The Effects of Alternative Seasonal Price Differentials on Milk Production in New York

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Uneven monthly milk production (seasonality) is a major problem to the New York dairy industry. This article estimates expected monthly milk production response to a set of hypothetical seasonal price differentials designed to reduce the degree of seasonality. The analysis is based on a random mail survey and farm record data. The results indicate that a seasonal price differential of $1.12 per cwt. (over three times the current differential) would be necessary to completely balance spring and fall production in New York, based on the perceptions of farmers surveyed. Also, producers with better managerial skills are shown to be able to reduce their seasonality at a significantly lower price differential than less skilled farm managers.

Introduction

New York dairy farmers produce significantly more milk in the spring than in the fall. For example, between 1980 and 1986, spring milk production (March, April, May, and June) averaged 35.8%, while fall production (August, September, October, and November) averaged 31.6% of total annual production (Federal Order No. 2 Statistical Handbook, 1957–1986). In other words, the state's dairy farmers produced on average over 13% more milk in the spring than they did in the fall.

Milk production seasonality has long been recognized as an important and serious problem facing the dairy industry, particularly among manufacturers of non-fluid dairy products, e.g. cheese and butter-powder. Uneven monthly supplies of raw milk between the spring and the fall raises handlers' operating costs and reduces their level of efficiency. The costs to handlers are primarily due to excess capacity in trucks, storage facilities, and plants, which may be run at capacity in the spring, but run at levels far below capacity for the remainder of the year. These costs are partially passed along to consumers in the form of higher prices. Seasonality also costs taxpayers, since surplus milk (in the form of butter, nonfat dry milk, and cheese) is removed in the spring under the dairy price support program. A more uniform milk production pattern would greatly reduce the costly seasonal balancing functions of this program.

To counter this problem, federal and state milk marketing orders in New York State have utilized seasonal price incentive programs since 1967. These programs are designed to even out seasonality by providing farmers financial incentives (disincentives) through the price. During the spring, deductions from the farm price discourage excess production, and in the fall premiums to the price stimulate additional production. In 1972, the deductions and premiums were doubled to keep pace with inflation. However, since 1972 these differentials have not changed, and in real terms, the financial incentives to change seasonal production have become substantially weaker.

The principal objective of this paper is to analyze anticipated production response to several hypothetical levels of seasonal price differentials. This research differs from the majority of previous research (i.e., Hall, et al.; Prindle and Livezey; Caine and Stonehouse; and the New York-New Jersey Milk Market Administrator's Office, 1984) in that it focuses on aggregate rather than individual production response to different seasonal price levels. The analysis is based on producer perceptions elicited from a mail survey sent to randomly selected

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dairy farmers in New York State, and farm record data on survey respondents obtained from the New York-New Jersey federal milk marketing order. Monthly perceived milk production responses to several seasonal price differentials are simulated for (1) the entire state, and (2) different segments of the state's dairy farm population, based on selected producer characteristics. The perceived production responses are used to evaluate the effectiveness of the current price incentive plan used to address the seasonality problem and to predict the price differential needed to balance spring and fall production.

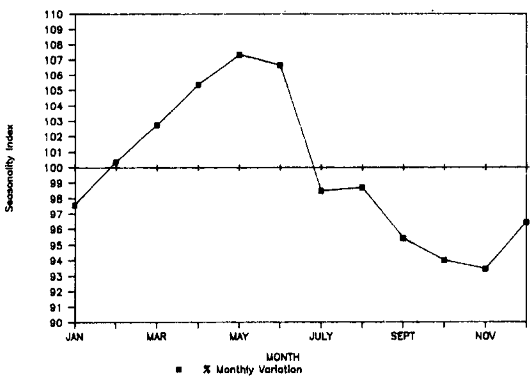

Figure 1. Variation in Milk Production New York State (12 month ave. = 100), 1980–1986

Background

Figure 1 illustrates the seasonal pattern of milk production by month for New York. In developing this figure, average monthly production for 1980–86 was divided by the 12 month average to show the monthly variation in milk production throughout the year.[1] New York milk production, on average, is highest in May with over 8% more milk being produced than the 12 month average, and lowest in November with about 6.5% less milk produced than the 12 month average.

Seasonality is due to the fact that a greater proportion of cows freshen in the spring than in other seasons of the year. The high degree of spring freshening is likely due to the availability of pasture during this season and the natural tendency for cows to freshen in the spring (Prindle). In addition to biological factors, seasonality is also caused by producer perceptions that spring milk production is more profitable (Quinn and Wasserman). On the other hand, recent research has indicated that these perceptions may in fact be incorrect (Hall, Oltenacu, and Milligan). The findings in Hall, et al. provide evidence that there is no significant relationship between net revenue (per herd) and season of the year. Hence, this evidence suggests that seasonality is not caused by profitability factors per se, but rather by farmer perceptions that spring milk production is more profitable than production in any other season.

Seasonality is far more of a problem for manufacturers of Class II products than for processors of fluid (Class I) products, because fluid eligible milk (Grade A) supplies generally satisfy the higher priced Class I demand first, with the remainder sold to Class II manufacturers.[2] Since more raw milk is always produced in New York than Class I demands, fluid processors have a fairly reliable source of raw milk in their plants year round, and therefore can build their operations based on their product demand and a uniform raw milk supply throughout the year. On the other hand, Class II balancing plants in the state face highly uneven excess supplies of raw milk. This phenomenon makes it difficult for these Class II balancers to operate their plants efficiently since in order to process all the excess raw milk in the spring they need to build plant capacity at a level where much will remain idle in the fall under the prevailing seasonality of milk production. For example, in 1985 the daily receipts for the three largest manufacturing plants in the New York-New Jersey federal milk marketing order were more than 38% higher in May than in November (Hall, Oltenacu, and Milligan). Since dairy cooperatives perform the market "balancing" function for raw milk throughout the year, they are especially vulnerable to this problem.

To respond to seasonality, 18 out of 48 federal milk marketing orders operated seasonal price incentive plans in 1986 (Kaiser). Individual producers will generally not consciously change their patterns of seasonality unless the economic incentives or disincentives associated with these programs make it profitable to adjust freshening management practices to achieve a more uniform

[1] The months in this figure were adjusted to have an equal number of days for comparison purposes. This was done by first computing average daily production for each month and then multiplying the resulting figure by 30.4375 (which is 365.25 days divided by 12). The data for computing this figure were obtained from the New York Agricultural Statistics Service, 1987.

[2] Federal and state milk marketing orders in the Northeast categorize raw Grade A milk into two classes: Class I and Class II. Class I includes all Grade A milk processed into fluid products and Class II includes all Grade A milk processed into manufactured dairy products. Under the classified pricing system used in all milk marketing orders, Class I handlers must pay higher minimum raw milk prices to farmers than the non-fluid Class II handlers of raw Grade A milk.

monthly production. Hence, to be effective, the seasonal program must be designed to offer incentives (disincentives) significant enough to induce an adequate number of producers to become seasonally-even or contra-seasonal to cause the aggregate supply of milk to be more uniform throughout the year. The economic incentives (disincentives) of all existing seasonal pricing programs take the form of penalties in the spring and price premiums in the fall. Two types of programs are commonly used: the Louisville and Base-Excess plans.

The New York-New Jersey and the New York State milk marketing orders have operated Louisville programs since 1967. The Louisville plan requires a specific amount of money to be withheld from the blend price during the spring and then added back, along with interest earned, in the fall. In March, April, May, and June, the Market Administrator withholds 20, 30, 40, and 40 cents per cwt., respectively, from the blend price and these proceeds are placed in an interest bearing escrow account. Then, in August, September, and October, the blend price is augmented by 25%, 30%, and 30%, respectively, of this escrow fund. In November, the remaining 15%, plus any interest, is added back to the blend price. On average, the current Louisville plan results in a total seasonal price swing of approximately 70 cents per cwt., including interest, which corresponds to about a $0.35 seasonal price differential (New York-New Jersey Milk Market Administrator's Office, 1986).

Base-Excess seasonal incentive programs also use price differentials, but operate differently than Louisville plans. Under Base-Excess plans, each producer is usually assigned a production "base," equal to average daily production during the four fall months (August through November). Prices paid to producers depend upon this base. Under a 12-month program, farmers receive the "base price" on all milk sold within their base and receive a lower "excess price" on milk sold over their base. According to current federal order provisions, the excess price cannot be lower than the lowest class price (Kaiser). While somewhat different in structure, both plans are meant to provide incentives for increasing fall production and/or decreasing spring production, thereby leveling out seasonality. Currently, economists in the Northeast are examining the possibility of replacing the Louisville plan with a Base-Excess plan in the New York-New Jersey and New England federal milk marketing orders.

The Louisville program has likely resulted in more even production than would have occurred without it. However, as Figure 1 indicates, New York still faces significant fluctuations in monthly milk production with the Louisville plan in place. The main reasons usually cited for the failure of the Louisville program to even out production more are: 1) the lack of financial incentives to producers to change their seasonal production patterns, and 2) the lack of producer awareness of the existence of the program.[3] A recent study of the impact of four seasonal pricing plans on net farm income levels found that the current Louisville plan had the least impact in terms of creating financial incentives to reduce seasonality of all plans considered (New York-New Jersey Market Administrator's Office, 1984). Of the other three programs evaluated in this research, a 12 Month Base-Excess plan offered the largest income incentives to reduce seasonality, followed by a Double Louisville and a 4-Month Base-Excess plans.[4]

While the effectiveness of the Louisville plan has been questioned and addressed in previous research, there is also evidence that the differentials of the Base-Excess plan are too low. A 1980 study of the Base-Excess plan used in Maryland concluded that the then existing incentives of the program were insufficient in terms of encouraging a more uniform monthly production (Prindle). Similar to one of the problems cited for the Louisville plan, the differential between the base and the excess price ($1.53 difference between the base and the excess price at that time) was too low according to the results of Prindle's study.

Methodology

This study was designed to estimate how dairy producers, in the aggregate, would adjust their existing monthly milk production in response to four hypothetical seasonal price differentials. The hypothetical seasonal differentials considered were designed to make prices received by farmers lower in the first half and higher in the second half of the year. Since no structure of how the price differentials would work was proposed or suggested in the survey, the results may be used to examine production response implications of both types of seasonal price incentive programs currently used in federal orders. The first scenario, which contains

[3] Under the current Louisville program, the take-outs and pay-backs to the blend price are not reported on producers' milk checks. Consequently, many producers may be unaware of the program and therefore do not respond to these financial incentives. Based on the dairy farmer survey results, 35% of the respondents were unaware of the Louisville plan.

[4] A Double Louisville plan works the same as the current program except the take-out and pay-back levels are doubled. A 4-month Base-Excess plan has the base and excess prices in effect only in the 4 spring months rather than year round as the 12-Month Base-Excess program operates.

no seasonal price differential, is used as a base to compare how producers would respond to different intra-year price differentials as well as to compare resulting seasonality coefficients with those of the now existing $0.35 differential associated with the Louisville program. In the three remaining scenarios, producers receive a $1.00, $2.00, and $3.00 per cwt. deduction from the blend price in January through June and similar premiums from July through December.[5] These price differentials were purposely higher than the Louisville plan actually used in New York in order to determine the differential that would balance spring and fall production. Since differentials of this magnitude have never been used in New York, a survey of the state's dairy farmers was needed to elicit producer perceptions of their likely response to these hypothetical pricing programs. The respondents' perceived production responses would not take place instantaneously, but would rather take one to two years to achieve, especially at the higher range of the price differentials. Hence, the estimated production responses in this analysis should be considered longer term.

The Data

The data used in this research were obtained from a mail survey conducted between November 1986 and January 1987. This survey was initiated as part of a more comprehensive study of milk production seasonality in New York (Oltenacu, Smith, and Kaiser). A total of 2,465 farmers were randomly selected from a population of the approximately 12,970 commercial dairy farmers in New York State. From this sample, 1,169 (47.4%) completed or partially completed questionnaires were returned.

In order to determine whether the respondents to the survey were representative of the New York dairy farm population, average values of selected farm characteristics for respondents were compared to published state averages. Based on average cow numbers per farm, production per cow, and production per farm, as reported in *New York Agricultural Statistics* for 1986, the survey respondents appeared to be quite representative of the overall population. For example, New York dairy farmers averaged 73 cows per farm, 12,401 pounds of milk per cow, and 905,273 pounds of milk per farm in 1985. These averages were very close to the survey respondents, who averaged 77 cows per farm, 12,922 pounds production per cow, and 995,024 pounds of milk production per farm.

Potential non-response bias in the survey was also tested. Eighty individuals from those who received, but did not return the questionnaire, were randomly selected for a telephone follow up interview. The purpose of the follow up was to ascertain whether there were any significant differences in responses between respondents and nonrespondents. There were no statistically significant differences between selected survey responses for the two groups (Oltenacu, Smith, and Kaiser). Hence, based on these procedures, the survey data were judged representative of New York dairy farmers with no apparent non-response bias.

Two sources of data were used to estimate within-year milk production response to the different pricing levels. The first source was information obtained from the survey. Producers were asked what percent of their annual production they would produce in the first six months and the second six months of the year for each of the four different seasonal price incentive programs. The responses to this question, in essence, represent farmers' perceptions regarding the benefits and costs of making adjustments in their seasonal patterns of milk production in response to the hypothetical pricing levels. Monthly rather than semi-annual information would have been desirable. However, it was felt that a lower survey response rate would have resulted due to the increased complexity of the question needed to elicit response at this level of detail.

All respondent that were in the Milk Diversion Program, the Dairy Termination Program, or were members of cooperatives that use seasonal price incentive plans were excluded from the sample. These farmers were excluded since they would have biased the patterns of normal production seasonality. The omission of these producers, in addition to respondents that did not complete all of the relevant questions for this analysis, brought the total number of usable questionnaires to 343.

To disaggregate each farmer's semi-annual perceived production response to a monthly basis, a second data source was needed. The second source of information was actual average monthly milk marketings of survey respondents from 1980 to 1986. These data were supplied by the New York-New Jersey Federal Milk Market Administrator's Office.

The Model

The following procedures and assumptions were used to estimate monthly milk production response

[5] In this article, the term "price differential" means the level of the deduction from or premium to the price rather than the total or absolute seasonal difference in price. For instance, a $2.00 price differential means that $2.00 is deducted from the farm price in the first half of the year, and $2.00 is added to the price in the second half of the year. Hence, a $2.00 price differential is equivalent to a $4.00 annual "swing" in the price.

to the alternative seasonal price levels. First, based on the survey responses, the percentage changes in production for January through June and for July through December were calculated for the \$1.00, \$2.00, and \$3.00 price differentials. This provided a measure of farmers' perceptions or assertions of how much they would be willing to decrease production in the first half and increase production in the second half of the year in response to these seasonal price differences. Next, each producer's indicated semi annual percentage changes in production for each differential were multiplied by his average monthly milk marketings as a percent of annual marketings (1980–86) in order to disaggregate response to a monthly basis. Each of the twelve months of the year were adjusted to have equal days in order to correct for biases caused by unequal days in actual months for comparison purposes. This was accomplished by first computing average daily milk marketings and then multiplying the resulting number by 30.4375 for each month. This resulted in all twelve "adjusted months" having an equal number of days. The following equation was used to accomplish the first adjustment:

$$(1) \qquad MP_{ij} = MP_i \times PR_{kj},$$

where:

MP_{ij} = Milk production (%), adjusted month i, under seasonal price differential j, (j = \$0.00, \$1.00, \$2.00, and \$3.00);
MP_i = Actual average milk production (%), adjusted month i, from 1980 to 1986;
PR_{kj} = Percentage change in semi-annual milk production k (i.e., k = January to June and July to December) from the \$0.00 price difference for seasonal price differential j (j = \$1.00, \$2.00, and \$3.00).

This procedure implicitly assumed that the price differential under the Louisville plan was zero, which was not true. In other words, the results from equation (1) were such that production under the zero price differential corresponded to actual average monthly production for each respondent even though a \$0.35 differential was already in effect. This was not a problem in calculating perceived production response for respondents who had no knowledge of the Louisville program since they were obviously unaware of the \$0.35 price differential. For these producers, who represented approximately 35% of the sample, production response was estimated using equation (1).

However, equation (1) had to be adjusted to reflect the \$0.35 differential for the survey respondents who did have knowledge of the Louisville program since they were aware of this differential. Equation (1), in effect, resulted in production response for price differentials ranging from \$0.35 to \$3.35 rather than \$0.00 to \$3.00, for these respondents since equation (1) did not adjust for the actual differential in effect for this period. Therefore, for respondents having knowledge of the Louisville plan, equation (1) was adjusted for the \$1.00, \$2.00, and \$3.00 differential using,

$$(2) \qquad AMP_{ij} = ((MP_{ij} - MP_{ij-1})/0.65) \times 0.35) + MP_{ij},$$

where:

AMP_{ij} = Adjusted milk production (%), adjusted month i, under seasonal price differential j (j = \$1.00, \$2.00, and \$3.00), adjusted to correct for the \$0.35 price differential (Louisville plan) for base period production.

The \$0.00 price differential was transformed using,

$$(3) \qquad AMP_{i0} = ((MP_{i0} - T_{i0})/0.65) \times 0.35) + T_{i0},$$

where:

$$T_{i0} = ((MP_{i0} - MP_{i1})/2) + MP_{i0}.$$

Through equations (2) and (3), the \$0.35 impact of the Louisville plan implicitly embodied in equation (1) was adjusted for the respondents having knowledge of the Louisville program.

Based on these procedures, seasonality coefficients were calculated for each price differential. The seasonality coefficient is defined as

$$(4) \qquad S_j = \left(\sum_{i=3}^{6} AMP_{ij} - \sum_{i=8}^{11} AMP_{ij}\right) / \sum_{i=8}^{11} AMP_{ij}$$

for j = \$0.00, \$1.00, \$2.00, and \$3.00. A positive coefficient implies a seasonal pattern, a zero coefficient implies no seasonal pattern, and a negative coefficient implies a contra-seasonal pattern of milk production. These coefficients were used to quantify changes in dairy farmers' seasonal patterns of production under the various pricing plans.

After estimating equations (1) through (4) for each producer having knowledge of the \$0.35 price differential, and equation (1) and (4) for those not having knowledge of the \$0.35 price differential, the results were averaged to obtain an aggregate perceived production response. A weighted average, based on the amount of milk each farmer produced, was used to account for differences in size and production per cow among survey respondents.

It must be stressed that the estimates of farmer production response to these price differentials are perceived responses. Obviously it is impossible to predict with complete certainty what would occur under these alternative price differentials since they have never been implemented before. Hence, some "crystal-balling" on the part of producers is inherent in the estimated production response, particularly for the higher segments of the price differential range, e.g. $2.00 and $3.00. However, because the perceived response to the differentials were adjusted by actual patterns of past seasonality (based upon 1980–86 historical marketings for each farm), the estimates of production responses probably give a fairly accurate indication of expected producer behavior.

Simulations and Tests

The model was used to simulate expected aggregate milk production response to these seasonal plans for (1) the entire state and (2) different segments of the state's producers to test whether each group would respond identically. The first simulation has three important results. First, the model was used to simulate the impact of alternative price differentials on New York seasonality. Estimates of seasonality were obtained for all seasonal price differentials in the $0.00 to $3.00 interval through linear interpolation. The relationship between seasonality and the level of the seasonal price differential is of particular interest to policy makers and cooperative officials in evaluating alternative pricing plans on an ex ante as opposed to ex post basis. Second, the price differential necessary to completely even out differences in spring and fall production was calculated. While complete elimination of seasonality is likely to be too costly as well as undesirable,[6] the level of this differential was computed for two reasons. First, it provides policy makers with an estimate of how much it would cost to have uniform spring and fall production. Second, this "complete balancing" differential serves as a useful number to compare production response between sub-groups in the sample (see second simulation described below). The effectiveness of the current Louisville program on reducing seasonality was also determined in the first simulation. Statistical tests of whether the current program had any impact on seasonality were performed.

A second test of simulations examined whether certain classes of farmers would be expected to respond differently to the different price scenarios. The model was solved for different segments of the sample population and statistical tests were conducted to ascertain whether production responses to the price differentials differed between groups. It was hypothesized that farmers with better managerial skills would be able to even out spring and fall production at a lower within year price difference than less managerial astute producers. Rather than constructing a "managerial ability" index to test this hypothesis, the sample was divided into several groups that were hypothesized to be proxies for these attributes and compared pairwise using a two-tailed t-test of whether their mean seasonality coefficients by price differential were statistically different.

The first pairing placed members of the Dairy Herd Improvement (DHI) association into one group, and nonmembers in another group. It was hypothesized that DHI members are better managers and would therefore balance within year production at a lower price differential than non-DHI members. The second pairing was based on a crude production efficiency measure, production per cow. Respondents were grouped by those that produced 14,000 pounds of milk per cow or less and those that produced more than 14,000 pounds of milk per cow in 1986. It was postulated that producers with higher production per cow are better managers and would even out seasonal production at a lower price difference than farmers with lower producing herds. The third pairwise test compared producers with 12 or less years of formal education with farmers with more than 12 years of formal education. A priori, more highly educated farm managers are expected to be more innovative and would be more responsive to adjusting monthly production patterns at lower price differences than their counterparts. A fourth and somewhat related comparison based on age was also made. Producers younger than the sample mean (42 years of age) are expected to be more innovative, on average, than older farmers and, therefore, would be more responsive to the price differentials in changing seasonal production. The fifth grouping was based on herd size, with the cow number division set at 65 cows. Producers with larger herds were hypothesized to be more price responsive in adjusting their production than farmers with smaller herds. Finally, a comparison was made between producers that rely substantially upon pasture feeding in the spring with those that use pastures less and utilize supplemental feeding more. The two groups were divided into producers who indicated they pastured milking cows for more than 12 hours per day in May and June and those that pastured cows 12 hours or less per

[6] It should be noted that the objective of seasonal price incentive plans is not to obtain a constant and completely uniform monthly supply of raw milk. Indeed some seasonality is probably desirable, especially from a milk production efficiency point of view. Rather the objective is to lessen the serious imbalance between spring and fall supply and demand that currently exists.

day in these two months. It was postulated that producers who used supplemental feeding and rely less on pasture feeding would balance spring and fall production at a lower differential than more pasture intensive farmers.

The Results

The results of the first simulation are presented in Figure 2, representing the relationship between production seasonality, as quantified by the seasonality coefficient, and alternative price differentials. As expected, the range of price differentials was more than sufficient to even out spring and fall milk production. The seasonality coefficient ranged from a high of 0.19, under the $0.00 price differential scenario, to a low of −0.17, under the $3 price differential. The figure also indicates that changes in aggregate perceived production response to these price differentials is more price sensitive in the $0.35 to $1.00 range of differentials. For instance, the seasonality coefficient was reduced by 0.17 points as the differential was increased from $0.00 to $1.00. As the differential was increased from $1.00 to $2.00, the seasonality coefficient declined by a lower increment of 0.13 points. Finally, as the price differential was increased from $2.00 to $3.00, the seasonality coefficient declined by only 0.06 points. This result is consistent with the fact that there are obviously limitations on the extent that producers perceive they can reverse their seasonal milk production patterns.

Based on the results of the first simulation, a seasonal price differential of about $1.12 per cwt. would balance spring and fall milk production in New York. This amount is 3.2 times more than the current differential of $0.35. Thus, the present

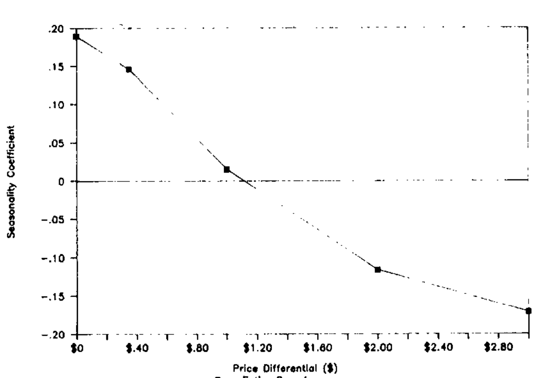

Figure 2. Estimated Seasonality Coefficient by Price Differential, Entire Sample

seasonal price differential would have to change significantly to completely level milk production in these two seasons of the year. In addition to balancing spring and fall production, a price differential of $1.12 would also reduce overall monthly variation in production. For instance, the variance of average monthly milk production as a percent of annual production falls from 0.31 percent to 0.14 percent when the price differential is increased from $0.00 to $1.00. This reduction in monthly variation of milk production due to the price differential is illustrated graphically in Figure 3, which shows the seasonality index by month for the $0.00 and the $1.00 price differential. This figure provides evidence that overall monthly variation in milk production is reduced when the price differential is increased from $0.00 to $1.00. It should be noted, however, that the extremely high price differentials of $2.00 and $3.00 cause a greater seasonal variation plan than no price differential at all. Under these large differentials, contra-seasonality becomes a problem.

The results of the first simulation also indicate that the current Louisville plan reduced seasonality in New York. From 1980 to 1986, the average seasonality coefficient at the $0.35 differential was 0.15. If the price of milk would have been uniform year round for this period, the seasonality coefficient would have been higher, i.e. approximately 0.19. A statistical test of the null hypothesis that the Louisville plan had no impact on lowering the seasonality coefficient was conducted. The null hypothesis was conclusively rejected at the 0.005 confidence level, providing evidence that the Louisville plan does reduce seasonality.[7]

Table 1 reports the results of the second set of simulations. In this table, the production responses to the price differentials are shown for the groupings of the sample based on selected farm characteristics.

Two of the most striking results of these simulations were the DHI/non-DHI and level of formal education comparisons. Producers with more formal education had satistically different seasonal

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[7] A standard one-tailed t-test of the difference between two means was used to test for the statistical significance of the Louisville plan in reducing seasonality. The following formula was used to compute the t-statistic:

$$t = [SC_0 - SC_{0.35}]/[(V(SC_0)/n_1) + (V(SC_{0.35})/n_2)]^{1/2}$$

where:

SC_j = Average seasonality coefficient, price differential j (j = 0.00 and 0.35); $V(SC_j)$ = Variance of the seasonality coefficient, price differential j (j = 0.00 and 0.35); n_i = sample size of both groups ($n_1 = n_2$ in this case). The computed t-statistic in this test was 2.72, indicating strong evidence to reject the null hypothesis that the Louisville plan had no impact on reducing seasonality.

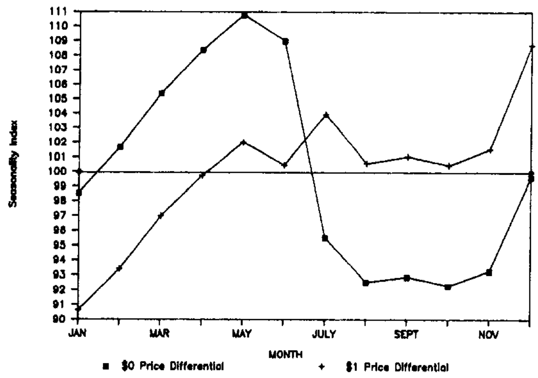

Figure 3. Monthly Variation in Milk Production for a $0 and $1 Price Differential

production responses than farmers with less formal education for all differentials considered. On average, farmers with more than 12 years of education needed a price difference of $0.95 and producers with 12 or less years of formal education required a price difference of $1.35 to even out production.

The DHI and non-DHI farmers had statistically different seasonality coefficients at every price differential except $2.00 and $3.00, with the DHI members having lower levels of seasonality than non-DHI members on average at these price differentials. The results showed that a balance between spring and fall production would be achieved at a $1.03 differential for DHI members and a $1.35 differential for nonmembers. These results support the hypothesis that efficiency and management ability are directly related to degree of price responsiveness to these programs since education and DHI membership likely reflect producers' managerial skill level.

Size of herd and production per cow were found to significantly affect production response to the hypothetical programs. Operations with smaller herds had significantly higher seasonality coefficients for the $0.00 through $1.00 differentials than farms with larger herd sizes. Not surprisingly, farmers with more than 65 cows required a lower seasonal price difference ($0.97) to balance spring and fall production than operations with 65 or fewer cows,

Table 1. Milk Production Response by Seasonal Price Differential for Selected Groups in the Survey Sample

Price Difference ($/Cwt.)	Education: <=12 Yrs (SC)	Education: 12+ Yrs (SC)	t-stat*	DHI: Member (SC)	DHI: Nonmember (SC)	t-stat*	Herd Size: <=65 Cows (SC)	Herd Size: >65 Cows (SC)	t-stat*
$0.00	0.214	0.164	2.160	0.174	0.230	−2.065	0.210	0.166	1.869
$0.35	0.176	0.115	2.940	0.130	0.189	−2.426	0.165	0.124	1.937
$1.00	0.039	−0.010	1.940	0.002	0.047	−1.330	0.030	−0.003	1.331
$2.00	−0.070	−0.163	2.695	−0.123	−0.097	−0.617	−0.097	−0.137	1.151
$3.00	−0.087	−0.258	2.512	−0.180	−0.148	−0.450	−0.149	−0.196	0.652
Balancing Price Diff ($/cwt)**	$1.35	$0.95		$1.03	$1.35		$1.23	$0.97	
No. of Observations	174	169		248	95		184	159	

Price Difference ($/Cwt.)	Lbs of Milk Produced/Cow: <=14000 (SC)	Lbs of Milk Produced/Cow: 14001+ (SC)	t-stat*	Age: <= 42 Yrs (SC)	Age: >42 Yrs (SC)	t-stat*	Hrs/Cow/Day Pasture Time: <12 Hrs (SC)	Hrs/Cow/Day Pasture Time: >=12 Hrs (SC)	t-stat*
$0.00	0.213	0.166	1.991	0.167	0.217	−2.083	0.176	0.202	1.092
$0.35	0.171	0.122	2.337	0.124	0.174	−2.320	0.132	0.160	1.331
$1.00	0.028	−0.002	1.097	−0.008	0.044	−1.977	0.004	0.026	0.840
$2.00	−0.112	−0.125	0.378	−0.140	−0.086	−1.547	−0.121	−0.110	0.315
$3.00	−0.177	−0.179	0.035	−0.188	−0.150	−0.583	−0.167	−0.175	−0.109
Balancing Price Diff ($/cwt)**	$1.20	$1.00		$0.95	$1.35		$1.03	$1.19	
No. of Observations	152	191		191	152		172	171	

*Two-tailed t-test for whether the means of the two groups are equal.

**Seasonal price differential that results in equal spring and fall milk production.

which required an average differential of $1.23. Producers with higher herd averages (greater than 14,000 pounds of milk per cow) had statistically lower seasonality coefficients than farmers with lower herd averages (14,000 pounds or less) for $0.00 through $1.00, but not for the $2.00 to $3.00 price difference intervals. The results imply that the higher producing herd group, on average, would balance production at a price differential of $1.00, while the lower herd average group would do so at a price difference of $1.20.

The relationships between age and price responsiveness, and between the average number of hours per day that cows were pastured in May and June and price responsiveness, were also statistically significant for lower price differentials. Farmers older than 42 years of age required a price differential of $1.35 to balance seasonal production, while farmers younger than 42 years of age needed only $0.95 to accomplish this. This result is probably highly correlated with the education result, implying better management skills of younger and more educated producers. Producers that relied significantly on pasture feeding in the spring were more seasonal than farmers that utilize pasture less intensively for the $0.00 and $0.35 differentials, but not for the $1.00 to $3.00 differentials. The average price differential necessary to balance out production for these two groups was $1.19 and $1.03, respectively. However, based on t-ratios, these two average price differentials were not statistically different from each other at the 10% significance level.

Summary and Implications

The purpose of this research was to analyze expected production response to four hypothetical seasonal price differentials designed to lessen seasonality in New York, including $0.00, $1.00, $2.00, and $3.00 per cwt. price deductions/premiums. Anticipated production response was estimated using data from a random mail survey and federal milk marketing order farm level data on survey respondents. A total of 343 producer responses were used in the estimating production response and two simulations were performed. The first simulation was performed on the entire sample to determine: (1) estimated seasonality coefficients by price differential; (2) the estimated differential needed to balance spring and fall milk production; and (3) to test whether there was a statistical difference between the Louisville plan and no seasonal price differential on seasonality. The second simulation examined whether certain sub-groups in the sample would respond differently to the price differentials.

The results of the first simulation showed that the seasonality coefficient ranged from 0.19 to −0.17 for the $0.00 to $3.00 per cwt. differentials. Furthermore, the empirical evidence suggests that it would take a seasonal price differential of about $1.12 per cwt. to eliminate seasonality in New York, over three times the current differential. In addition, it was shown that the current Louisville plan is effective in significantly reducing seasonality compared with no program at all. The results of the second simulation illustrated several striking differences between sub-groups of farmers in the sample. In general, producers who: were members of DHI, had more years of formal education, had larger herd sizes and greater production per cow, were younger, and who relied less intensively on pasture feeding were able to balance spring and fall production at a lower price differential than their counterparts in the sample.

There are several important comments worth noting. The $1.12 price differential estimated in this research to balance seasonality would likely be unacceptable to farmers. Moreover, a $1.12 price penalty/premium would probably be rejected by the overseers of the federal milk marketing order program, the Agricultural Marketing Service of USDA. Thus, it appears that seasonality will not be totally eliminated through the pricing structure alone, which is not surprising.

On the other hand, the present price differential under the Louisville plan is probably too low, since it has not been adjusted since 1972. In real terms, the current differential is far lower than it was in 1972. For example, when deflated by the consumer price index, the $0.35 differential today is less than one-half of what it was in 1972. Consequently, doubling the current seasonal price differential in New York may be reasonable and politically acceptable. Based on the empirical estimates of expected production response in Figure 2, if the $0.35 differential was increased to $0.70, the seasonality coefficient would fall from 0.15 to 0.08, reducing seasonality to one-half its current level. The same result might be accomplished with a Base-Excess program, if the differential was equivalent to this. Policy makers might also consider changing these differentials from an absolute amount to a percentage of the annual average price so that inflation would not erode the differential. For example, rather than doubling the current differential to $0.70, the differential could be fixed at 6% of the market price ($0.70 divided by the 1986 annual average price $12.09). Using this or a comparable adjustment mechanism would protect the financial incentives offered by these programs from becoming trivial in inflation adjusted terms.

While seasonal price incentives alone are not likely to eliminate seasonality completely, the findings in this study are promising. Increasing the current differential would be expected to have a significant impact on this problem. Additionally, educational programs by institutions such as dairy cooperatives and Cooperative Extension to make farmers aware of the problem and to offer advice on management techniques to lower seasonality would undoubtedly help. Finally, if cooperatives and proprietary handlers found it profitable to implement their own seasonal plans in addition to those of the federal milk marketing order's, further reductions in seasonality are possible.

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