AN ECONOMIC ANALYSIS OF AGRICULTURAL PRICE POLICY BIAS TOWARD PRODUCERS OR CONSUMERS: A CASE STUDY OF U.S. DAIRY PRICING POLICIES

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Milk prices in the U.S. are greatly influenced by two programs administered by the USDA-the Federal Milk Marketing Order Program and the Dairy Price Support Program (see USDA, 1969, Manchester, 1971, and Hallberg and King, 1980). The Marketing Order Program as authorized through the Agricultural Marketing Agreement Act of 1937 permits the establishment of use classes for Grade A milk, and establishes minimum prices to be paid by the handlers of milk used in each use class. A substantial proportion of the Grade A milk produced in the U.S. is subject to Federal Milk Marketing Order regulation. In addition to the 47 federal milk marketing orders in 1977, there were 17 state milk marketing orders designed for similar purposes. Virtually all of the Grade A milk produced in the nation in 1977 was subject to federal or state milk marketing orders (Hallberg and King).

The Dairy Price Support Program, authorized by the Agricultural Act of 1949, is designed to support the average price farmers receive for milk at a level of parity determined by Congress or by the Secretary of Agriculture (see USDA, 1969). Dairy prices are supported through open market purchases and sales of manufactured dairy products (eq. butter, powder, and cheese) by the Commodity Credit Corporation and through a variety of donation programs (Hallberg and King).

In recent years these programs have received severe criticism on grounds that they cause substantial welfare losses (Masson and Eisenstat, 1980). In a quite thorough recent analysis, Dahlgran(1980) estimates the social cost[1] of dairy market regulation in 1976 to have been $131 million-slightly over 1 percent of cash receipts from farm marketing of dairy products in 1976. Dahlgran also estimates substantial income transfers from fluid milk consumers to Grade A milk producers ($439 million), from

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[1] Deadweight losses plus costs of administering the program.

Grade A producers to manufactured dairy product consumers ($366 million), and from Grade B producers to manufactured dairy product consumers ($200 million).

Such estimates of the cost of regulation have been criticized on conceptual grounds (Cochrane, 1980) as well as on the basis that they do not take cognizance of the benefits of regulation (Blakley, Manchester, 1980). One such benefit is alleged to be price stability. Recent work suggests this to be a non-trivial benefit (Hallberg, 1980), although assignment of a dollar value to price stability does not appear to be feasible. Nevertheless, as Dahlgran has shown, it is conceivable that the price stability achieved as a result of regulations could have resulted in a sufficient supply function shift so as to completely offset the estimated social costs.

In view of the above considerations, a more relevant question might be: given the amount of milk available to the marketing system, have the regulations tended to favor producers or consumers. It is fairly clear that milk used in various dairy products is not now priced at levels corresponding to those which (by existing theoretical norms) would maximize consumer welfare. It is also clear that, since the elasticities of demand for the various dairy products differ, it is possible for milk to be priced in such a way as to maximize milk producers' gross income. The extent to which milk prices set or encouraged by present regulations tend toward either of these two extremes is, however, unknown.

In this paper we shall address the question posed above. More specifically, we estimate for each of the past 20 years and for milk used to produce the major dairy products (1) a set of prices that would have maximized milk producers' gross income, and (2) a set of prices that would have maximized consumer welfare from consumption of dairy products. Actual prices and income will be compared with prices and income generated from the above two solutions to determine the degree of producer or consumer "bias" built into the current regulations, and to determine if there has been any noticeable trend in this "bias" over the past 2 decades.

THE MODEL

Suppose we have two use classes of milk—Class I and Class II—and suppose that for each use class the annual farm level demand can be written

$$(1) \qquad q_i = a_i + b_i P_i \qquad \text{for } i = \text{I, II}$$

where q_i represents the per capita demand for milk used in the i-th use class and P_i represents the farm price of milk used in the i-th use class. These functions can be used to derive a simple national model of the

U.S. dairy industry as shown in Figure 1.[2] Here D_I and D_{II} represent the derived aggregate demand functions at the farm level, and TQ represents the total quantity of milk supplied.

Maximization of Producer Revenue

Figure 1 shows the price-quantity combinations (P_i^* and Q_i^*) for the two different use-classes of milk which result in the maximum producer revenue obtainable given that $Q_I^* + Q_{II}^* = TQ$. These price-quantity combinations are found (in the general case) by solving the following quadratic programming problem:

$$\text{(2)} \qquad \text{maximize } R = \sum_i P_i Q_i = \sum_i P_i(a_i + \sum_j b_{ij} P_j)$$

subject to:

$$\text{(3)} \qquad a_i + \sum b_{ij} P_j = Q_i \qquad \text{for all } i$$

$$\text{(4)} \qquad \sum_i Q_i = TQ$$

$$\text{(5)} \qquad P_i, Q_i \geq 0 \qquad \text{for all } i$$

If the solution to this problem yields positive prices and quantities (as is the case in Figure 1), then it is easily shown by solving the Lagrangian problem that the solution implies marginal revenues in all markets are equal.

Maximization of Consumer Welfare

Figure 1 also shows the price-quantity combinations (P^c and Q^c) for the two different use classes of milk which result in the maximum welfare to consumers defined as the total utility derived from consumption of the two classes of milk. Here the maximization problem (in the general case) is:

$$\text{(6)} \qquad \text{Max } U = \sum_i \int_0^{q_i} (A_i + \sum_j B_{ij} Q_j)\, d Q_i$$

subject to:

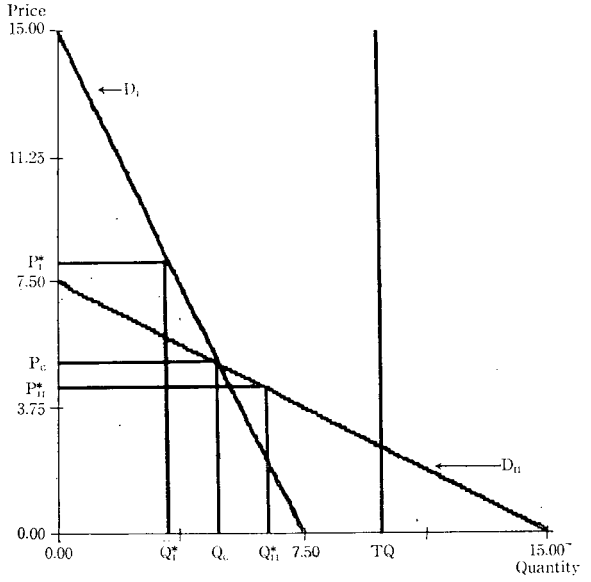
$$\text{(7)} \qquad A_i + \sum_j B_{ij} Q_j = P_i \qquad \text{for all } i$$

$$\text{(8)} \qquad \sum_i Q_i = TQ$$

$$\text{(9)} \qquad P_i, Q_i \geq 0$$

[2]In this hypothetical example $Q_I = 7.5 - 0.5\ P_I$, $Q_{II} = 15 - 2P_{II}$, and $TQ = 10$

FIGURE 1 ILLUSTRZTION OF "OPTIMAL" SOLUTIONS



where the functions, $A_i + \sum_j B_{ij} Q_j = P_i$, in equation (6) are derived from the demand functions, $a_i + \sum_j b_{ij} P_j = Q_i$, in equation (2).[3] If the solution to this problem yields positive prices and quantities (as is the case in Figure 1), then it is easily shown by integrating and solving the Lagrangian problem that the solution implies prices in all markets must be equal.

MODEL SPECIFICATION AND GENERATION OF OPTIMAL PRICES

For the purposes of this study, six different uses of milk were considered:

1. Butter
2. Cheese
3. Evaporated Milk
4. Fluid Milk Products
5. Frozen Products
6. Other Uses

The different uses of milk are assumed to constitute separate markets, but the demand for one use class is assumed to be a function of its own price and the price of all other uses. Thus, the farm level demand functions are

[3]Whether or not this solution is the one that would actually maximize consumer welfare (or more appropriately, consumer utility) is debatable as the literature will show. It is, nevertheless, the non-discriminatory, competitive solution, and hence will serve as one of the two extremes with which to compare actual price.

specified as:

$$(10) \qquad Q_{it} = a_{it} + \sum_{j=1}^{6} b_{ijt} P_{jt} \qquad i = 1, 2, \ldots, 6$$

where Q_{it} represents the quantity of fluid milk equivalent (on a butterfat basis) used in the i-th use in year t, and P_{jt} represents the farm price of milk used in the j-th use in year t. The a_{it} and b_{ijt} are derived from own-price and cross-price elasticities which were taken or derived from George and King (1971) and Brandow (1961) (see Table 1). Data on quantity and prices together with the elasticities shown in Table 1 were used to compute these parameters as follows:

$$\hat{b}_{ijt} = \varepsilon_{ij} \frac{Q_{it}}{P_{jt}} \quad \text{and} \quad \hat{a}_{it} = Q_{it} - \sum_{j=1}^{6} \hat{b}_{ijt} P_{jt}.$$

Net exports, net additions to stocks, and military consumption were subtracted from published data on annual utilization of milk to derive Q_{it} so as to capture the purely commercial component of the domestic dairy market. The effective buying price of fluid milk was taken as the price of fluid milk products (P_{4j}), the Class III price in the Chicago Regional Federal Milk Marketing Order was taken as the price of milk used in frozen products (P_{5j}), and the price of milk used in other products (P_{6j}), was assigned the price of milk used in that product most frequently having the lowest use value - evaporated milk.

TFBLE 1. MATRIX OF PRICE ELASTICITIES AT THE FARM LEVEL.

	Butter	Cheese	Evaporated Milk	Fluid Milk	Frozen Products	Other Uses
Butter	−.46086	.00153	.000386	.00678	.00105	.00000
Cheese	.00084	−.35214	−.00006	.00117	.00473	.00000
Evaporated Milk	.00166	.00095	−.28090	.20127	.00065	.00000
Fluid Milk	.00099	.00052	.00883	−.32395	.00035	.00000
Frozen Products	.00056	.00554	−.00016	−.00086	−.45114	.00000
Other Uses	.00000	.00000	.00000	.00000	.00000	−.36600

Solutions to the revenue maximization problem for each of the years 1960 through 1979 were obtained with the aid of a quadratic programming algorithm much as was done by Ladd and Updegraff (1969). These solutions were checked for realism by comparing the solution quantity levels with what were felt to be reasonable minimum consumption levels. The minimum consumption level of each product was derived from the 1965 USDA Food Consumption Survey (USDA, 1965). Minimum consumption levels were selected as those levels consumed by households in the $3,000 to $4,000 income bracket. These 1965 minimum consumption levels were

divided by the 1965 average consumption levels to get 1965 minimum consumption ratios. The 1965 minimum consumption ratios were multiplied by each year's actual consumption level to get each year's minimum consumption levels. The 1965 ratios of the minimum consumption level to the average consumption level for each product are given in Table 2. Based on the comparison made, it was felt that the solution values were reasonable and that the programming problem need not be further constrained, although the consumption of evaporated milk did fall below the minimum consumption level for that product in some years.

TABLE 2. PERCENTAGE RATIOS OF MINIMUM 1965 CONSUMPTION TO ACTUAL 1965 CONSUMPTION.

Product	Percent
Butter	93%
Cheese	76%
Evaporated Milk	64%
Fluid Milk	75%
Frozen Products	79%

The solution to the consumer welfare maximization problem for each year is quite straightforward since it is known, *a priori,* that all six prices should be equal. We modified this result somewhat, however, to reflect the fact that milk used for fluid products must meet higher quality standards than does milk used in other products, and, thus, should command a higher price. We assumed the price of milk used for fluid products would be 7 percent higher than the price of milk used for other dairy products based on estimates of the costs of producing Grade A and Grade B milk made by Frank, et. al. (1977).[4]

EMPIRICAL RESULTS

Actual and "optimal" values of prices, quantities, and gross farm income are shown in Tables 3, 4, and 5. The results indicate that producers' gross income could have been increased during the 1960–79 period by a reallocation of milk among the six different use classes consistent with a more discriminatory pricing scheme. This increase would have been possible had more milk been marketed in the butter, cheese, frozen products, and other dairy product markets at lower prices, and had less milk been marketed in the fluid market at higher prices. These results are, of course, consistent with the elasticities assumed here—elasticities of demand for butter, cheese, frozen products, and other dairy products are slightly higher than for fluid milk.

[4]Three percent was chosen since this resulted in a price difference of 27cent per cwt in 1974—the cost difference that Frank, et al. (1977) estimated for 1974.

TABLE 3. ACTUAL AND "OPTIMAL" PRICES IN CENTS PER HUNDREDWEIGHT, 1960–79.

Year	Butter	Cheese	Evaporated Milk	Fluid Products	Frozen Products	Other Uses	Weighted Average
			Actual Prices				
1960	302	308	305	548	315	305	421
1961	322	312	311	544	321	311	421
1962	309	299	296	537	317	296	412
1963	309	305	299	531	311	299	412
1964	314	311	307	534	318	307	415
1965	322	318	313	536	333	313	423
1966	380	384	368	583	380	368	479
1967	393	386	379	617	399	379	499
1968	410	403	393	649	417	393	523
1969	429	433	412	677	442	412	548
1970	452	461	428	693	466	428	565
1971	472	474	444	711	481	444	580
1972	490	501	458	726	508	458	600
1973	611	626	557	829	630	557	715
1974	693	704	702	993	710	702	833
1975	754	758	733	995	772	733	866
1976	828	843	818	1100	858	818	953
1977	847	855	834	1090	868	834	954
1978	942	952	911	1170	972	911	1042
1979	1071	1085	1054	1332	1101	1054	1185
			"Optimal" Producer Prices				
1960	144	266	691	830	181	230	458
1961	173	270	701	820	188	238	455
1962	164	256	683	816	194	222	446
1963	163	266	703	801	183	227	446
1964	165	271	719	801	188	235	448
1965	166	272	739	792	200	234	456
1966	198	337	866	830	216	275	511
1967	209	333	922	894	239	287	534
1968	216	344	955	940	247	292	560
1969	225	380	1054	977	268	306	585
1970	246	417	1141	994	292	320	602
1971	265	429	1192	1019	304	337	616
1972	270	456	1261	1026	326	339	636
1973	345	576	1488	1125	408	404	751
1974	386	636	1899	1384	451	584	878
1975	446	705	1982	1352	513	604	907
1976	488	790	2329	1495	581	685	998
1977	520	817	2424	1480	602	719	998
1978	587	918	2643	1563	688	776	1084
1979	665	1044	3038	1778	775	913	1233
			"Optimal" Consumer Prices				
1960	368	368	379	379	379	368	375
1961	375	375	387	387	387	375	382
1962	364	364	375	375	375	364	370
1963	365	365	376	376	376	365	372
1964	370	370	381	381	381	370	377
1965	380	380	391	391	391	380	387

1966	440	440	453	453	453	440	448
1967	455	455	469	469	469	455	464
1968	476	476	491	491	491	476	486
1969	501	501	516	516	516	501	510
1970	521	521	538	538	538	521	531
1971	537	537	553	553	553	537	547
1972	559	559	577	577	577	559	570
1973	680	680	701	701	701	680	693
1974	783	783	807	807	807	783	797
1975	826	826	851	851	851	826	841
1976	911	911	939	939	939	911	927
1977	916	916	945	945	945	916	932
1978	1006	1006	1037	1037	1037	1006	1023
1979	1145	1145	1181	1181	1181	1145	1164

TABLE 4. ACTUAL AND "OPTIMAL" QUANTITIES IN MILLIONS OF POUNDS, 1960–79.

Year	Butter	Cheese	Evaporated Milk	Fluid Products	Frozen Products	Other Products	Total
			Actual Quantities				
1960	30696	13219	5012	58500	9186	6496	123109
1961	32874	13825	4947	57500	9304	7258	125708
1962	33969	14741	4769	57719	9483	5570	126251
1963	33969	15392	4548	58370	9692	3231	125202
1964	31870	15493	4544	58642	10004	5965	126968
1965	29020	16695	4324	58843	10312	4987	124181
1966	24033	18006	3995	58546	10269	5064	119913
1967	26401	17963	3739	56890	10294	3446	118733
1968	25192	18851	3716	56311	10702	2453	117225
1969	23924	19743	3238	55165	10742	3296	116108
1970	24155	21476	2896	54176	10816	3488	117007
1971	24103	22587	2818	53699	10705	4655	118567
1972	22941	24727	2688	54970	10750	3949	120025
1973	18778	26208	2609	54010	10850	3035	115490
1974	19504	27536	2513	52033	10971	3029	115586
1975	20023	26577	2433	52478	11694	2129	115334
1976	19544	29553	2204	52769	11420	4779	120269
1977	21973	29621	2089	52588	11479	4948	122698
1978	19822	30674	2000	51333	11544	6236	121609
1979	19500	32396	2019	51521	11533	6654	123623
			"Optimal" Producer Quantities				
1960	38178	13834	3743	49342	10930	7082	123109
1961	40005	14455	3706	48637	11023	7882	125708
1962	41429	15459	3510	48641	11131	6080	126251
1963	41475	16054	3283	49402	11472	3517	125202
1964	38949	16637	3283	49789	11834	6476	126968
1965	35591	17518	3083	50389	12154	5446	124181
1966	29413	18752	2813	51156	12247	5532	119913
1967	32160	18803	2567	49309	12141	3752	118733
1968	30759	19784	2555	48795	12649	2683	117225
1969	29226	20554	2105	47980	12638	3605	116108

1970	29303	22156	1791	47323	12625	3810	117007
1971	29059	23312	1727	46936	12466	5067	118567
1972	27750	25467	1584	48430	12469	4324	120025
1973	22591	26895	1568	48534	12560	3341	115490
1974	23537	28418	1504	46152	12758	3216	115586
1975	23845	27190	1442	47143	13448	2266	115334
1976	23299	30167	1217	47455	13067	5064	120269
1977	25939	30036	1118	47356	13052	5197	122698
1978	23314	31020	1064	46582	13054	6573	121609
1979	22957	32779	1086	46762	13060	6978	123623
			"Optimal" Consumer Quantities				
1960	27570	12326	4362	64488	8355	6007	123109
1961	30333	12851	4324	63030	8459	6711	125708
1962	31154	13629	4125	63521	8717	5104	126251
1963	31099	14343	3955	64043	8792	2971	125202
1964	29225	14896	3977	64228	9123	5520	126968
1965	26587	15565	3787	64134	9510	4598	124181
1966	22267	17099	3558	62901	9385	4703	119913
1967	24451	16843	3311	61444	9491	3193	118733
1968	23284	17655	3276	60890	9857	2262	117225
1969	22056	18669	2855	59551	9941	3036	116108
1970	22418	20496	2558	58249	10077	3209	117007
1971	22552	21545	2498	57685	9988	4299	118567
1972	21419	23723	2382	58769	10103	3629	120025
1973	17788	25423	2339	56845	10305	2790	115490
1974	18324	26468	2314	55274	10305	2902	115586
1975	19129	25749	2253	55015	11159	2030	115334
1976	18628	28725	2048	55348	10940	4580	120269
1977	21131	28883	1956	54930	11028	4769	122698
1978	19187	30064	1877	53286	11198	5997	121609
1979	18866	31770	1905	53478	11161	6443	123623

Had milk been priced so as to maximize consumer welfare, on the other hand, gross farm income from the sale of milk would have been lower in each of the past 20 years. This would have happened as a result of a decrease in price and an increase in quantity of milk used in fluid products, and by an increase in price and a decrease in quantity of milk used in all other products. Again these results were not unexpected and are quite in line with the relative demand elasticities for the different dairy products.

Of perhaps greater interest and importance is the relationship of actual prices of milk used in the different dairy products and of the weighted average price of milk to the two extreme sets of prices estimated here. This relationship can be inferred for each of the six use classes from the data in Tables 3 and 4. Figures 2 through 7 show this relationship somewhat clearer for the weighted average price and for the price of milk used in selected products.

Some rather striking conclusions are revealed by these comparisons. First, the window between the weighted average price for producer

TABLE 5. ACTUAL GROSS REVENUE AND GROSS REVENUE FROM SALE OF MILK UNDER PRODUCER REVENUE MAXIMIZATION AND UNDER CONSUMER WELFARE MAXIMIZATION, 1960–79.

(million dollars)

Year	Actual Revenue	Revenue Under: Producer Revenue Maximization	Revenue Under: Consumer Welfare Maximization
1960	5,180	5,636	4,615
1961	5,296	5,726	4,803
1962	5,197	5,623	4,676
1963	5,153	5,583	4,653
1964	5,269	5,693	4,782
1965	5,254	5,658	4,806
1966	5,742	6,122	5,376
1967	5,924	6,340	5,508
1968	6,136	6,569	5,694
1969	6,360	6,796	5,925
1970	6,614	7,042	6,216
1971	6,873	7,304	6,482
1972	7,204	7,633	6,839
1973	8,263	8,669	7,999
1974	9,625	10,153	9,210
1975	9,983	10,465	9,700
1976	11,465	12,004	11,148
1977	11,709	12,243	11,434
1978	12,666	13,187	12,445
1979	14,650	15,243	14,394

revenue maximization and that for consumer welfare maximization is relatively small (less than $1.00/cwt), and has gotten progressively smaller over the 20 year period (from 83cent/cwt in 1960 to 69cent/cwt in 1979). Of perhaps greater surprise is the fact that the actual weighted average price, while in 1960 slightly closer to that price which would have maximized producer welfare, has over the 20 year period moved progressively closer to that price which would have maximized consumer welfare (see Figures 2 & 3). In 1979 the actual weighted average price was only 21cent/cwt above that price at which consumer welfare would have been maximized, but 48cent/cwt below that price at which producer revenve would have been maximized.

Since the extreme prices were determined subject to the restriction that the total quantity of milk marketed in each –ear equals the actual

	Percent Deviation of Producer Revenue from Actual Producer Revenue Under: Producer Revenue Maximization	Consumer Welfare Maximization
1960	8.8	−10.9
1979	4.1	− 1.7

FIGURE 2 WEIGHTED AVERAGE PRICE RECEIVED BY FARMERS FOR ALL MILK, 1960~1979

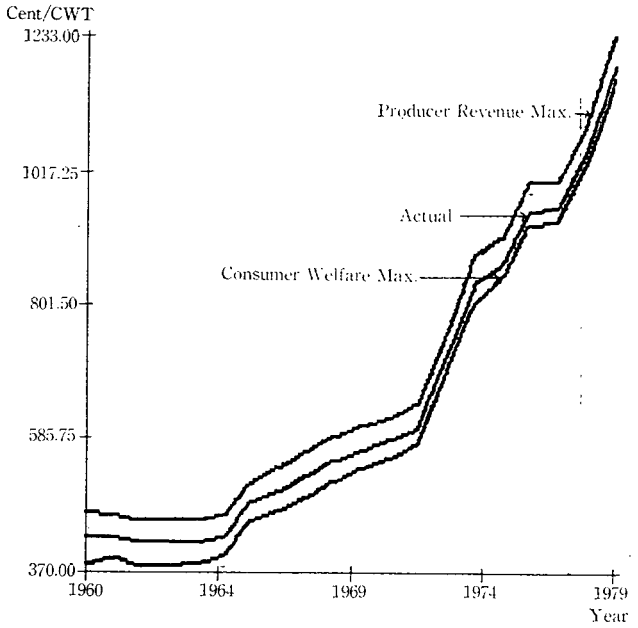


FIGURE 3 "OPTIMAL" WEIGHTED AVERAGE PRICE RECEIVED BY FARMERS FOR ALL MILK AS A PERCENT OF ACTUAL WEIGHTED AVERAGE PRICE RECEIVED BY FARMERS FOR ALL MILK, 1960 ~ 1979

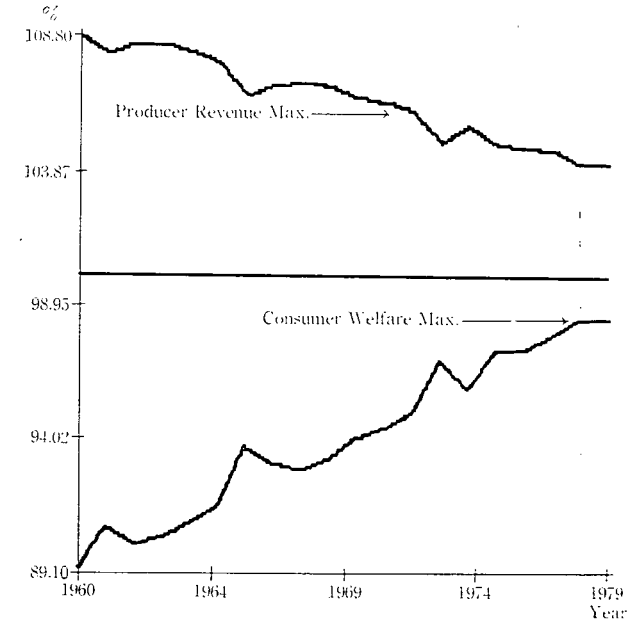


FIGURE 4 "Optimal" Prices for Milk Used for Butter as a Percent of Actual Price for Milk Used for Butter, 1960 ~ 1979

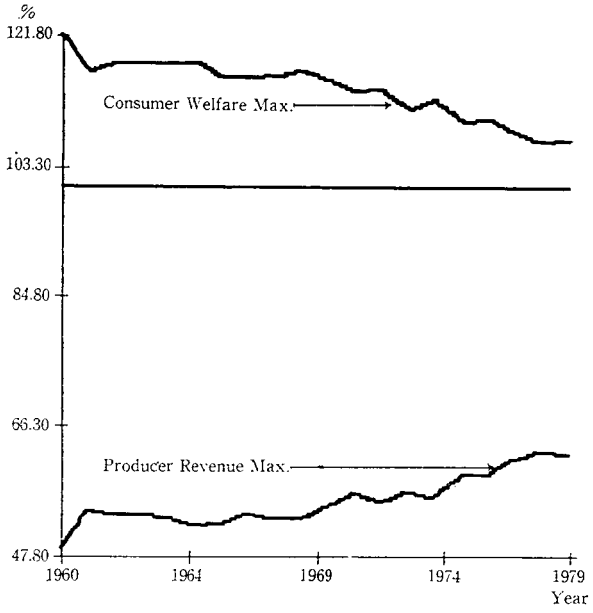


FIGURE 5 "Optimal" Prices for Milk Used for Cheese as a Percent of Actual Price for Milk Used For Cheese, 1960 ~ 1979

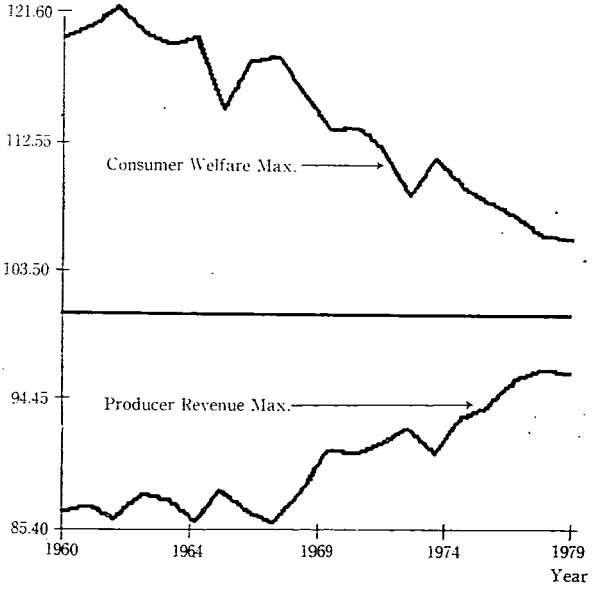


FIGURE 6 "Optimal" Prices for Milk Used for Fluid Products as a Percent of Actual Price for Milk Used for Fluid Products, 1960 ~ 1979

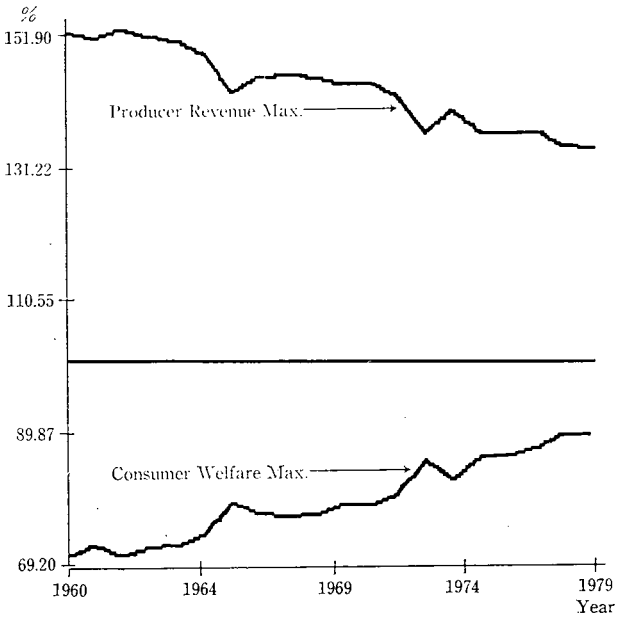
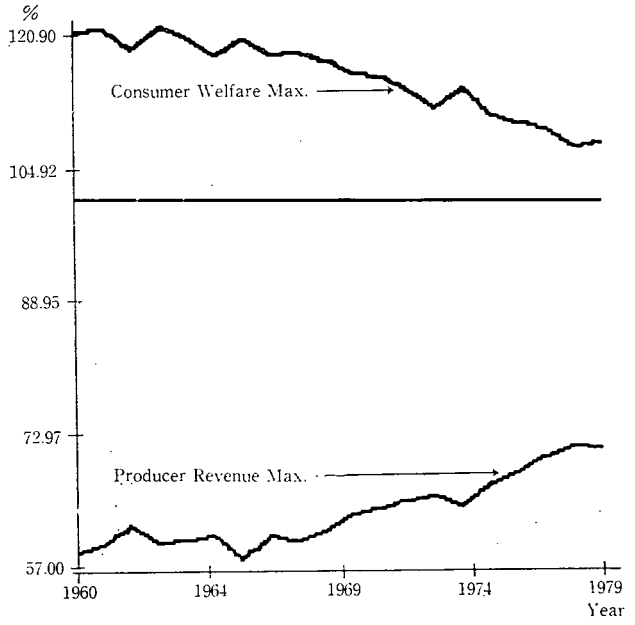


FIGURE 7 "Optimal" Prices for Milk Used for Frozen Products as a Percent of Actual Price for Milk Used for Frozen Products, 1960 ~ 1979



quantity marketed, the above statements also apply to producer revenue. The following tabulation puts into perspective the relation of actual producer revenue to producer revenue under the two extreme cases:

For milk used in butter, evaporated milk, and frozen products, the difference in cents/cwt between the actual price and the price at which consumer welfare would have been maximized has widened slightly over the past 20 years (Table 3). On a percentage basis, however, the actual prices for all use classes except cheese has gotten steadily closer to the price which would have maximized consumer welfare (Figures 4 through 7). In all cases except cheese, the actual prices even in 1960 were closer to the prices at which consumer welfare would have been maximized than to those prices at which producer revenue would have been maximized.

CONCLUSIONS

This study has corroborated what previous studies have concluded—given the amount of milk marketed, prices of the different use classes of milk are not set so as to be consistent with those that would maximize consumer welfare. Hence, producer revenue is somewhat higher than would be the case if milk were priced more in line with consumer interests. This implies that there is effected a transfer of income from consumers to producers given the amount of milk actually marketed.

On the other hand, neither are prices of the different use classes of milk set so as to maximize producer revenue. In fact, given the amount of milk marketed over the past 20 years, milk prices have been more in line with those price levels that would maximize consumer welfare than with those that would maximize producer revenue. Indeed, this is more true today than it was in 1960 and may reflect the fact that the regulatory authorities have in recent years recognized (1) less of a need for income enhancement for milk producers, and/or (2) the voice of those speaking on behalf of consumers.

Given that producer revenue appears to be only about 1.5–2.0 percent above what it would be if milk prices were set so as to maximize consumer welfare (as contrasted to nearly 11 percent above in 1960), the implied consumer-to-producer income transfer may well be a small price to pay for the price and marketing stability that existing dairy programs impart.

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