plan

California wholesale and retail milk trade has been regulated since the 1930s.[1] Briefly, the plan may be described by its two basic components: (1) state-regulated producer prices for four different milk classes and state-regulated retail prices for Class I dairy products[2] and (2) a pooling system which defines producer receipts as a function of production rights (quota) and the predetermined prices. The milk prices determined in (1) were established administratively after detailed periodic cost analyses and public hearings and, as Milligan (1978) notes, have consistently been the effective market prices. Under (2), the state guarantees producers a share in Class I sales and then acts essentially as a clearinghouse for all quota-related milk produced in California. The production or quota rights in (2) were originally allocated according to historical production with limited entry of new producers.

Under the above plan, dairies ship milk according to their blend price which is determined in the following way. Each firm has production rights or a quota on which it is entitled to receive the wholesale price for market grade milk. Milk sold in amounts above the quota but within the historical production base of the dairy brings a somewhat lower price. Overbase shipments command the lower Class IV milk price which, although unregulated by the state, is determined largely by federal support prices. The blend price of each dairy is then the average price per hundredweight determined as a weighted average of its quota, base, and overbase prices where the weights correspond to the relative size of each type shipment.

The processors who receive dairy shipments utilize milk in fluid form or process it into a variety of products. The retail prices for Class I products are administered, while the prices of other products are unregulated. The actual supply of Class I products is determined by processors through dispensation of available market milk according to the Class I price and the unregulated price of other dairy products.

Conceptually, the behavior of the wholesale and retail markets may be depicted as in figures 1 and 2, respectively. In figure 1, the highest wholesale price p_q is received for quota shipments; the lower price p_b is received for base shipments. With demand curve D and supply S_1, the price p* results which, in the absence of general equilibrium considerations, is the same as the free-market solution. As noted above, however, the most likely situation is that the federal price support p_f is operative on overbase shipments; i.e., the supply curve is at, say, S_2 thus leading to production and sales q_w.

In figure 2, the retail market for milk is divided into two major components: Class I products (fluid milk and related products, such as cream and

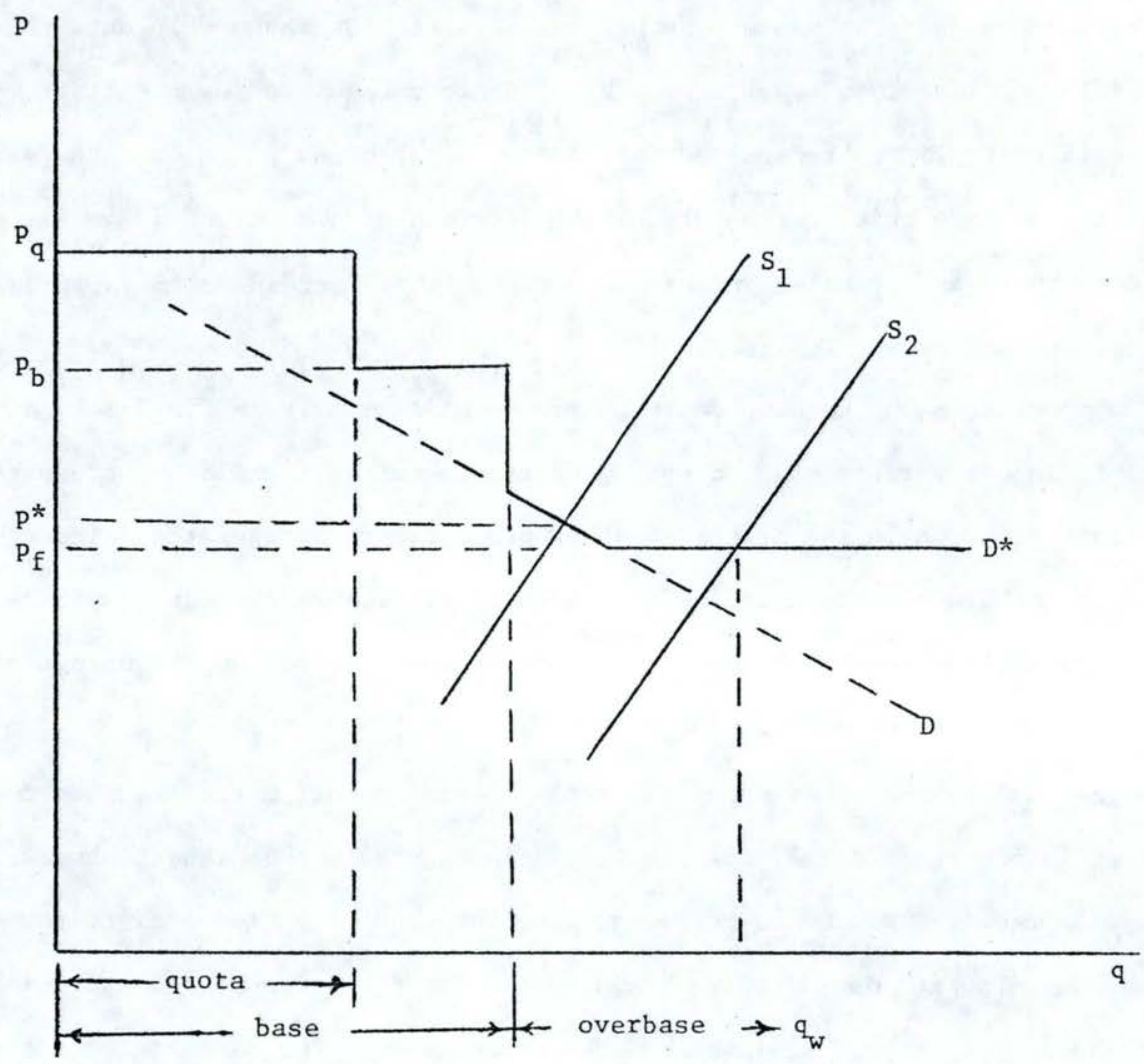

FIGURE 1. Wholesale California Milk Market

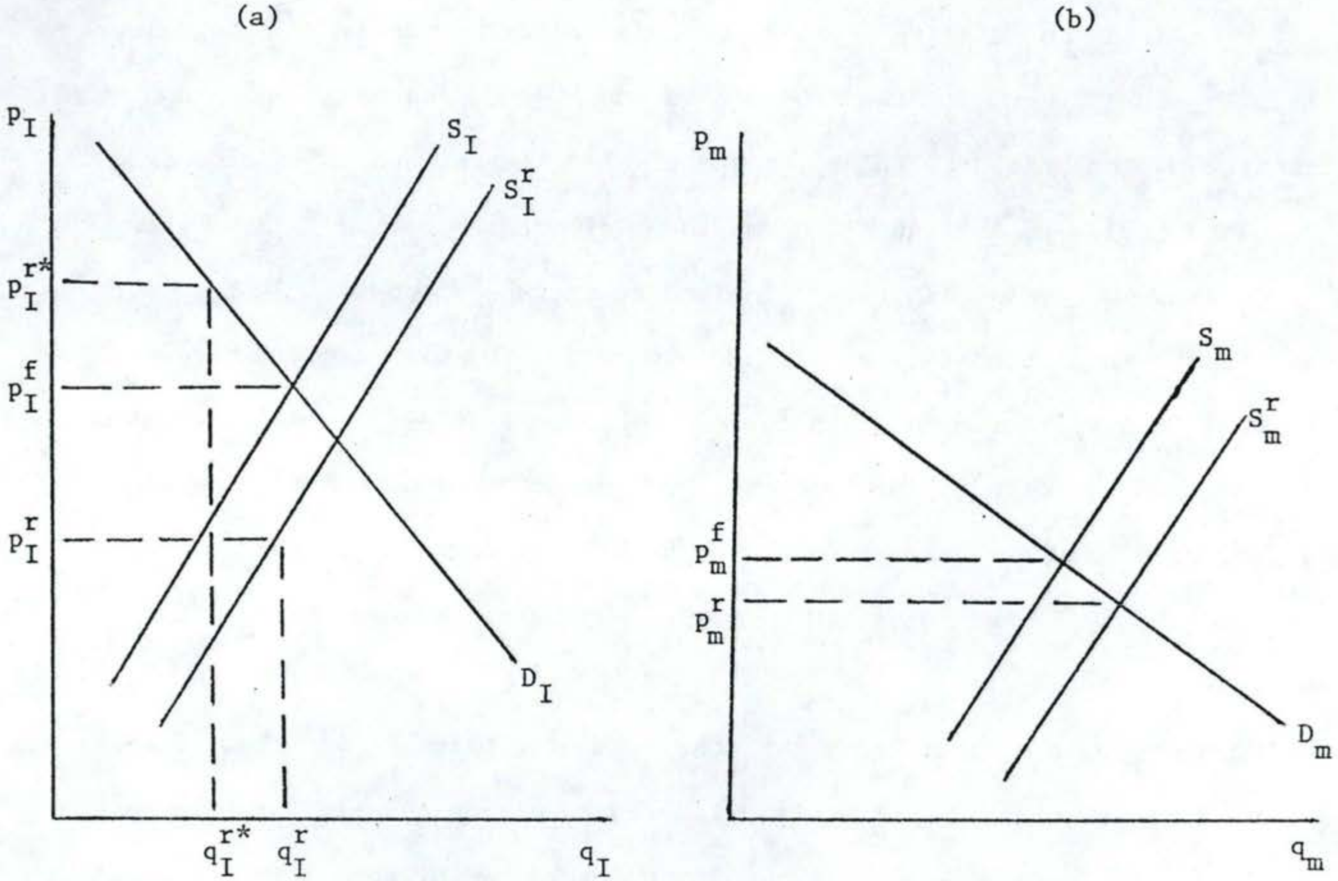

FIGURE 2. Retail California Milk Market

yogurt) and manufactured products (such as ice cream, cheese, and nonfat dry milk). Since milk is not perfectly substitutable between these two major end uses, a separate and distinct supply curve is indicated for each.[3] Suppose, initially, the free-market supplies are S_I and S_m and demands are D_I and D_m with free-market prices p_I^f and p_m^f, respectively. The effects of introducing a regulated price p_I^r in figure 2(a) may be evaluated as follows. First, if $p_I^r < p_I^f$, the lower Class I price will lead to increased supply and thus lower price in the manufactured market. The lower price for milk used in manufactured products, in turn, leads to an increase in supply for Class I products. After succeeding rounds of adjustment, supply and quantity may be represented in figure 2 by S_I^r and q_I^r, respectively, in the Class I market; and the resulting price and supply in the manufactured market may be represented by p_m^r and S_m^r, respectively.[4]

Suppose, on the other hand, that the regulated price is set above free-market equilibrium at p_I^{r*}. At this price the resulting quantity of milk purchased for use in Class I products would be determined by demand at q_I^{r*}. All other milk would be forced into the manufactured market and thus increase supply and depress price there.

From the above discussion, the Class I milk market in California [see figure 2(a)] apparently thus behaves as a standard disequilibrium model. Price and quantity are determined along the supply (demand) curve if regulated price is below (above) equilibrium price. Furthermore, it is possible to isolate the Class I market for econometric purposes so that the extent of this disequilibrium can be analyzed. That is, the complicated regulations of the wholesale milk market may be summed up by noting that production of market grade milk is essentially prescribed by the state through wholesale prices and production rights and by federal price supports. Hence, the supply of Class I products can be conditioned simply on wholesale milk production q_w. Second, the complicated interactions between the Class I and manufactured product markets can be fully accounted for by appropriately conditioning the supply and demand for Class I milk products on the price of manufactured products.[5] Thus, standard disequilibrium econometric techniques become appropriate for the analysis.

III. A Disequilibrium Framework

Beginning with the work of Fair and Jaffee (1972), substantial effort has been devoted to the formulation and estimation of disequilibrium market models (Maddala and Nelson, 1974; Goldfeldt and Quandt, 1975; Hartley and Mallela, 1977; Hartley, 1977). The most basic of these models consists of a demand equation, a supply equation, and an equation which identifies the quantity transacted as the smaller of quantity demanded and quantity supplied. This model may be written as

$$\begin{aligned} D_t &= X_t' \Delta_1 + \beta_1 P_t + \varepsilon_{1t} \\ S_t &= X_t' \Delta_2 + \beta_2 P_t + \varepsilon_{2t} \\ Q_t &= \min (D_t, S_t) \qquad t = 1, 2, \ldots, T \end{aligned} \tag{1}$$

where D_t, S_t, and Q_t are quantity demanded, quantity supplied, and quantity transacted, respectively; P_t is price with corresponding unknown parameters, β_1 and β_2; and X_t is a column vector of exogenous variables in addition to price with unknown parameter vectors, Δ_1 and Δ_2, respectively. The error terms, ε_{1t} and ε_{2t}, are assumed to be normally distributed around zero means with constant variances, σ_1^2 and σ_2^2, respectively, with both serial and contemporaneous independence.

The log-likelihood function corresponding to model (1) is given by

$$\ln L = \sum_{t=1}^{T} \ln \left[\int_{q_t}^{\infty} f_{D_t,S_t} (q_t, S_t)\, ds_t + \int_{q_t}^{\infty} f_{D_t,S_t} (d_t, q_t)\, dd_t \right] \quad (2)$$

where $f_{D_t,S_t}(\cdot)$ is the joint density of the subscripted variables. Sen (1976) has demonstrated that a solution to the likelihood equations corresponding to a local maximum is consistent and asymptotically normal. Hartley (1977) shows that a local maximum of (2) may be calculated by a stepwise Gauss-Seidel type of iterative scheme. His method involves replacing the unobserved endogenous variables (D_t and S_t) by their respective expected values conditioned on observed quantity and provisional parameter estimates, obtaining new parameter estimates by standard techniques, recomputing the conditional expectations, and proceeding iteratively until suitable convergence criteria are satisfied.

IV. The Model

Using the maximum-likelihood technique developed by Hartley (1977), the estimated model for the retail Class I dairy product market in California under the disequilibrium hypothesis is

$$D = \underset{(.248)}{18.3} - \underset{(.078)}{.124} (P_I) - \underset{(.072)}{.147} (C) + \underset{(.0028)}{.0952} X$$

$$S_t = \underset{(2.13)}{12.2} + \underset{(.584)}{.754} (P_I) - \underset{(.198)}{.0133} (P_m) + \underset{(.112)}{.303} q_w + \underset{(.0052)}{.00684} T$$

$$Q = \min (D, S)$$

where

D = logarithm of fluid milk demanded (gallons)

P_I = logarithm of fluid milk price deflated by the consumer price index (dollars per gallon)

C = logarithm of cereal price deflated by the consumer price index (cents per 12 ounces)

X = school lunch dummy variable (one if school is in session; zero, otherwise)

S = logarithm of fluid milk supplied (gallons)

P_m = logarithm of butter price deflated by the consumer price index (cents per pound)

q_w = logarithm of market grade milk production (gallons)

T = time trend variable (July, 1974 = 1; August, 1974 = 2; etc.)

Q = logarithm of sales of fluid milk (gallons).

To estimate this model, 30 monthly observations from mid-1974 through 1976 are used. All price data are obtained from the U. S. Bureau of Labor Statistics. The California consumer price index is taken from the California Department of Finance. Sales and production quantities are published by the California Crop and Livestock Reporting Service. Asymptotic standard error estimates (reported in parentheses) are obtained from the inverse Hessian of the log-likelihood function (2). All estimated elasticities are qualitatively sensible and, with the exception of manufacturing price in the supply equation, statistically significant.

By way of comparison with results reported by other investigators, the elasticity estimates are also of reasonable magnitudes. Demand and supply are inelastic with respect to own price and manufacturing price, respectively.

Supply, on the other hand, appears more responsive to changes in market grade production. By implication, changes in federal support prices, which are at least partially linked to manufacturing price, have a relatively small effect on California processors. Changes in quota variables and producer prices which impact on production, on the other hand, appear to shift the retail supply relationship significantly.

V. Impact of Market Regulation

To evaluate the effect of milk market regulation, the estimated structural model can be used to predict comparable quantities demanded and supplied over the sample period (columns 1 and 2 of table 1). Examining these results, a systematic trend toward market disequilibrium is not apparent. In fact, differences in observed and estimated quantities appear to be growing smaller over time. Furthermore, the market appears to be characterized by excess demand in a majority of cases although actual magnitudes of predicted disequilibria vary substantially.

To further examine the effect of regulations, the equilibrium quantity and price are simulated from the reduced form under the hypothesis of equilibrium corresponding to the above structural estimates (columns 4 and 6, respectively). Not surprisingly, the agreement between equilibrium price and observed price in column 5 is not close due to the highly inelastic nature of both demand and supply. Interestingly, however, departures of the predicted equilibrium price from observed price are not one-sided in sign or magnitude and, as a result, the average difference is only about 2 percent. The results presented in table 1 thus do not seem to support the contention that the market has been characterized by persistent excess supply during

TABLE 1

Predicted Supply, Demand, and Price Under Disequilibrium and Equilibrium
July, 1974, to December, 1976

Time period	Demand	Supply	Quantity Observed	Quantity Equilibrium	Price Observed	Price Equilibrium
	1	2	3	4	5	6
	1,000 gallons				dollars per half gallon	
1974						
July	54,922	59,131	54,366	55,431	0.71695	0.66563
Aug.	55,044	58,639	55,678	55,470	0.71760	0.67439
Sep.	60,356	57,285	55,713	59,944	0.71755	0.75821
Oct.	60,083	57,780	59,653	59,770	0.71755	0.74839
Nov.	59,517	56,573	57,048	59,110	0.71580	0.75651
Dec.	59,523	56,918	55,705	59,153	0.71670	0.75362
1975						
Jan.	59,614	57,114	59,064	59,249	0.71455	0.75069
Feb.	59,485	55,618	53,024	58,934	0.71435	0.76987
Mar.	59,701	57,605	56,351	59,367	0.71360	0.74650
Apr.	59,697	57,700	56,324	59,368	0.71355	0.74601
May	59,946	57,856	58,026	59,575	0.69640	0.73202
June	54,500	57,904	52,900	54,814	0.69615	0.66465
July	54,653	58,488	55,054	55,010	0.69560	0.66011
Aug.	54,684	58,533	54,632	55,040	0.69560	0.66024
Sep.	60,349	57,340	58,159	59,839	0.69565	0.74485
Oct.	60,447	57,671	60,980	59,960	0.69545	0.74221
Nov.	60,565	56,881	55,795	59,954	0.69545	0.75455
Dec.	60,669	57,431	58,472	60,110	0.69550	0.74932
1976						
Jan.	59,367	61,931	60,115	59,607	0.69500	0.67282
Feb.	60,976	57,823	54,530	60,425	0.69395	0.74660
Mar.	61,090	60,031	60,541	60,806	0.69435	0.72090
Apr.	61,151	60,594	57,909	60,930	0.69555	0.71611
May	61,375	61,471	56,791	61,222	0.69545	0.70952
June	55,880	61,258	54,936	56,367	0.69550	0.64862
July	55,990	61,586	57,184	56,489	0.69255	0.64486
Aug.	56,147	61,475	56,793	56,609	0.69160	0.64747
Sep.	61,939	60,215	59,513	61,526	0.69070	0.72889
Oct.	61,978	60,747	61,482	61,628	0.69430	0.72669
Nov.	62,066	60,102	60,602	61,618	0.69335	0.73495
Dec.	62,024	60,652	61,060	61,648	0.69330	0.72810
Average	59,125	58,812	57,280	58,966	0.70165	0.71678

recent years. In point of fact, the market appears to be in a state of excess demand on the average.

To determine the importance of the effects of the Class I milk quota in California and investigate the real magnitude of the effects, the welfare analysis in table 2 is developed. Results show the producer and consumer welfare effects of removing the Class I quota and price regulations and returning to equilibrium in the retail market (given the existence of controls in the wholesale market). In the context of the recent results developed by Just and Hueth (1979), the producer effects pertain to milk processors and retailers alone since supply estimates are conditioned on wholesale market transactions. Dairy farmers who sell in the wholesale market would presumably not experience sizable (if any) welfare effects from removal of Class I quotas since milk transactions in the wholesale market even at the margin are determined largely by federal price supports. The consumer effects in table 2, on the other hand, represent welfare effects on the consuming public and are partial in the sense that cereal prices are assumed to be unaffected by adjustment of Class I milk prices to equilibrium levels.

As is evident from table 2, the welfare effects of deregulation are quite small. In per capita terms, the consumer effects are never larger than 40 cents per capita per month. Furthermore, the Class I marketing plan appears to favor the consumer. Removal of quotas would reduce consumers' real income by an average of only \$3.2 million per month. On the other hand, producers (meaning processors and retailers) would gain less than twice that amount. The overall welfare effects of \$2.8 million per month are thus not large and may be a small price to pay for the associated reduction in price variability (from a retail price standard deviation of 1.0 cents per half gallon to over 3.9 cents per half gallon).

TABLE 2

Welfare Gains From Deregulation
July, 1974, to December, 1976

Time period	Consumers	Producers	Net
		1,000 dollars	
1974			
July	4,786	- 3,079	1,707
August	4,982	- 5,304	- 322
September	- 7,608	15,623	8,014
October	- 3,787	3,988	201
November	- 6,415	10,062	3,647
December	- 6,863	13,038	6,174
1975			
January	- 4,445	4,754	308
February	- 9,921	21,246	11,325
March	- 6,282	11,354	5,071
April	- 6,285	11,333	5,047
May	- 5,562	7,975	2,412
June	1,769	939	2,709
July	3,945	- 4,004	- 58
August	3,503	- 2,955	548
September	- 7,335	9,920	2,584
October	- 4,631	3,142	- 1,488
November	- 1,026	16,952	6,689
December	- 7,916	10,374	2,458
1976			
January	3,109	- 3,849	- 739
February	-10,428	20,091	9,662
March	- 3,479	3,851	372
April	- 5,100	9,503	4,403
May	- 5,366	11,817	6,450
June	3,891	- 2,118	1,772
July	6,109	- 6,926	- 816
August	5,184	- 5,400	- 216
September	- 6,552	9,320	2,767
October	- 4,137	4,330	193
November	- 6,103	7,475	1,372
December	- 4,867	5,644	776
Average	- 3,202	5,970	2,767

VI. Conclusions

This paper has examined the effects of a quota which apparently leads to a classic case of market disequilibrium (given controls which exist in related markets). Although a great deal of consumer criticism has been levied against the Class I milk market quota, the results of this paper show that controls have been adjusted to keep the market remarkably close to equilibrium. Furthermore, on net, the quota appears to have operated in favor of consumer interests at the expense of processors and retailers. Finally, it must be pointed out that a major objective of milk market controls in California has been to stabilize prices as implied by the very title of the plan. The school lunch program, for example, has been an important factor leading to seasonal variability in demand; consumers would face milk prices of much less stability in the absence of Class I market controls (table 1). The benefits of stability, of course, are not reflected in the welfare effects in table 2. If the producer group, for example, is relatively risk averse, then the present plan which achieves stability at the expense of producers while benefiting consumers may well be socially preferable, even in a Pareto sense, to free-market equilibrium.

FOOTNOTES

[†]Giannini Foundation Paper No.

[*]Chambers, The Ohio State University; Just, Moffitt, and Rowe, all at the University of California, Berkeley.

[1]For a complete description of the legislative history and many institutional features of this plan, see California Department of Food and Agriculture (1974).

[2]Class I dairy products are made from market grade milk which is produced under more rigid sanitary standards than manufacturing grade milk.

[3]Actually, the higher grade of milk used for Class I products may be freely substituted for lower grades in manufactured products but not vice versa. Thus, both supply curves may have distinct discontinuities at these points where the price of milk used in manufactured products becomes higher than that of milk used in Class I products. Consistent with historical data, the diagrams are depicted only for the alternative case.

[4]It also seems reasonable that demands in each market may adjust in response to changes in price in the other market. However, the following arguments and resulting model are not substantively altered by this phenomenon (other than simply conditioning the demand curves on the other prices).

[5]In the results that follow, the manufactured product price is not used as a determinant of Class I product demand since the statistical analysis did not attribute any significance to it.

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