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Creating Synthetic Cheese Futures: A Method for Matching Cash and Futures Prices in Dairy

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ABSTRACT

A critical issue in understanding relationships between cash and futures markets is identifying the relevant and comparable cash and futures prices used in the analysis. In dairy markets, problem arises from the simple fact that there exists no daily cash market for milk. The focal dairy cash market is the spot market for cheddar cheese at the Chicago Mercantile Exchange, while cheese futures contract was only recently developed. In this article we utilize deterministic relationship between regulated prices for Class III milk and wholesale prices for cheese, dry whey and butter to develop *synthetic cheese futures* which approximate cheese futures prices since year 2000. Based on the measured accuracy of the synthetic cheese futures series, it would be preferred in conducting research related to price dynamics between cash and futures prices in dairy, as opposed to conducting analyses using cash and futures price pairs that are not pricing the same commodity (i.e., cash cheese and Class III milk futures prices).

Keywords: Cheese futures, Federal Milk Marketing Orders

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Introduction

There has been considerable interest in recent years concerning the overall performance of commodity futures markets, and the extent to which futures activity leads to price instability in cash markets. Much of the recent work in futures/cash price relationships has focused on the first moment of the price distribution and deep (large volume) markets (e.g. Irwin, Sanders and Merrin, 2009; Sanders, Irwin and Merrin, 2010; Hamilton, 2009; Gilbert, 2010). However, equally important are the relationships between the second and higher moments of futures/cash price distributions. Specifically, does price action in the futures market result in increased instability (volatility) in cash markets? As noted by Witherspoon (1993), market composition may impact market stability, and, as noted by Fortenbery and Zapata (2004), this may be more apparent in thin markets.

Dairy markets are unique for several reasons, not the least of which is the relative age of the futures markets for dairy. Dairy futures markets have existed since 1993, but underwent continual re-design through the early 2000's. The re-designs were in response to both changes in dairy market structure, and changes in dairy policy. One of the major changes to dairy pricing occurred in 2000 when Federal Milk Marketing Order reform overhauled methods for pricing farm-level milk.

Early work on dairy pricing suggested that there were problems with the relationships between dairy futures and cash markets (Fortenbery and Zapata, 1997). In later work, it appeared that the issues had resolved themselves (Fortenbery, Cropp and Zapata, 1997; Thraen 1999). However, recent price action has again called into question the relationship between futures and cash markets for dairy, the impacts of technical innovation in the dairy sector on price performance, and the role of public policy in promoting price stability. Past work on price performance is dated given recent changes in both production and price policy.

A critical issue in understanding relationships between cash and futures markets is identifying the relevant and comparable cash and futures prices used in the analysis. In grains and cattle markets this is a straightforward choice – terminal or local elevator prices may be used to measure cash grain prices whereas auction prices at a specific terminal market can be used to measure cash cattle prices (Fortenbery and Zapata 1993; Koontz, Garcia and Hudson 1990). These can then be compared directly to futures prices to measure relative price performance. In dairy markets, however, problems arise because there exists a daily cash market for cheese but not for milk, and the most active futures contract for dairy is a milk contract. While there is a new cheese futures contract, its history is not sufficient to measure price dynamics between cash and futures markets, and it is currently very thinly traded.

The objective of this paper is to present a methodology for the development of a synthetic futures contract for cheese that can be used to back-cast current cheese futures prices and thus provide a sufficient time series for understanding price dynamics between cash and futures prices for dairy. The paper proceeds with a discussion of domestic milk pricing regulation, including details on the role various dairy products play in determining USDA regulated prices. Next, we describe the development of a synthetic dairy futures contract that can be compared to market generated cash prices for cheddar cheese, and evaluate their performance relative to the recent period in which cheddar cheese futures have actually traded. The method presented approximates cheese futures prices by exploiting the implications of federal milk market regulations as well as the established record of co-movements of basic dairy products. The paper concludes by detailing the opportunities for price discovery implications that can be drawn through use of the synthetic futures price for cheddar cheese.

Dairy Price Relationships

Federal Milk Marketing Order regulations stipulate that the minimum price dairy farmers receive for milk is determined monthly based on wholesale prices of basic dairy commodities: butter, nonfat dry milk, cheddar cheese, and dry whey. The most widely tracked cash dairy market is the CME spot market for cheddar cheese traded in either 40lbs blocks or 500lbs barrels. With the exception of dry whey, all other commodities listed above also have an active and transparent cash market. In contrast, the most liquid dairy futures market is the Class III milk contract for which there is no cash market pairing. Other futures contracts for dairy commodities are either not actively traded, or have been only recently listed on the exchange. Given this situation, the question of how to model the information flow between cash and futures markets for dairy becomes a challenge. The simplest approach might be to use the CME spot market for cheddar cheese, and the most liquid futures market – CME Class III milk futures. That approach, however, presents several problems and can lead to model misspecification. Due to Federal Milk Marketing Order regulations, the relationship between spot cheese prices and Class III milk futures prices depends in important ways on the expected prices for other dairy products, but the impacts are not always symmetric. The cheese price is determined by market action (although highly correlated with the values of other dairy product prices), while the Class III milk futures contracts settles against the USDA announced Class III price that is determined from a set of specific mathematical relationships to other dairy products. The announced Class III price, in turn, helps determine the regulated minimum milk price dairy farmers must receive.

As an alternative, one could use prices from the recently introduced cheddar cheese futures contract as a counterpart to the spot cheddar cheese market. However, this would restrict any analysis to post July 2010 when the current CME futures contract for cheese first started trading. This may not be a sufficient time series to measure long-run relationships between cash and futures markets. Most information related to dairy price dynamics following market reforms since 2000 would be lost, and some major events of interest would not be covered.

To address this issue we exploit the deterministic relationship between regulated prices for Class III milk and wholesale prices for the dairy products that drive both milk and cheese prices to develop a *synthetic cheese futures* price series, i.e. a simulated price series that represents what cheese futures would have looked like had they been trading from 2000 forward. This is done in two steps, based on the evolution of other dairy futures contracts.

In March 2007 a dry whey futures contract was listed on the CME, allowing us to develop a no-arbitrage condition between dairy product futures markets (whey, butter, and milk) that bounds the synthetic cheese futures prices within an interval equal to the transaction costs of arbitrage between these contracts. In other words, a linear function of other dairy futures contracts is used to simulate cheese futures prices from early 2007 through 2012. This sub-set of the synthetic cheese futures series we refer to as the *implied cheese futures*.

Prior to March 2007, dry whey futures did not exist. For the period January 2000 through to March 2007, cheese futures prices are simulated based on futures prices for milk and butter, and cash whey prices. This subset of the synthetic cheese futures series we refer to as *approximate cheese futures*. Combing the approximate cheese futures with the implied cheese futures series results in the synthetic cheese futures prices that span from January 2000 through the introduction of the actual cheese futures contract. The synthetic cheese futures prices can be employed in econometric analysis to evaluate price dynamics between futures and spot dairy prices, and form the foundations for analysis of information flows, and the role of speculation in dairy futures.

Federal Milk Pricing Regulations

The long-established cooperative practice of milk price discrimination based on final milk use was enshrined in law with the Agricultural Marketing Agreement act of 1937. Setting different minimum prices for beverage and manufacturing purposes is known as classified milk pricing. It is accompanied by producer pooling areas known as Federal Milk Marketing Orders (FMMO). While processors pay different prices to the pool, based on the type of product they manufacture, all dairy farmers receive a uniform price, corrected only for their location and milk quality.

Three objectives of the FMMOs are: 1) insuring market price stability, 2) preventing processors from exercising market power over milk producers and 3) insuring adequate supply and orderly marketing of fluid milk. The primary instrument FMMOs use to achieve these objectives is to set minimum prices which handlers of Grade A milk must pay to farmers. The Federal Agriculture Improvement and Reform Act of 1996 enabled the Secretary of Agriculture to establish minimum prices based on the value of milk as an ingredient in basic dairy commodities. According to this multiple components pricing scheme, enacted in January 2000, milk is priced as a sum of the value of ingredients with desirable nutritional qualities: milk protein, butterfat, and other milk solids (lactose, whey proteins and minerals) (Federal Register, 1999). This regulation creates a deterministic relationship between the prices for cheese, butter, dry whey and Class III milk. This is what allows us to develop no-arbitrage conditions between cheese and futures prices for other dairy products.

Four Milk Classes

The Federal Milk Marketing Order reform of 2000 established four milk classes:

Class I: Milk used in all beverage milk.

Class II: Milk used in soft and perishable manufactured products such as fluid cream products, yogurts, ice creams, cottage cheeses and other.

Class III: Milk used in the production of cream cheese and hard manufactured cheese.

Class IV: Milk used for the production of butter and milk powders such as nonfat dry milk, skim milk powder, and whole milk powder.

USDA announces the Class III milk price monthly. It is based on national average wholesale prices for cheddar cheese, dry whey and butter. The Class IV milk price is determined in similar fashion from wholesale prices of nonfat dry milk and butter. Major producers of these manufactured dairy products are surveyed weekly. Monthly announced dairy product prices are calculated as the weighted average of weekly surveyed prices, with weekly volume used as weights. The central premise of multiple component pricing is that wholesale prices of cheese, butter, dry whey and nonfat dry milk serve as reliable sources of information regarding the values of milk protein, butterfat, other milk solids, and nonfat milk solids. For example, milk protein value is inferred from the cheddar cheese price, and the price of dry whey is used to determine the value of other milk solids.

Valuing Milk Components

In order to calculate the value of milk ingredients (protein, butterfat, and other solids) from average product prices, information is needed on per-unit manufacturing costs, referred to as *make allowance* and yield, i.e. the amount of each milk ingredient needed in order to produce one unit of a dairy product of interest. In most cases, the equation tying together milk component values with average product price takes the following form:

$$\text{Component Price (\$/lb)} = \left[\text{Product price (\$/lbs) - Make Allowance}\right] \times \text{Yield} \qquad (1)$$

The milk ingredients valued via equation (1) are butterfat, nonfat milk solids, and other milk solids. Butterfat value $\left(P_{bf}\right)$ is derived from the national average wholesale price of butter $\left(P_B\right)$. The water content of one pound of butter is assumed to be 17.4%, which means that butterfat yield $\left(Y_{bf}\right)$, i.e. the amount of butter that can be produced from 1 pound of butterfat, is equal to 1.211. Currently, the butter make allowance $\left(MA_B\right)$ stands at 0.1715 \$/lbs. Make allowances for dairy products change very infrequently, and only after a lengthy administrative process that involves public hearings where manufacturers present arguments on what should be deemed a fair assessment of production costs. In particular, the butter make allowance value has changed only 4 times since the beginning of 2000.

Nonfat dry milk is produced by separating milkfat from skim milk, then evaporating and spray-drying skim milk to produce a powered product. The value of nonfat milk solids $\left(P_{nms}\right)$ is calculated from wholesale prices of nonfat dry milk $\left(P_{NDM}\right)$ using a make allowance $\left(MA_{NDM}\right)$ of \$0.1678/lbs and a yield $\left(Y_{nms}\right)$ of 0.99, which accounts for spillage (e.g. farm-to-plant loss in milk volume). In the production of cheese, whey proteins, as well as most of the lactose and milk minerals, are drained to make liquid whey. Liquid whey is then dried to a powder with less than 3% moisture content. The dry matter contained in dry whey is referred to as "other milk solids." The value of other milk solids $\left(P_{oms}\right)$ is calculated from wholesale prices of dry whey $\left(P_{DW}\right)$ with the make allowance $\left(MA_{DW}\right)$ set at \$0.1991 and an assumed yield $\left(Y_{oms}\right)$ of 1.03.

The value of milk protein $\left(P_{mp}\right)$ is calculated from the average wholesale price of cheddar cheese 4 to 30 days old. The cheese is sold in 40 pound blocks or 500 pound barrels. Cheese yield depends nonlinearly on the amount of protein and butterfat in milk, and the interaction of these components is recognized as an important contributor to yield. The following formula for the price of milk protein accounts for this effect

$$P_{mp} = \left(P_C - MA_C\right) \times Y_{mp} + \left\{\left[\left(P_C - MA_C\right) \times 1.572\right] - 0.9 \times P_{bf}\right\} \times 1.17 \quad (2)$$

where P_C is the surveyed price of cheese, MA_C is the cheese make allowance, currently at \$0.2003/lbs, $Y_{mp} = 1.383$ is the cheese yield from protein, and P_{bf} is the value of butterfat, calculated from the price of butter as explained above. The constant 1.572 is the multiplier accounting for interaction effects between protein and butterfat. Finally, the assumed ratio of protein to butterfat in cheese is 1.17 which explains the last multiplier.

Equations (1) and (2) enable the calculation of values for milk protein, butterfat, other milk solids and nonfat dry milk. In order to calculate minimum Class III and Class IV milk prices, standard milk composition is assumed in terms of percentages of each component. For both classes, final milk composition by weight is assumed to be 3.5% butterfat and 96.5% skim milk, with skim milk assumed to have 9% milk solids. These classes differ in value of skim milk solids. For Class IV:

$$P_{ClassIVSkim} = 9 \times P_{nms} \quad (3)$$

For Class III, the price of skim milk $\left(P_{ClassIIISkim}\right)$ is calculated as

$$P_{ClassIIISkim} = 3.1 \times P_{mp} + 5.9 \times P_{oms} \quad (4)$$

Final milk prices for Class III $\left(P_{ClassIII}\right)$ and Class IV milk $\left(P_{ClassIV}\right)$ are calculated as

$$P_{ClassIII} = 3.5 \times P_{bf} + 0.965 \times P_{ClassIIISkim} \quad (5)$$

$$P_{ClassIV} = 3.5 \times P_{bf} + 0.965 \times P_{ClassIVSkim} \quad (6)$$

The entire procedure USDA uses to arrive at the Class III and Class IV manufacturing milk prices is summarized in a flowchart in Figure 1.

Simplifying Milk Price Formulas

Equations (1)-(6) can be presented in reduced form, tying Class III and IV milk prices to prices of cheese, butter, dry whey and nonfat dry milk directly. The expression for Class IV milk price can be rewritten as

$$P_{ClassIV} = \left[3.5P_B \times Y_{bf} + 8.685 \times P_{NDM} \times Y_{nms}\right] - \left[3.5 \times MA_B \times Y_{bf} + 8.685 \times MA_{NDM} \times Y_{nms}\right] \quad (7)$$

Using current values for yields and make allowances, this can be further simplified to:

$$P_{ClassIV} = \left[4.2385 \times P_B + 8.5982 \times P_{NDM}\right] - 2.1697 \quad (8)$$

Similarly, for Class III milk, equations (4) and (5) can be reduced to:

$$\begin{aligned} P_{ClassIII} &= 0.3496 \times Y_B \times P_B + 5.6935 \times Y_{oms} \times P_{DW} + \left[2.9915 \times Y_{mp} + 5.022\right] \times P_C \\ &\quad - \left[0.3496 \times Y_B \times MA_B + 5.6935 \times Y_{oms} \times MA_{DW} + \left[2.9915 \times Y_{mp} + 5.022\right] \times MA_C\right] \end{aligned} \quad (9)$$

Using current values for yields and make allowances, this can be further simplified to:

$$P_{ClassIII} = 0.4238 \times P_B + 5.8643 \times P_{DW} + 9.6393 \times P_C - 3.1710 \quad (10)$$

Dairy Futures Markets

While commodity exchanges experimented with a variety of dairy futures contracts through the 1990s, only three contracts were still listed following the FMMO pricing reform of 2000. They were all traded at the Chicago Mercantile Exchange (CME), and included cash-settled Class III milk futures, cash-settled Class IV milk futures, and butter futures with physical delivery. Responding to requests from industry in subsequent years, the CME made several changes to their dairy futures products. For example, a cash-settled butter contract was introduced in 2005, with the size being half of the original deliverable butter contract. Likewise, a cash-settled dry whey contract was introduced in March 2007. A nonfat dry milk cash-settled contract, discontinued in 2000, was redesigned and reintroduced in 2008 followed by a deliverable nonfat dry milk contract in 2009. Soon after, the deliverable butter and deliverable nonfat dry milk contracts were delisted. Most recently, a cash-settled cheese contract was introduced in 2010. Its trade volume has continued to grow, in contrast to the deliverable international skim milk powder contract also introduced in 2010.

A common trait of all dairy futures contracts currently trading is that they stipulate cash-settlement against official USDA announced monthly prices. For that reason, at contract expiry, there is no measureable basis between the terminal futures price and the announced USDA cash price for a given commodity.[1] Using futures prices for the various dairy products,

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[1] Basis is the difference between the cash price and the futures price for a given asset

equations (1) and (2) can be used to calculate implied futures prices of individual milk components: butterfat, protein and other milk solids. Also, based on equations (8) and (10), we can introduce a set of no-arbitrage conditions between various dairy futures contracts. Of particular interest is the no-arbitrage relationship between Class III milk, and butter, cheese and dry whey futures. Replacing monthly announced product prices with futures prices, equation (10) can be rewritten as

$$f_{ClassIII} = 0.4238 \times f_B + 5.8643 \times f_{DW} + 9.6393 \times f_C - 3.1710 \qquad (11)$$

Rearranging equation (11) to isolate cheese futures prices on the left hand side, we can express cheese futures price as a linear function of Class III milk, butter and dry whey futures prices.

$$f_C = 0.1037 \times f_{ClassIII} - 0.0440 \times f_B - 0.6084 \times f_{DW} + 0.3290 \qquad (12)$$

Another way to explain equation (12) is to say that we can fully replicate returns to cheese futures using Class III, dry whey and butter futures. For that reason, we will refer to the price obtained using equation (12) as implied cheese futures.

Implied Cheese Futures Prices

The performance of the no-arbitrage condition in equation (12) over the period July 2010-July 2012 (the period corresponds with actual cheese futures prices) is summarized in Table 1. It presents the actual differences between the implied cheese futures prices and actual cheese futures prices. Note that implied futures performs extremely well, with the average difference between implied and actual cheese futures being less than 0.1% in absolute value, with the standard standard deviation of the difference not exceeding 0.7%. Given that dry whey futures started trading in March 2007, use of the implied cheese futures allows the analysis of cash/futures price dynamics to cover at least 5 years with almost no measurement error from the simulated prices when compared to actual cheese futures prices.

Approximate Cheese Futures Prices

While implied cheese futures can be calculated post March 2007, two issues prevent us from doing so for the period 2000-2007. First, the dry whey futures contract did not exist prior to March 2007. Second, the cash-settled butter contract only started trading in October 2005. The only available butter contract for the period 2000-2005 stipulated physical delivery as a settlement requirement. This may cause the terminal butter futures price to deviate slightly from the announced USDA monthly butter price. While the USDA price reflects prices for the four or five weeks of a particular month, weighted by volume sold in that week, the terminal butter price primarily reflected spot market prices at the time of delivery.

The approach we take to calculating cheese futures prices prior to March 2007 is to project announced dry whey prices on to contemporaneously announced Class III and Class IV milk prices, as well as dry whey prices from the previous month. This results in the relationship below which can be estimated through regressions analysis:

$$P_{DW,t} = \alpha + \beta_1 P_{ClassIII,t} + \beta_2 P_{ClassIV,t} + \beta_3 P_{DW,t-1} + \varepsilon_t \qquad (13)$$

The coefficients from equation (13) are obtained using the most recent information available at the time a particular projection is made. To illustrate with an example, consider a person in July 2005, seeking to forecast the dry whey price for October 2005. The information set available to that person includes Class III and Class IV milk prices, dry whey prices announced from 1999 through June 2005, as well as futures Class III and Class IV milk prices for the following year.[22] Initially, one would use historic USDA announced prices available in July 2005 to estimate parameters of the regression. The results of this particular regression are presented in Table 2. Then, consecutive forecasting can be done for August, September and finally October 2005. Regression coefficients are thus updated once a month to account for the new market information.

Once we have obtained the projected dry whey futures price, we can insert it into equation (12) and calculate the approximate cheese futures price. We identify two different approximation techniques, depending on whether the deliverable or cash settled butter contract is used. Approximation method 1 uses cash-settled butter, and Approximation method 2 is based on the deliverable butter contract. To evaluate the performance of these approximation methods, we compare them with the implied cheese futures series from April 2007 through June 2012 (Figure 2). As noted earlier, implied futures are nearly identical to actual cheese futures. By comparing approximate with implied, rather than actual cheese futures, our comparison period is more than doubled, making the performance analysis more robust. Over the stated comparison period, approximate cheese futures perform rather well, with a mean difference for the 2nd nearby series (i.e. sequence of futures prices for contracts second in line to expiry) of less than 1% with a standard deviation less than 3% of the implied cheese prices. The full results are presented in Table 3. While tight for nearby delivery, note that fit does worsen with increases in time to maturity. Furthermore, while approximation may work sufficiently well on average, there do seem to be periods where approximation performs rather poorly, as illustrated in Figure 2. This is particularly the case for spring and summer 2007, spring 2011 and summer 2012. Observing the dynamics of USDA announced monthly dry whey prices in Figure 3, we see that the stated periods were generally characterized by dramatic changes in dry whey prices that are not captured by simple linear regressions. Should this be a reason to worry that implied cheese futures are poorly approximated for period prior to 2007, for which we cannot conduct performance analysis? We do not believe such concerns are warranted. The key reason there was no dry whey futures market prior to 2007 is because dry whey prices were rather stable and predictable, as illustrated in Figure 3. Consequently, the linear projection method we used should work very well for all periods prior to 2007, with the exception of winter 2006/2007 when dry whey prices unexpectedly more than doubled.

By combining implied futures prices with approximate futures prices, a synthetic futures price series can be constructed. Based on the measured accuracy of the overall series, it would

[2] Although FMMO reform did not start until January 2000, USDA did announce dairy products monthly prices for all months of 1999.

be preferred in conducting research related to price dynamics between cash and futures prices in dairy, as opposed to conducting analyses using cash and futures price pairs that are not pricing the same commodity (i.e., cash cheese and Class III milk futures prices).

Conclusions

In this article we develop methods that can be used for calculating synthetic cheese futures for period after the FMMO pricing reform, i.e. since January 2000. The synthetic futures are derived using two different strategies: the first that simulates cheese futures post March 2007, and the second that simulates cheese futures prior to 2007. Two different strategies are necessary due to differences in the market information available between the time periods.

The series constructed post March 2007 is referred to as *implied futures*. It is constructed using futures prices for other dairy products and USDA pricing formulas. Implied cheese futures exhibit an extremely tight fit with actual cheese futures. This is as expected since any differences could be quickly arbitraged away.

Simulated prices from early 2000 to March 2007 are referred to as *approximate futures*. They are estimated using forecasted dry whey prices because the dry whey futures contract did not exist over this time period. The simulation method works well for most of the time where direct comparison with either actual or implied cheese futures is possible. Relative stability of dry whey prices prior to spring 2007 make us confident that approximate cheese futures prices resemble closely what actual cheese futures would have traded for in the early 2000s. Combing the approximate and implied price series, we construct *synthetic futures prices*. Analyses regarding price discovery and volatility spillovers between cash and futures markets, and impacts of futures speculation in dairy can now proceed by utilizing the CME spot cheese market for cash prices, and synthetic cheese futures prices obtained through the methods presented here as the relevant futures prices. This is the focus of our current work.

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Table 1.Deviations from Actual Cheese Futures, July 2010-July 2012

	1st nearby		2nd nearby		3rd nearby		4th nearby	
	cents	%	cents	%	cents	%	cents	%
Implied Cheese Futures								
Mean	-0.09	-0.06%	-0.09	-0.05%	-0.06	-0.05%	-0.13	-0.09%
St. dev.	0.69	0.43%	0.98	0.59%	0.94	0.57%	1.06	0.65%
Maximum	1.75	1.04%	2.67	1.76%	2.53	1.53%	2.77	1.54%
Minimum	-6.83	-4.38%	-6.96	-3.95%	-3.39	-2.15%	-6.61	-3.73%

Note: Implied cheese futures are obtained through linear combination of futures prices for Class III milk, dry whey and cash-settled butter contracts. Federal milk marketing order rules allow these three futures prices to fully replicate the cheese futures price Assuming no arbitrage opportunities hold, the difference actual vs. implied prices is solely due to transactions costs. The descriptive statistics listed in this table are obtained by subtracting implied from actual cheese futures. The 1st nearby contract is the futures contract closest to expiry, the 2nd nearby contract is the contract second closest to expiry, etc. For example, on July 10, 2012 the 1st nearby contract was July 2012 contract, and the 2nd nearby was August 2012 contract.

Table 2. Projecting Dry Whey prices – An Example using July 2005 Information.

Variable	Coefficient	Standard Error	T-statistic
Intercept	-1.39	0.25	-5.56
Ln(Class III Milk)	0.15	0.05	3.00
Ln(Class IV Milk)	0.25	0.09	2.78
Ln(Dry Whey (Lag 1))	0.76	0.05	15.20
Number of Observations	78		
R^2	0.90		

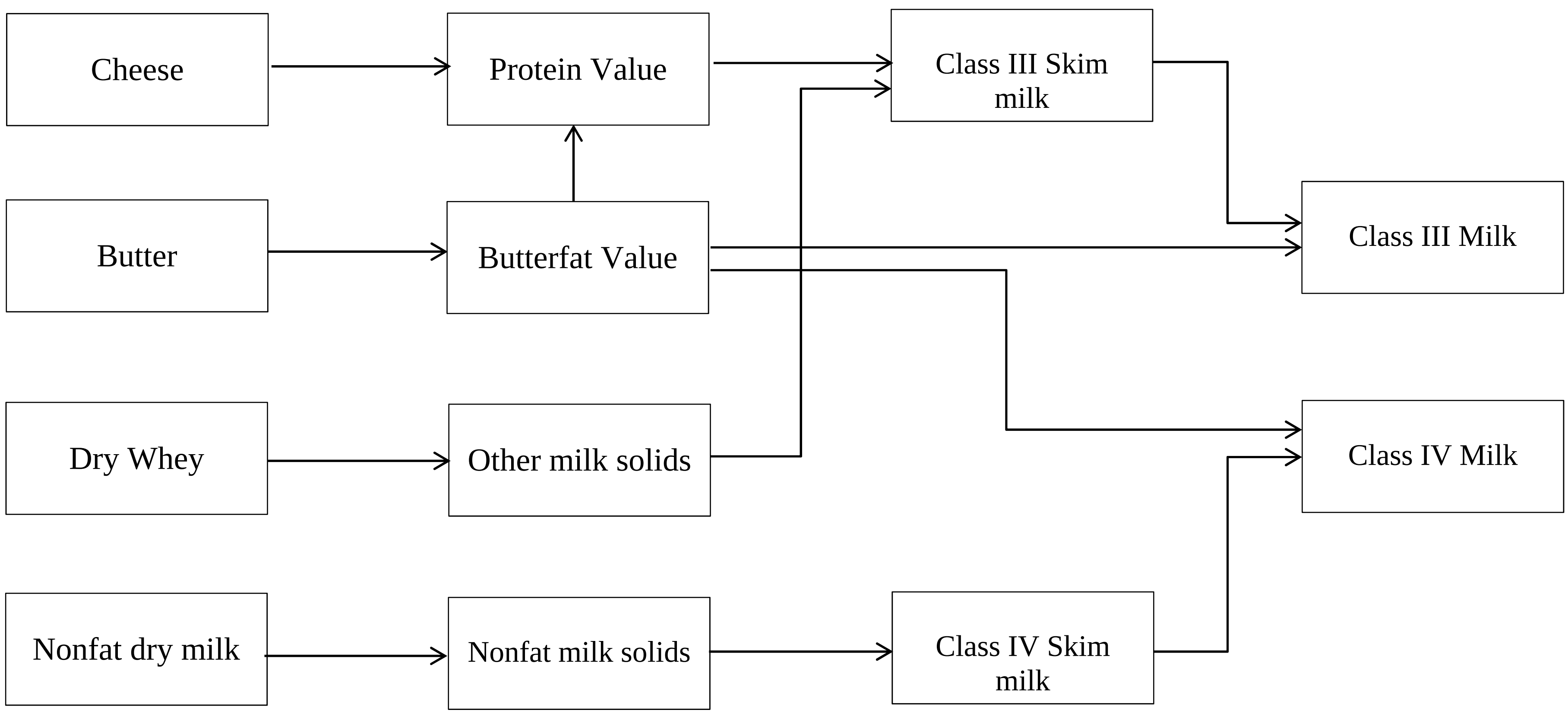
Note: The dependent variable is the logarithm of Monthly USDA announced dry whey prices.

Table 3. Deviations from Implied Cheese Futures, April 2007-July 2012

	1st nearby		2nd nearby		3rd nearby		4th nearby	
	cents	%	cents	%	cents	%	cents	%
Approximate Cheese Futures, Method 1 (Projected Dry Whey)								
Mean	-0.55	-0.27%	-1.24	-0.64%	-1.76	-0.96%	-2.22	-1.26%
St. dev.	2.53	1.41%	4.88	2.73%	6.60	3.78%	7.85	4.56%
Minimum	4.40	2.23%	9.26	5.03%	13.29	7.56%	14.16	7.99%
Maximum	-10.30	-5.37%	-19.46	-9.59%	-25.94	-14.14%	-31.95	-17.99%
Approximate Cheese Futures, Method 2 (Projected Dry Whey, Deliverable Butter) (through December 2010 only)								
Mean	-0.88	-0.43%	-1.91	-0.95%	-2.57	-1.35%	-2.55	-1.40%
St. dev.	2.83	1.57%	5.15	2.85%	6.82	3.85%	7.83	4.54%
Minimum	3.45	2.18%	3.97	3.40%	5.39	3.72%	5.80	4.21%
Maximum	-10.40	-5.43%	-19.42	-9.57%	-25.92	-14.13%	-31.97	-18.00%

Note: Approximate Cheese Futures, Method 1 is obtained using cash-settled butter futures contract, while Approximate Cheese Futures, Method 2 uses the deliverable butter contract. The deliverable butter contract was delisted in December 2010. The descriptive statistics listed in this table are obtained by subtracting approximate from implied cheese futures

Figure 1. Flowchart diagram of classified milk pricing in Federal Milk Marketing Orders



Note: Surveyed national average cash prices of butter are used to infer the value of butterfat. Protein value is calculated using survey prices of cheese and the imputed value of butterfat. Other milk solids are imputed from surveyed cash prices for dry whey, and nonfat milk solids are imputed from surveyed cash nonfat dry milk prices. The Class IV skim milk price is obtained from imputed nonfat milk solids. The Class IV milk price is obtained from the imputed butterfat value and class IV skim milk value. Imputed other milk solids and imputed protein values are used to calculate the Class III skim milk price. Finally, the Class III skim milk price, together with the imputed butterfat value give us the Class III milk price.

Figure 2. Approximate vs. Implied Cheese Futures, April 2007-July 2012

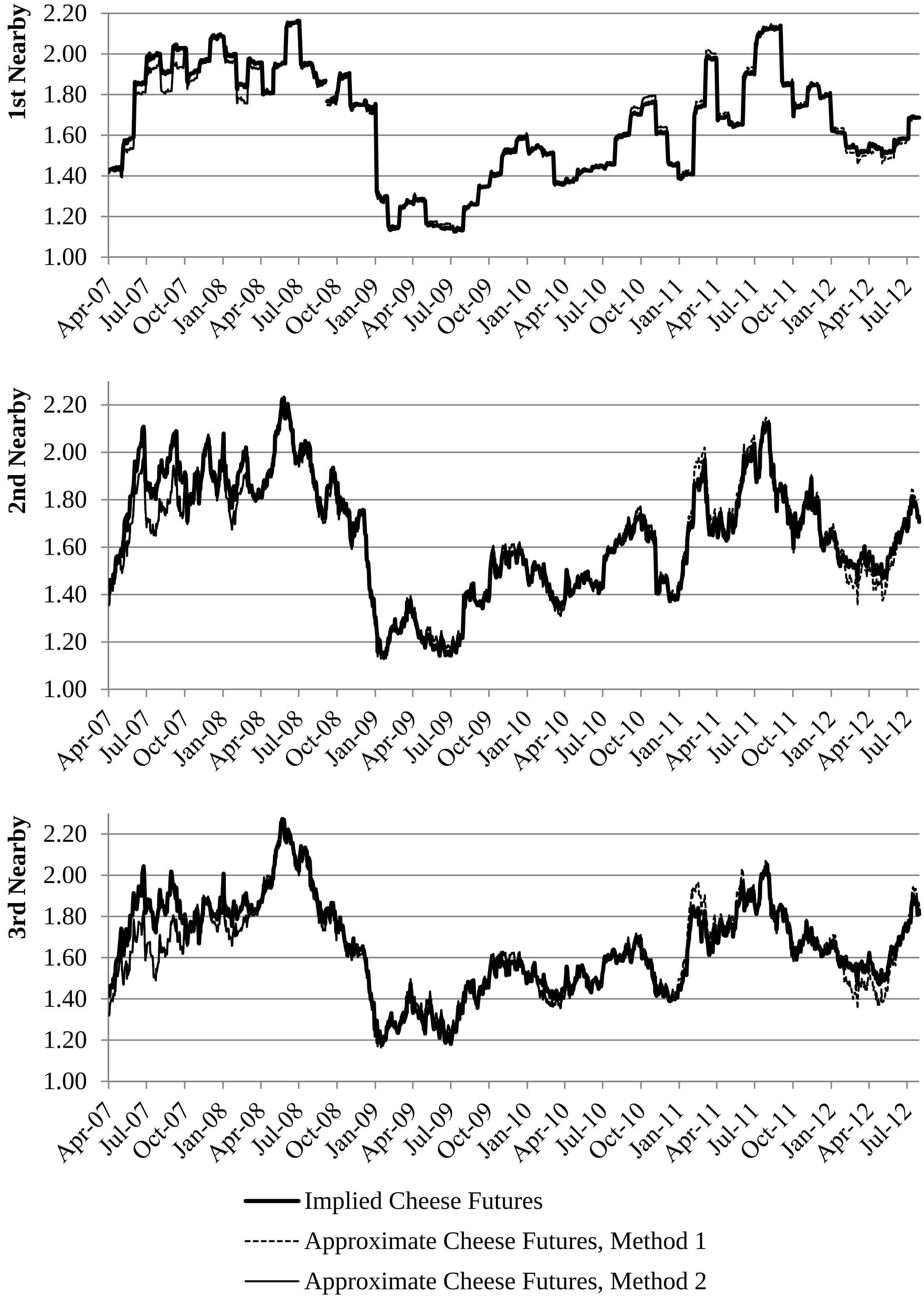


Figure 3. USDA Monthly Announced Dry Whey Price, January 2000-June 2012