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A FRAMEWORK FOR EVALUATING THE  
ECONOMIC IMPACT OF CLASSIFIED PRICING OF MILK

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Pricing milk according to use (classified pricing) is a basic part of federal milk marketing orders and state milk control. Under classified pricing, there are three key prices in determining production and consumption of milk: (1) the "Class I" price paid by processors of fluid milk, (2) the "U.S. manufacturing milk" price paid by processors of manufactured dairy products, and (3) a weighted "all wholesale milk" price reflecting an average price received by all dairy farmers. The minimum difference between the Class I price and the U.S. manufacturing price (from here on referred to as the Class I differential) is a policy variable established under federal milk marketing orders. The objective of this paper is to analyze the effects of increasing, decreasing, or having no-minimum Class I differentials on regional fluid milk consumption, milk production, prices received by farmers, and the U.S. manufacturing milk price. This link between classified pricing policy and consumption, production, and prices is important in analyzing the broader implications of federal milk marketing orders.

THE MODEL

A nine-region model of milk consumption and production in the continental United States was developed. For simplicity, a three-region model is illustrated in Figure 1. The regional demand for fluid milk, which depends on the prevailing Class I price in that region, is represented by  $F_1$ ,  $F_2$ , and  $F_3$ . The regional milk supply, which depends on the

Part D

Part C

Part B

Part A

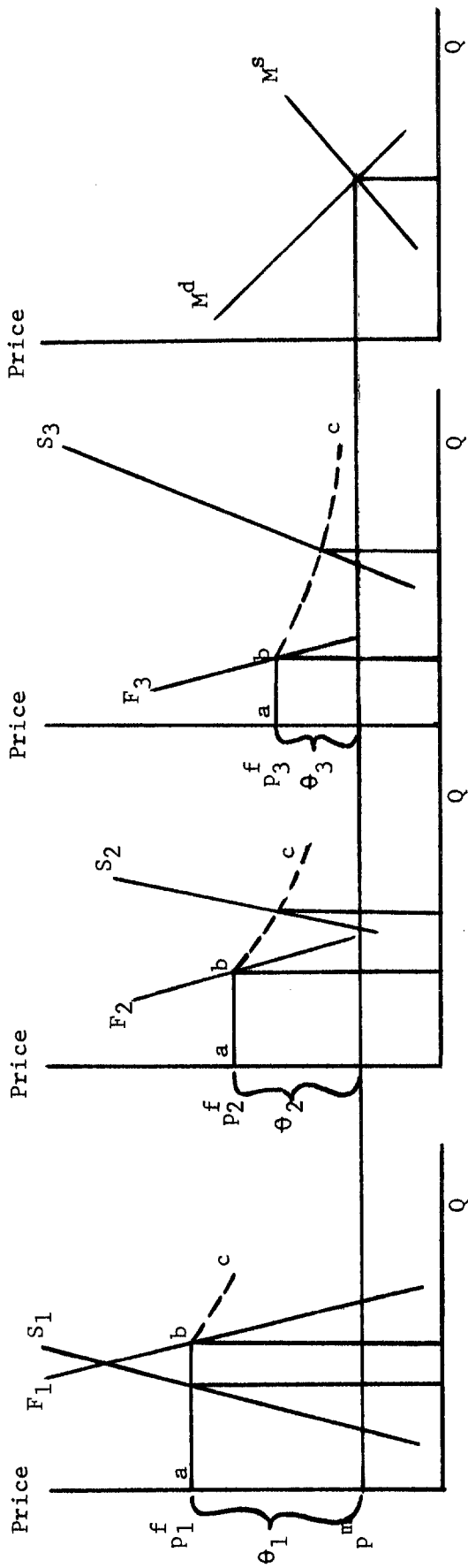


Figure 1. Partial equilibrium model of the U.S. classified pricing program.

all wholesale milk price in each region, is represented by  $S_1$ ,  $S_2$ , and  $S_3$ . Within each region, the demand for manufacturing milk is assumed to be infinitely elastic at the U.S. manufacturing milk price ( $P^m$ ). The U.S. manufacturing milk price is determined by the intersection of the aggregate U.S. demand for manufacturing milk ( $M^d$ ) and the total supply of milk available for manufacturing after the higher priced fluid demand is met ( $M^s$ ).

Under federal milk marketing orders minimum Class I prices are set above the U.S. manufacturing price. The differential between these prices varies from one region to another. This is illustrated by different values of the Class I differential ( $\theta_1$ ,  $\theta_2$ , and  $\theta_3$ ) in Figure 1. Without a change in Class I pricing policy, these differentials would be expected to remain fairly constant over time.

The average revenue to farmers per one hundred pounds of milk (the all wholesale milk price) reflects both Class I and manufacturing milk sales and is illustrated with lines labeled abc in Figure 1. This average revenue can be written as:

$$(1) \quad P_i^w = \frac{P_i^f F_i + P^m (S_i - F_i)}{S_i}$$

where

$i = 1$  to 9 regions,

$P_i^f$  = regional Class I milk price,

$P^m$  = U.S. manufacturing milk price,

$F_i$  = regional milk used as Class I (including Class I milk shipped to other regions), and

$S_i$  = regional milk production.

If the quantity of milk produced in a region increased relative to the quantity used as fluid, a larger proportion of the milk must be sold at the lower manufacturing price ( $P^m$ ). Therefore, the average revenue would decline as illustrated by the bc segment of the abc curve in Figure 1. The average revenue curve (abc) becomes the effective demand curve facing producers in a given region. It is the intersection of this curve with the regional supply (S) that would determine the quantity of milk produced in each region.

The region illustrated in Part A of Figure 1 is deficit in fluid milk, therefore, the all wholesale milk price would be equal to the Class I price.<sup>1/</sup> The quantity produced within that region would be determined by the intersection of the ab segment of the abc curve and  $S_1$ . The horizontal distance between that intersection and the fluid demand curve is the quantity of fluid milk that would be shipped into that region from a surplus region(s). The regions illustrated in Parts B and C of Figure 1 produce more milk than is used as fluid.

The  $M^S$  curve in Part D of Figure 1 shows the quantity of milk available for manufacturing for all regions (after fluid demand has been met) at all possible manufacturing milk prices. The higher the manufacturing milk price, the greater will be the quantity of milk available for manufacturing. This is because the resulting higher Class I prices would tend to decrease fluid consumption and the higher all

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<sup>1/</sup> Because of seasonal variation in production, a region probably would have to import 20 percent or more of its fluid milk before it could utilize most of its own production as fluid Class I sales. Some of its milk production would be diverted to manufacturing during part of the year, causing the all wholesale milk price to be below the Class I price.

wholesale milk prices would encourage production, leaving more milk available for manufacturing.

This annual partial equilibrium model exists over time. Changes in population, tastes and preferences, price of substitutes and other factors affecting demand would be shifting the demand curves over time. On the supply side, changes in feed and other input prices, returns from competing farm enterprises, and other factors affecting supply would be shifting the supply curves over time. These shifts along with specific Class I differentials established under federal milk marketing orders would generate a series of annual equilibrium quantities and prices over time.

Assuming a continued federal order Class I pricing policy through 1985, forecasts of supply and demand shifts were made and expected regional equilibrium production, fluid consumption, Class I prices, and U.S. manufacturing milk prices were determined. These forecasts were based upon expected inflation, feed costs, input prices, and other factors affecting the dairy industry. The forecasting procedure employed trend analysis, available supply and demand models, and subjective judgment. These forecasted prices and quantities allowed the supply and demand curves discussed above and illustrated in Figure 1 to be positioned for each year over the 1975 to 1985 period. The slopes of the demand and supply curves were calculated assuming what appeared to be reasonable supply and demand elasticity estimates. This procedure is discussed in more detail in the next section.

### A MATHEMATICAL REPRESENTATION OF THE MODEL

The more general regional model, of which the three-region model shown in Figure 1 is a special case, can be written in the following equations:

$$(2) \quad F_i(t) = a_i(t) + b_i(t)P_i^f(t)$$

$$(3) \quad S_i(t) = c_i(t) + d_i(t)P_i^w(t)$$

$$(4) \quad M^d(t) = e(t) + f(t)P^m(t)$$

and identities:

$$(5) \quad P_i^f(t) = P^m(t) + \theta_i(t)$$

$$(6) \quad P_i^w(t) = P^m(t) + \gamma_i(t)\theta_i(t)$$

$$(7) \quad M^s(t) = \sum_{i=1}^a (S_i(t) - F_i(t))$$

where

$i = 1$  to 9 regions,

$t =$  year,

$F_i(t) =$  fluid milk consumption,

$S_i(t) =$  total milk production,

$M^d(t) =$  total U.S. manufacturing milk consumption,

$P^m(t) =$  U.S. average manufacturing milk price,

$P_i^f(t) =$  Class I milk price,

$P_i^w(t) =$  all wholesale milk price,

$M^s(t) =$  total milk available in the U.S.,

$\theta_i(t) =$  Class I milk price differential,



$\gamma_i(t)$  = percentage of milk used as Class I, and  
 $a_i(t)$ ,  $b_i(t)$ ,  $c_i(t)$ ,  $d_i(t)$ ,  $e(t)$ , and  $f(t)$  are intercept and  
slope coefficients for supply and demand equations.

Equation (6) is equivalent to equation (1) when  $\gamma$  is equal to the  
actual percentage of total milk used for fluid consumption.

Because less information is available on interregional milk shipments  
than on all wholesale milk prices, the percentage of Class I utilization is  
estimated from the all wholesale milk price, manufacturing milk price, and  
the Class I differential as:

$$\gamma_i(t) = \frac{P_i^w(t) - P^m(t)}{\theta_i(t)}$$

The equilibrium condition for each year is:

$$(8) \quad M^d(t) = M^s(t).$$

The intercept and slope parameters of the model for the 1975 to 1985  
period were calculated using the forecasted equilibrium prices and  
quantities and the estimates of demand and supply elasticity. The  
parameters of the supply and demand equations were calculated for each  
year. The slopes and intercepts of the fluid demand equations were  
estimated as:

$$b_i(t) = \frac{P_i^t(t)^0}{F_i(t)^0 \eta_i^f(t)} = \text{slope}$$

and

$$a_i(t) = b_i(t)F_i(t)^0 + P_i^f(t)^0 = \text{intercept},$$

where

$o$  refers to forecasted equilibrium quantity and price, and

$\eta_i^f(t)$  = elasticity of fluid demand in the  $i$ th region and  $t$ th year.

The slopes and intercepts of the supply equations were estimated as

$$d_i(t) = \frac{P_i^w(t)^d}{S_i(t)^d E_i^s(t)} = \text{slope}$$

and

$$C_i(t) = d_i(t) S_i(t)^o + P_i^w(t)^o = \text{intercept},$$

where

$o$  refers to forecasted equilibrium quantity and price and

$E_i^s(t)$  = elasticity of milk production response in year  $t$  to a change  
in the all wholesale milk price in year  $t$ .

The slope and intercept of the aggregate U.S. demand for manufacturing milk were estimated as:

$$f(t) = \frac{P^m(t)^o}{M^d(t)^o \eta^m(t)} = \text{slope and } e(t) = -f(t)M^d(t)^o + P^m(t)^o = \text{intercept},$$

where

$o$  refers to forecasted equilibrium quantity and price and

$\eta_i^f(t)$  = elasticity of demand for manufacturing milk.

All the parameters of the model that are consistent with the forecasted equilibrium prices and quantities have now been calculated. The

model can be solved for the equilibrium U.S. manufacturing milk price in any year. From the equilibrium condition (equation 8), the manufacturing price would be:

$$P^m(t) = \frac{e(t) + \sum_{i=1}^a \left[ a_i(t) - c_i(t) - d_i(t)\gamma_i(t)\theta_i(t) + b_i(t)\theta_i(t) \right]}{\sum_{i=1}^a \left[ d_i(t) - b_i(t) \right] - f(t)}$$

All other prices and quantities can then be calculated from this equilibrium manufacturing milk price. Changing any one of the parameters will change the equilibrium prices and quantities from those forecasted.

#### ANALYZING POLICY ALTERNATIVES

The policy variable of interest in this paper is the Class I differential ( $\theta_i(t)$ ). Reducing the Class I differential in all regions would lower Class I prices in all regions and encourage more fluid milk consumption. All wholesale milk prices in most regions would be expected to fall, which would reduce total U.S. milk production. Higher fluid consumption and lower milk production in the aggregate would reduce the quantity of milk available for manufacturing at the original manufacturing milk price, and, thereby, the manufacturing milk price would be expected to rise to a new equilibrium level.

A lagged milk production response to a price change was built into the model. When the all wholesale milk price in any year deviated from that forecasted, because of a policy or other change, it is assumed that the supply curve for the next and all subsequent years would shift.<sup>2/</sup> The

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<sup>2/</sup> This shift is only due to the change in policy variable and is in addition to the effect of the exogenous supply shifters that are already reflected in the forecasted supply equations.

new intercept for the supply curve in  $t + 1$  would then be:

$$C_i(t + 1)' = C_i(t + 1) + \frac{E_i^L(t) \left( P_i^W(t) - P_i^W(t)^O \right) S_i(t)}{P_i^W(t)^O}$$

where

$C_i(t + 1)$  = the supply intercept calculated from the forecasted price and quantity and supply elasticity for year  $t + 1$  and  
 $E_i^L(t)$  = supply elasticity of a one-year lagged response to a deviation of the all wholesale milk price from the forecasted equilibrium all wholesale milk price in  $t$ .

If no policy change is introduced, the solution to the model will be the forecasted equilibrium quantity since  $P_i^W(t) - P_i^W(t)^O$  would be zero.

The supply curve intercept ten years after a policy change was instituted would reflect the original intercept calculated from the forecasted price and quantity plus the 10 shifts calculated from the deviation of the all wholesale milk price from the forecasted all wholesale milk price for each of the prior 10 years.

A second lagged supply response assumption could be selected. This lagged supply response to a deviation in milk prices from the baseline is a form of distributed lag. Results from the Nerlove distributed lag, polynomial lag, or other lag structure of up to five years from the price change are reflected in the model. When the all wholesale milk price in any year deviated from that forecasted, because of a policy change, it is assumed that the supply curve for the next and all subsequent years would shift in the following five years. The new intercept for the supply curve in the year after a policy change would be:

$$C_i(t+1)' = C_i(t+1) + \frac{E_i^{L1}(t) \left( P_i^W(t) - P_i^W(t)^0 \right) S_i(t+1)}{P_i^W(t)^0}$$

where  $E_i^{L1}(t)$  is the first year lag response.

The new intercept for the supply curve five years after a policy change reflects the deviations in price from the base line price for the previous five years as follows:

$$C_i(t+5)' = C_i(t+5) + \frac{E_i^{L1} \left( P_i^W(t+4) - P_i^W(t+4)^0 \right) S_i^W(t+4)}{P_i^W(t+4)^0}$$

$$+ \dots$$

$$+ \dots$$

$$+ \frac{E_i^{L5} \left( P_i^W(t) - P_i^W(t)^0 \right) S_i(t)}{P_i^W(t)^0}$$

where  $E_i^{L1}$ ,  $E_i^{L2}$ ,  $E_i^{L3}$ ,  $E_i^{L4}$ ,  $E_i^{L5}$  are the assumed response elasticities.

#### REGIONAL IMPACT ON PRODUCER PRICES

Reducing the Class I differential (from  $\theta$  to  $\theta'$  in Figure 2) would result in a higher U.S. manufacturing milk price and a lower Class I price. The demand curve facing the producers would shift from abc to a'b'c' in Figure 2. The impact on specific regions depends upon the region's Class I utilization percentage. For example, in Figure 2 a region with a very high utilization (supply  $S_3$ ) would be expected to become more deficit with lower Class I differentials. On the other extreme, lower Class I differentials may result in a higher all wholesale milk price for some regions with a very low utilization of total milk as fluid (supply  $S_1$  in Figure 2).

## RESULTS

An expected set of Class I differentials was developed for each of the three alternatives analyzed and the model solved for new equilibrium prices and quantities for the 1977 to 1985 period. The impact of each alternative was observed as a deviation from the forecasted prices and quantities.

The Class I differentials assumed when forecasting the prices and quantities for the continued policy and for each of the three alternative Class I pricing policies are shown in Table 1. The Class I differentials for the increased and decreased differential alternatives were selected somewhat arbitrarily and are included to show the impact of making rather minor changes in Class I pricing policy under federal orders. The Class I differentials that would be expected if classified pricing were dropped as a market order policy are also shown in Table 1.<sup>3/</sup>

Results are shown in Table 1 for only two of the 10 years for which the model was run--1977, the first year of the assumed policy change, and 1985, the last year of the forecast.<sup>4/</sup>

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<sup>3/</sup> For more discussion on why the difference between fluid milk prices paid by bottlers in the central fluid markets and the manufacturing milk prices paid by processors in the rural areas would not equal zero, see the report by the USDA's Economic Research Service, "The Economic Impact of Alternative Federal Milk Marketing Order Class I Price Structures." These Class I differentials primarily reflect the difference in milk prices f.o.b. at central city plants and milk prices f.o.b. country plants. The differential, in the longer run, would also reflect the price difference needed to provide the incentive for some Grade A producers to continue to produce fluid eligible (Grade A) milk.

<sup>4/</sup> This analysis assumes that the manufacturing milk price is at a market clearing level (above the price support). If the manufacturing milk price was at the price support level with the government purchasing dairy products, lowering the Class I and manufacturing price differential would not be expected to affect the manufacturing milk price. The full decrease in the differential would be reflected in lower Class I prices as the manufacturing milk price would remain unchanged. Lowering the Class I differential would tend to decrease the amount of dairy products the government would purchase under the price support program.

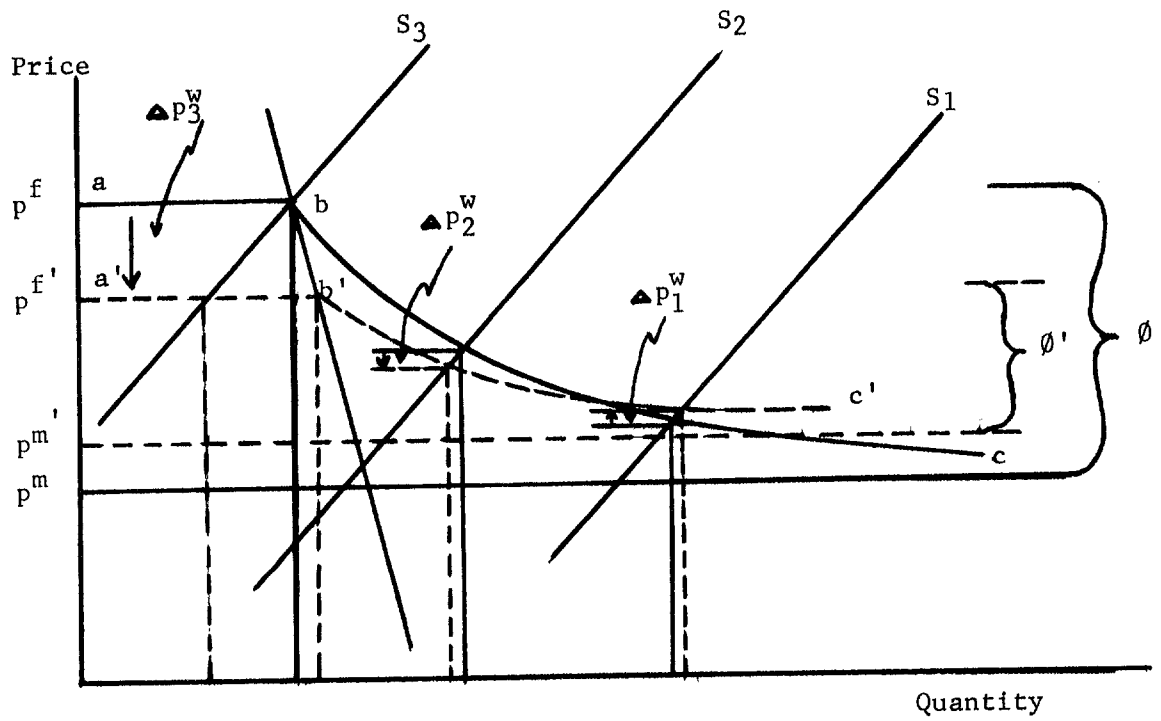


Figure 2. Three possible impacts on regional all wholesale milk prices of lower class I differentials in all U.S. regions.

Table 1. Estimated deviation of selected milk prices and quantities from those forecasted assuming a continued pricing policy caused by increasing, decreasing, or no minimum Class I differentials under federal milk marketing orders, 1977 and 1985.

	1977				1985			
	Fore- cast	Change from forecast			Fore- cast	Change from forecast		
		In- crease	De- crease	No mini- mum		In- crease	De- crease	No mini- mum
----- dollars per cwt. -----								
<u>Assumed Class I differential:</u>								
Northeast .....	2.95	0.45	-0.75	-2.45	2.95	0.45	-0.75	-2.20
Corn Belt .....	2.05	0.45	-0.75	-1.15	2.59	0.45	-0.75	-0.95
Lake States .....	1.60	0.45	-0.75	-1.20	1.60	0.45	-0.75	-0.95
Southeast .....	3.50	0.45	-0.75	-1.80	4.00	0.45	-0.75	-1.84
South Central .....	2.72	0.45	-0.75	-1.82	3.43	0.45	-0.75	-2.21
Plains .....	2.02	0.45	-0.75	-1.15	2.55	0.45	-0.75	-0.95
Mountain .....	2.53	0.45	-0.75	-2.03	2.53	0.45	-0.75	-1.78
Southwest .....	1.35	0.45	-0.75	-0.95	2.35	0.45	-0.75	-1.70
Northwest .....	2.17	0.45	-0.75	-1.77	2.17	0.45	-0.75	-1.52
<u>U.S. manufacturing milk price</u> .....								
	8.90	-0.11	0.18	0.43	11.91	-0.18	0.30	0.71
<u>All wholesale milk price:</u>								
Northeast .....	10.39	0.11	-0.19	-0.80	13.40	0.04	-0.06	-0.38
Corn Belt .....	9.58	0.05	-0.09	0.01	12.59	-0.04	0.08	0.42
Lake States .....	9.14	-0.03	0.06	0.24	12.15	-0.10	0.18	0.56
Southeast .....	11.64	0.21	-0.37	-0.95	14.65	0.06	-0.11	-0.38
South Central .....	10.61	0.16	-0.28	-0.73	13.62	0.02	-0.05	-0.35
Plains .....	9.39	0.04	-0.07	0.04	12.40	-0.05	0.09	0.43
Mountain .....	10.19	0.11	-0.20	-0.59	13.20	0.04	-0.07	-0.18
Southwest .....	9.94	0.16	-0.27	-0.37	12.95	0.01	-0.02	-0.04
Northwest .....	9.75	0.06	-0.10	-0.24	12.76	-0.01	0.02	0.13
----- millions of pounds -----								
<u>Milk production (continental U.S.):</u>								
Northeast .....	32,075	21	-36	-148	31,789	186	-317	-1,660
Corn Belt .....	19,704	6	-11	1	16,805	-27	48	559
Lake States .....	30,472	-7	11	48	31,294	-302	523	1,643
Southeast .....	5,640	12	-21	-55	6,285	126	-227	-660
South Central .....	10,189	14	-24	-64	9,608	110	-197	-743
Plains .....	5,303	1	-2	1	4,227	-12	20	155
Mountain .....	2,895	2	-3	-10	2,986	18	-31	-89
Southwest .....	13,174	16	-26	-37	16,256	126	-218	-190
Northwest .....	5,234	2	-4	-10	5,605	6	-8	27
Total U.S. ....	124,686	67	-116	-274	124,855	231	-407	-958
<u>U.S. fluid milk consumption</u> .....								
	55,202	-295	490	1,207	58,834	-194	319	755



Increasing Class I differentials in 1977 would result in a U.S. manufacturing milk price per 100 pounds about 11 cents lower than if a continued pricing policy was followed (Table 1). Producer prices would be higher in all regions except in the Lake States. Fluid consumption on a product pound basis would be about 300 million pounds lower, and total milk production would be about 67 million pounds higher. By 1985 the U.S. manufacturing milk price would be 18 cents lower than what it would have been under a continued pricing policy. By 1985 milk production would be about 231 million pounds more and fluid consumption 194 million pounds less than if a continued pricing policy had been followed (Table 1).

Lowering Class I differentials below those assumed under a continued pricing policy would have about the opposite effect as did raising the differentials (Table 1).

A no-minimum differentials alternative likely would result in a U.S. manufacturing milk price 43 cents higher in 1977 and 71 cents in 1985 than if a continued pricing policy was followed (Table 1). Producer prices would be higher in the Lake States, Corn Belt, and Plains regions. The Lake States producers would receive the greatest increase in prices--24 cents in 1977 and 56 cents in 1985. In 1977 the greatest decrease in producer prices would be 95 cents in the Southeast, 73 cents in the South Central, and 80 cents in the Northeast regions. By 1985 the difference between those prices forecasted under a continued pricing policy and the prices under the no-minimum differential alternative would only be about half the magnitude of those for 1977. By 1985 U.S. fluid consumption would be about 755 million pounds more and milk production about 960 million pounds less under the no-minimum differential alternative than under a continued pricing policy (Table 1).

## IMPLICATIONS

Increasing Class I differentials over the 1977 to 1985 period by the amount discussed above would result in fluid milk prices per half-gallon about 1.2 to 1.5 cents higher and cheese prices per pound about 1 to 1.7 cents lower than if a continued pricing policy was followed.

A no-minimum differential would result in fluid milk prices per half-gallon about 4.5 to 6 cents lower and cheese prices per pound about 4.4 to 7 cents higher than if under a continued pricing policy. This represents an upper estimate of the impact that classified pricing has on consumer prices.

Higher Class I differentials generally are of the greatest advantage to producers in the Northeast, Southeast, South Central, Southwest, and Mountain regions but to the disadvantage of producers in the Upper Midwest, especially Minnesota and Wisconsin. The opposite is true for the decreased and the no-minimum differential alternatives. Therefore, the decreased and no-minimum differential alternatives would reduce total U.S. milk production and tend to shift milk production towards the Upper Midwest. By 1985 milk production in the Lake States, Corn Belt, and Plains would be almost 2.5 billion pounds more with a no-minimum differential than if the continued pricing policy was followed. For the same period, milk production would be expected to be about 1.6 billion pounds less in the Northeast, 0.8 billion pounds less in the Southeast, and 0.7 billion pounds less in the South Central with a no-minimum differential than if the continued pricing policy was followed.