An Empirical Analysis of Wholesale Cheese Pricing Practices on the Chicago Mercantile Exchange (CME) Spot Cheese Market

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Abstract

The CME spot cheese market performs a number of key functions in the United States dairy industry. The CME spot cheese prices are used as reference prices in contract cheese market, and they also influence the government-set prices of milk within the system of Federal and State Milk Marketing Orders. The CME spot cheese market performs a critical price-discovery function in the United States dairy industry. This research evaluates the nature of pricing practices used by CME cheese wholesalers during the period of 2000-2010. The analysis focuses on the farm-to-wholesale price transmission process, which reflects the nature of cost pass-through at the CME spot cheese market. The empirical evidence presented in the paper indicates that the CME wholesale cheese pricing practices are consistent with the ones predicted by the profit-maximization models of oligopolistic behavior. This type of pricing practices is expected to be found in markets with similar to the CME spot cheese market structural characteristics: a small number of sellers trade a homogenous product in a market environment with inelastic demand and limited entry.

Key words: asymmetric price transmission, cheese industry, Chicago Mercantile Exchange, cost pass-through, dairy industry, Federal Milk Marketing Orders, oligopoly, price regulation, spot market, supply chain management.

Introduction

The Chicago Mercantile Exchange (CME) spot cheese market performs a number of key functions in the United States dairy industry[1]. First, it is a market of last resort for buyers and sellers of bulk, commodity cheddar cheese in two forms. The first, block cheddar, is of a type and packaging that is consistent with food manufacturing, foodservice, and retail uses of cheddar cheese. The second, barrel cheese, is of a quality and cost that is oriented towards the production of processed cheese, which is especially important in foodservice. Unanticipated needs or unplanned surges in production result in purchases and sales on the margin. This represents an exceedingly small share of the total market, but the valuation on the spot market has been accepted as an indicator of valuation for the last 100 years.

This leads to the second and perhaps most broadly important function or outcome of the CME spot market. By the design and consent of buyers and sellers, CME spot cheese prices are used as reference prices in the contract market, which encompasses more than 90% of cheese manufactured in the United States. Contract prices are typically established to move with the settled CME price, plus or minus a marginal adjustment that may reflect measurable, functional parameters of the cheese, such as moisture content or fat content, or that may simply reflect premiums or discounts for style (mozzarella, swiss, etc) and packaging (5-pound loaf, frozen, etc).

Third, the CME spot cheese prices influence prices of milk at the farm level set under Federal and some State milk marketing orders[2]. The California Dairy Marketing and Milk Pooling program uses the CME spot cheese prices to establish the value of protein in milk used to make cheese, called Class 4b milk. The Class 4b price may be used in setting the Class 1 price for farm milk used in fluid or beverage milk processing, if it is higher than the Class 4a price, which pertains to butter and nonfat dry milk processors. Federal Milk Marketing Orders (FMMOs) use a similar logic to establish Class III (milk used in cheese manufacturing) and Class I (fluid milk) prices, but instead of using the CME price directly, they use a census-type price survey of bulk cheese (and butter and nonfat dry milk) manufacturers from around the United States. Inasmuch as industry practice is to base contract prices on the CME spot prices, it is no surprise that the CME and USDA reported prices are virtually identical (GAO report 2007; Table 1). Other states that have milk pricing regulations use the FMMO prices by reference or implicitly, for example the Western New York State Order.

[1] The spot (cash) cheese trade has been taking place on the Chicago Mercantile Exchange since 1997, after being moved from the National Cheese Exchange (NCE, Green Bay, WI). The predecessor of the NCE is the Wisconsin Cheese Exchange (Plymouth, WI), where the spot cheese trade started in 1918. Also in the early 1900s, a spot exchange for cheese was located in Cuba, NY. The NY exchange was consolidated with the Plymouth exchange to facilitate a truly national spot market. For a historical overview of cheese exchanges see Hamm and March (1995), Mueller et al. (1996) and Manchester and Blayney (1997).

[2] Almost all raw milk produced in the United States is marketed within the system of Federal and State Milk Marketing Orders, which use the classified milk pricing principle to determine milk prices. Within the system of Federal Milk Marketing Orders, there are four classes of milk that are based on four different final uses of raw milk. Class I milk is used to produce fluid beverage milk products, Class II milk is used to manufacture "soft" dairy products (yogurt, cottage cheese, ice cream, etc.), Class III milk is used to manufacture hard, soft, and cream cheeses and the associated whey products), and Class IV milk is used to produce butter and dry milk.

The CME spot cheese market is a low volume market in which a relatively small number of traders regularly participate. Typically less than 1% of the total volume of cheese produced in the country is traded on it (Table 1; GAO report 2007). Its major participants are large cheese/food processing companies and large agricultural cooperatives manufacturing cheese, who also operate in the contract cheese market. In light of the role that the Exchange spot cheese market plays for milk as well as cheese price discovery in the dairy industry, these CME market characteristics have raised concerns about occasional market manipulations allegedly taking place on this market (Mueller et al. 1996; Mueller, Marion and Sial 1997; Mueller and Marion 2000; GAO report 2007; U.S. Departments of Agriculture and Justice 2010a,b; Carstensen 2010; Gould 2010).

Despite a significant role that the CME spot cheese market performs in the modern dairy industry, research examining pricing issues relevant to this market is practically absent. To the best of our knowledge, only one systematic research project was undertaken, and it was during the time when the spot cheese trade took place on the National Cheese Exchange (NCE) prior to being moved to the CME. Mueller et al. (1996, 1997) and Mueller and Marion (2000) conducted an extensive empirical analysis of the conduct on the NCE and its performance during the period of 1988-1993, when the issue of susceptibility of this market to price manipulations was raised.

In addition, there is a group of empirical studies that analyzed a variety of pricing issues in the overall cheese industry. Chavas and Kim (2004, 2005) evaluated the effects of the price support program performing a price floor function on the price dynamics and price volatility in the U.S. cheese industry. Franklin and Cotterill (1994), Cotterill and Samson (2002) and Kim and Cotterill (2008) examined a number of pricing issues in the national branded cheese industry, including pricing and market strategies, market power and the nature of cost pass-through. Kinnucan and Forker (1987), Awokuse and Wang (2009) and Stewart and Blayney (2011) analyzed asymmetries in the price transmission process at the farm-to-retail and wholesale-to-retail levels of the cheese industry.

Given the importance of the CME spot cheese market in the modern dairy industry and the lack of research relevant to this market, the objective of this paper is to evaluate the nature of pricing practices currently used by the CME spot cheese market participants. The analysis focuses on the farm-to-wholesale price transmission process, which reflects the nature of cost pass-through at the CME spot market for cheddar cheese. The estimated magnitude of cost pass-through can be used to infer pricing methods used by cheese wholesalers, and it is possible to distinguish between a perfectly competitive pricing and an imperfectly competitive pricing. Furthermore, by using an econometric framework that allows for asymmetric adjustment of wholesale cheese prices to increases and decreases in milk price, we can identify whether these asymmetries exist and analyze their nature. The analysis is based on publicly available data reported by various agencies of the United States Department of Agriculture. The period of analysis is January 2000 – December 2010.

The manuscript is organized as follows. First, a discussion of the CME spot cheese market structural characteristics is presented. Next, a traditional theoretical framework used to analyze the mechanism of vertical price transmission is discussed, and is used to develop an econometric model to be estimated. The following sections discuss data and estimation results. The major findings of the analysis are summarized in the conclusion.

Chicago Mercantile Exchange (CME) Spot Cheese Market

The CME spot cheese market is a low volume market and is concentrated. During the period of 2000-2009, less than 1.5% of the total cheddar cheese volume produced in the country was sold on the CME, which represented less than 0.5% of the total cheese production (Table 1). Although there are 30-40 members in this market, only a small number of buyers and sellers actively trade on the Exchange (GAO report 2007). These are large cheese/food manufacturers and large agricultural cooperatives. The buyers and sellers trading on the CME are also active participants in the contract cheese market. Since the 1980s, only one variety of cheese, cheddar cheese, has been traded on the Exchange. It is sold in 40 pound blocks and 500 pound barrels.

As reported by GAO (2007), during the period of 1999-2007, two market participants bought 74% of all block cheese, and three market participants sold 67% of all block cheese. Four market participants bought 56% of all barrel cheese and two market participants sold 68% of all barrel cheese. In addition to the low relative volume of trade, transactions are infrequent. For example, during the period of 1998-2006, the average number of transactions per trading session was in the range of 0.4-2.2 for barrel cheese, and it was in the range of 1.4-3.5 for block cheese (GAO report 2007).

The CME spot cheese market structural characteristics are similar to the ones typically associated with imperfectly competitive market structures: a high degree of product homogeneity, inelastic short-run demand/supply, a relatively small number of traders (i.e. high market concentration) and a relatively high barriers to entry. Cheddar cheese traded on the CME is a highly standardized product with inelastic short-run demand and supply, there are relatively few large market participants and a group of smaller firms, the entry is relatively limited because it requires a potential entrant to be able to buy or sell very large quantities of cheese on the spot[3]. The presence of these market structural characteristics may cause a presence of imperfectly competitive pricing strategies.

In addition, some market participants may have incentives to influence the CME cheese prices in order to control the contract cheese market and/or to influence prices of milk used in cheese manufacturing. Cheese pricing strategies in the contact market typically depend on the type of buyers (Hayenga 1979; Manchester and Blayney 1997). At the first handler level, contract prices are based on the Exchange price on the day of cheese production plus or minus a premium. In the case of institutional buyers, a monthly or a weekly price list is developed, and its prices are directly tied to the Exchange prices. Cheese prices in contracts with large food-service chains are based on the Exchange prices of the previous month. Prices of highly differentiated cheese products with well developed brands, which are sold at the retail level, are typically based on weekly price lists; their prices tend to be more loosely related to the Exchange prices and are affected by other factors such as the magnitude of marketing costs and margin considerations.

[3] Mueller et al. (1996) and Mueller, Marion and Sial (1997) discuss some of these factors in the case of the National Cheese Exchange.

Cheese processors who buy cheese to manufacture processed cheese products would benefit from lower CME spot cheese prices[4]. Agricultural cooperatives involved in cheese manufacturing would benefit from higher CME spot cheese prices because this would lead to higher prices for Class III milk. However, agricultural cooperatives might also benefit from lower cheese prices, if their financial incentives are considered in light of the overall cheese supply chain. As in the case with cheese processors, a lower level of the CME cheese price used to price cheese in contract market may allow cheese sellers to increase their margin; this ability would depend on the nature of pricing structure used in cheese contracts.

Given the CME spot cheese market structural characteristics and potential incentives of its participants, we hypothesize that pricing practices used by cheese wholesalers are consistent with an imperfectly competitive pricing rather than with a perfectly competitive pricing. The following section presents a theoretical framework used to develop an econometric model to test this hypothesis.

Theoretical Framework

To analyze the CME wholesale cheese pricing practices, an economic framework often used to analyze the mechanism of vertical price transmission is employed. This framework is also used to analyze the nature of cost pass-through[5]. Equation (1) represents a linear farm-to-wholesale price transmission process in the setting of this study. The price of output (downstream price) is specified as a linear function of the input price (upstream price).

$$WP = a + b*FP, \tag{1}$$

where *WP* is the CME wholesale cheese price, *FP* is a farm-level price of milk used in cheese manufacturing, *a* is a non-negative constant, and *b* is a farm price transmission coefficient (i.e. a cost pass-through).

Milk is the key input used in cheese manufacturing, representing about 90% of the cost in bulk product manufacturing. The farm price in the above equation is represented by the Class III milk price. This is a government-set minimum price that milk processors have to pay for milk used in cheese manufacturing within the system of Federal Milk Marketing Orders. Farmers do not receive this price directly. Rather they receive a weighted average of all milk class prices, called the Uniform or blend price. As such, the Class III milk price is not a "farm price" in the conventional sense of what is paid to the farmer, but it is the transaction price relevant to the farmer-first-handler level of the supply chain, and it is most of the input cost in cheese production.

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[4] The net benefits from either lower or higher Exchange cheese prices vary across the cheese industry participants and depend on the stage of the supply chain where they operate and on the design of pricing strategies. See Mueller et al. (1996) and Mueller, Marion and Sial (1997) for a discussion of the motives of traders on the National Cheese Exchange.

[5] There is a large group of studies that analyzed the vertical price transmission mechanisms and the nature of cost pass-through in agricultural and food industries. Some of the studies relevant to our analysis are the following: George and King (1971) systemize the types of pricing methods used by food wholesalers (processors) and retailers. Cotterill (1998), Cotterill, Egan and Buckhold (2001) and Kosicki and Cahill (2006) present a comparison of models/approaches that can be used to evaluate the magnitude of cost pass-through.

The Class III milk price is announced by the 5th of the month following the month in which this price applies. Therefore, during the current month only the previous month Class III milk price is known. The flow of the causation effect from the previous month Class III milk price (*FP*) to the current month CME spot cheese price (*WP*) is ensured in the cheese industry institutional environment.

Given that wholesale margin is the difference between wholesale price and farm price:

(2) $$WM=WP-FP,$$

substituting (1) into (2) yields the identity for wholesale margin:

(3) $$WM = a + (b-1)*FP.$$

The magnitude of the coefficients in equations (1) and (3) provides evidence on the pricing method used by wholesalers[6]. The magnitude of $b=1$ and $a>0$ would reflect a fixed absolute markup pricing consistent with perfect competition characterized by a "sticky" margin ($WM=a$). In the case of imperfectly competitive pricing, two special cases can be considered ($b<1$ and $b>1$).

If a profit-maximizing monopolist operates in a market environment with linear demand and constant marginal cost, the magnitude of *b* is equal to 0.5 (i.e. incomplete cost pass-through). The first-order profit-maximization condition for this monopolist can be rearranged to express its output price as a function of marginal cost: $P = 0.5 + 0.5*MC$. The constant *a* is non-negative in this case. A profit-maximizing oligopoly in a similar market environment would yield the magnitude of *b* in the range from 0.5 (monopoly) to 1 (perfect competition). The output price stabilization practice would be consistent with pricing predicted by these models.

In the case of a profit-maximizing monopoly and a profit-maximizing oligopoly operating in a market environment with non-linear demand and constant marginal cost, the magnitude of *b* is greater than 1 (i.e. more than a complete cost pass-through). The oligopoly cost pass-through is greater than one and is smaller than the monopoly cost pass-through. The first-order profit-maximization conditions for monopoly and oligopoly are:

$P = \left(\frac{1}{1+\frac{1}{\eta}} \right) \times MC$ and $P = \left(\frac{1}{1+\frac{1}{N \times \eta}} \right) \times MC$, respectively ($\eta_{Q,P} = \frac{dQ}{dP} \times \frac{P}{Q} < 0$ is the market demand elasticity, and *N* is the number of firms in the case of oligopoly). The constant *a* is zero in these models. The terms in the parentheses (i.e. cost pass-through) must be greater than one for the output price to exceed marginal cost[7]. Introducing *N* in the FOC for oligopoly decreases the

[6] Carman and Sexton (2005) and Bolotova and Novakovic (2012) use a similar approach to analyze pricing methods used by supermarkets in the fluid milk market. A discussion of the models and concepts presented in this section can be found in the standard microeconomics text-books, for example see Besanko and Braeutigam (2002).

[7] The cost pass-through is greater than one, if the absolute value of market demand elasticity is greater than one (i.e. monopolist and oligopolists price on the elastic region of market demand curve, in which case marginal revenue is positive).

magnitude of cost pass-through, as compared to the monopoly case. The fixed percentage markup pricing (George and King 1971; Carman and Sexton 2005; Bolotova and Novakovic 2012) is consistent with pricing predicted by these models; this pricing method reflects the margin stabilization strategy.

The behavior of wholesale margin is conditional on the magnitude of cost pass-through. If $b=1$ (a perfect competition case), wholesale margin is constant: $WM=a$ (equation (3)); the margin does not respond to the changes in the farm price in this case. If $b>1$ or $b<1$ (an imperfect competition case), wholesale margin responds to the changes in the farm price. In the case of incomplete cost pass-through ($b<1$), wholesale margin decreases (increases), given a farm price increase (decrease). In the case of more than a complete cost pass-through ($b>1$), wholesale margin increases (decreases), given a farm price increase (decrease). Therefore, the margin response to the same change in the farm price is different under the two presented scenarios of imperfectly competitive pricing.

The models discussed in this section assume perfect competition on the input side and the seller market power on the output side. Given that Class III milk price is government-set, the exercise of market power on the industry input side is considerably diminished. Furthermore, although both the buyer and seller sides of the CME spot cheese market tend to be concentrated, the market is supply-driven. The CME cheese price is a function of the available cheese supply controlled by the seller side of the market. Therefore, these models are suitable for analyzing the CME spot cheese market pricing strategies.

Econometric Model

Equation (1) is used as a base to specify an econometric model to be estimated. In this equation, the cost pass-through is restricted to be invariant to increases and decreases in the farm price. A large number of studies analyzing the vertical price transmission mechanisms in agricultural markets report a presence of asymmetries in the adjustments of prices at different stages of the food supply chain[8]. The most frequently discussed causes of these asymmetries are market power and tacit collusion, government intervention in the price-setting process, and adjustment and menu costs.

To allow for asymmetric adjustment of the CME wholesale cheese price to increases and decreases in the Class III milk price, we incorporate the Houck (1977) procedure to specifying and estimating nonreversible functions into wholesale price equation (1). The Houck approach is based on segmenting an independent variable of interest into its increasing and decreasing phases in order to explore asymmetries in the adjustment of the dependent variable to increases and decreases in the independent variable. Equation (4) represents a general version of the Houck model.

(4) $$Y_t^* = a_0 \times t + a_1 \times INC_t^* + a_2 \times DEC_t^*,$$

[8] See Meyer and von Cramon-Taubadel (2004) and Frey and Manera (2007) for systematic surveys of studies focusing on asymmetric price transmission. The former also discusses the factors that may explain asymmetries in the price adjustment processes.

where Y_t^* is the sum of all period-to-period changes in the dependent variable from its initial value, INC_t^* is the sum of all period-to-period increases and DEC_t^* is the sum of all period-to-period decreases in the independent variable from its initial value. INC_t^* is always positive, and DEC_t^* is always negative. If a_0 is non-zero, then it appears as a trend coefficient.

The model specified by equation (4) was originally developed as a static model. In many applications, corresponding econometric models were specified as distributed lag models to account for dynamic effects. In addition to evaluating asymmetries in terms of the magnitude of price transmission, this approach allows to analyze asymmetries in terms of the speed of price transmission.

By combining equations (1) and (4), we specify an econometric model to be estimated (equation (5)). This is a linear distributed lag model.

(5) $$WP_t^* = \alpha_0 \times t + \sum_{i=0}^{N} \beta_i^+ \times FP\_INC_{t-i}^* + \sum_{i=0}^{M} \beta_i^- \times FP\_DEC_{t-i}^* + u_t \, .$$

The majority of the notations used in equation (5) are as explained above. *N* and *M* are the number of lagged terms for increasing and decreasing phases of the farm price, respectively. Due to the specifics of the Class III milk price announcement procedure mentioned earlier, the previous month Class III milk price is used as the current month *FP* in the econometric model. β_i^+ and β_i^- are the farm price transmission coefficients (i.e. cost pass-through) for increasing and decreasing phases of the farm price, respectively. u_t is the error term.

The null hypothesis of the symmetry in terms of the speed[9] of the CME wholesale cheese price adjustment to increases and decreases in the farm price would be supported if *N*=*M*. The null hypothesis of the symmetry in terms of the magnitude of the CME wholesale cheese price adjustment would be supported if $\beta_0^+ = \beta_0^-$ (for the current month effect) and $\sum_{i=o}^{N} \beta_i^+ = \sum_{i=0}^{M} \beta_i^-$ (for the cumulative effect). Furthermore, the magnitude of the estimated cost pass-through is to be interpreted in light of the discussion presented in the previous section. The empirical evidence supporting a perfectly competitive pricing would include the magnitude of cost pass-through equal to one and a symmetric adjustment of the wholesale cheese price to increases and decreases in the Class III milk price. The empirical evidence on the magnitude of cost pass-through statistically smaller or greater than one and a presence of asymmetries in the wholesale cheese price response would indicate the presence of imperfectly competitive pricing.

The estimated coefficients from equation (5) can be used to calculate the price transmission elasticities (Kinnucan and Forker 1987; Lass, Adanu and Allen 2001; Capps and Sherwell 2007; Bolotova and Novakovic 2012). The elasticities calculated based on the current month effect of

[9] See Meyer and von Cramon-Taubadel (2004) for a discussion of different types of asymmetry in the price adjustment process (i.e. in terms of speed, magnitude, etc.).

the Class III milk price change are: $e_{INC} = \beta_0^+ \times \frac{\overline{FP_t}}{\overline{WP_t}}$ (the farm price-increase transmission elasticity) and $e_{DEC} = \beta_0^- \times \frac{\overline{FP_t}}{\overline{WP_t}}$ (the farm price-decrease transmission elasticity), where $\overline{FP_t}$ and $\overline{WP_t}$ are sample means for the Class III milk price series and the CME wholesale cheese price series, respectively. Similarly, the elasticities calculated based on the cumulative effect of the Class III milk price changes are $e_{INC} = \sum_{i=0}^{N} \beta_i^+ \times \frac{\overline{FP_t}}{\overline{WP_t}}$ and $e_{DEC} = \sum_{i=0}^{M} \beta_i^- \times \frac{\overline{FP_t}}{\overline{WP_t}}$ [10].

The magnitude of price transmission elasticities can be interpreted conditional on the magnitude of cost pass-through. The price transmission elasticity in a perfectly competitive market is equal to the ratio of the farm price to the wholesale price, because the cost pass-through is equal to one in this case. The elasticity corresponding to an oligopolistic/monopolistic market with linear demand is smaller than the ratio of the farm price to the wholesale price, and the elasticity characterizing an oligopolistic/monopolistic market with non-linear demand is greater than this ratio. This is because the cost pass-through is smaller than one in the former case and is greater than one in the latter case.

Data

The variables used in econometric analysis are collected from the databases maintained by the USDA Agricultural Marketing Service (AMS). CME cheddar cheese prices are reported by the USDA AMS Dairy Market News Portal and are represented by two price series: cheddar prices for 500 pound barrels and cheddar prices for 40 pound blocks. CME cheddar cheese prices are originally reported on a daily basis, but they are also available on a weekly and a monthly basis. Class III milk prices are reported in the USDA AMS Milk Marketing Order Statistics Public Database. Class III milk price is determined and announced (reported) on a monthly basis. The econometric analysis is conducted using monthly data, the frequency at which both cheese and milk prices are available. The period of analysis is January 2000 – December 2010.

CME cheddar cheese prices are reported in $/pound. Class III milk prices are reported in $/hundredweight[11]. As a general rule, about 10 pounds of milk yields 1 pound of cheese. Therefore, instead of using the Class III milk price expressed in $/cwt in the econometric models, we use a yield adjusted measure of the cost of milk incurred to produce one pound of cheese. This variable is obtained by dividing Class III milk price expressed in $/cwt by 10. This simple transformation allows for easier interpretation of the parameter estimates.

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[10] The price transmission elasticity calculated based on the current month effect of the farm price change is often referred to as the short-run price-transmission elasticity, and the one calculated based on the cumulative effect of the farm price changes is referred to as the long-run price-transmission elasticity (Kinnucan and Forker 1987; Capps and Sherwell 2007). Lass, Adanu and Allen (2001) use a different terminology: a former is referred to as the current elasticity, and the latter is referred to as the short-run elasticity.

[11] One hundredweight (cwt) contains 100 pounds.

Estimation Results

Two econometric models were estimated. One model used the CME cheddar barrel price as the dependent variable, and the other model used the CME cheddar block price as the dependent variable[12]. The Ordinary Least Squares (OLS) estimation procedure was used to estimate econometric models. The estimation results of the two models were very similar. Therefore, we present and discuss the estimation results for the model which has the CME cheddar block price as the dependent variable. The estimation results along with the outcomes of statistical tests are summarized in Table 2[13].

The estimation results indicate that the estimated coefficients for the current month price and its first lag are statistically significant for the increasing phase of the Class III milk price[14], and only the estimated coefficient for the current month price is statistically significant for the decreasing phase of the Class III milk price. This empirical evidence reflects the presence of asymmetry in the speed of the CME cheddar cheese price adjustment.

All estimated coefficients for the segmented phases of the Class III milk price are statistically significant from zero at the 1% significance level. The constant, which captures the trend effect in this particular specification of econometric model, has a low magnitude and is not statistically significant. The explanatory power of the model is high, suggesting that the cumulative changes in the Class III milk price explain approximately 72% of the cumulative changes in the CME cheddar block price. The estimated model allows distinguishing between the immediate (i.e. the current month) and cumulative (i.e. the current and lagged months) effects of changes in the Class III milk price on the CME cheddar cheese price.

The cumulative effect of the Class III milk price increase is exactly the same as of the Class III milk price decrease (i.e. symmetric in terms of the magnitude of cheese price response). The magnitude of cost pass-through is 0.70. The null hypothesis $\beta_0^+ + \beta_1^+ = \beta_0^-$ fails to be rejected[15]. The null hypotheses of a perfectly competitive pricing $\beta_0^+ + \beta_1^+ = 1$ and $\beta_0^- = 1$ are rejected in favor of the alternative hypotheses $\beta_0^+ + \beta_1^+ < 1$ and $\beta_0^- < 1$. Furthermore, the null hypotheses of a profit-maximizing monopoly pricing (linear demand) $\beta_0^+ + \beta_1^+ = 0.5$ and $\beta_0^- = 0.5$ are rejected in favor of the alternative hypotheses $\beta_0^+ + \beta_1^+ > 0.5$ and $\beta_0^- > 0.5$. The magnitude of cost pass-

[12] The cheddar cheese (block and barrel) and Class III milk price series were tested for a presence of the unit root using the standard and modified Dickey-Fuller tests. The null hypothesis of a presence of the unit root is rejected in all cases. For example, the standard DF test statistics for cheddar barrel price, cheddar block price and Class III milk price are -3.21, -3.29 and -3.18, respectively. These values are below the standard DF test statistic critical value at the 10% significance level, -2.57 (i.e. the null hypothesis of the unit root is rejected).

[13] As indicated by the Durbin-Watson statistics, there is a presence of autocorrelation in the estimated models (the magnitude of DW-Statistic in the cheddar block model is 1.35; Table 2). Given that the OLS estimator is unbiased in the presence of autocorrelation, the magnitude of the estimated coefficients is not affected by this process, but the standard errors of the estimated coefficients are affected. The autocorrelation-robust standard errors are computed based on the Newey-West approach; these standard errors are used to conduct all statistical tests.

[14] While we use "Class III milk price" in our discussion of the estimation results, it should be kept in mind that the original variable used in the econometric models is the first lag of this price.

[15] The outcomes of statistical tests on the wholesale cheese pricing methods are presented in Table 2. These tests were conducted using a one-tailed T-test and the 10% significance level.

through equal to 0.7 along with the T-test outcomes suggest that the wholesale cheese pricing practice used at the CME spot market for cheddar cheese is consistent with a profit-maximizing behavior of oligopoly in the market with linear demand and constant marginal cost.

The immediate impact (i.e. the current month effect) of the increasing and decreasing phases of the Class III milk price on the CME cheddar cheese price is somewhat different from the pattern discussed above. The estimated coefficient for the current month Class III milk price-increase is 1.31, and the estimated coefficient for the current month Class III milk price-decrease is 0.70. The current month CME cheese price adjustment is asymmetric, as indicated by the magnitude of cost pass-through and the T-test outcome. The null hypothesis of a symmetric adjustment of the CME cheddar cheese price to increases and decreases in the Class III milk price $\beta_0^+ = \beta_0^-$ is rejected in favor of the alternative hypothesis of a positive asymmetric adjustment $\beta_0^+ > \beta_0^-$. The null hypotheses of a perfectly competitive pricing $\beta_0^+ = 1$ and $\beta_0^- = 1$ are rejected in favor of the alternative hypotheses $\beta_0^+ > 1$ and $\beta_0^- < 1$ for the Class III milk price increase and decrease, respectively.

The magnitude of the estimated coefficients for the current month changes in the Class III milk price and T-test outcomes provide evidence on the presence of imperfectly competitive pricing. The current month milk price increase is transmitted at a much higher rate than the current month milk price decrease; the ratio of the former to the latter is equal to 1.87. Furthermore, the milk price-decrease transmission is incomplete (0.70), and the milk price-increase transmission is more than a complete (1.31). The first effect is consistent with the profit-maximizing behavior of oligopoly in the market with linear demand and constant marginal cost. The second effect is consistent with the profit-maximizing behavior of monopoly/oligopoly in the market with non-linear demand and constant marginal cost.

The wholesale margin analysis can help understand the observed pricing behavior in the case of the cumulative and immediate effects of the Class III milk price changes. The wholesale margin behavior depends on the magnitude of cost pass-through[16]. First, consider the cumulative effect case, where the CME cheese price response is symmetric to the increase and decrease in the Class III milk price and the cost pass-through is incomplete. If Class III milk price increases (decreases) by \$1/10 pounds, CME cheddar block price increases (decreases) by \$0.70/pound and wholesale margin decreases (increases) by \$0.30/pound. If the cost pass-through is incomplete, an increase (a decrease) in the milk price causes the wholesale margin to decrease (increase).

Second, in the case of the immediate effect of the Class III milk price change, the CME cheddar cheese price response is asymmetric. Furthermore, the rate of milk price-increase transmission is greater than one, and the rate of milk price-decrease transmission is smaller than one. If Class III milk price increases by \$1/10 pounds, CME cheddar cheese price increases by \$1.31/pound and wholesale margin increases by \$0.31/pound. If Class III milk price decreases by \$1/10 pounds, CME cheddar cheese price decreases by \$0.70/pound and wholesale margin increases by \$0.30/pound. While the CME cheddar cheese price moves in the same direction with

[16] Equations (1) and (3) and the estimates of cost pass-through are used to determine the response of wholesale cheese price and wholesale margin to the changes in the Class III milk price.

the Class III milk price, the wholesale margin always increases, regardless of either an increase or a decrease in the Class III milk price.

Finally, we calculate the Class III milk price transmission elasticities. During the analyzed period of time, the average CME cheddar block price is $1.4452/pound and the average Class III milk price, which represents the cost of milk used in cheese manufacturing, is $1.3382/pound. The ratio of the milk price to the cheese price is 0.9260 (i.e. the share of the farm value of milk in the wholesale cheese price). The current month price transmission elasticities are 1.21 for the Class III milk price-increase and 0.65 for the Class III milk price-decrease. The current month increase (decrease) in the Class III milk price by 1% leads to an increase (a decrease) in the CME cheddar block price by 1.21% (0.65%).

As indicated by the magnitude of price transmission elasticities, the CME cheese price response is highly asymmetric because the rate of the transmission of milk price-increase is almost two times higher than the rate of the transmission of milk price-decrease. Furthermore, the former is more than a complete (i.e. greater than one in magnitude) and the latter is incomplete (i.e. smaller than one in magnitude). When the cumulative effect of changes in the cost of milk used in cheese manufacturing is considered, both the increase and decrease in the Class III milk price cause the same magnitude response in the CME cheddar block price. An increase (a decrease) in the Class III milk price by 1% causes the CME cheddar block price to change by 0.65%.

Conclusion

The empirical evidence characterizing the mechanism of vertical price transmission and the nature of cost pass-through in the wholesale market for cheddar cheese at the Chicago Mercantile Exchange (CME) indicates that pricing practices used by cheese wholesalers are not consistent with perfect competition, but tend to be consistent with pricing methods used by profit-maximizing oligopolists. This empirical evidence is consistent with the pricing patterns that may be expected to be found in the markets with similar to the CME spot cheese market structural characteristics: a relatively small number of sellers (i.e. high market concentration) trade a highly standardized (homogeneous) product in a market environment with inelastic demand and limited entry.

The empirical findings indicate that the transmission of the Class III milk price-decrease is always incomplete. In contrast, the transmission of the Class III milk price-increase may be either incomplete or more than complete depending on the time period considered. The pattern of the immediate impact of changes in the Class III milk price reflects the presence of a significant asymmetry. Under this pattern, the CME cheese price increases (decreases) given a Class III milk price increase (decrease), but the wholesale margin always increases regardless of either an increase or a decrease in the Class III milk price. The ability to pass a cost increase completely, which increases the wholesale margin, and at the same time to pass a cost decrease incompletely, which also increases the margin, may be evidence of a presence of some degree of market power exercised by cheese wholesalers.

References

Awokuse, T.O. and X. Wang. 2009. Threshold Effects and Asymmetric Price Adjustments in U.S. Dairy Markets. *Canadian Journal of Agricultural Economics* 57: 269-286.

Besanko, D. and R.R. Braeutigam. 2002. *Microeconomics: An Integrated Approach.* John Wiley & Sons, Inc.

Bolotova, Y**.** and A.M. Novakovic. 2012. The Impact of the New York State Milk Price Gouging Law on the Price Transmission Process and Supermarket Pricing Strategies in the Fluid Whole Milk Market. *Agribusiness: An International Journal* 28: 377-399.

Capps, O. Jr. and P. Sherwell. 2007. Alternative Approaches in Detecting Asymmetry in Farm-Retail Price Transmission of Fluid Milk. *Agribusiness: An International Journal* 23: 313-331.

Carman, H.F. and R.J. Sexton. 2005. Supermarket Fluid Milk Pricing Practices in the Western United States. *Agribusiness: An International Journal* 21: 509-530.

Carstensen, P.C. 2010. Comments for the United States Departments of Agriculture and Justice Workshops on Competition Issues in Agriculture. Legal Studies Research Paper Series Paper No. 1103, University of Wisconsin Law School, Madison, WI. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1537191

Chavas, J-P. and K. Kim. 2005. An Econometric Analysis of Price Dynamics in the Presence of a Price Floor: The Case of American Cheese. *Journal of Agricultural and Applied Economics* 37: 21-35.

Chavas, J-P. and K. Kim. A Heteroscedastic Multivariate Tobit Analysis of Price Dynamics in the Presence of Price Floors. 2004. *American Journal of Agricultural Economics* 86: 576-593.

Cotterill, R.W. and P.O. Samson. 2002. Estimating a Brand-level Demand System for American Cheese Products to Evaluate Unilateral and Coordinated Market Power Strategies. *American Journal of Agricultural Economics* 84: 817-823.

Cotterill, R., L. Egan, and W. Buckhold. 2001. Beyond Illinois Brick: The Law and Economics of Cost Pass-through in the ADM Price Fixing Case. *Review of Industrial Organization* 18: 45-52.

Cotterill, R.W. 1998. Estimation of Cost Pass Through to Michigan Consumers in the ADM Price Fixing Case. Research Report No. 39, Food Marketing Policy Center, University of Connecticut, Storrs, CT. http://ageconsearch.umn.edu/bitstream/25148/1/rr980039.pdf

Franklin, A.W. and R.W. Cotterill. 1994. Pricing and Market Strategies in the National Branded Cheese Industry. Research Report No. 26, Food Marketing Policy Center, Department of Agricultural and Resource Economics, University of Connecticut, Storrs, CT. http://ageconsearch.umn.edu/bitstream/25170/1/rr940026.pdf

Frey, G. and M. Manera. 2007. Econometric Models of Asymmetric Price Transmission. *Journal of Economics Surveys* 21: 349-415.

George, P.S. and G.A. King. 1971. Consumer Demand for Food Commodities in the United States, with Projections for 1980. Giannini Foundation Monograph No. 26, Department of Agricultural and Resource Economics, University of California, Davis. http://ageconsearch.umn.edu/bitstream/11936/1/ms710026.pdf

Gould, B.W. 2010. Consolidation and Concentration in the U.S. Dairy Industry. *Choices* 25. http://www.choicesmagazine.org/magazine/article.php?article=123

Hamm, L.G. and R. March. 1995. The National Cheese Exchange: Impacts on Dairy Pricing. Dairy Markets and Policy - Issues and Options, # M-7, Program on Dairy Markets and Policy, Cornell University, Ithaca, NY.

Hayenga, M.L. 1979. Cheese Pricing System. WP-38, Department of Agricultural Economics, University of Wisconsin-Madison, Madison, WI. http://www.aae.wisc.edu/fsrg/publications/Archived/wp-38.pdf

Houck, J.P. 1977. An Approach to Specifying and Estimating Nonreversible Functions. *American Journal of Agricultural Economics* 59: 570-572.

Kim, D. and R.W. Cotterill. 2008. Cost Pass-through in Differentiated Product Markets: The Case of U.S. Processed Cheese. *Journal of Industrial Economics* LV: 32-47.

Kinnucan, H.W. and O.D. Forker. 1987. Asymmetry in Farm-Retail Price Transmission for Major Dairy Products. *American Journal of Agricultural Economics* 69: 285-292.

Kosicki, G. and M.B. Cahill. 2006. Economics of Cost Pass Through and Damages in Indirect Purchaser Antitrust Cases. *The Antitrust Bulletin* 51: 599-630.

Lass, D.A., M. Adanu, and P.G. Allen. 2001. Impacts of the Northeast Dairy Compact on New England Retail Prices. *Agricultural and Resource Economics Review* 30: 83-92.

Manchester, A.C. and D.P. Blayney. 1997. The Structure of Dairy Markets: Past, Present, Future. Agricultural Economics Report No. 757, Commercial Agriculture Division, Economic Research Service, U.S. Department of Agriculture. http://ageconsearch.umn.edu/bitstream/33929/1/ae970757.pdf

Meyer, J. and S. von Cramon-Taubadel. 2004. Asymmetric Price-transmission: A Survey. *Journal of Agricultural Economics* 55: 581-611.

Mueller, W.F. and B.W. Marion. 2000. Market Power in the Cheese Industry: Further Evidence. *Review of Industrial Organization* 17: 177-191.

Mueller, W.F., B.W. Marion, and M.H. Sial. 1997. Price Leadership on the National Cheese Exchange. *Review of Industrial Organization* 12: 145-170.

Mueller, W.F., B.W. Marion, M.H. Sial, and F.E. Geithman. 1996. Cheese Pricing: A Study of the National Cheese Exchange. A Report of the Food System Research Group, Department of Agricultural Economics, University of Wisconsin-Madison prepared for the Wisconsin Department of Agriculture, Trade and Consumer Protection Investigation into Cheese Pricing. http://www.aae.wisc.edu/fsrg/CheeseStudy.htm

Stewart, H. and D.P. Blayney. 2011. Retail Dairy Prices Fluctuate with the Farm Value of Milk. *Agricultural and Resource Economics Review* 40: 201-217.

United States Departments of Agriculture and Justice. 2010a. A Series of Workshops "Agriculture and Antitrust Enforcement Issues in our 21st Century Economy". http://www.justice.gov/atr/public/workshops/ag2010/index.html

United States Departments of Agriculture and Justice. 2010b. Dairy Industry Workshop (Madison, WI), one of the "Agriculture and Antitrust Enforcement Issues in Our 21st Century Economy" Workshops. http://www.justice.gov/atr/public/workshops/ag2010/wisconsin-agworkshop-transcript.txt

United States Government Accountability Office (GAO) Report to Congressional Requesters. 2007. Spot Cheese Market: Market Oversight Has Increased, but Concerns Remain About Potential Manipulation. http://www.gao.gov/new.items/d07707.pdf

Wooldridge, J.M. 2003. *Introductory Econometrics: A Modern Approach.* Thomson South-Western.

Table 1: The Chicago Mercantile Exchange (CME) cheddar cheese sales as a percentage of the U.S. cheese production: 2000-2009.

Year	CME cheddar sales (carloads[1])		Cheese production (mill. pounds)		CME cheddar sales as a percentage of cheese production		Wholesale price			
							CME		USDA NASS	
							barrel	block	barrel	block
	barrel	block	cheddar	all varieties	cheddar	all varieties	$/pound	$/pound	$/pound	$/pound
2000	584	623	2,819	8,258	1.80	0.61	1.1109	1.1465	1.0985	1.1332
2001	209	501	2,747	8,261	1.09	0.36	1.4052	1.4386	1.4039	1.4165
2002	194	644	2,822	8,547	1.25	0.41	1.1438	1.1822	1.1575	1.1808
2003	109	590	2,701	8,557	1.09	0.34	1.2703	1.3172	1.2771	1.297
2004	239	806	3,004	8,873	1.46	0.49	1.6036	1.6492	1.6216	1.6325
2005	190	805	3,046	9,149	1.37	0.46	1.4484	1.4928	1.4621	1.4821
2006	180	353	3,124	9,525	0.72	0.24	1.219	1.2385	1.2305	1.2318
2007	485	451	3,057	9,777	1.29	0.40	1.7411	1.7578	1.7267	1.7172
2008	492	704	3,186	9,913	1.58	0.51	1.8357	1.8558	1.8836	1.8801
2009	545	1,179	3,207	10,109	2.26	0.72	1.2518	1.2961	N/A	N/A
Average	**323**	**666**	**2,971**	**9,097**	**1.39**	**0.45**	**1.4030**	**1.4375**	**1.4291**	**1.4412**

[1] A carload includes 40,000-44,000 pounds of cheese. The conversion is made assuming that the carload is 42,000 pounds of cheese.
Source: authors' tabulations of the USDA NASS cheese production and price data and USDA AMS cheese price data.

Table 2. The Chicago Mercantile Exchange (CME) spot cheese market: The OLS estimation results of cost pass-through (CPT) and the hypotheses test outcomes on the wholesale cheese pricing practices.

Independent variable	Dependent variable: CME cheddar block price		CME wholesale cheese pricing practices: hypotheses tests (T-ratio; p-value)
			The cumulative effect of changes in FP
	Est. coef. (CPT)	T-ratio	$Ho: \beta_0^+ + \beta_1^+ = \beta_0^-$ fails to be rejected { $Ha: \beta_0^+ + \beta_1^+ > \beta_0^-$ } (0.20; 0.8405)
$FP\_INC_t^*$ (β_0^+)	1.31*	6.48	$Ho: \beta_0^+ + \beta_1^+ = 1$ is rejected in favor of $Ha: \beta_0^+ + \beta_1^+ < 1$ (-5.34; 0.0000)
$FP\_INC_{t-1}^*$ (β_1^+)	-0.61*	-2.71	$Ho: \beta_0^+ + \beta_1^+ = 0.5$ is rejected in favor of $Ha: \beta_0^+ + \beta_1^+ > 0.5$ (3.50; 0.0007)
$FP\_DEC_t^*$ (β_0^-)	0.70*	11.65	$Ho: \beta_0^- = 1$ is rejected in favor of $Ha: \beta_0^- < 1$ (-5.08; 0.0000)
Constant	0.02	0.96	$Ho: \beta_0^- = 0.5$ is rejected in favor of $Ha: \beta_0^- > 0.5$ (3.28; 0.0013)
DW-statistic	1.35		*The immediate (current month) effect of changes in FP*
R2	0.72		$Ho: \beta_0^+ = \beta_0^-$ is rejected in favor of $Ha: \beta_0^+ > \beta_0^-$ (2.72; 0.0074)
Sample size	130		$Ho: \beta_0^+ = 1$ is rejected in favor of $Ha: \beta_0^+ > 1$ (1.54; 0.1261)
			$Ho: \beta_0^- = 1$ is rejected in favor of $Ha: \beta_0^- < 1$ (-5.08; 0.0000)
			$Ho: \beta_0^- = 0.5$ is rejected in favor of $Ha: \beta_0^- > 0.5$ (3.28; 0.0013)

*The estimated coefficient is statistically significant at the 1% significance level:
Ho: β=0 and Ha: β≠0; the T-statistic (*df*=126) rejection regions are (-∞;-2.58] and [2.58; +∞).
A set of hypotheses on the wholesale cheese pricing practices (one-tailed T-test, 10% significance level):
$Ho: CPT = c$ is rejected in favor of $Ha: CPT > c$: the T-statistic rejection region is [1.28; +∞);
$Ho: CPT = c$ is rejected in favor of $Ha: CPT < c$: the T-statistic rejection region is (-∞; -1.28].
c denotes the CPT magnitude: *c*=1 under perfect competition, *c*=0.5 under monopoly with linear demand, 0.5<*c*<1 under oligopoly with linear demand, and *c*>1 under monopoly/oligopoly with non-linear demand.
$Ho: CPT^+ = CPT^-$ (symmetry) is rejected in favor of $Ha: CPT^+ > CPT^-$ (positive asymmetry): the T-statistic rejection region is [1.28;+∞).
All T-ratios are computed using the autocorrelation-adjusted standard errors (Newey-West approach).