#8629

1990

Dairy industry and trade

SPATIAL DISTRIBUTION OF THE U.S. DAIRY INDUSTRY: LONG TERM IMPACTS OF POLICY CHANGE

by

Jork Sellschopp

and

Robert J. Kalter,

Cornell University

to be presented at the

1990 Joint AAEA/WAEA/CAEFMS/AERE Annual Meeting

August 4 - August 9, 1990

Vancouver, British Columbia

AAEA 1990

Jork Sellschopp received a Ph.D. in Agricultural Economics from Cornell University in 1989. He holds an M.B.A. from Columbia University and a B.S. in Sugar Technology from Louisiana State University. From 1963 to 1970, he worked in cane production and sugar manufacturing in Peru and, from 1973 to 1982, in the engineering of agro-industrial installations in Brazil. From 1986 to 1989 he participated in a research project about future directions for the upstate New York agricultural economy.

Robert J. Kalter is a professor in the Department of Agricultural Economics at Cornell University and was chairman of the department from 1985 to 1988. He received a Ph.D. in Economics from the University of Wisconsin, Madison, in 1966 and joined the Cornell faculty the same year. He holds an M.S. in Economics and a B.S. in Agricultural Economics, both from the University of Wisconsin, Madison. In 1972 and 1973, he was an analyst with the U.S. Department of the Interior, and from 1977 to 1979 he headed the Leasing Policy Development Office of the U.S. Department of Energy.

SPATIAL DISTRIBUTION OF THE U.S. DAIRY INDUSTRY:

LONG TERM IMPACTS OF POLICY CHANGE

Milk production in the U.S. is heavily concentrated in the Lake States, Northeast, Corn Belt, and Pacific States. Jointly, these four regions produce more than 75 percent of all milk, possess above 70 percent of all dairy cows, and contain above 65 percent of all dairy farms in the country. Economic policy, normally implying a distorted resource allocation and public expenditures in exchange for a higher degree of equity, presupposes an ongoing analysis of the economic effects of specific policy measures. As part of such ongoing endeavor, the potential long term responses of the dairy industry's spatial distribution to changes in current policy are to be examined.

BACKGROUND

The geographical framework used in the study consists of the ten USDA production regions.[1] The chief dairy policies in the U.S. are the price support program, through national support prices for American-type cheese, butter, and non-fat dried milk (NFDM), and the classified pricing of Grade A or fluid grade milk, through mandatory fluid price differentials, one for each of the country's approximately forty milk marketing orders (MMO).

The mechanisms through which changes in these policies act on the relative regional levels of dairying and, thus, on the spatial distribution of the industry can best be described in terms of a regional raw milk market. The diagram of such a market is shown in Figure 1. The demand curve is the horizontal aggregate of raw milk demands for fluid use, manufacturing use for consumption, and manufacturing use for program sales to the government. Its position, normalized for varying market size, is similar in all regions. Such similarity does not prevail, of course, in the case of regional supply curves, their location being a function of technology and factor costs.

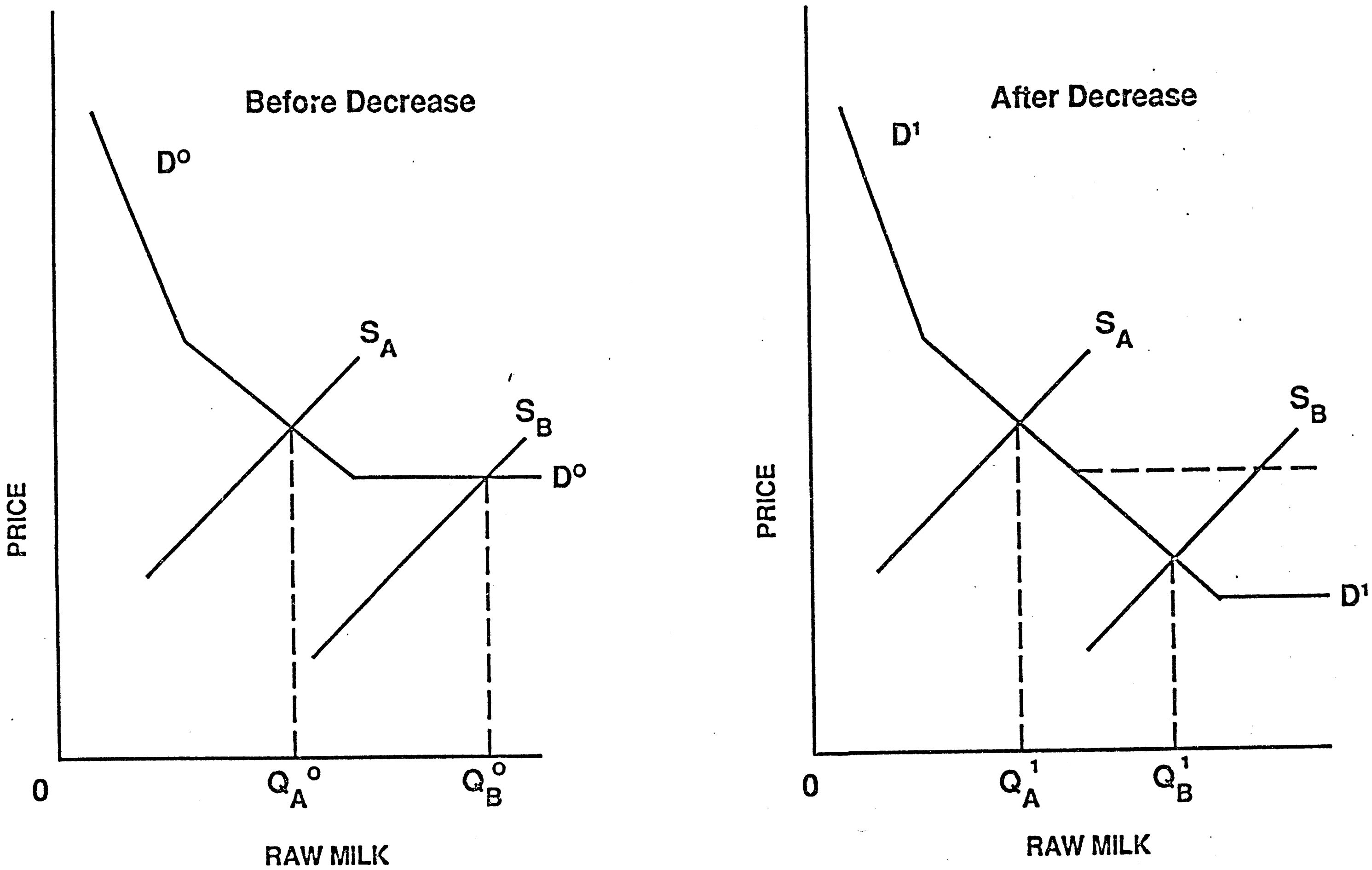


FIGURE 1. EFFECT OF A DECREASE IN PRICE SUPPORT ON THE REGIONAL VOLUME OF RAW MILK

The way in which a decrease of the manufacturing milk support price affects the equilibrium volume of raw milk, and thus the number of dairy cows, is also shown in Figure 1. The supply curve S_A belongs to a region with relatively high production costs. At Q_A^0, all milk goes to fluid use or to the manufacture of market-bound dairy products, no dairy products being sold to the government. S_B, on the other hand, belongs to a region with a relatively low production cost. At Q_B^0, some of the region's manufactured dairy products are sold to the government at current support prices. A change in the level of price support, from D^0 to D^1, will affect the volume of raw milk produced in region B but not in A. In region B, volume will decline with a reduction in price support until, at Q_B^1, equilibrium ceases to be bound by the horizontal part of the demand curve. If price support is reduced past this point, the horizontal part of demand is non-binding and will no longer influence the volume of raw milk produced. The magnitude of the decline from Q_B^0 to Q_B^1 depends on the elasticity of S_B. Supply elasticities are small in the short run but increase over time.

In the absence of a mandatory price differential, raw milk market equilibrium occurs where the supply and aggregate demand curves intersect. The respective fluid and manufacturing use volumes are indicated on the individual demand curves by the equilibrium price. For simplicity, demand in Figure 2 appears without the price support segment, while supply is shown as a completely inelastic market period supply. The differential "d" introduces a wedge between fluid and manufacturing milk prices. The higher fluid price P_F reduces fluid volume, thereby causing an increase in milk available for manufacturing use which, in turn, drives down manufacturing milk price P_M. Under classified pricing conditions, equilibrium exists at the intersection of supply and the average revenue curve AR_{F+M}, the resulting "blend price" P_B being above the undistorted equilibrium price P_E. Obviously, with a more elastic long term supply curve, the total raw milk volume will be increased as well.

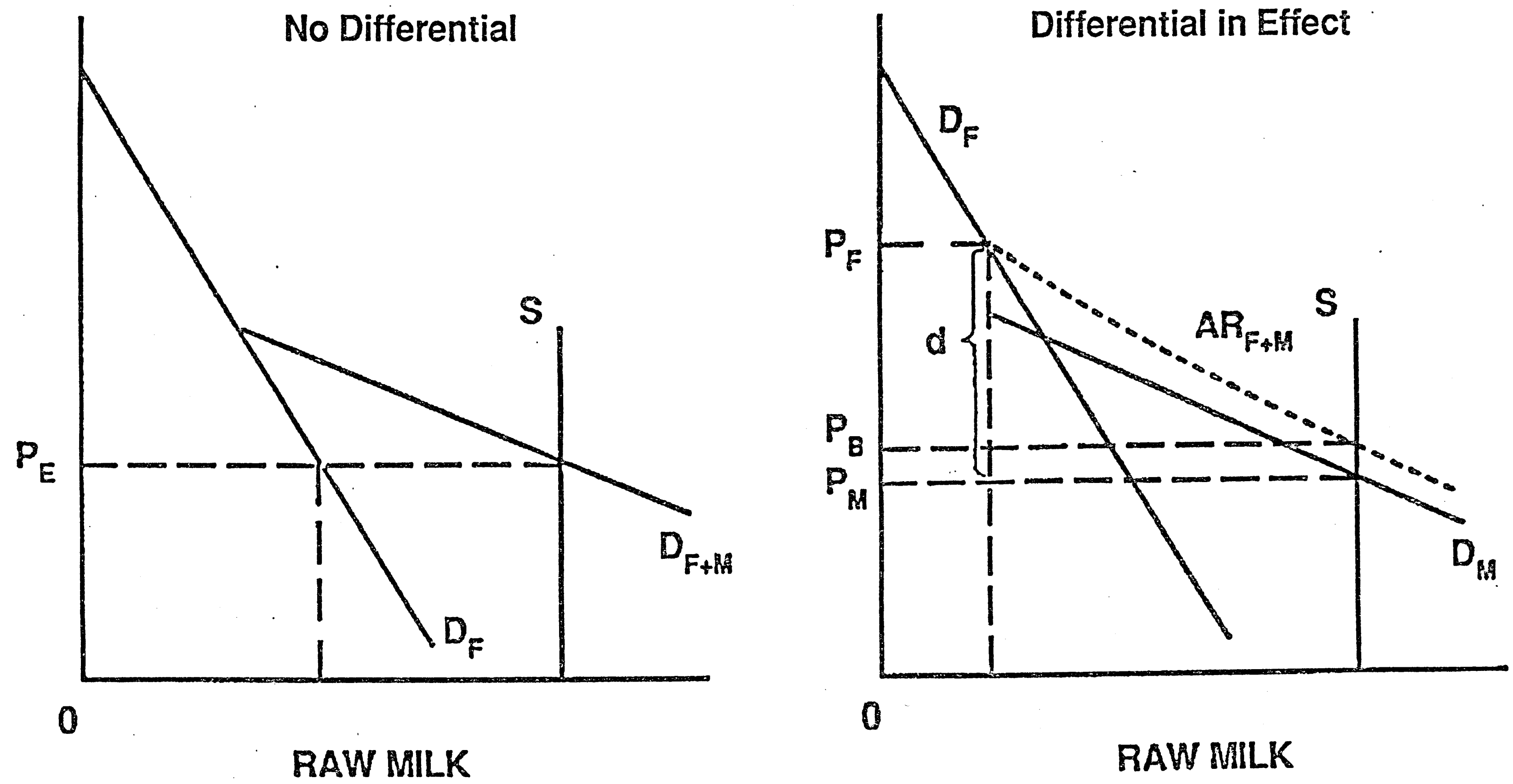


FIGURE 2. EFFECT OF A MANDATORY FLUID GRADE DIFFERENTIAL ON THE MARKET PERIOD PRICE OF RAW MILK

The present national structure of regional fluid price differentials is shaped somewhat like a funnel, the vortex being located in the state of Wisconsin. This structure was originally intended to stimulate fluid milk supply in all Milk Marketing Order areas East of the Rocky Mountains, while covering the cost of supplementing it from the Lake States, the supplier of last resort.

METHOD OF ANALYSIS

In order to obtain quantitative results elucidating the effect of these changes on the dairy industry distribution, AGTEC (Agricultural Sector Spatial Equilibrium Model for the Study of Technical Change), an existing price-endogenous spatial equilibrium model of the U.S. agricultural sector, was used (Sellschopp and Kalter). Its main characteristics are: (1) It defines the U.S. agricultural sector in terms of three principal production factors (cropland, pasture land, and labor) for each of the ten USDA production regions. (2) It maximizes consumers' and producers' surplus, with respect to 21 agricultural commodities, in ten regional domestic consumption markets, as well as in markets for export and commercial stocks. (3) Linear regional factor supply and final commodity demand functions are explicitly specified. (4) Factor demand and commodity supply functions are specified implicitly by technical coefficients and cost figures of alternative activities. Of these, there are 314 in primary production, 340 in secondary production, and 1,918 in interregional transportation. (5) All factor and final commodity markets are assumed to function at perfectly competitive conditions. An immediate attainment of long term equilibrium is assumed.

AGTEC is formulated in the General Algebraic Modeling System (GAMS) and can be solved by the Modular In-core Non-linear Optimization System (MINOS) algorithm. It consists of approximately 900 equations and 3000 variables.[2] The Kuhn-Tucker conditions are found to imply the existence of competitive economic equilibrium throughout. For reasons of parameter availability, 1982 was chosen as the base year of the model. The source of most of the technical coefficients is the Firm Enterprise Data System (USDA 1982), while the majority of right-hand-side values are taken from other official statistics (USDA 1983). Price elasticities are taken from House, and all interregional transportation costs from Hickenbotham. Reasonably close approximations of observed base year quantities and prices were obtained at base year parameter values.

Into this model, the mechanisms linking dairy policy to the long term equilibrium of regional raw milk markets were incorporated. For the price support program, the translation of policy changes into model parameter specifications was simple. Support prices of the included products entered AGTEC as constant objective function coefficients. Since those prices are all tied to a stipulated manufacturing milk support price, only the latter needs to be specified.[3] This was done at various levels, down to where price support no longer is binding.

For the fluid differentials, a conversion of existing MMO differentials into a set of production region equivalents was required. These regional differentials were modeled in AGTEC through adjustment of the exogenous prices of fluid use and manufacturing use milk, two intermediate commodities that intervene in the setting of dairy processing activity costs.[4] Differentials were specified jointly for all regions, either at base year levels or at zero. The one exception to this is a situation in which the entire nation constitutes a single marketing order (SMO), to which one average fluid differential was assigned.

RESULTS AND DISCUSSION

Model results detailing national and regional dairy cow numbers for nine different dairy policy scenarios are listed in Table 1. For each such scenario, AGTEC selected the factor supply, and commodity production, processing, transportation and demand activities, as well as their activity levels, to maximize consumers' plus producers' surplus.

Table 1. Policy Parameters and the Number of Dairy Cows.

Scenario	Base Year Differentials	Mfg. Milk Support Price	Dairy Cows by Region, Millions										
			NE	LS	CB	NP	AP	SE	DL	SP	MN	PA	Total
1	Yes[a]	13.10[a]	2.265	3.370	1.201	.154	.604	.650	.297	.497	.735	1.227	11.000
2	Yes	13.20	2.324	3.593	1.267	.154	.604	.650	.297	.497	3.183	1.731	14.300
3	Yes	13.05	2.220	2.993	1.078	.154	.604	.650	.297	.497	.615	1.071	10.179
4	Yes	13.00	2.199	2.764	.996	.154	.604	.650	.297	.497	.615	1.071	9.847
5	Yes	12.50	2.197	2.743	.989	.154	.604	.650	.297	.497	.613	1.069	9.813
6	Yes	11.90	2.195	2.709	.989	.154	.604	.650	.297	.497	.611	1.067	9.773
7	SMO[b]	13.10	2.181	4.018	2.195	.154	.604	.650	.297	.497	.957	1.896	13.451
8	SMO[b]	12.50	1.857	3.100	1.193	.154	.604	.652	.298	.497	.460	1.071	9.886
9	No	13.10	1.770	3.418	.970	.155	.608	.654	.299	.500	.346	1.064	9.785

a Base year conditions. b Single marketing order assumption.

With respect to the manufacturing milk support price, its increase causes the total number of dairy cows to rise (Scenario 2) while its decrease causes them to decline (Scenarios 3 and 4). The same response occurs in the Northeast, Lake States, Corn Belt, Mountain States, and Pacific States while, in the remaining regions, cow numbers do not change at all. Below a certain level, there is no response to further support price decreases in any of the regions (Scenarios 5 and 6).

The regions showing a response are those which have a relatively low production cost and where, at base year conditions, program sales are taking place. The ones showing no response are those which, at base year conditions, are producing fluid milk only. This indicates that cow numbers are affected by changes in support price only in regions where the latter is binding. That is exactly what can be expected in terms of Figure 1. It is simple to identify the effect of such regional responses on the national dairy industry distribution.

With respect to the fluid price differentials, their removal causes the total number of cows to decline and their distribution to change (Scenario 9). The new total of cows indicates that the base year support price has become non-binding, thus revealing the existence of a price support effect of the removed differentials. The same total's changed distribution, on the other hand, reveals the existence of a direct distribution effect.

In order to identify such direct distribution effect, one must compare the results of Scenario 9 with those of Scenario 6. In Scenario 9, price support is not binding and there are no fluid differentials to produce a distribution effect. In Scenario 6, differentials are in place while price support, through manufacturing milk support price or fluid differentials, is not binding either. Any difference in distribution, therefore, is due to the direct distribution effect of the differentials. In order to identify the differentials' price support effect, one must compare the results of Scenarios 9 and 7. In Scenario 9, there are no fluid differentials to produce any direct distribution effect, but the base year manufacturing milk support price is in place. In Scenario 7, base year support price also is in place, and so are fluid differentials. The base year differentials' direct distribution effect, however, has been neutralized by making all differentials equal to the one of the single marketing order. Any difference in distribution, therefore, is due to the differentials' price support effect.

SUMMARY AND CONCLUSIONS

The support price of manufacturing milk acts on the spatial industry distribution solely through its effect on the government purchase component of regional raw milk demand. Fluid differentials, though, act through their relative regional size as well as through the absolute size of their national average. The first of these actions produces the previously identified direct distribution effect, and the second the price support effect. The latter, actually, is compounding the price support effect of the manufacturing milk support price. If the scenarios listed in Table 1 are classified by the level of these effects rather than by individual policy parameters, the impacts of policy change on the dairy industry distribution can be illustrated by just four scenarios. They are listed in Table 2 as a two-dimensional layout of the fluid differentials direct distribution effect and the compounded price support effect (Scenarios 2, 6, 7, and 9). The base year conditions are listed as reference (Scenario 1).

The first two-effect combination consists of the differentials' direct distribution effect and a level of price support, binding above base year conditions. It is obtained by simply raising the base year manufacturing milk support price. To obtain the second combination, differentials' distribution effect and non-binding price support, it is enough to phase out the manufacturing milk support price, since, by itself, the price support effect of the differentials is insufficient to

Table 2. Impact of Policy Effects on the Distribution of the U.S. Dairy Industry.

Scenario	Base Year Differentials	Mfg. Milk Support Price	Direct Distrib. Effect	Price Support Level	Dairy Cows by Region, Percent					
					NE	LS	CB	MN	PA	Others
1	Yes[a]	13.10[a]	Yes	Binding	20.60	30.64	10.92	6.68	11.14	20.02
2	Yes	13.20	Yes	Binding	16.25	25.13	8.86	22.26	12.10	15.41
6	Yes	11.90	Yes	Non-Bdg	22.46	27.72	10.12	6.25	10.92	22.54
7	SMO[b]	13.10	No	Binding	16.21	29.87	16.32	7.11	14.10	16.37
9	No	13.10	No	Non-Bdg	18.09	34.93	9.92	3.53	10.88	22.65

a Base year conditions.

b Single marketing order assumption.

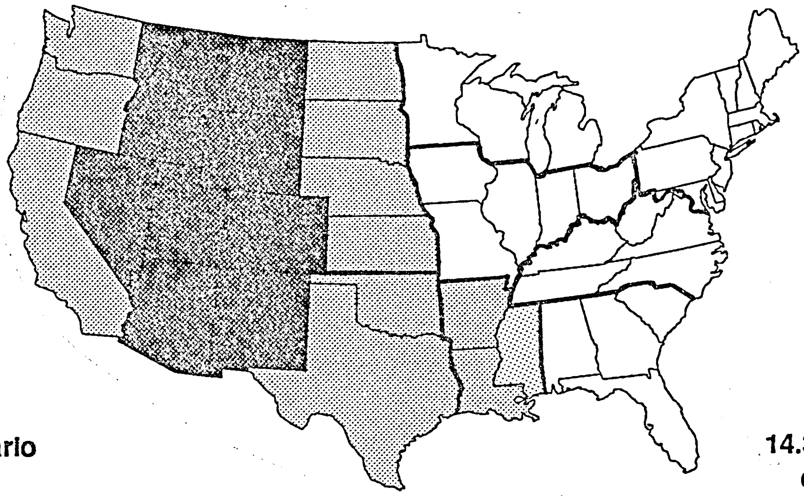
keep price support at a binding level. To change the second combination into the third, binding price support level without any direct distribution effect of the differentials, all base year differentials are substituted by the one for the SMO situtation. The fourth and final combination, no direct distribution effect and a non-binding level of price support, is achieved by removing all fluid differentials while the manufacturing milk support price remains at its base year level. Without the differentials' price support effect, the base year manufacturing milk support price is unable to sustain price support at a binding level. The spatial impacts of these four combinations appear in Figure 3.

An increase in price support, such as occurs in Scenario 2, will cause the dairy industry to gravitate towards the West. Intuitively, this makes sense since the western regions are likely to benefit from their absolute advantage in production costs, without their additional output having to compete in distant domestic consumption markets. This scenario does imply a substantial increase in public expenditure.

A decrease in price support, such as occurs in Scenario 6, will shift the industry towards the East. This also appears logical since, with less government purchases, an advantage will be held by the regions located closest to the main centers of consumption. This advantage will be reinforced for regions in which MMO fluid use differentials are large, such as the Northeast.

In Scenario 7, the direct distribution effect of base year fluid differentials is eliminated, with price support effects of the differentials and the manufacturing milk support price remaining in place. This will tend to concentrate the industry in the Midwest, as one would expect in view of the national structure of the differentials. At the same time, a binding level of price support is likely to lead to an expansion of the industry in the West, such as occurs in Scenario 2.

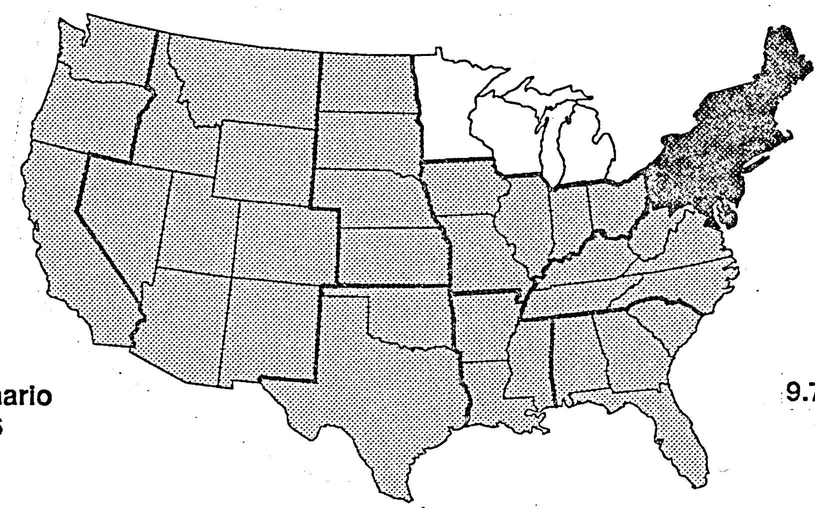
Finally, in Scenario 9, both the fluid differentials' direct distribution effect and any price support effect, produced by either



Scenario 2

14.300 Mill. cows

Raw Milk Price Support - Binding, Above Base Year Level
Distribution Effect of Base Year Differentials - Yes



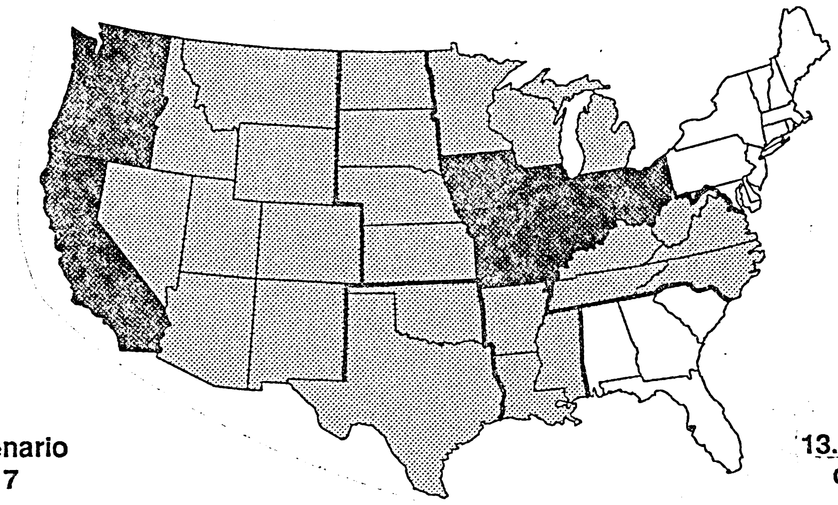
Scenario 6

9.773 Mill. cows

Raw Milk Price Support - Non-Binding
Distribution Effect of Base Year Differentials - Yes

FIGURE 3. RESPONSE OF THE U.S. DAIRY INDUSTRY DISTRIBUTION TO POLICY EFFECTS

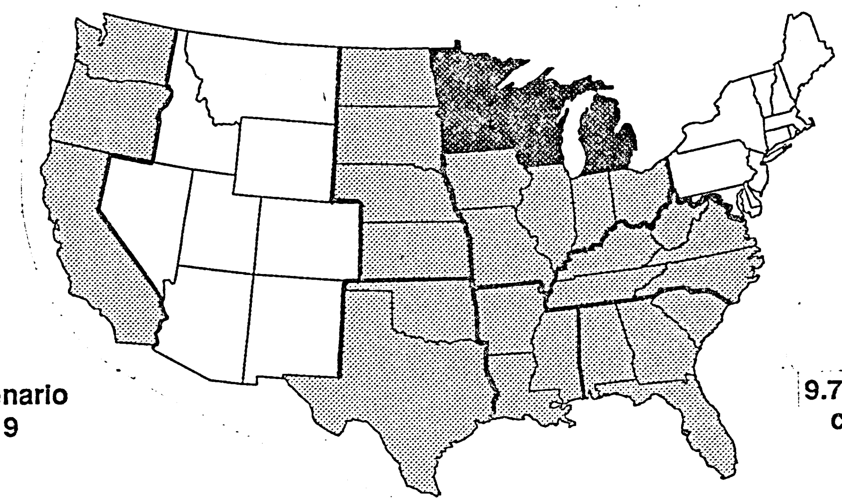
- Increase greater than 1% of total number of cows
- Change less than 1% of total number either way
- Decrease greater than 1% of total number of cows



Scenario 7

13.451 Mill. cows

Raw Milk Price Support - Binding At Base Year Level
Distribution Effect of Base Year Differentials - No



Scenario 9

9.785 Mill. cows

Raw Milk Price Support - Non-Binding
Distribution Effect of Base Year Differentials - No

FIGURE 3. (Continued)

- Increase greater than 1% of total number of cows
- Change less than 1% of total number either way
- Decrease greater than 1% of total number of cows

fluid price differentials or the manufacturing milk support price, are eliminated. This will cause the industry to concentrate in the Midwest, especially in the Lake States region. Producers there, having the lowest fluid differentials and also the lowest fluid use fraction, will be hurt least by a phasing out of classified pricing and will be able to survive best without any manufacturing milk support price. Their comparative advantage will improve with respect to the previous scenarios.

It can be concluded, then, that any change in the analyzed dairy policy parameters is liable to affect the long term spatial distribution of the industry. The sensitivity of this distribution to policy changes is shown by the fact that a set of four combinations of plausible policy changes is causing geographical shifts in completely different directions. As the leverage of policy effects increases with rising productivity, policy decisions will need to be analyzed ever more carefully.

1. The regions are: Northeast (NE), Lake States (LS), Corn Belt (CB), Northern Plains (NP), Appalachia (AP), Southeast (SE), Delta States (DL), Southern Plains (SP), Mountain States (MN), Pacific States (PA).

2. The GAMS formulation of AGTEC may be requested from the authors.

3. The prices paid for dairy commodities by the government are derived by the following formulas:

$$PP_{cc} = (SP_{mm} + MA_{cc} - WV) / PY_{cc}$$
$$PP_{bt} = (SP_{mm} + MA_{bt})\ BF / PY_{bt}$$
$$PP_{dm} = (SP_{mm} + MA_{bt})\ (1 - BF) / PY_{dm}$$

where mm = Manufacturing Milk
cc = Cheddar Cheese
bt = Butter
dm = Non-Fat Dried Milk (NFDM)
PP = Government Purchase Price, c/lb
SP = Policy Determined Support Price, $/cwt
MA = Make Allowance, $/cwt of Class II Milk
WV = Whey Value, $/cwt of Class II Milk
PY = Product Yield, lbs/lb of Class II Milk
BF = Butter Fraction of Butter + Powder Revenue

The make allowances used are those in effect during the base year. Revenue fractions of butter and NFDM in the butter-and-powder activity output were calculated at base year quantities and prices.

4. The raw milk market equilibrium price (P_E) after fluid differential removal was calculated as follows:

$$P_E = P_M + d(e_F/e_M)$$

where P_M = Manufacturing milk price before differentials removal
d = Fluid price differential
e_F = Fluid milk elasticity of demand
e_M = Manufacturing milk elasticity of demand

REFERENCES

Hickenbotham, T. L. "Vegetable Oil as a Diesel Fuel Alternative: An Investigation of Selected Impacts in the U.S. Agricultural Sector". Unpublished Dissertation, University of Minnesota, 1987.

House, R. M. "USMP Regional Agricultural Programming Model: Theoretical and Data Description," Manuscript. Economic Research Service, U.S. Department of Agriculture, 1985.

Sellschopp, J. and R. J. Kalter. Bovine Somatotropin: Its Impacts on the Spatial Distribution of the U.S. Dairy Industry. A. E. Research 89-14, Department of Agricultural Economics, Cornell University, September 1989.

U.S. Department of Agriculture, Economic Research Service. "Firm Enterprise Data System (FEDS), Crop and Livestock Enterprise Research Budgets." Unpublished Data Files, 1979-82.

________ Agricultural Statistics 1983. U.S. Government Printing Office, Washington, DC, 1983.