Impacts of the Northeast Interstate Dairy Compact on New England Milk Supply

Charles F. Nicholson, Budy Resosudarmo, and Rick Wackernagel

Department of Community Development and Applied Economics
The University of Vermont

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Background

During the first year of the Northeast Interstate Dairy Compact, milk production in the six New England states increased by about 57 million pounds, or about 1.3% of production compared to the 12 months prior to the Compact. Increases in milk production were largest in Connecticut (31 million pounds) and Vermont (21 million pounds), whereas Maine and New Hampshire experienced increases of less than 10 million pounds. Production in Massachusetts and Rhode Island declined by 9 million and 0.4 million pounds, respectively. Because the rate of increase for New England was larger than the US average, the Compact Commission incurred obligations to the CCC for purchases of dairy products.

The increase in milk production in New England has led some observers to attribute the increase to the Compact. However, few formal studies to date have explored the role of factors other than the Compact that also may have affected New England milk supply. The principal effects of the Compact that are likely to influence milk production include higher milk prices (or the expectation of higher prices), and the potential for lower price-related risk. Due to falling grain prices and higher milk prices, the milk-feed price ratio increased continuously starting in the quarter before initiation of the Compact. The variance of the milk-feed price ratio in previous periods is an indicator of price risk. Price risk is likely to have the effect of decreasing milk production (Dillon, 1977). The variance of the milk-feed price ratio increased during the first year of the Compact relative to the same period a year earlier, so that changes in price risk may not have contributed to an increase in milk production. Factors other than the prices and risk that may have influenced milk production include favorable weather conditions and higher hay prices in the New England states.

Thus, the objective of this study is to examine the impact of the Compact on milk production in the six New England states. An adequate study of the Compact's impacts needs to control for factors other than prices and risk that may have changed since the Compact came into existence.

Methods

The analysis herein relies on a two-equation 'random coefficients' model to predict the relationship between milk production and price levels controlling for other factors. A random coefficient model allows the impact of prices (and other factors) to differ for each of the six states. This is desirable given the differences in farm characteristics and market proximity among the New England states.

The underlying theory supporting the variables considered for inclusion in the random coefficients model can be found in Dillion (1977). The variables used in most previous studies of milk supply response include the price of milk relative to other prices (usually input prices), risk measures, time trends, seasonal dummy variables and lagged values of cow numbers and milk per cow (Dixon et al.,1991; Chavas et al., 1990). The random coefficients model developed for this study uses more explicit representations of biological factors underlying seasonal variation in milk per cow and cow numbers by including summer rainfall and temperature deviation variables rather than seasonal dummies.

The random coefficients model (Swamy, 1974) is specified as:

$$
\begin{aligned}
& y_i = X_i b_i + e_i \text{ , i} = 1,...,\text{N groups (states)} \\
& \mathrm{E}[e_{\mathrm{i}}] = 0, \\
& Var[e_{\mathrm{i}}] = s^{2} I, \\
& b_i = b + v_i, \\
& E[v_i] = 0 \\
& Var[v_i] = \Gamma
\end{aligned}
$$

Where y_i is a dependent variable, X_i is a matrix of independent variables, b_i is a vector of coefficients relating y_i and X_{i} for each i=*1,…,N* group, b is a constant, e_i and v_i are error terms, *E[ ]* indicates the expected value operator, *Var[ ]* indicates the variance-covariance matrix, σ^2 is a constant, and *G* is a matrix. This model allows the relationship between y_i and X_i to vary for each group (states in this case).

The model estimated herein contains two equations, one for cow numbers and the other for milk per cow. The relationship between these variables and the independent variables is specified as follows:

$$MPC_{st}^{C} = \exp\{b_{s0} + b_{s1} \cdot Ln(MPC_{s,t-1}^{C}) + b_{s2} \cdot Ln(PMF_{s,t-1}^{C}) + b_{s3} \cdot Ln(TEMPDEV_{st}) + e_{st}\}$$

$$CN_{st}^{C} = \exp\{a_{s0} + a_{s1} \cdot Ln(CN_{s,t-1}^{C}) + a_{s2} \cdot Ln(PMF_{s,t-1}^{C}) + a_{s3} \cdot Ln(SRAIN_{st}) + a_{s4} \cdot Ln(SRAIN_{st})^2 + x_{st}\}$$

Where MPC_{st} is milk per cow in state *s* during quarter *t* and the superscript ^{C} indicates this is the actual value with the Compact, $PMF_{s,t-1}$ is the milk-feed price ratio during quarter *t-1*, $TEMPDEV_t$ is the squared deviation from a temperature of 50 degrees F during quarter *t*, CN_{st} is the number of milk cows in state *s* during quarter *t* and the superscript ^{C} indicates this is the actual value with the Compact, $SRAIN_{st}$ is inches of summer rainfall, and e and x are error terms.

One equation in the model estimates the relationship between cow numbers and factors such as prices, and the other equation estimates the relationship between milk per cow and factors such as prices. Cow numbers and milk per cow predicted by the equations are multiplied to obtain an estimate of milk production. This model is similar to that used by Dixon et al. (1991) to examine the impacts of dairy policy changes in the mid-1980s. Because in any given quarter milk production and milk prices are simultaneously determined, the model uses values of relative prices in a previous period (in this case, the previous quarter) rather than the relative prices in the current period. In addition, the values of the lagged relative prices were transformed to natural logarithms prior to model estimation, as in Dixon et al. (1991).

Once an empirical relationship between factors such as relative prices and cow numbers or milk per cow has been determined, the model can be used to estimate the impacts of the Compact on milk supply. To do this, an estimate of the prices that would have occurred had the Compact not existed must be developed. These price estimates are used with the coefficients from the random coefficients model to predict milk production that would have occurred in the absence of the Compact. The difference between milk production under the actual prices and the predicted milk production under 'non-Compact' prices provides an estimate of the impact of the Compact on milk production.

A number of different methods could be used to estimate prices that would have prevailed in the absence of the Compact. For the analyses reported in the next section, we developed two independent estimates of the milk prices that would have prevailed without the Compact. For New England, state all-milk prices are calculated as the sum of the Zone 21 Order 1 blend price, butterfat premiums based on butterfat differentials and mean butter fat tests, handler over-order premiums from a survey of handlers in each state, state-mandated payments (currently applicable only in Maine) and the Compact over-order premium[1] (Sharon Slayton, NASS, personal communication). Using this calculation as a base, one estimate of the prices that would have prevailed without the Compact is the state all-milk price less the over-order premiums paid to farmers by the Compact Commission. This estimate ignores effects that the Compact may have on the Order 1 blend price (the principal component of the state all-milk price in New England) and any interactions that may have occurred between Compact-mandated over-order premiums and voluntary premiums paid by milk handlers.

The second estimate of the state all-milk price in absence of the Compact is the sum of an estimated 'non-Compact' blend price, applicable butterfat premiums, and an estimated 'non-Compact' handler premium. The estimated 'non-Compact' blend prices use an adjustment to actual blend prices based on class utilization by quarter for the Compact period and the previous six years. These estimated non-Compact blend prices are $.05 to $.06 higher than the actual blend prices. The estimated 'non-Compact' handler premiums are calculated as the mean handler premiums by quarter during the three years prior to the implementation of the Compact. For the purpose of this calculation, handler premiums were estimated using as the state all-milk price less the Zone 21 blend price, butterfat premiums, and the Compact over-order premium. In states other than Maine, estimated handler premiums were about the same or somewhat higher

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[1] This sum is rounded to the nearest $0.10 to reflect differences arising from milk receipts at

as in the period prior to implementation of the Compact. For Maine, handler over-order premiums calculated in this way were sometimes negative—an unlikely value—and efforts to discuss the result with NASS staff to determine the source of the discrepancy have not yet been successful. Thus, no price estimate based on this method is reported for Maine. Because the second estimate attributes all changes from mean levels of previous years to the Compact, it is thus likely to overestimate the impacts of the Compact on these components of the state all-milk price[2].

Results

The variables included in the random coefficients model of cow numbers include cow numbers in the previous quarter, the milk-feed price ratio in the previous quarter, the milk-land price ratio for two quarters previous, summer rainfall, and summer rainfall squared (Table 1). Although this model contains relatively few variables, it has high explanatory power, theoretically consistent signs, and statistically significant model coefficients. All variables have a positive impact on milk production with the exception of the square of summer rainfall, which indicates, essentially, that too much rain can lower summer forage production. The low probability value for the χ^2 indicates that the coefficients are statistically different for the six states.

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different zones for each state.

[2] For some states, the Compact is estimated to affect the blend price and handler premiums in opposite directions. Thus, the prices under this method may not represent an overestimate of the Compact's impact on prices because the effects offset one another to an uncertain extent.

Table 1. Results of Random Coefficients Models of Cow Numbers and Milk Per Cow, Aggregated Estimates[1]

Independent Variable	Dependent variable	
	Cow numbers	Milk per cow
Cow numbers in previous quarter	+0.83	--
	(20.89)	
Milk per cow in previous quarter	--	+0.86
		(19.17)
Milk-feed price ratio in previous quarter	+0.07	+0.08
	(1.89)	(2.41)
Milk-land price ratio 2 quarters previous	+0.02	--
	(1.20)	
Summer rainfall	+0.48	--
	(3.42)	
Square of summer rainfall	-0.09	--
	(-3.18)	
Squared deviation from 50 degrees F	--	-0.004
		(-1.83)
Constant	--	1.10
		(2.93)
Model Evaluation Characteristics		
Adjusted R^2	.97	.74
Number of observations	240	240
Number of groups	6	6
Residual standard deviation	0.22	.03
χ^2 for test of homogeneity of state coefficients	74.23	13.84
Probability value for χ^2	.000	.838

[1] Aggregated estimates indicate responsiveness for the region as a whole, whereas state-level coefficients (not reported) indicate differences in responsiveness among states.

Note: All variables expressed in natural logarithms.

Note: t-statistics in parenthesis below coefficient values.

A different set of variables is included in the equation for milk per cow (Table 1). In this model, milk per cow in the previous quarter, the milk-feed price ratio in the previous quarter, the deviation from temperature away from 50 degrees F, and a constant are all statistically significantly different from zero and have theoretically consistent signs. The explanatory power of the milk per cow equation is lower than that for cow numbers, but is still good for models of this type. In contrast to the cow numbers equation, the χ^2 test provides evidence that the relationship between the included variables and milk per cow does not differ by state. Although important in theory, the variance of milk-feed price ratios (i.e., risk variables) were not included in the final models because they were statistically insignificant. Thus, risk (as measured by past price variance) appears to have relatively little impact on cow numbers or milk per cow.

Estimates of Non-Compact Prices

Milk prices in the absence of the Compact are predicted to be lower in most cases than actual prices. For most states and for most quarters, the price estimated by subtracting the Compact over-order premium from the state all-milk price (subsequently referred to as estimate 1) is higher than the estimated price based on an estimate of the 'non-Compact' blend price, the butter premium, and estimated 'non-Compact' handler premiums (subsequently referred to as estimate 2). The estimated influence of the Compact on state all-milk prices is given by the difference between actual prices and the two estimated prices. Price estimate 1 is closer to the actual prices during the Compact period for most states and quarters, so the estimated aggregate impact of the Compact on all-milk prices is slightly smaller than that predicted by estimate 2 prices.

In addition, because of variations in the underlying blend prices during the Compact period—and therefore changes in the amount of the Compact over-order premium—the difference between the actual prices and price estimates is smaller later in the Compact period. In Vermont, for example, the difference between actual and estimated prices was more than $1.00 in the third quarter of 1997, but narrows to about $0.20 in the first quarter of 1998. Thus, the impact of the Compact on milk prices, and therefore milk production, is likely to be larger earlier in the Compact period.

Estimates of Cow Numbers and Milk Per Cow

The increase in milk prices under the Compact is estimated to have increased the number cows on farms in New England compared to cow numbers that would have been observed without the Compact (Table 2). The impact of the Compact on total number of animals is small, about 700—0.2% of actual cow numbers—and is concentrated in Massachusetts and New Hampshire. Connecticut and Maine are estimated to have retained about 100 more cows than they would have without the Compact, and Rhode Island and Vermont are estimated to have essentially no change in cow numbers as a result of the Compact.

As expected, higher milk prices under the Compact are estimated to have increased milk per cow in all six New England States (Table 2). The estimated increases range from about 20 pounds per cow per quarter in Rhode Island to just under 50 pounds per cow per quarter in Connecticut. The percentage increase over the milk per cow that would have been expected in the absence of the Compact range from 0.4% in Rhode Island to 1.2% in Connecticut. Milk per cow is estimated to have increased 0.7% for the New England region due to the increase in milk prices under the Compact. Because these percentage increases are higher than those for cow numbers, more of the increase in total milk production is attributable to changes in milk per cow than cow numbers.

Table 2. Estimated Impact of the Compact on Cow Numbers and Milk Per Cow, by State

Variable, State	Actual	Price Estimate 1[1]	Price Estimate 2[2]	Difference Actual-Estimate 1	Difference Actual-Estimate 2
Cow Numbers, 000 [3]					
Connecticut	29.8	29.6	29.6	0.1	0.1
Maine	39.5	39.4	[4]	0.1	[4]
Massachusetts	25.3	25.1	25.1	0.2	0.2
New Hampshire	18.3	18.0	18.0	0.2	0.2
Rhode Island	2.0	2.0	2.0	0.0	0.0
Vermont	157.8	157.8	157.8	0.0	0.0
Total, All States	272.5	271.9	[4]	0.6	[4]
Total, States excluding Maine	233.2	232.5	232.5	0.7	0.7
Milk Per Cow[5]					
Connecticut	4,397	4,351	4,350	46	47
Maine	4,189	4,166	[4]	22	[4]
Massachusetts	4,218	4,195	4,192	23	26
New Hampshire	4,482	4,457	4,456	26	26
Rhode Island	3,938	3,919	3,918	18	20
Vermont	4,131	4,097	4,094	34	38
Weighted Average, All States	4,202	4,166	[4]	36	[4]
Weighted Average, States excluding Maine	4,200	4,166	4,164	34	37

[1] Price estimate 1 equals the state-all-milk price minus the Compact over-order premium.
[2] Price estimate 2 equals the sum of an estimated'non-Compact' blend price, butterfat premiums, and an estimated 'non-Compact' handler premium.
[3] Mean value of actual and estimated cow numbers for each state during 1997:3 to 1998:2.
[4] Not reported because no price estimate 2 was made for Maine.
[5] Mean value of actual and estimated milk per cow for each state during 1997:3 to 1998:2.

Estimates of Milk Production

Using the coefficients from the random coefficients models for cow numbers and milk per cow and prices estimated in the absence of the Compact allows estimates of milk production by state. The difference between the estimated values and actual milk production provides an estimate of the impact of the Compact on milk production for each of the six New England states. The total increase in milk production for the six New England states attributed to increased milk prices under the Compact is 45 million pounds under price estimate 1, and 43 million pounds for the states other than Maine under price estimate 2 (Table 3). These amounts represent increases of 1.0% over the milk production predicted in the absence of the Compact. To put these increases into perspective, it is helpful to compare them to the total increase in milk production during the Compact period compared to the previous year. The increase in production using estimate 1 equals 79% of the increase in milk production from the previous year, and the increase in production using price estimate 2 for the 5 states other than Maine equals about 90% of the increase in milk production from the previous year.

Table 3. Estimated Impact of the Compact on Milk Production, by State, 1997:3 to 1998:2

State	Milk Production, million pounds			Difference	
	Actual	Price Estimate 1[1]	Price Estimate 2[2]	Actual-Estimate 1	Actual-Estimate 2
Connecticut	523.0	515.6	515.4	7.4	7.6
Maine	662.0	656.8	[3]	5.2	[3]
Massachusetts	426.0	421.0	420.5	5.0	5.5
New Hampshire	327.0	321.4	321.3	5.6	5.7
Rhode Island	31.5	30.9	30.8	0.6	0.7
Vermont	2,607.0	2,585.7	2,583.5	21.3	23.5
Total, All States	4,576.5	4,531.4	[3]	45.1	[3]
Total, States excluding Maine	3,914.5	3,874.6	3,871.5	39.9	43.0

[1] Price estimate 1 equals the state-all-milk price minus the Compact over-order premium.
[2] Price estimate 2 equals the sum of an estimated'non-Compact' blend price, butterfat premiums, and an estimated 'non-Compact' handler premium.
[3] Not reported because no price estimate 2 was made for Maine.

The impact of the price increases on milk production varies by state. The largest increase in milk production occurs in Vermont, but New Hampshire and Rhode Island experience the largest percentage increases due to the Compact (Table 3). The proportion of the change in milk production from the previous year also differs by state. In Vermont, the increase in milk production from 1996-97 accounted for by the increase in prices under the Compact accounted for 101 to 113% of the increase of 21 million pounds from 1996-97 to 1997-98. That is, our results suggest that milk production in Vermont would have declined somewhat in 1997-98 if milk prices had been at the levels estimated without the Compact. For New Hampshire, the increase in milk production due to the Compact was nearly equal to the increase from 1996-97 to 1997-98. In the other states, the proportion of the increase accounted for by increased prices under the Compact tends to be lower. In Connecticut and Maine, price increases under the Compact are estimated to have contributed between one-quarter and a bit above one-half of milk production increases compared to the year before the Compact.

Our analysis thus predicts the unsurprising result that price enhancement under the Compact has increased milk production. However, given the ongoing debates in political arenas about the impacts and desirability of the formation of Compacts, empirical evidence about the impacts on milk supply can contribute to more informed decisions by policy makers and producer groups. In addition, the evidence suggests that most of the changes in milk production in the six New England states during 1997 and 1998 were the result of Compact-related price enhancement, rather than underlying biological factors. This also contributes useful information to the debate about future directions for US dairy policy.

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