# The Effects of FMMOs Pricing Regimes on Milk Price Behavior and Dairy Farm Profitability

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**Abstract**

This research evaluates the effects of the key changes that took place in the design of Class III milk pricing within Federal Milk Marketing Orders (FMMOs) on milk price behavior and dairy farm profitability over three milk pricing regimes: Minnesota-Wisconsin price series (1960s – 1995), Basic Formula Price (1995-1999) and Multiple Component Pricing (2000-present). An autoregressive conditional heteroscedasticity (ARCH) model is estimated to evaluate the effects of changes in the dairy industry institutional environment on the Class III milk price level and volatility over the analyzed period of time. The empirical evidence presented in the paper indicates that changes in the level of Class III milk price were rather minor in magnitude. However, changes in the milk price volatility were dramatic. There is empirical evidence indicating that the private Exchange spot cheese price is the main determinant of the Class III milk price, which is consistent with the design of Class III milk pricing during the analyzed FMMOs milk pricing regimes.

**Key words:** dairy farm profitability, Federal Milk Marketing Orders, milk price volatility, regulated pricing.

## 1. Introduction

The performance of the system of milk pricing within Federal Milk Marketing Orders (FMMOs) has attracted increased attention in the dairy industry community, government and academia (GAO Report 2007; Carstensen 2010; DOJ and USDA Workshops 2010a,b; USDA DIAC 2011**)**. First, a dramatic increase in the volatility of milk prices received by dairy farmers observed during the recent decade has adversely affected dairy farm profitability. Second, the effects that the private Exchange spot cheese market (currently Chicago Mercantile Exchange spot cheese market) has on FMMOs milk pricing have raised concerns because of the susceptibility of this market to price manipulations. The design of the Federal milk pricing system has evolved over the last several decades. As a result, the effects of the Exchange spot cheese prices on FMMOs milk pricing have increased.

The core of the FMMOs classified pricing system is manufacturing milk price (currently Class III milk price; BFP and M-W price in the past). In addition to being used to price a large share of raw milk used in manufactured dairy products (currently cheese), this price has been a mover of the overall pricing structure within FMMOs. The procedure of Class III milk price determination changed from this price being based on unregulated manufacturing grade milk price to this price being calculated using a series of price formulas, where wholesale cheese price is the major determinant.

The Exchange spot cheese prices have historically affected dairy industry pricing. The Exchange spot cheese prices have been used as reference prices in cheese contracts used to transact more than 90% of cheese produced in the country. Furthermore, they began affecting pricing of Class III milk within FMMOs by being used in the milk price determination procedure beginning in 1995. Starting in January 2000, the USDA National Agricultural Statistics Service (NASS) survey-based cheddar cheese prices are used in the Class III milk price formulas. These prices are practically at the same level as the Exchange spot cheese prices (Table 1), because surveyed cheese manufacturing plants report prices referenced to the Exchange spot cheese prices.

The objective of this research is to analyze changes in the Class III milk price behavior over three FMMOs milk pricing regimes: Minnesota-Wisconsin price series, Basic Formula Price, and Multiple Component Pricing. The changes in the level and volatility of Class III milk price are evaluated by taking into account the key changes in the dairy industry institutional environment and the effect of the Exchange spot cheese prices. The changes in the Class III milk price behavior

are compared to the changes in milk production costs over the analyzed period to evaluate their effects on the dairy farm profitability.

The paper is organized as follows. Section 2 provides a background on the design of FMMOs milk pricing system over three milk pricing regimes: Minnesota-Wisconsin price regime (M-W regime), Basic Formula Price (BFP regime) and current Multiple Component Pricing regime (MCP regime). The increasing role of the Exchange spot cheese prices in FMMOs milk pricing is highlighted. Section 3 presents a descriptive statistical analysis providing a preliminary empirical evidence on the Class III milk price behavior over three milk pricing regimes. Section 4 develops an econometric model, and it is followed by Section 5 discussing the estimation results. Section 6 presents the dairy farm profitability analysis, and it is followed by the conclusion.

## 2. FMMOs Milk Pricing Regimes and the Design of Class III Milk Pricing

The FMMOs classified milk pricing system determines the minimum prices for Grade A milk that regulated milk handlers at the first level (i.e. processors and manufacturers) have to pay based on the final (end) use of milk represented by a number of milk classes. Milk pricing within FMMOs has historically been based on a classified pricing principle. The price of milk used to produce fluid milk products (i.e. Class I milk) has been tied to the price of milk used for manufacturing purposes (i.e. currently Class III milk) and has been higher than this price.

Milk classes are distinguished from milk grades. There have been two grades of milk: Grade A and Grade B. Only Grade A milk can be used to produce fluid milk products; it can also be used to produce manufactured dairy products. Grade B milk can only be used in manufactured dairy products. Originally, Grade B milk had to meet somewhat lower sanitary standards than Grade A milk, and consequently Grade B milk had lower production costs. Pricing of Grade B milk has never been regulated, and this price was a result of the interaction of supply and demand conditions. Over time, production of Grade A milk increased and production of Grade B milk decreased. In 1999 approximately 97% of all milk marketed satisfied Grade A standard; about 60-65% of this milk was used to produce manufactured dairy products (Manchester and Blayney 2001).

***Minnesota-Wisconsin (M-W) price regime (1960s-1995)***

In early 1960s, the Minnesota-Wisconsin (M-W) price was introduced as a base price for manufacturing milk within FMMOs. The M-W price was the average price calculated based on prices paid for Grade B milk by manufacturers of cheese, butter and non-fat dry milk in Minnesota and Wisconsin, which represented a region of surplus production of manufacturing grade milk. The M-W milk price represented the value of milk under unregulated competitive environment. The M-W price was calculated using a two-stage procedure and was based on prices collected through systematic surveys conducted by the USDA National Agricultural Statistics Service (NASS) (USDA ERS Dairy Outlook 1996).

At the first stage, each month approximately 170 plants located in Minnesota and Wisconsin were surveyed to collect prices that they actually paid for Grade B milk during the previous month. At this stage, the base month M-W price was calculated as the average price for all milk of manufacturing grade delivered f.o.b plant or receiving station. At the second stage, the change from the base month was determined by using a survey of a smaller group of plants conducted to collect prices actually paid during the first half of the base month, and to get opinions as to the price expected to be paid during the second part of the base month. The final M-W price was determined using the base-month price, information collected at the second stage and historical prices of milk and manufactured dairy products. The final M-W price was announced no later than the 5$^{th}$ of the month following the base month[1].

During this period of time another Federal program, Milk Price Support Program**,** affected dairy industry pricing. This program established support prices for manufactured dairy products (cheddar cheese, butter and non-fat dry milk), which were tied to the support price for milk used for manufacturing purposes. These price supports performed a price floor function. Commodity Credit Corporation (CCC) guaranteed to purchase any amount of specified manufactured dairy products that manufacturers were willing to sell at the announced support prices. When the M-W price was below the milk price support level, the latter was used as a base price in FMMOs milk price determination procedure.

As for the prices paid for cheese in contract cheese market, they were formula-based and were referenced to cheese prices at the Wisconsin Cheese Exchange spot market (Plymouth, WI). In 1975, Wisconsin Cheese Exchange was renamed as the National Cheese Exchange and was

[1] For example, if the base month was April, the April M-W price was announced on or before May, 5$^{th}$.

moved to Green Bay, WI[2]. The Exchange spot cheese prices directly affected cheese prices specified in cheese contracts. Contract cheese prices influenced prices paid for Grade B milk, which in turn affected the level of M-W price within FMMOs. A substantial decrease in the level of government intervention in cheese purchases and sales during the mid-1980s increased the role of the Exchange as a market-based mechanism in the price determination process in the dairy industry.

During the period of 1960-1990, the quantity of Grade B milk produced and the number of plants processing Grade B milk began to decrease (GAO Report 1989). This situation posed a question of the value of using M-W milk price series for the purpose of milk pricing in FMMOs, and consequently it was replaced with the Basic Formula Price (BFP).

***Basic Formula Price (BFP) regime (1995-1999)***

The BFP was introduced in June 1995, and it was a temporary alternative because the share of Grade B milk was projected to decline. The BFP still reflected the value of unregulated Grade B milk in Minnesota and Wisconsin. The BFP aimed to better reflect the value of Grade A milk used in dairy product manufacturing within FMMOs. The BFP was calculated using a two-stage procedure (USDA ERS Dairy Outlook 1996). The first stage was exactly the same as the first stage in the M-W price determination procedure. The base-month price under BFP still reflected the value of unregulated Grade B milk in Minnesota and Wisconsin.

The novelty of BFP was in the second stage, when the change (adjustment) to the base-month price was determined. This change was calculated as the difference in the value of milk used for manufacturing purposes between the base and previous months. The value of milk was calculated using wholesale prices of selected manufactured products (cheddar cheese, butter, nonfat dry milk and buttermilk powder) and manufactured product yield rates. This approach to pricing is based on a multiple component principle, which is also referred to as price formula. The value of milk was determined using the value of cheese (equation [1]) and the value of butter and non-fat dry milk (equation [2]).

$$\text{Cheese value} = 9.87 * P_{\text{cheese}} + 0.238 * P_{\text{butter}} \quad [1]$$

$$\text{Butter/NFDM value} = 4.27 * P_{\text{butter}} + 8.07 * P_{\text{NFDM}} + 0.42 * P_{\text{buttermilk powder}} \quad [2]$$

[2] Wisconsin Cheese Exchange (Plymouth, WI) was organized in 1918 and became a primary location of the cheese exchange activities in the country. A historical overview of the cheese exchanges is presented in Hamm and March (1995), Mueller et al (1996) and Manchester and Blayney (1997).

The constants used in the formulas are the average yield rates. For example, 9.87 in equation [1] indicates that 9.87 pounds of cheese are produced from 100 pounds of milk. In the case of cheese, the National Cheese Exchange (NCE) spot price for cheddar cheese sold in 40 pound blocks was used in the formula. Starting in May 1997, when the spot cheese market was moved from NCE to Chicago Mercantile Exchange (CME), the USDA NASS survey-based price of cheddar cheese sold in 40 pound blocks replaced the NCE spot cheese price in milk price formula. The final BFP was the sum of the base month price and the adjustment. The price announcement procedure remained the same.

During the period of 1995-1999, the role of the Exchange spot cheese market in the dairy industry became more complex, as compared to the pre-1995 period. In addition to being used as reference prices in contract cheese market, the Exchange spot cheese prices started influencing pricing of milk within FMMOs.

It should be mentioned that the move of the spot cheese market from NCE to CME was accompanied by a number of changes (GAO Report 2007). The frequency of trading was changed from a weekly trading at NCE to a daily trading at CME. While at NCE traders were required to be present in person and their identities were known, the CME trading was anonymous and traders were represented by professional brokers. As compared to NCE, CME spot cheese market is under a stronger regulatory oversight.

***Multiple Component Pricing Regime (2000-present)***

As a result of the Federal Order reform, a completely new milk pricing system was introduced in January 2000. The BFP was replaced with a set of formulas conceptually similar to the adjustment used in BFP calculation. Since January 2000 Class III milk price is calculated using a series of price formulas (equations [3] – [7][3]), which include the values of key components (protein, other solids and butterfat) of the final (end) products manufactured from raw milk (cheese, butter and whey). The level of Class III milk price is affected by wholesale prices of these products, the average yield rates and plant processing costs.

[3] Milk price formulas and related discussion can be found on the USDA Agricultural Marketing Service web-page under Milk Marketing Order Section (link “prices” and link “milk prices-description”). Class III milk price is in $ per hundredweight (cwt), and final product prices are in $ per pound.

*Class III milk price = Class III skim milk price *0.965 + Butterfat price *3.5* [3]

*Butterfat price = (Butter price – 0.1715)*1.211* [4]

*Class III skim milk price = Protein price *3.1 + Other solids price *5.9* [5]

*Other solids price = (Dry whey price – 0.1991)*1.03* [6]

*Protein price = (Cheese price – 0.2003)*1.383 +*

*[(Cheese price – 0.2003)*1.572 – Butterfat price *0.9]*1.17* [7]

The formula constants are of two types. The constants subtracted from the product prices are the plant manufacturing allowances that approximate manufacturing costs (not including milk cost). The constant by which the difference between the product price and plant manufacturing allowance is multiplied represents the manufactured product yield rate.

Equations [3] – [7] can be simplified to express Class III milk price as a function of wholesale prices of cheese, butter and dry whey (equation [8]). The cheese value is a major determinant of the Class III milk price level[4].

*Class III milk price =*

*= 9.6393*Cheese price + 0.4237*Butter price + 5.8643*Dry whey price – 3.1713* [8]

The cheese price used in Class III milk price formulas is determined by the USDA Agricultural Marketing Service using the USDA National Agricultural Statistics Service survey-based wholesale cheese prices. USDA NASS calculates and reports average monthly prices of cheddar cheese sold in 500 pound barrels and 40 pound blocks (these are the same styles of cheese that are currently traded at CME spot cheese market)[5]. The monthly average prices for two cheese styles are calculated by weighting weekly cheese prices by cheese volume. The cheese price determined by the USDA AMS for the purpose of FMMOs pricing is based on prices of both styles of cheddar cheese (barrel and blocks). As in the case of M-W and BFP milk pricing regimes, Class III milk price is announced on or before the 5$^{th}$ of the month which follows the month to which this price applies.

During the analyzed period of time, the spot cheese market takes place at the Chicago Mercantile Exchange. As before, its prices have a direct effect on cheese prices set in cheese contracts, and they continue influencing the level of Class III milk price. Due to the nature of Class

[4] For example, in 2009, the share of cheese value in Class III milk price was in the range of 83.14-89.57%, with the average of 86.12% (Bolotova and Novakovic 2011).

[5] The survey description and reports are available on the USDA NASS web-page (USDA NASS Dairy Product Prices).

III milk price formulas, the effect of CME cheddar cheese prices on milk pricing is stronger in the modern MCP regime, as compared to BFP regime. First, the MCP price determination procedure completely avoids using the value of unregulated Grade B milk. Second, the level of Class III milk price under MCP is directly related to the level of wholesale cheese price.

In summary, the design of Class III milk pricing within FMMOs evolved from this price being based on unregulated Grade B milk price to being determined using wholesale prices of manufactured dairy products, with cheese price being a major determinant. The identified changes in the design of Class III milk pricing have intensified the effects that the Exchange spot cheese prices have on Class III milk pricing.

## 3. Descriptive Statistical Analysis

While the design of Class III milk pricing within FMMOs has evolved over time, the Exchange spot cheese prices have historically affected Class III milk price determination procedure. During the recent decades, only cheddar cheese has been traded at the Exchange spot cheese market. In particular, two styles of cheddar cheese: cheddar sold in 40 pound blocks and cheddar sold in 500 barrels[6]. Therefore, the empirical analysis proceeds with analyzing the behavior of Class III milk price and the Exchange spot cheddar cheese prices. The analyzed Class III milk price is the announced price, which is the minimum price that the first level handlers have to pay for Class III milk.

This section presents a preliminary empirical evidence on the changes in the level and volatility of Class III milk price and the Exchange cheddar cheese prices over the analyzed milk pricing regimes. The monthly cheddar cheese prices and Class III milk prices used in the empirical analysis are obtained from the USDA Agricultural Marketing Service Dairy Market Statistics Annual Summaries and Milk Marketing Order Statistics public database.

To capture the effects of the key changes in the dairy industry institutional environment, the Minnesota-Wisconsin price regime is split into two periods. The first one is associated with active milk price support (01/83-12/89), and the second one is associated with inactive milk price support (01/90-05/95). Furthermore, the BFP regime is also divided into two periods. The first one

[6] Cheddar sold in 40 pound blocks is used to produce cut and wrapped cheeses. Cheddar sold in 500 barrels is used to manufacture processed cheese products. The Exchange spot cheese prices of cheddar block and cheddar barrel typically move in a very similar manner.

(BFP/NCE) encompasses the time period when the spot cheese market took place at the National Cheese Exchange (06/95-04/97). The second one (BFP/CME) encompasses the time period when the spot cheese market took place at the Chicago Mercantile Exchange (05/97-12/99). The average milk and cheese prices and the coefficients of variations are calculated for each analyzed period/regime (Table 2). Figure 1 depicts Class III milk price and cheddar block price over the analyzed regimes/periods.

The changes in the average level of milk and cheese prices are rather small in magnitude, but the changes in the volatility of these prices are dramatic across the analyzed regimes/periods. The increase in the level of milk and cheese prices is in the range of 15%-17% between M-W regime with active milk price support and MCP regime. The cheese price volatility increased by 186%, and the milk price volatility increased by 243% during the same period of time. There were no any significant changes in the level and volatility of cheese and milk prices between the two sub-periods of M-W regime (active and inactive Milk Price Support Program).

The largest magnitude milk and cheese price increases correspond to BFP/NCE period. As compared to M-W regime with inactive milk price support, the average cheese and milk prices increased by approximately 9-10%. A shift from BFP/NCE period to BFP/CME period is characterized by the most dramatic increase in the volatility of cheese and milk prices, and by a rather minor increase in the average level of these prices. The volatility of cheddar barrel (block) price increased by 50% (67%), and the volatility of milk price increased by almost 90%. The move of the spot cheese market from NCE to CME was accompanied by a change in the trade frequency. A daily trading at CME, as compared to a weekly trading at NCE, might have been a major cause of the observed increase in the cheese price volatility, and consequently in the milk price volatility.

A shift from BFP/CME period to MCP regime is characterized by a rather small increase in the level of cheese and milk prices and by a substantial increase in their volatility. The average cheddar barrel (block) price increased by 3.6% (2.1%), and the average milk price increased by 6%. The cheese price volatility increased by 33%, and the milk price volatility increased by 41%.

Given that under current MCP regime Class III milk price is determined using a series of price formulas, which practically align the behavior of this price and cheese price, this design of the milk price determination procedure might have contributed to the observed increase in the volatility of milk price in MCP regime, as compared to BFP regime. The use of a survey-based wholesale prices of three different manufactured dairy products (cheese, butter and whey) in milk

price formulas is likely to contribute to the observed increase in the volatility of milk price relative to the volatility of cheese price.

## 4. Econometric Model

The objective of the econometric analysis is to evaluate the magnitude and statistical significance of the differences (changes) in the level and volatility of Class III milk price over three milk pricing regimes. In the econometric analysis, BFP/NCE and BFP/CME are used as separate periods. The price observations corresponding to M-W regime with active Milk Price Support program are excluded. In the case of MCP regime, only the first three years of price data are included to make a number of observations approximately equal across the analyzed milk pricing regimes.

An autoregressive conditional heteroscedasticity (ARCH) model is used to conduct econometric analysis. A general specification of the ARCH(m) model used in this research is represented by equations [9] and [10][7]. Equation [9] describes the conditional mean process, and equation [10] describes the conditional variance process over time. In the conditional mean equation, the dependent variable (*Y*) is a function of a set of exogenous variables ***(Z***). The dependent variable in the conditional variance equation (i.e. the current variance of *Y*) is the squared error term from the conditional mean equation; it is modeled as a function of the past variances (i.e. the ARCH effect)[8]. The conditional variance equation can be expanded by including a set of exogenous variables of interest that are hypothesized to affect the conditional variance process over time .

$$y_t = \psi_0 + \psi_1 \times \overline{z_t} + u_t \text{ [9]} \qquad [9]$$

$$u_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \alpha_2 \times u_{t-2}^2 + \ldots + \alpha_m \times u_{t-m}^2 + v_t \text{ [10]} \qquad [10]$$

[7] A noise process $u_t$ satisfying variance equation [10] is described as an autoregressive conditional heteroscedastic process of order *m*, denoted as ARCH(m).

[8] See Wooldridge (2003) for a discussion of this particular specification of the ARCH model.

[9] $u_t$ is a white noise, $E(u_t) = 0,\ \ E(u_t u_s) = \sigma^2$ for $t = s$ and 0 otherwise.

[10] The sufficient stationarity (regularity) condition requires $\alpha_0 > 0$ and $\alpha_j \geq 0$ for all $j \leq m$.

Equations [11] and [12] represent the specification of the ARCH (1) model[11] to be estimated to evaluate changes in the Class III milk price and variance over the analyzed milk pricing regimes/periods.

$$MP_t = \psi_0 + \psi_1 \times CP_t + \psi_2 \times BFP/NCE_t + \psi_3 \times BFP/CME_t + \psi_4 \times MCP_t + u_t \quad [11]$$

$$u_t^2 = \alpha_0 + \alpha_1 \times u_{t-1}^2 + \alpha_2 \times BFP/NCE_t + \alpha_3 \times BFP/CME_t + \alpha_4 \times MCP_t + v_t \quad [12]$$

$MP_t$ (\$/pound) is Class III milk price in month *t*. The Class III milk price is originally announced in \$/hundredweight. For the purpose of empirical analysis it is converted in \$/pound to be comparable with cheese price[12]. $CP_t$ (\$/pound) is the average Exchange cheddar cheese price (the average of cheddar block and barrel) in month *t*. Class III milk price is announced on a monthly basis. Therefore, only the current month cheese price is hypothesized to influence the current month Class III milk price.

$BFP/NCE_t$ is a binary variable. It is equal to 1 if a milk price (variance) observation belongs to the Basic Formula Price and National Cheese Exchange period (06/1995-04/1997), and it is equal to 0 otherwise. $BFP/CME_t$ is a binary variable. It is equal to 1 if a milk price (variance) observation belongs to the Basic Formula Price and Chicago Mercantile Exchange period (05/1997-12/99), and it is equal to 0 otherwise. $MCP_t$ is a binary variable. It is equal to 1 if a milk price (variance) observation belongs to the first three years of the Multiple Component Pricing regime (01/2000-12/2002), and it is equal to 0 otherwise. The observations belonging to the Minnesota-Wisconsin milk pricing regime with inactive milk price support (01/1990-05/1995) represent the reference group[13].

According to the milk price formulas used in BFP and MCP regimes, the estimated coefficient for cheese price in the conditional mean equation is expected to be in the range of 0.964-0.987. The economic meaning of this coefficient is the yield rate. The estimated coefficients for binary variables are to be interpreted as follows. The estimated coefficients in the milk price

[11] In ARCH(1) model m=1, indicating that only the first lag of the squared error term is included in the conditional variance equation. During the preliminary estimation stage, more than one lag of the squared error term was included in the econometric model, but they lacked statistical significance.

[12] Class III milk price in \$/cwt is divided by 10 to convert in \$/pound. Approximately 10 pounds of milk is required to produce one pound of cheese.

[13] A set of monthly binary variables was included in the ARCH(1) model during the preliminary estimation stage. As a group, these variables were not statistically significant. Therefore, they were not included in the final specification of the ARCH(1) model.

equation $\psi_2$, $\psi_3$ and $\psi_4$ capture the shifts in the Class III milk price level in BFP/NCE, BFP/CME and MCP regimes/periods, respectively, relative to M-W price regime with inactive milk price support. The estimated coefficients in the conditional variance equation $\alpha_2$, $\alpha_3$ and $\alpha_4$ capture the shifts in the milk price variance in BFP/NCE, BFP/CME and MCP regimes/periods, respectively, relative to M-W price regime with inactive milk price support. The ARCH(1) model is estimated using the Ordinary Least Squares (OLS) estimation procedure.

## 5. Estimation Results

Table 3 summarizes the ARCH(1) model estimation results for two specifications of the econometric model. One model specification is as discussed earlier. Another model specification includes only binary variables for the analyzed regimes/periods. In the case of the econometric model specification with binary variables only, R2 in the conditional mean equation is 0.18, and R2 in the conditional variance equation is 0.63. This suggests that variation in the binary variables for BFP/NCE regime/period, BFP/CME regime/period and MCP regime explains 18% of variation in the Class III milk price and 63% of variation in the conditional price variance. Including the Exchange spot cheese price in the econometric model increases R2 in the conditional mean equation to 90% and decreases R2 in the conditional variance equation to 0.09%. This provides empirical evidence indicating that the Exchange spot cheese price is the main determinant of the Class III milk price.

*Conditional mean equation*

The estimated coefficient for the Exchange spot cheese price is 0.94. After multiplying by 10, this coefficient should be compared to the coefficients in the Class III milk price formulas: 9.87 in BFP regime and 9.64 in MCP regime. The estimated coefficient for the Exchange spot cheese price is within the expected range and is statistically significant. If the current month average Exchange spot cheese price (average of cheddar block and cheddar barrel) increases (decreases) by $1/pound, the current month Class III milk price increases (decreases) by $0.94/pound or by $9.4 per hundredweight.

The estimated coefficient for BFP/NCE regime/period is not statistically significant. The estimated coefficients for BFP/CME regime/period and MCP regime are -0.03 and -0.05, and they are statistically significant. These estimation results imply that while controlling for variation in the Exchange spot cheese price, the average Class III milk price in BFP/NCE regime/period is at

approximately the same level as in M-W price regime with inactive milk price support (reference group). The average Class III milk price is lower by $0.03/pound ($0.3/cwt) and $0.05/pound ($0.5/cwt) in BFP/CME regime/period and MCP regime, as compared to M-W price regime with inactive milk price support.

There is no statistically significant difference between the average Class III milk price in BFP/NCE regime/period and BFP/CME regime/period (Table 3: Z-test ratio/p-value are 1.12/0.2628). Similarly, there is no statistically significant difference between the average Class III milk price in BFP/CME regime/period and MCP regime (Table 3: Z-test ratio/p-value are 1.15/0.2537). In contrast, the average Class III milk price in BFP/NCE regime/period is statistically higher than in MCP regime (Table 3: Z-test ratio/p-value is 2.65/0.0088).

If we assume that the average Exchange spot cheese price is on average at approximately the same level over the analyzed period of time, the announced average Class III milk price is lower in BFP/CME regime/period and MCP regime, as compared to M-W price regime and BFP/NCE regime/period.

*Conditional variance equation*

The estimated coefficient for BFP/NCE regime/period is not statistically significant. The estimated coefficients for BFP/CME regime/period and MCP regime are 0.006 and 0.003, and they are statistically significant. This implies that the Class III milk price conditional variance is higher in these two regimes, as compared to M-W price regime with inactive milk price support (reference group). The BFP/NCE conditional variance is statistically lower than the BFP/CME conditional variance (Table 3: Z-test ratio/p-value are -2.37/0.0186) and the MCP conditional variance (Table 3: Z-test ratio/p-value are -1.32/0.1884).

The BFP/CME conditional variance is not statistically different from the MCP conditional variance (Table 3: Z-test ratio/p-value are 1.26/0.2079). In the latter case, the Z-ratio is 1.26, which is very close to a cut-off value of 1.28[14]. This test outcome suggests that the conditional variance in BFP/CME regime/period may be considered to be statistically higher than the conditional variance in MCP regime.

The estimation results indicate that the Class III milk price variance is not different between BFP/NCE regime/period and M-W price regime with inactive price support. However, the conditional variance shift between BFP/NCE and BFP/CME is positive, statistically significant

[14] A note to Table 3 explains Z-tests.

and the largest in magnitude. This empirical evidence supports the hypothesized effect of the increase in trade frequency during the period when the spot cheese market was moved from the National Cheese Exchange (a weekly trading) to the Chicago Mercantile Exchange (a daily trading).

In summary, the ARCH(1) model estimation results indicate that the level of the announced average Class III milk price (while controlling for variation in the Exchange spot cheese price) has not increased, but the price variance has increased over the analyzed milk pricing regimes.

## 6. An Analysis of Dairy Farm Profitability

Table 4 presents descriptive statistics (the averages and the coefficients of variation) of selected data from milk production budgets developed by the USDA Economic Research Service. The milk value, gross value, variable costs and total production costs (all in $/cwt) are used in the dairy farm profitability analysis presented in this section. The averages and coefficients of variation are calculated for these variables for each analyzed milk pricing regime. Also, the announced average Class III milk price and its coefficient of variation (from Table 2) are included in the analysis.

The announced Class III milk price is the minimum price that first level handlers have to pay for Class III milk. In addition, the announced Class III milk price is the mover of the overall FMMOs milk pricing structure. Dairy farmers within the same FMMO receive a mail-box price, which is based on prices received for all milk classes sold in this Order. The mail-box price also includes adjustments, such as the over-order premiums (which marketing cooperatives negotiate with dairy processors) and payments of dairy farmers to cooperatives involved in milk marketing. The milk value reported in milk production budgets reflects the mail-box price. During the analyzed period of time, the share of the announced Class III milk price in the milk value is 91% on average. Gross value includes milk value, other income from dairy operation and livestock sales. The share of milk value in gross value is 90% on average.

The average Class III milk price increased from $11.74/cwt in M-W price regime with active milk price support to $13.80/cwt in MCP regime (an 18% increase). In a similar manner, the reported milk value increased from $12.89/cwt to $15.39/cwt during the same period of time (a 19% increase). The total milk production costs increased from $13.34/cwt to $20.32/cwt (a 52% increase).

The total milk production costs are approximately equal to milk value during M-W price regime with active milk price support. During each consequent regime, an increasing divergence between milk value and total milk production costs is observed, because the total milk production costs increased at a much higher rate than milk value (and Class III milk price). As a result, the difference between the gross value and total milk production costs changed from a positive $0.71/cwt in M-W price regime with active milk price support to a negative $3.02/cwt in modern MCP regime. This difference was a positive 5% of the gross value in M-W price regime, and it was a negative 17% of the gross value in MCP regime. While the volatility of the total milk production costs increased 2 times during the analyzed period, the volatility of milk value increased almost 5 times.

## 7. Conclusion

The analysis presented in the paper indicates that the role of the private Exchange spot cheese market and spot cheese prices in FMMOs milk pricing has increased over time and has become most complex in the current MCP regime. Each consequent change in both the design of Class III milk pricing and the Exchange institutional environment as well as the interaction of these changes coincide with the observed increases in the volatility of the Exchange spot cheese prices and Class III milk price. Given that the Class III milk price has historically been a mover of the overall pricing structure within FMMOs, this affects the performance of the overall FMMOs pricing system and consequently the dairy farm profitability.

During M-W price regime, Class III milk price was tied to unregulated Grade B milk price, which reflected milk production costs. In addition, active Milk Price Support Program ensured that dairy farmers avoided financial losses. During the current MCP regime, Class III milk price is a formula-based. It is a function of a survey-based wholesale prices of manufactured dairy products, with cheese being the main determinant. The current Class III milk price tends to be more connected with the revenue side of cheese manufacturing industry and does not have much connection with the cost of dairy farm operations. While milk production costs have been increasing over the last decades, they have not been reflected in the level of Class III milk price, and consequently in the level of milk prices received by dairy farmers within FMMOs.

There are other factors of the dairy industry institutional environment that may have contributed to the observed behavior of milk prices over the analyzed period of time. The most important of them include a diminishing level of domestic government price support and increasing exposure of domestic dairy industry to the fluctuations taking place in international markets, increasing concentration and consolidation at the processing and retail level, and increasing level and volatility of agricultural input prices.

In the absence of milk price support program and in the presence of increasing exposure of domestic dairy industry to the volatility of international dairy markets, the monthly price announcements may contribute to the observed volatility of milk prices. Furthermore, the empirical evidence presented in the paper may suggest that a move from a weekly trade at the National Cheese Exchange to a daily trade at the Chicago Mercantile Exchange might have been a cause of a dramatic increase in the cheese and consequently milk price volatility during BFP regime, as compared to M-W price regime with inactive milk price support. According to current milk price formulas, Class III milk price is a function of wholesale cheese price, which ensures the immediate effect of the Exchange cheese price on the Class III milk price.

Finally, it is important to consider the primary role of the private Exchange spot cheese market and how this role might affect the FMMOs milk pricing. The Exchange spot cheese market is a thin (low volume) market where a relatively small number of sellers and buyers actively participate on a regular basis. The Exchange spot cheese market has historically performed a price discovery function in the cheese industry. The Exchange spot cheese prices have been used as reference prices in cheese contracts used to transact practically all cheese sold in the country.

Cheese pricing strategies in contract market vary and typically depend on the type of buyers (Hayenga 1979; Mueller et al 1996; Manchester and Blayney 1997). At the first handler level, contract prices are based on the Exchange price on the day of cheese production plus a premium. In the case of institutional buyers, a monthly or a weekly price list is developed, and its prices are tied to the Exchange price. Cheese prices in contracts with large food-service chains are based on the Exchange price corresponding to the previous month. Prices of highly differentiated cheese products with well-developed brands sold at the retail level are typically based on weekly price lists. These prices tend to be loosely related to the Exchange prices and are affected by other factors such as the magnitude of marketing costs and margin consideration.

These designs of contract cheese pricing systems may suggest that some of the Exchange spot cheese market participants may have incentives to benefit from lower Exchange spot cheese prices (Mueller and Marion 1997, 2000). The presence of these incentives and the actual ability of market participants to affect the Exchange spot cheese prices (i.e. the effectiveness of their strategic behavior) may have adverse effects on the performance of the FMMOs milk pricing system reflected in a lower Class III milk price and consequently in a lower profitability of dairy farmers.

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Table 1: Wholesale Cheddar Cheese Prices:
Chicago Mercantile Exchange and USDA NASS (2000-2009).

| Year | Wholesale cheddar cheese prices | | | |
|---|---|---|---|---|
| | Chicago Mercantile Exchange spot prices | | USDA NASS survey-based prices used in FMMOs price formulas | |
| | barrel | block | barrel | block |
| | $/pound | $/pound | $/pound | $/pound |
| 2000 | 1.1109 | 1.1465 | 1.0985 | 1.1332 |
| 2001 | 1.4052 | 1.4386 | 1.4039 | 1.4165 |
| 2002 | 1.1438 | 1.1822 | 1.1575 | 1.1808 |
| 2003 | 1.2703 | 1.3172 | 1.2771 | 1.297 |
| 2004 | 1.6036 | 1.6492 | 1.6216 | 1.6325 |
| 2005 | 1.4484 | 1.4928 | 1.4621 | 1.4821 |
| 2006 | 1.219 | 1.2385 | 1.2305 | 1.2318 |
| 2007 | 1.7411 | 1.7578 | 1.7267 | 1.7172 |
| 2008 | 1.8357 | 1.8558 | 1.8836 | 1.8801 |
| 2009 | 1.2518 | 1.2961 | N/A | N/A |
| Average | 1.4030 | 1.4375 | 1.4291 | 1.4412 |

*Data source: USDA Agricultural Marketing Service and USDA National Agricultural Statistics Service.*

Table 2: The Level and Volatility of the Exchange Spot Cheddar Cheese Prices and Class III Milk Price over FMMOs Milk Pricing Regimes (1983-2011).

| | Cheddar barrel price | Cheddar block price | Class III milk price |
|---|---|---|---|
| | $/pound | $/pound | $/cwt* |
| *Minnesota-Wisconsin Price regime with active milk price support and National Cheese Exchange: 01/83-12/89* | | | |
| Average | 1.24 | 1.28 | 11.74 |
| CV** | 0.07 | 0.07 | 0.07 |
| *Minnesota-Wisconsin Price regime with inactive milk price support and National Cheese Exchange: 01/90-05/95* | | | |
| Average | 1.24 | 1.27 | 11.76 |
| CV | 0.08 | 0.08 | 0.08 |
| *Basic Formula Price regime and National Cheese Exchange: 06/95-04/97* | | | |
| Average | 1.35 | 1.40 | 12.77 |
| CV | 0.10 | 0.09 | 0.09 |
| *Basic Formula Price regime and Chicago Mercantile Exchange: 05/97-12/99* | | | |
| Average | 1.39 | 1.44 | 13.00 |
| CV | 0.15 | 0.15 | 0.17 |
| *Multiple Component Pricing regime and Chicago Mercantile Exchange: 01/00-12/11* | | | |
| Average | 1.44 | 1.47 | 13.80 |
| CV | 0.20 | 0.20 | 0.24 |

* Cwt = 100 pounds.
** CV is the coefficient of variation (it is a ratio of the standard deviation to the mean).
Class III milk price is M-W price and BFP in M-W and BFP regimes, respectively.

Table 3: Class III Milk Price Behavior over FMMOs Milk Pricing Regimes:
The ARCH(1) Model Estimation Results.

| Variable | Est. Coefficient (Z-ratio) | Est. Coefficient (Z-ratio) |
|---|---|---|
| *Mean equation: Dependent Variable is milk price ($/pound)* | | |
| Exchange Spot Cheese Price | | 0.94* (30.80) |
| BFP/NCE (06/95 – 04/97) | 0.10* (2.84) | -0.01 (-0.99) |
| BFP/CME (05/97 – 12/99) | 0.12* (2.45) | -0.03* (-1.75) |
| MCP (01/00 – 12/02) | -0.07#2 (-1.43) | -0.05* (-3.79) |
| Constant | 1.18* (79.77) | -0.004 (-0.10) |
| R2 | 0.18 | 0.90 |
| D-W Statistic | 0.42 | 1.76 |
| ARCH test p-value | 0.0000 | 0.0467 |
| BFP/NCE = BFP/CME [a] | -0.41 (0.6839) | 1.12 (0.2628) |
| BFP/CME = MCP [a] | 2.90 (0.0043) | 1.15 (0.2537) |
| BFP/NCE = MCP [a] | 3.03 (0.0029) | 2.65 (0.0088) |
| *Variance equation: Dependent Variable is conditional price variance* | | |
| E2 | 0.746* (13.86) | 0.089 (1.10) |
| BFP/NCE (06/95 – 04/97) | 0.003 (0.41) | -0.0001 (-0.05) |
| BFP/CME (05/97 – 12/99) | 0.012* (2.15) | 0.006* (2.92) |
| MCP (01/00 – 12/02) | 0.007 (1.17) | 0.003#1 (1.63) |
| Constant | 0.001 (0.44) | 0.001 (0.55) |
| R2 | 0.63 | 0.09 |
| D-W Statistic | 1.55 | 1.99 |
| BFP/NCE = BFP/CME [b] | -1.40 (0.1642) | -2.37 (0.0186) |
| BFP/CME = MCP [b] | 0.96 (0.3373) | 1.26 (0.2079) |
| BFP/NCE = MCP [b] | -0.65 (0.5161) | -1.32 (0.1884) |

M-W regime with inactive milk price support (01/90 – 05/95) is the reference group.
The Z-ratios are calculated using autocorrelation-adjusted standard errors based on Newey-West approach.
* The estimated coefficient is statistically significant at the 10% significant level using a two-sided Z-test: Ha: $\beta=0$, Ha: $\beta\neq0$; the Z statistic rejection regions are $(-\infty; -1.64]$ and $[1.64; +\infty)$.
#1 The estimated coefficient is statistically significant at the 10% significance level using a one-sided Z test: Ha: $\beta=0$, Ha: $\beta>0$; the Z statistic rejection region is $[1.28; +\infty)$.
#2 The estimated coefficient is statistically significant at the 10% significance level using a one-sided Z test: Ha: $\beta=0$, Ha: $\beta<0$; the Z statistic rejection region is $[-1.28; +\infty)$.
[a] A Z-test on the change in the milk price level between individual regimes. The cell entry is the Z-ratio and p-value.
[b] A Z-test on the change in the conditional price variance between individual regimes. The cell entry is the Z-ratio and p-value.

Table 4: The Level and Volatility of Milk Price/Value and Milk Production Costs over FMMOs Milk Pricing Regimes (1983 – 2011).

| | Class III milk price | Milk value | Gross value | Variable costs | Total milk production costs | Gross value – Total costs |
|---|---|---|---|---|---|---|
| | $/cwt* | | | | | |
| *Minnesota-Wisconsin Price regime with active milk price support: 01/83-12/89* | | | | | | |
| Average | 11.74 | 12.89 | 14.05 | 8.13 | 13.34 | 0.71 |
| CV** | 0.07 | 0.04 | 0.04 | 0.06 | 0.05 | 0.78 |
| *Minnesota-Wisconsin Price regime with inactive milk price support: 01/90-05/95* | | | | | | |
| Average | 11.76 | 12.97 | 14.49 | 9.72 | 15.02 | -0.53 |
| CV | 0.08 | 0.04 | 0.04 | 0.13 | 0.07 | -2.21 |
| *Basic Formula Price regime: 06/95-12/99* | | | | | | |
| Average | 13.02 | 14.18 | 15.61 | 11.45 | 17.19 | -1.58 |
| CV | 0.15 | 0.08 | 0.07 | 0.06 | 0.04 | -0.84 |
| *Multiple Component Pricing regime: 01/00-12/11* | | | | | | |
| Average | 13.8 | 15.39 | 17.30 | 12.01 | 20.32 | -3.02 |
| CV | 0.24 | 0.18 | 0.17 | 0.20 | 0.10 | -0.70 |
| *% increase between MCP regime and M-W regime with active milk price support* | | | | | | |
| | 18 | 19 | 23 | 48 | 52 | |

* Cwt = 100 pounds.

** CV is the coefficient of variation (it is a ratio of the standard deviation to the mean).

Figure 1: Class III Milk Price and the Exchange Spot Cheddar Block Price (1983 – 2011).