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

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A two-equation random coefficients model and two estimates of milk prices in the absence of the Northeast Interstate Dairy Compact (Compact) are used to estimate the impact of minimum price regulation for fluid milk products on milk production in the New England states. Estimated responses to price enhancement differed by state for cow numbers, but parameters for milk per cow were not significantly different among states. The amount of increase in milk production attributed to the Compact is estimated at 45 million pounds (about 1% of production) during the first year of minimum price regulation, primarily due to increased milk per cow.

One stated purpose of the Compact is to assure the New England region of an adequate supply of fluid milk. An additional objective is to maintain the number of dairy farms in the region. The Northeast Dairy Compact Commission (Commission) attempts to achieve these objectives by setting minimum prices that processors pay for fluid (Class I) milk sold in the six New England states regulated by the Compact. Under the legislation authorizing the Compact, if the rate of increase for New England milk production exceeds the U.S. average, the Commission will incur financial obligations to the Commodity Credit Corporation (CCC). Although these obligations are not directly related to purchases of dairy products under the Dairy Price Support Program, they are designed to offset possible increases in costs to the CCC resulting from higher New England milk production.

During the first year of minimum price regulation under the 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 onset of minimum price regulation. 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 actually fell, by 9 million and 0.4 million pounds. Because the overall rate of increase for the New England states exceeded the U.S. average, the Commission incurred financial obligations to the CCC during the first year of minimum price regulation.

The increase in milk production in New England has led some observers to attribute the entire increase to the effects of minimum price regulation under the Compact. However, few formal studies to date have explored the role of factors other than price regulation that also may have affected New England milk supply. The principal effects of Compact price regulation 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 minimum price regulation under the Compact. 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

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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 weather conditions and higher hay prices in the New England states (Wackernagel 2000).

The impact of the Compact on milk supplied by New England farmers is important because changes in milk supply serve as one indicator of how well the objective of maintaining a dairy production base in New England is being achieved. In addition, changes in milk production in New England—despite its small share of national milk production—may have implications for dairy product prices in other areas of the U.S. Although interest in the use of compacts to price milk has grown in other areas of the U.S. since the start of price regulation under the Compact, there is relatively little published research on the market impacts of the one dairy compact already in existence. Thus, the objective of this study is to examine the impact of the minimum price regulation under the Compact on milk production in the six New England states.

Methods

The analysis herein relies on a two-equation random coefficients model to examine the relationship between milk production and milk prices, controlling for other factors. A random coefficients model approach allows the estimated parameters to differ for each of the six states, a desirable trait given the differences in farm characteristics and market proximity among the New England states. The dependent variable in one equation is the number of cows, and in the other equation is milk production per cow. Milk production for each state is calculated by multiplying cow numbers and milk per cow predicted from their respective equations. This model is similar to that used by Dixon et al. (1991) to examine the impacts of dairy policy changes in the mid-1980s.

The underlying theory supporting the variables considered for inclusion in the random coefficients model can be found in Dillon (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 production per cow (Sun et al. 1995; Dixon et al. 1991; Chavas et al. 1990). The random coefficients model developed for this study uses more explicit representations of climatic factors underlying seasonal variation in milk production per cow and cow numbers by including summer rainfall and temperature deviation variables rather than seasonal dummies.

The random coefficients model (Swamy 1974) can be specified as:

$$y_i = X_i\beta_i + \varepsilon_i,\ i = 1, \ldots, N \text{ groups (states)}$$

$$E[\varepsilon_i] = 0,$$

$$Var[\varepsilon_i] = \sigma^2 I,$$

$$\beta_i = \beta + \nu_i,$$

$$E[\nu_i] = 0$$

$$Var[\nu_i] = \Gamma$$

where y_i is a dependent variable, X_i is a matrix of independent variables, β_i is a vector of coefficients relating y_i and X_i for each $i = 1, \ldots, N$ group, β is a constant, ε_i and ν_i are error terms, $E[\ ]$ indicates the expected value operator, $Var[\ ]$ indicates the variance-covariance matrix, σ^2 is a constant, and Γ is a matrix.

The variables considered in the process of constructing the econometric model included the price of milk relative to the price of key inputs such as grain, hay, labor, and interest rates. Climatic variables included inches of summer rainfall (a key factor in forage production and quality), and the deviation of temperature from 50 degrees F (which is the middle of the range described as optimal for dairy cows, Foley et al. 1972). The variation in relative prices of milk and inputs in the previous two years was included to determine if price risk affected cow numbers and(or) milk per cow. Due to the biological lags inherent in dairy production, cow numbers and milk per cow in the previous quarter are included in the models.

Quarterly data from 1991 through the second quarter of 1998 are used to estimate the econometric model. Because milk production and milk prices are simultaneously determined in any given quarter, single-equation econometric models typically use values of relative prices in previous quarters rather than the relative prices in the current quarter as explanatory variables. The use of lagged price variables implies that the model does not require a full set of equations to estimate prices, production, and demand simultaneously, as some previous studies of dairy policy options have done (e.g., Kaiser 1994). In addition, the values of the lagged relative prices were transformed to natural logarithms prior to model estimation, as in Dixon et al. (1991).

The relationship between the dependent variables and the independent variables reported in table 1 is specified as follows:

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

	Dependent variable	
Independent 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 (1.89)	+0.08 (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[b]	.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

[a]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.

$$(1) \quad MPC^C_{st} = \exp\{\beta_{s0} + \beta_{s1} \cdot Ln(MPC^C_{s,t-1}) + \beta_{s2} \cdot Ln(PMF^C_{s,t-1}) + \beta_{s3} \cdot Ln(TEMPDEV_{st}) + \varepsilon_{st}\}$$

$$(2) \quad CN^C_{st} = \exp\{\alpha_{s0} + \alpha_{s1} \cdot Ln(CN^C_{s,t-1}) + \alpha_{s2} \cdot Ln(PMF^C_{s,t-1}) + \alpha_{s3} \cdot Ln(SRAIN_{st}) + \alpha_{s4} \cdot Ln(SRAIN_{st})^2 + \xi_{st}\}$$

where MPC_{st} is milk production per cow in state s during quarter t and the superscript ^{C} indicates this is the actual value with Compact minimum price regulation, $PMF_{s,t-1}$ 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 ε and ξ are error terms.

Model predictions of cow numbers and milk per cow are derived as follows:

$$(3) \quad \hat{MPC}^C_{st} = \exp\{\hat{\beta}_{s0} + \hat{\beta}_{s1} \cdot Ln(MPC^C_{s,t-1}) + \hat{\beta}_{s2} \cdot Ln(PMF^C_{s,t-1}) + \hat{\beta}_{s3} \cdot Ln(TEMPDEV_{st})\}$$

$$(4) \quad \hat{CN}^C_{st} = \exp\{\hat{\alpha}_{s0} + \hat{\alpha}_{s1} \cdot Ln(CN^C_{s,t-1}) + \hat{\alpha}_{s2} \cdot Ln(PMF^C_{s,t-1}) + \hat{\alpha}_{s3} \cdot Ln(SRAIN_{st}) + \hat{\alpha}_{s4} \cdot Ln(SRAIN_{st})^2\}$$

where the ^ indicates that MPC and CN are predicted values and that the values of the β and α are as estimated by the random coefficients model. Predicted milk production is equal to:

$$(5) \quad \hat{MILK}^C_{st} = \hat{MPC}^C_{st} \cdot \hat{CN}^C_{st}$$

To predict the values of MPC and CN without the Compact, values of $PMF_{s,t-1}$ that would have existed in the absence of price regulation were estimated using two alternative methods (the derivation of these alternative PMF values is discussed in more detail subsequently). These "no Compact" PMF values were used with the coefficients estimated from equations (3) and (4) to predict the values of MPC, CN, and $MILK$ that would have prevailed without price regulation under the Compact. Thus,

$$(6) \quad \hat{MPC}^{NC}_{st} = \exp\{\hat{\beta}_{s0} + \hat{\beta}_{s1} \cdot Ln(MPC^{NC}_{s,t-1}) + \hat{\beta}_{s2} \cdot Ln(PMF^{NC}_{s,t-1}) + \hat{\beta}_{s3} \cdot Ln(TEMPDEV_{st})\}$$

$$(7) \quad \hat{CN}^{NC}_{st} = \exp\{\hat{\alpha}_{s0} + \hat{\alpha}_{s1} \cdot Ln(CN^{NC}_{s,t-1}) + \hat{\alpha}_{s2} \cdot Ln(PMF^{NC}_{s,t-1}) + \hat{\alpha}_{s3} \cdot Ln(SRAIN_{st}) + \hat{\alpha}_{s4} \cdot Ln(SRAIN_{st})^2\}$$

where the superscript NC indicates that these are the values that would have prevailed in the absence of the Compact.

Note that because the values of milk production per cow and cow numbers in the previous period affect current milk per cow and cow numbers, the effect of minimum price regulation under the Compact in a given quarter carries over into subsequent quarters. As an example, consider cow numbers. If higher prices result in increased cow numbers in the first quarter, this larger number of cows then influences subsequent values of cow numbers through the term $CN_{s,t-1}$.

The impact of the Compact on milk production per cow and cow numbers is then estimated as the difference between the predictions that use PMF "with" Compact price regulation and the predictions that use the estimated *PMF* "without" Compact price regulation, or:

$$\text{(8)} \qquad \Delta^C(M\hat{P}C_{st}) = M\hat{P}C^C_{st} - M\hat{P}C^{NC}_{st}$$

$$\text{(9)} \qquad \Delta^C(C\hat{N}_{st}) = C\hat{N}^C_{st} - C\hat{N}^{NC}_{st}$$

where Δ^C indicates the estimated change due to price increases under Compact price regulation, and the other variables are as defined previously.

The estimate of milk production that would have occurred in the absence of Compact price regulation is given by:

$$\text{(10)} \qquad MI\hat{L}K^{NC}_{st} = [MPC^C_{st} - \Delta^C(M\hat{P}C_{st})] \cdot [CN^C_{st} - \Delta^C(C\hat{N}_{st})]$$

and the difference in milk production attributable to price increases under the Compact is given by:

$$\text{(11)} \qquad \Delta^C(MI\hat{L}K_{st}) = MILK^C_{st} - MI\hat{L}K^{NC}_{st}$$

As a starting point for derivation of the values of *PMF* that would have existed in the absence of Compact price regulation, consider the definition of the all-milk price prior to the implementation of the Compact (for states except Maine, which has additional mandated premiums):

$$\text{(12)} \qquad P^{All\text{-}Milk}_{st} = P^{Blend}_t + 10 \cdot (BFC_{st} - 3.5) \cdot BFD_t + OOP^{Handler}_{st}$$

where $P^{All\text{-}Milk}_{st}$ is the all-milk price in state s during quarter t, P^{Blend}_t is the Federal Order 1 blend price in quarter t, BFC_{st} is the average butterfat content of milk from state s during quarter t (as reported by Order 1), BFD_t is the butterfat differential per 0.1% butterfat (as reported by Order 1), and $OOP^{Handler}_{st}$ is the weighted average amount of all over-order premiums paid by handlers in state s for all classes of milk during quarter t.

If the Compact over-order premium is defined as C_t, then the impact of the Compact on the state all-milk price can be expressed mathematically as:

$$\text{(13)} \qquad \Delta^C(P^{All\text{-}Milk}_{st}) = \frac{\partial P^{Blend}_{st}}{\partial C} \cdot C_t + \frac{\partial OOP^{Handler}_{st}}{\partial C} \cdot C_t + C_t$$

where as above Δ^C indicates the impact of the Compact, and the $\partial P/\partial C$ and $\partial P/\partial OOP$ represent the changes in P and OOP that result from over-order premiums under the Compact. Equation (13) explicitly recognizes that Compact over-order premiums may result in changes in the blend price and over-order premiums paid by handlers but assumes that the Compact has no impact on butterfat content or butterfat differentials. Although the equation as written specifies that the Compact over-order premium in quarter t has possible effects on the blend price and handler premiums in that same quarter, it would be easy to generalize this to allow for impacts across quarters.

The Compact may have an effect on the blend price if C affects total utilization in the four classes of milk specified by Order 1, or if the total size of the pool for Order 1 is increased because milk supplies increase as a result of higher prices, or if additional producers are pooled under the order. Mathematically, the blend price is equal to:

$$\text{(14)} \qquad P^{Blend}_t = \frac{\left(\sum_i P^i_t \cdot UTIL^i_t\right) - \tau}{POOL_t}$$

where P^i is the classified price for class i = *I, II, III, IIIA* in New England,[1] $UTIL^i$ is the amount of milk used in making products of class i, τ represents adjustments to the value of milk such as inventory reclassification or transportation credits, and $POOL_t$ is the sum of all producer milk pooled under the order. If the Compact increases prices for Class I products at the retail level, class I utilization may fall. Lower Class I utilization may result in greater use of milk for other (usually lower-valued) products. To the extent that it occurs, this will lower the numerator of the expression for the blend price. If the size of the pool increases either because milk production in New England increases or the higher price attracts additional milk supplies from states like New York, the denominator of the expression for the blend price will become larger. Both of these potential effects would tend to lower the blend price, all other things being equal.

In addition, the Compact over-order premium may affect the weighted average of premiums paid by handlers for all classes of milk in the New England States. The estimated weighted average of handler premiums paid for all classes of milk are calculated as the NASS-reported state all milk price less the blend price, butterfat differentials, and the Compact over-order premium (during the period of Compact price regulation). These estimates of handler premiums are approximate because state all milk prices are rounded to the nearest \$0.10. In part this rounding reflects the fact that NASS data collection procedures rely on a small number of cooperating handlers in each state. The estimated weighted average premiums show relatively modest changes during the Compact period

[1] Class IIIA prices are used because they were the relevant price during the period of analysis (i.e., through mid-1998). Class IIIA has since been replaced by Class IV under the reform of Federal Orders on January 1, 2000.

compared to previous years. In Vermont, handler premiums during the Compact period are somewhat higher than previously. In most other states, the estimated average handler premium is nearly the same in the years before and after the Compact.

Anecdotal evidence from key contacts in the New England dairy industry indicates that Class I premiums initially disappeared when Compact price regulation began in July 1997. Although handler premiums for other classes of milk may have been unaffected, lower Class I handler premiums should have been reflected in a decrease in weighted average premiums paid by handlers. However, this is not observed in the NASS data. The discrepancies in the NASS and industry estimates of changes in handler premiums, make it difficult to accurately assess the impact of Compact price regulation on the weighted average of handler premiums since its implementation.

Hypotheses about the relationship between Compact over-order premiums and the blend price and handler over-order premiums can be expressed as:

$$(15) \qquad \begin{bmatrix} \dfrac{\partial P_t^{Blend}}{\partial C_t} < 0, \\ \dfrac{\partial OOP_{st}^{Handler}}{\partial C_t} \begin{cases} > 0 \\ < 0 \\ = 0 \end{cases} \end{bmatrix}$$

When the signs of these terms are substituted into the equation relating Compact over-order premiums to changes in the state all-milk price, that equation can be re-written as:

$$(16) \qquad \Delta^C(P_{st}^{All-Milk}) = (1 + \gamma_t + \eta_{st}) \cdot C_t$$

where γ_t is the effect of the Compact over-order premium on the blend price and is less than zero, and η_{st} is the effect of the Compact over-order premium on over-order premiums paid by handlers, which may be positive, negative, or zero. Although unlikely to be the case in practice, note that the change in all-milk price can be negative if $-(\gamma_t + \eta_{st}) > 1$.

Now, consider two specifications to estimate the individual state all-milk prices that would have prevailed without Compact price regulation. Estimate 1 can be expressed as

$$(17) \qquad P_{st}^{Estimate\ 1} = P_{st}^{All-Milk,C} - C_t$$

which assumes that $\Delta^C = C$, or alternatively that $\gamma_t = 0$ and $\eta_{st} = 0$. For states in which the impact of the Compact on handler over-order premiums might be negative (i.e., the Compact premium substitutes in part for premiums previously paid by handlers), the difference between the actual price and the price that would have prevailed without the Compact is overstated because the effects on the blend price and handler over-order premiums are ignored. Overstating the impact of the Compact on milk prices has the effect of overestimating the impact of the Compact on milk production, because prices affect both milk per cow and cow numbers. Alternatively, if average handler premiums were positively affected by the Compact (perhaps because higher total premiums become part of farmers' expectations), the use of Estimate 1 may overstate or understate the difference in prices—and therefore the difference in milk production—depending on whether the effect of the decrease in blend price is offset by the increase in handler over-order premiums.

A 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 adjusts the 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 weighted average handler premiums for all classes of milk by quarter during the three years prior to the implementation of the Compact. Three years of data are used for handler premiums to reflect industry practices in the period immediately prior to implementation of minimum price regulation. For the purpose of this calculation, handler premiums are estimated 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 are about the same or somewhat higher as in the period prior to implementation of minimum price regulation under 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 were not successful. Thus, no price estimate based on this method is reported for Maine.

Estimate 2 can be written as:

$$(18) \qquad P_{st}^{Estimate\ 2} = P_t^{Blend,NC} + 10 \cdot (BFC_{st} - 3.5) \cdot BFD_t + OOP_{st}^{Handler,\ NC}$$

where BFC_{st} and BFD_t determine the butterfat premium that is assumed unchanged by the Compact over-order premium, and

$$(19) \qquad P_t^{Blend,NC} = P_t^{Blend,C} - \sum_{i=I}^{IIIA} P_t^i \cdot \Delta^C U_t^i$$

Where

$$(20) \qquad U_t^i = \frac{UTIL_t^i}{POOL_t}$$

The impact the Compact on utilization in the tth quarter of the Compact period is assumed to be

$$(21) \qquad \Delta^C U_t^i = U_t^i - \frac{1}{6}\sum_{j=1}^{6} U_{(26+t)-4j} \qquad \text{for } t = 1, \ldots, 4$$

and the initial quarter of observations is the first quarter of 1991. That is, the changes in the percentage of class utilization are the differences between the values observed during quarter t during the Compact period, and the average values of class utilization of the same quarters in the previous six years. Note that the value of $\Delta^C U$ is negative, so that the estimated non-Compact blend price is larger than the actual blend price.

Handler over-order premiums in the absence of the Compact during the tth quarter of the Compact period are estimated as the average value for the same quarters during 1995 to 1997:2, or

$$(22) \qquad OOP_{st}^{Handler,NC} = \frac{1}{3}\sum_{j=1}^{3} OOP_{s(26+t-4j)}^{Handler} \qquad \text{for } t = 1, \ldots, 4$$

where the initial observation is the first quarter of 1991.

The estimates of the non-Compact blend price and handler premiums assume that 1) average values in previous periods are representative of what would have occurred in the absence of the Compact, and 2) all changes from average values in previous years are attributable to the Compact. This latter assumption overstates the impact of the Compact on the blend price and handler premiums because it does not include other factors that may have affected these components of the state all-milk price. The net effect on price estimate 2—and therefore on milk production—of attributing all changes in the blend price and handler premiums to Compact price regulation depends on the direction and magnitude of other factors influencing those two variables. Although these other factors were not formally examined in this study, the relatively short time period considered and limited estimated effects on blend price and handler premiums suggest that other factors do not markedly affect price estimate 2.

Results

The variables included in the cow numbers equation of the random coefficients model 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). All variables exhibit a positive relationship with milk production except for 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.

A different set of variables is included in the equation for milk production per cow (table 1). In this equation, 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 production per cow equation is lower than that for cow numbers. 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 found to be statistically insignificant. Thus, risk (as measured by past price variance) appears to have relatively little impact on cow numbers or milk production per cow.

Milk prices in the absence of the Compact are predicted to be lower in most cases than actual prices (table 2). 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 price regulation under the Compact—and therefore changes in the amount of

Table 2. Comparison of Actual and Estimated Non-Compact Milk Prices, by State and Quarter

State, Price	Year:Quarter 97:3	97:4	98:1	98:2
Connecticut				
Actual all-milk price	14.53	15.80	15.43	15.00
Estimate 1[a]	13.22	15.25	15.25	14.59
Estimate 2[b]	13.18	15.20	15.28	14.76
Maine				
Actual all-milk price	14.43	15.57	15.20	14.57
Estimate 1	13.12	15.02	15.02	14.16
Estimate 2	c	c	c	c
Massachusetts				
Actual all-milk price	14.67	15.97	15.43	15.40
Estimate 1	13.35	15.42	15.49	14.76
Estimate 2	13.24	15.30	15.49	14.91
New Hampshire				
Actual all-milk price	14.57	15.87	15.57	15.20
Estimate 1	13.25	15.32	15.39	14.79
Estimate 2	13.23	15.27	15.42	14.92
Rhode Island				
Actual all-milk price	14.50	15.73	15.53	14.90
Estimate 1	13.19	15.18	15.35	14.61
Estimate 2	13.18	14.97	15.36	14.65
Vermont				
Actual all-milk price	14.17	15.57	15.27	14.93
Estimate 1	12.85	15.02	15.09	14.53
Estimate 2	12.80	14.85	15.05	14.56

[a]Price estimate 1 equals the state-all-milk price minus the Compact over-order premium.
[b]Price estimate 2 equals the sum of an estimated 'non-Compact' blend price, butterfat premiums, and an estimated 'non-Compact' handler premium.
[c]Not reported due to discrepancies between estimated handler premiums and those mentioned in personal communications with Sharon Slayton, NASS.

the Compact over-order premium—the difference between the actual prices and price estimates is smaller later in the first year of price regulation under the Compact. In Vermont, for example, the difference between actual and estimated prices was more than $1.00 in the third quarter of 1997, but narrowed to about $0.20 it the first quarter of 1998. Thus, the impact of the Compact on milk prices, and therefore milk production, is likely to be larger during the first two quarters of Compact price regulation.

The increase in milk prices under the Compact is estimated to have increased the number of cows on farms in New England compared to cow numbers that would have been observed without the Compact (table 3). 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. The small response in cow numbers is consistent with the biological lags inherent in herd expansion through replacements and the costs of purchasing additional animals from outside New England.

Higher milk prices under the Compact are estimated to have increased milk per cow in all six New England States (table 3). 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 management adjustments are typically easier to make than changes in herd size, the percentage increases are higher than those for cow numbers. As a result, more of the increase in total milk production is attributable to changes in milk per cow than cow numbers.

The total increase in milk production for the six New England states attributed to increased milk prices due to Compact price regulation is 45 million pounds under price estimate 1, and 43 million pounds for the states other than Maine under price estimate 2 (table 4). 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 five states other than Maine equals about 90% of the increase in milk production from the previous year.

The impact of Compact price regulation on milk production varies by state. The largest increase occurs in Vermont, but New Hampshire and Rhode Island experience the largest percentage increases (table 4). 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, the results suggest that milk production in Vermont would have declined somewhat in 1997–98 if milk prices had

Table 3. Estimated Impact of Compact Price Regulation on Cow Numbers and Milk Per Cow, by State

Variable, State	Predicted with Compact	Predicted Without Compact		Difference With and Without Compact	
		Price Estimate 1[a]	Price Estimate 2[b]	Price Estimate 1[a]	Price Estimate 2[b]
Cow Numbers, 000[c]					
Connecticut	29.8	29.6	29.6	0.1	0.1
Maine	39.5	39.4	[d]	0.1	[d]
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	[d]	0.6	[d]
Total, States excluding Maine	233.2	232.5	232.5	0.7	0.7
Milk Per Cow[e]					
Connecticut	4,397	4,351	4,350	46	47
Maine	4,189	4,166	[d]	22	[d]
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	[d]	36	[d]
Weighted Average, States excluding Maine	4,200	4,166	4,164	34	37

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

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, higher prices due to the Compact are estimated to have contributed between one-quarter and one-half of milk production increases compared to the year before the Compact. A detailed summary of the results for cow numbers, milk per cow, and milk production by state and quarter is provided in appendix tables 1 and 2.

Table 4. Estimated Impact of Compact Price Regulation on Milk Production, by State, 1997:3 to 1998:2

State	Annual Milk Production, million pounds			Difference With and Without Compact	
	Actual With Compact	Predicted Without Compact, Price Estimate 1[a]	Predicted Without Compact, Price Estimate 2[b]	Price Estimate 1[a]	Price Estimate 2[b]
Connecticut	523.0	515.6	515.4	7.4	7.6
Maine	662.0	656.8	[c]	5.2	[c]
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	[c]	45.1	[c]
Total, States excluding Maine	3,914.5	3,874.6	3,871.5	39.9	43.0

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

Conclusions

The results of this study suggest that much of the recent increase in milk production in New England states is due to higher milk prices during the first year of minimum price regulation under the Compact. Although the result that higher milk prices have resulted in more milk production is not surprising, an empirical estimate of the magnitude of the response to price enhancement provides information useful to evaluate the Compact as a public policy instrument. The analysis herein considers only the first year of Compact price regulation, but the increase in milk production provides evidence that the policy objective of maintaining a milk production base in New England is being met. Milk production in New England, however, has been relatively stable during the past decade (Wackernagel 1999), and the increase in milk production estimated by this study is not significantly different from long-term trends. Although not addressed by this study, the increase in New England milk production due to Compact price regulation suggests the potential for impacts on prices in national dairy product markets. Further research should examine this possibility to more fully document the impacts of the Compact. In addition, about 25% of milk pooled under Federal Order 1 is produced in the state of New York. Thus, some New York dairy producers receive higher prices due to the Compact. This study did not examine the increase in milk production in New York due to the Compact, but a supply response of similar magnitude by New York producers would increase the likelihood of changes in the class utilization in Federal Order 1, and of impacts in national dairy product markets.

The estimated increase in milk production found by this study does not imply that the Compact is helping to achieve another of its stated objectives: maintaining the number of dairy farms in the six New England states. The higher milk prices have undoubtedly improved the financial condition of many farms in the region, but further research is needed to determine whether the price incentives under the Compact are sufficient to markedly affect survival of farms in financial difficulty.

This study also suggests that impact of Compact price regulation on milk production differs for the six New England states. Vermont experiences the largest increase in milk, but percentage increases in milk supply are largest in New Hampshire and Rhode Island. Although the estimated parameters in the cow numbers equation differed by state, the impact of Compact price enhancement on herd size was small. In contrast, the responsiveness of milk production per cow to the milk-feed price ratio had a larger impact on milk production, despite no statistically significant difference in responsiveness by state. Overall, the differences in production response to Compact price enhancement do not markedly change the distribution of milk production among the six New England states.

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Appendix Table 1. Detailed Results by State and Quarter, Estimate 1 of 'Non-Compact' Price

State, Quarter	Milk per cow, lbs per quarter			Cow numbers, 000			Milk production, mil lbs per quarter		
	Actual	Predicted	Difference	Actual	Predicted	Difference	Actual	Predicted	Difference
Connecticut									
1997:3	4,167	4,167	0	30.0	30.0	0.0	125.0	125.0	0.0
1997:4	4,267	4,210	55	30.0	29.9	0.1	128.0	125.8	2.2
1998:1	4,500	4,419	77	30.0	29.8	0.2	135.0	131.7	3.3
1998:2	4,655	4,571	81	29.0	28.8	0.2	135.0	131.5	3.5
Total							523.0	514.1	8.9
Maine									
1997:3	4,225	4,225	0	40.0	40.0	0.0	169.0	169.0	0.0
1997:4	4,103	4,075	28	39.0	38.9	0.1	160.0	158.6	1.4
1998:1	4,077	4,046	30	39.0	38.8	0.2	159.0	157.2	1.8
1998:2	4,350	4,327	22	40.0	39.9	0.1	174.0	172.5	1.5
Total							662.0	657.2	4.8
Massachusetts									
1997:3	4,192	4,192	0	26.0	26.0	0.0	109.0	109.0	0.0
1997:4	4,200	4,168	32	25.0	24.8	0.2	105.0	103.4	1.6
1998:1	4,160	4,116	44	25.0	24.7	0.3	104.0	101.6	2.4
1998:2	4,320	4,277	42	25.0	24.7	0.3	108.0	105.6	2.4
Total							426.0	419.6	6.4
New Hampshire									
1997:3	4,263	4,263	0	19.0	19.0	0.0	81.0	81.0	0.0
1997:4	4,444	4,414	29	18.0	17.7	0.3	80.0	78.3	1.7
1998:1	4,556	4,513	41	18.0	17.6	0.4	82.0	79.6	2.4
1998:2	4,667	4,620	45	18.0	17.7	0.3	84.0	81.6	2.4
Total							327.0	320.5	6.5
Rhode Island									
1997:3	3,800	3,800	0	2.0	2.0	0.0	7.6	7.6	0.0
1997:4	3,850	3,827	23	2.0	2.0	0.0	7.7	7.5	0.2
1998:1	4,000	3,971	28	2.0	2.0	0.0	8.0	7.7	0.3
1998:2	4,100	4,074	25	2.0	2.0	0.0	8.2	8.0	0.2
Total							31.5	30.8	0.7
Vermont									
1997:3	4,070	4,070	0	158.0	158.0	0.0	643.0	643.0	0.0
1997:4	3,994	3,950	44	158.0	158.0	0.0	631.0	624.0	7.0
1998:1	4,045	3,985	59	157.0	157.0	0.0	635.0	625.7	9.3
1998:2	4,418	4,351	61	158.0	158.0	0.0	698.0	687.7	10.3
Total							2,607.0	2,580.4	26.6

Note: Due to the use of cow numbers, milk per cow, and the milk-feed price ratio from the previous quarter in the econometric model, the model predicts that that higher prices under the Compact did not have an effect until 1997:4. Thus, the impacts for 1997:3 are shown as zero.

Appendix Table 2. Detailed Results by State and Quarter, Estimate 2 of 'Non-Compact' Price

State,	Milk per cow, lbs per quarter			Cow numbers, 000			Milk production, mil lbs per quarter		
Quarter	Actual	Predicted	Difference	Actual	Predicted	Difference	Actual	Predicted	Difference
Connecticut									
1997:3	4,167	4,167	0	30.0	30.0	0.0	125.0	125.0	0.0
1997:4	4,267	4,214	51	30.0	29.9	0.1	128.0	126.0	2.0
1998:1	4,500	4,431	66	30.0	29.8	0.2	135.0	132.1	2.9
1998:2	4,655	4,588	65	29.0	28.8	0.2	135.0	132.2	2.8
Total							523.0	515.4	7.6
Maine									
1997:3									
1997:4									
1998:1									
1998:2									
Total									
Massachusetts									
1997:3	4,192	4,192	0	26.0	26.0	0.0	109.0	109.0	0.0
1997:4	4,200	4,170	30	25.0	24.8	0.2	105.0	103.5	1.5
1998:1	4,160	4,121	39	25.0	24.7	0.3	104.0	101.9	2.1
1998:2	4,320	4,286	33	25.0	24.7	0.3	108.0	106.1	1.9
Total							426.0	420.5	5.5
New Hampshire									
1997:3	4,263	4,263	0	19.0	19.0	0.0	81.0	81.0	0.0
1997:4	4,444	4,416	27	18.0	17.8	0.3	80.0	78.4	1.6
1998:1	4,556	4,518	37	18.0	17.7	0.3	82.0	79.9	2.1
1998:2	4,667	4,628	38	18.0	17.7	0.3	84.0	82.0	2.0
Total							327.0	321.3	5.7
Rhode Island									
1997:3	3,800	3,800	0	2.0	2.0	0.0	7.6	7.6	0.0
1997:4	3,850	3,828	22	2.0	2.0	0.0	7.7	7.5	0.2
1998:1	4,000	3,970	29	2.0	2.0	0.0	8.0	7.7	0.3
1998:2	4,100	4,072	27	2.0	2.0	0.0	8.2	8.0	0.2
Total							31.5	30.8	0.7
Vermont									
1997:3	4,070	4,070	0	158.0	158.0	0.0	643.0	643.0	0.0
1997:4	3,994	3,953	41	158.0	158.0	0.0	631.0	624.5	6.5
1998:1	4,045	3,991	53	157.0	157.0	0.0	635.0	626.6	8.4
1998:2	4,418	4,362	52	158.0	158.0	0.0	698.0	689.3	8.7
Total							2,607.0	2,583.5	23.5

Note: Due to the use of cow numbers, milk per cow, and the milk-feed price ratio from the previous quarter in the econometric model, the model predicts that that higher prices under the Compact did not have an effect until 1997:4. Thus, the impacts for 1997:3 are shown as zero.