Analyzing Relationships between Cash and Futures

Dairy Markets Using Partially Overlapping Time Series

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1. Introduction

The U.S. Dairy industry has experienced several changes over the last two decades. Some of the more salient features include continued increases in yield, regional shifts in production accompanied with an increasing role of large farms, and major changes in dairy policy and milk pricing (Bozic & Gould, 2009). As a consequence of low milk support prices, the volatility of milk price has increased dramatically across all categories of milk utilization. An increasingly uncertain economic environment characterized by large swings in milk and dairy product prices resulted in new instruments being made available to manage price risk. Beginning in 1993, futures contracts were introduced to meet the needs of the dairy industry. In this paper we present the history of dairy futures and evaluate their performance as risk management tools. We employ partially overlapping time series model (Smith, 2005) to examine the magnitude and sources of volatility of dairy futures prices. Next, we present a new tool to visualize risk premiums in futures markets and use it to test whether risk premiums in Class III futures prices existed in 2001-2009 period. Finally, in contrast to the standard theory of futures markets which postulates that volatility of futures price will increase as time to maturity decreases (the so called Samuelson effect), we find evidence of a more complex relationship with systematic declines in volatility as contracts approach maturity over the last month prior to expiry. We name this *Inverse Samuelson effect*, and explain the causes.

The paper is organized as follows. We first provide a short outline of the economic environment faced by the US milk industry and US federal dairy policy. This is followed by a detailed history of dairy futures in Section 3. Section 4 describes the new tool developed to measure and visualize risk premiums in futures markets applied to the most popular dairy futures contract. In Section 5 follows with a description of econometric model used in the paper. Section 6 describes the data used in estimation and

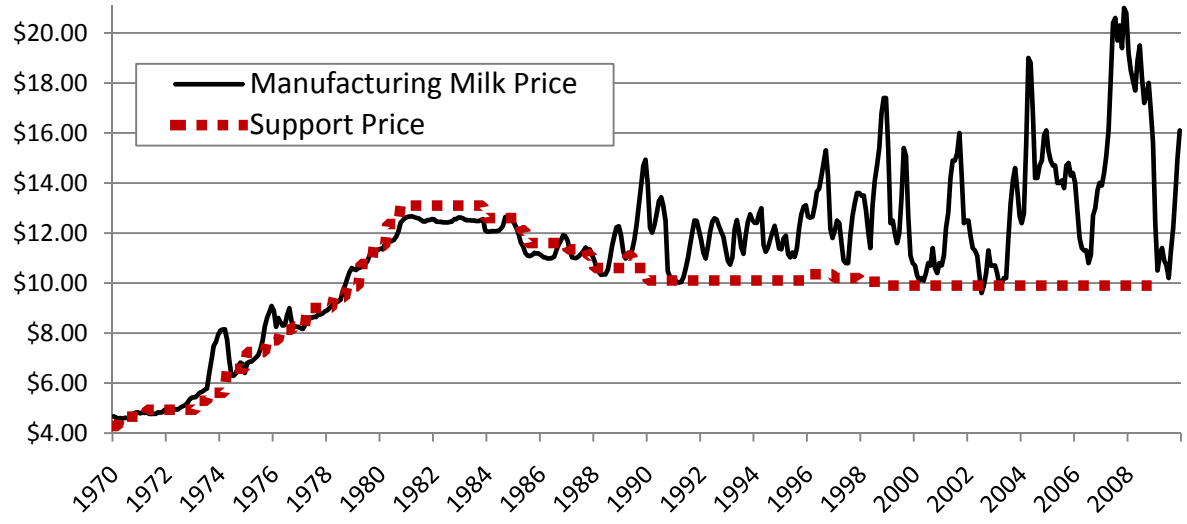
in section 7 we present and discuss model results. The paper concludes with a summary of the main findings and a discussion of issues for further research.

2. Economic environment of the U.S. dairy industry

In this section we provide a short overview of the U.S. dairy industry and its economic environment. This is by no means meant to be an extensive account, and for further analysis of the trends and structural changes mentioned we refer the reader to Bozic & Gould (2009), Blayney (2006) and Blayney et al. (2006).

Milk prices were relatively stable until the early 1990s, as support prices were binding most of the time. With the lowering of support prices and reductions of government stocks of storable dairy products, milk price risk increased significantly. It has been widely reported that the variance of manufacturing milk prices has increased, and that can be easily seen in Figure 1.

Figure 1. Manufacturing Milk Price: 1970-2009



What has, to our knowledge, not been analyzed extensively so far is the nature of business cycles, and possible structural breaks in milk price dynamics induced by changes in dairy policy. To that end, we use

a frequency domain approach to construct a sample spectrum of milk prices. We do this separately for the periods January 1970 – April 1991 (the period of price stability) and September 1988 – December 2009 (the period of increased price volatility) to identify if there was any change in the relative contribution to variance across frequencies. Results are presented in Figure 2a and 2b.

Figure 2a. Manufacturing Milk Price:
Sample Spectrum (Jan 1970-Apr 1991)

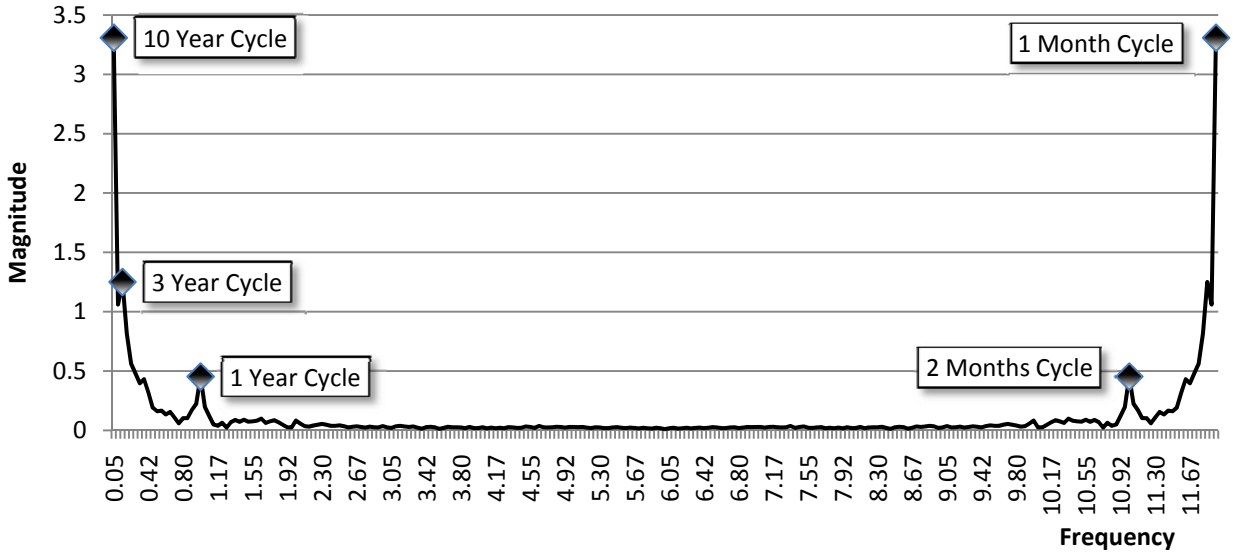
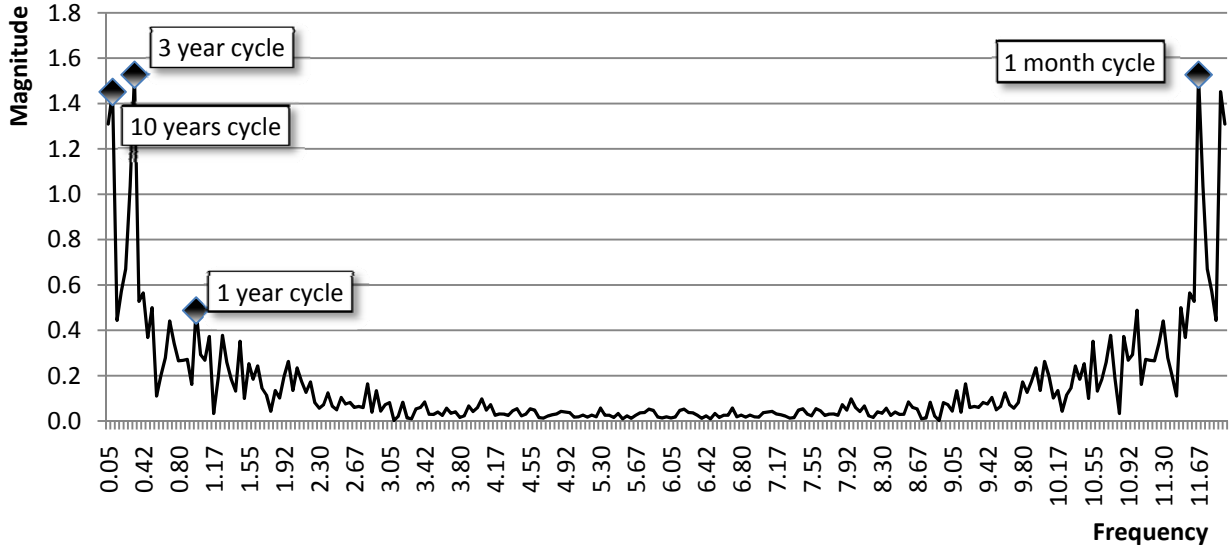


Figure 2b. Manufacturing Milk Price: Sample Spectrum
(Sep 1988-Dec 2009)



To construct a sample spectrum we followed Klingenberg (2005). We chose the cutoff points for the sub-samples in order to satisfy constraints imposed by the Fourier analysis function in Excel. This constraint requires that the number of observations in each sample must equal 2^n, for some n. We chose periods corresponding to 256 months (based on monthly data). A useful reference for the interpretation of periodograms is Hamilton (1994, Chp 7). For both periods we find peaks at frequencies corresponding to a 10 year cycle, a 1 year cycle and a 1 month cycle. In the earlier period, we also find significant evidence of a 2 month cycle. The principal difference, however, is that in the later period we find a very high peak at a frequency of 0.33, which corresponds to a 3 year cycle. This corroborates a simple reading of figure 1, where we find dips in milk prices occurring in 1997, 2000, 2003, 2006 and 2009. It seems reasonable to conclude that by setting support prices at very low levels, US dairy policy opened the door for classic boom-bust cycles in milk production, where initial periods of very low milk prices push many farmers out of the market, which results in much higher prices later inducing many new entrants or expansion of existing farms. By causal observation of Figure 1 we also see that amplitude of 3 year cycle has in fact been increasing.

3. History of Dairy Futures

Once it became clear that milk prices were entering an era of increased volatility, it did not take long for the private sector to offer new hedging tools to the dairy industry. The first dairy futures contracts were introduced by the Coffee, Sugar, and Cocoa Exchange (CSCE - now part of the New York Board of Trade) in New York in 1993. Prior to that there was little interest in a futures contract for dairy products because cash prices were supported by binding government imposed price floors. However, beginning in the early 1990's, dairy prices began trading in ranges that exceeded the government imposed price floors, and price volatility began to emerge (Figure 1). This, in turn, resulted in previously unknown risks on the price side of dairy

markets, and opportunities to manage price risk were sought. The initial impetus for the development of dairy futures contracts came from the cheese and confectionary industries. Cheese makers were concerned about price volatility in cheddar cheese and milk (cheddar is used as the reference price for many cheeses produced domestically), and candy makers were concerned about price volatility in non-fat dry milk. Many of the confectionary firms were already used to hedging both cocoa and sugar at the CSCE, and once they began to experience price volatility in non-fat dry milk (another important ingredient to chocolate candy making), they wanted a way to manage that risk as well. Since the confectionary firms were already using contracts traded at the CSCE, this seemed the logical place to develop the non-fat dry milk contract. As a result, the CSCE rolled out a cheddar cheese and a non-fat dry milk futures contract in 1993. Since prices for cheddar cheese and milk are highly correlated, it was assumed that other dairy firms, including dairy farmers, would cross hedge their milk price risk with the cheddar cheese futures contract. Despite a significant promotional effort on the part of the exchange, volume was very thin.

One reason given for the thin volume was the lack of cross hedging of milk in cheese futures. In response, the CSCE developed and launched a futures contract for fluid milk in 1995. However, this contract also suffered from a lack of trading volume. In spite of low participation in dairy contracts at the CSCE, the Chicago Mercantile Exchange (CME) launched a nearly identical fluid milk contract in 1996. This marked the first time since wheat in the 1950's that two domestic futures exchanges competed head to head for trade in nearly identical product. In addition to milk, both exchanges also launched a butter futures contract in 1996. As with the earlier dairy contracts, trade in butter futures was nearly non-existent.

Following changes in federal milk policy, both exchanges re-designed their fluid milk contracts in 1997, and converted them to a Basic Formula Price contract (BFP). The BFP was introduced in 1995 and was the USDA monthly announced price off which milk prices for individual producers were determined. The BFP was based on USDA survey data adjusted by a product price formula. BFP contracts replaced the fluid milk contracts developed earlier, and provided a hedge opportunity for individual dairy producers using the reference off which their market prices were paid.

In addition to its BFP contract, the Chicago Mercantile Exchange launched a cheddar cheese contract in 1997. As a result the only unique contract still in existence in New York was the non-fat dry milk contract. However, this did not last long. In 1998, the Chicago Exchange rolled out a dry milk contract, and a dry whey futures contract.

In 2000, the New York market eliminated its dairy contracts, and Chicago became the sole market for the trade of dairy futures contracts. In addition, the BFP milk contract and Cheddar Cheese contract were merged and converted to a Class III milk contract (this is the milk used to make cheese), and a nonfat dry milk and dry whey contracts were discontinued, and new Class IV milk contract was introduced. Class IV milk is the milk used for products such as butter and non-fat dry milk.

Table 1. Specifications of Dairy Futures Contracts

Contract	Contract Size	Terminal Price/Settlement	Date First Traded
Cheddar Cheese (NYCSCE)	10,500 lbs of Cheddar cheese, in 40-lbs blocks	Physical Delivery	June 1993 (discontinued)
Nonfat Dry Milk (NYCSCE)	11,000 lbs in 25-kilo bags	Physical Delivery	June 1993 (discontinued)
Fluid-milk Contract (BFP) (NYCSCE)		Cash Settled	April 8, 1997 (discontinued)
BFP Milk contract (CME)	200,000 lbs (50,000lbs and 100,000lbs available)	BFP price, Cash settled	1997 (changed to Class III Milk contract in 2000)
Butter	40,000 lbs	Physical Delivery	March 20, 1997
Class III Milk	200,000 lbs of Class III Milk	USDA Announced Class III Price for contract month, Cash Settled	February 1, 2000 (Replaced BFP)
Class IV Milk	200,000 lbs of Class IV Milk	USDA Announced Class IV Price for contract month, Cash Settled	July 10, 2000
Cash-Settled Butter	20,000 lbs	USDA Announced Butter price for contract month, Cash Settled	September 19, 2005
Dry Whey	44,000 lbs	USDA Announced Dry Whey price for contract month, Cash Settled	March 19, 2007
Nonfat Dry Milk	44,000 lbs of Nonfat Dry Milk	USDA Announced Nonfat Dry Milk price, Cash Settled	October 10, 2008
Deliverable Nonfat Dry Milk	44,000 lbs	Physical Delivery	April 20, 2009

Responding to requests from industry, CME made several changes to their milk futures products. Cash-settled butter contract was introduced in 2005, and its size is half of the old deliverable butter contract. Cash settled dry whey was introduced in March 2007. A Nonfat dry milk cash-settled contract, discontinued in 2000, was redesigned and reintroduced in 2008 followed by deliverable nonfat dry milk contract in 2009. Looking at the open interests of actively trading contracts in Figure 3, we observe that having “double” contract for butter and

nonfat dry milk may not be useful as most traders seem to have migrated to the cash-settled contract for butter, and the deliverable contract in the case of nonfat dry milk.

Table 2. Dairy Prices: Correlations 2000-2009

	Class III	Class IV	Nonfat Dry Milk	Butter
Class IV	0.83	1		
Nonfat Dry Milk	0.65	0.89	1	
Butter	0.54	0.46	0.04	1
Dry Whey	0.54	0.64	0.71	0.14
Cheddar Cheese	0.95	0.78		
Fluid Milk	0.97	0.90		

Table 2. shows correlations between selected dairy prices over the last 10 years. Note that the Class III price is strongly correlated with Cheddar Cheese prices (NASS survey for the last week of the month) and fluid milk prices. The Class IV announced price is strongly correlated with fluid milk and nonfat dry milk. Butter, dry whey and nonfat dry milk show weak correlation, justifying separate futures contracts for these products. Since nonfat dry milk has its own contract, purpose of Class IV contract is not obvious to see at first hand. The reason why this contract is still offered on the exchange must be found in the intricacies of federal classified milk pricing system. Class I (fluid milk) is priced based on formula that varies depending on relative price of Class III and Class IV price. Thus, even though much of the time Class IV contract is not useful for any hedging, in periods when Class IV is “mover” of Class I price, it would be Class IV, not Class III that is used for cross-hedging price risk for fluid milk.

Figure 3a. Open Interest - Class IV Milk Futures

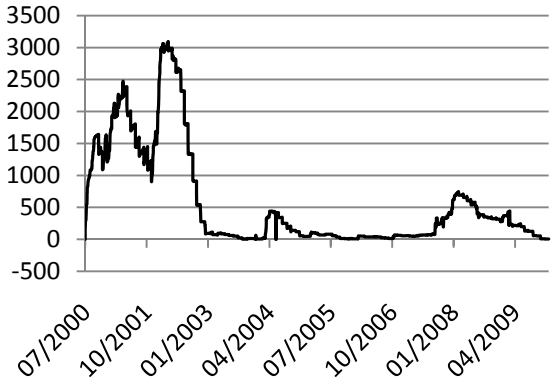


Figure 3b. Open Interest - Dry Whey (Cash Settled)

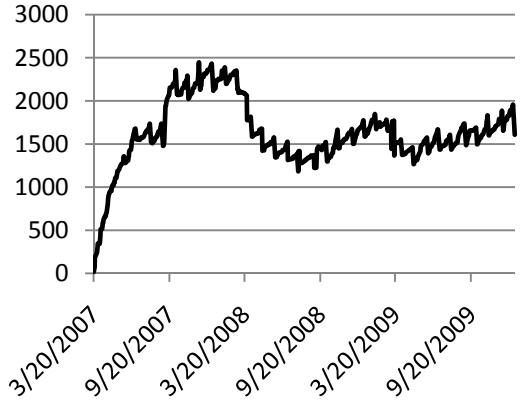


Figure 3c. Open Interest - Nonfat Dry Milk (Deliverable)

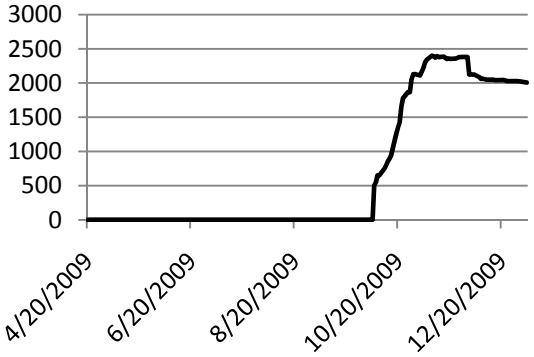


Figure 3d. Open Interest - Nonfat Dry Milk (Cash Settled)

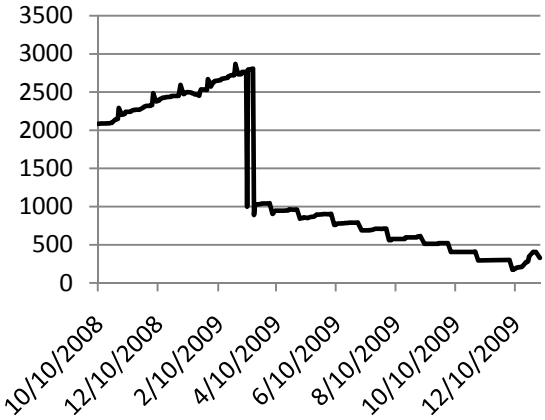


Figure 3e. Open Interest: Butter (Deliverable)

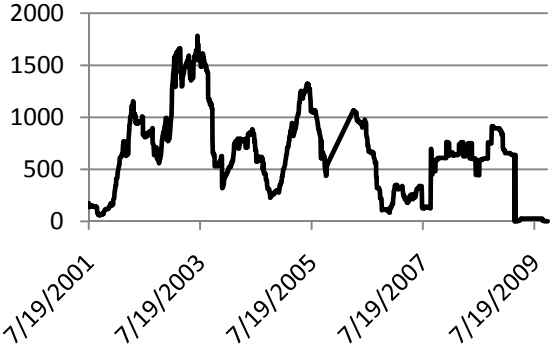


Figure 3f. Open Interest - Butter (Cash Settled)

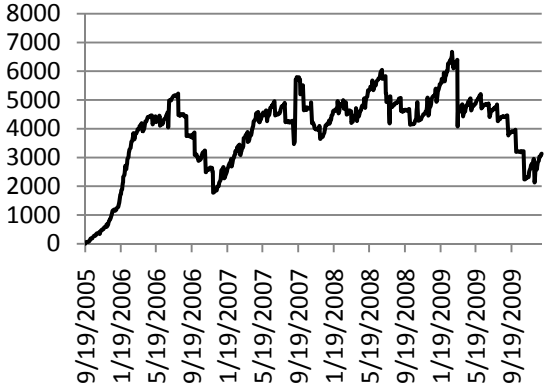
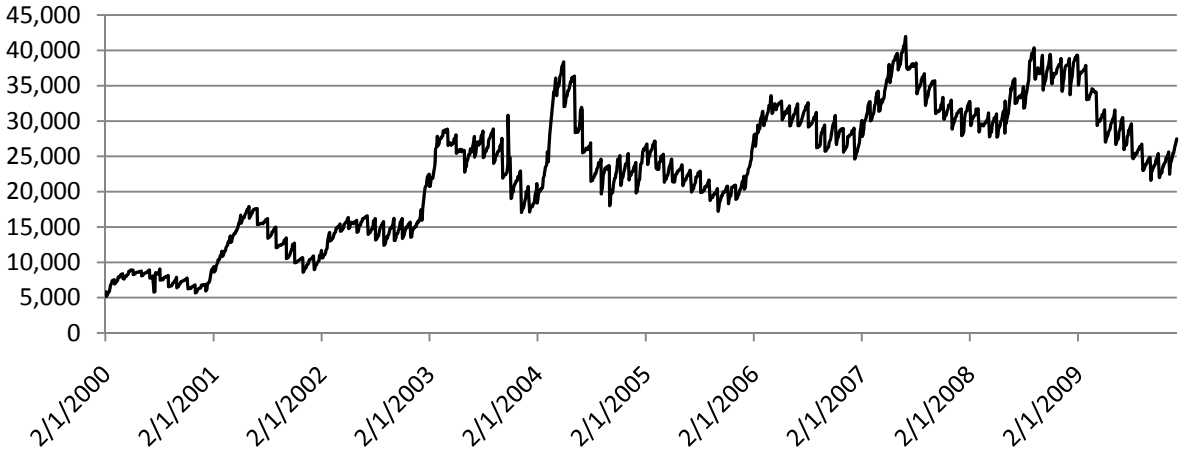


Figure 3g. Open Interest - Class III Milk Futures



4. **Visualizing risk premium in futures markets**

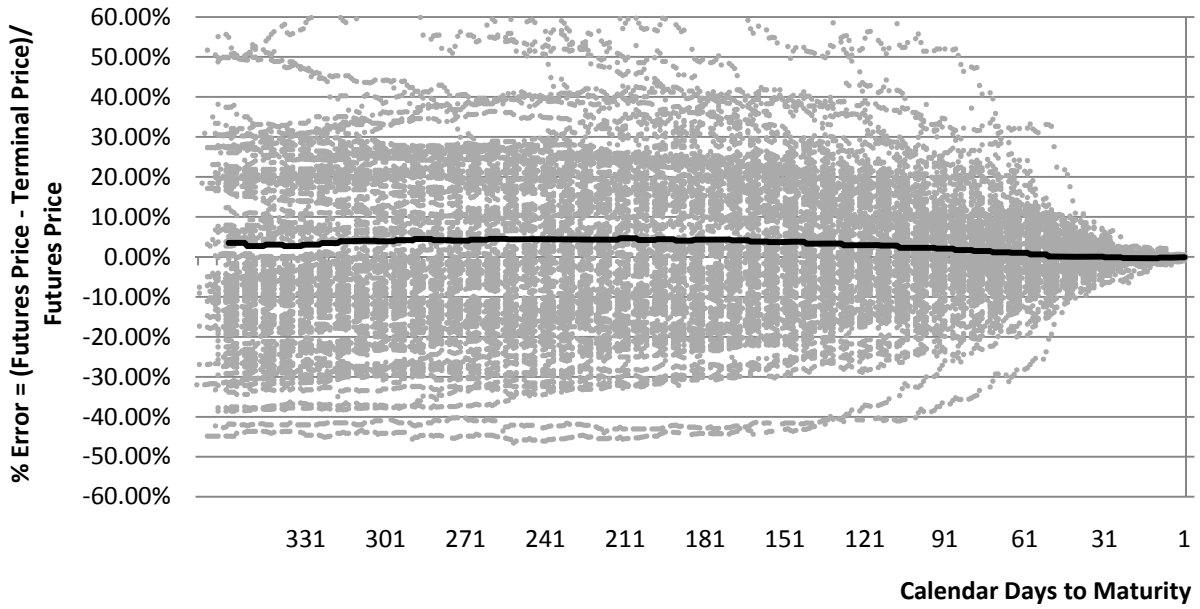
One question of interest is – is there a risk premium in milk futures prices? Keynes' theory of normal backwardation postulates that speculators, taking long positions, will ask for rewards for accepting price risk from hedgers, and therefore, futures prices will be a downward biased forecast of terminal cash prices. A standard way to test for presence of risk premium is to look if mean of futures prices change is significantly different from zero. In other words, if futures prices are downward biased, they should exhibit an upward trend as time to maturity decreases.

To examine this for milk, for each futures contract at time t with d days to maturity the percentage difference between the current futures price $F_{d,t}$, and the terminal settlement price P_T is calculated. Note that P_T is *unknown* before expiration time T, and only discovered ex post:

$$\%Error_{d,t} = \frac{F_{d,t} - P_T}{F_{d,t}}$$

Using scatter diagrams, plots of prediction errors are developed, with time to maturity d on the X-axis, and percentage prediction errors, $\%Error_{d,t}$ on the Y-axis. If there is no risk premium, we would expect the mean of distribution of $\%Error_d$ for a particular time-to-maturity d to be zero. While risk premium is always positive by definition, marginal risk premiums can be either positive or negative. If the mean of $\%Error_d$ is below zero, evidence exists that d days to maturity, futures prices are systematically downward biased, and marginal risk premiums are positive, i.e. investors earn net returns from holding long futures positions. If, on the other hand, the mean of $\%Error_d$ is significantly above zero, that means that futures prices are systematically *upward* biased, the marginal risk premium at d days to maturity is negative, and traders earn profits for holding *short* positions.

Figure 4. Realized Prediction Error of Futures Prices
Class III Milk Futures



While work on nonparametric analyses of risk premiums is at the beginning stages, we do use this tool to visualize prediction errors for Class III futures prices. Figure 4 presents realized prediction errors for the period 2000-2009. Gray dots represent individual prediction errors, while the bold black line plots mean prediction errors for each time-to-maturity d. We find that futures price prediction errors are centered around zero, i.e. there does not seem to be non-zero marginal risk premiums. That justifies modeling futures prices in our econometric model as martingales.

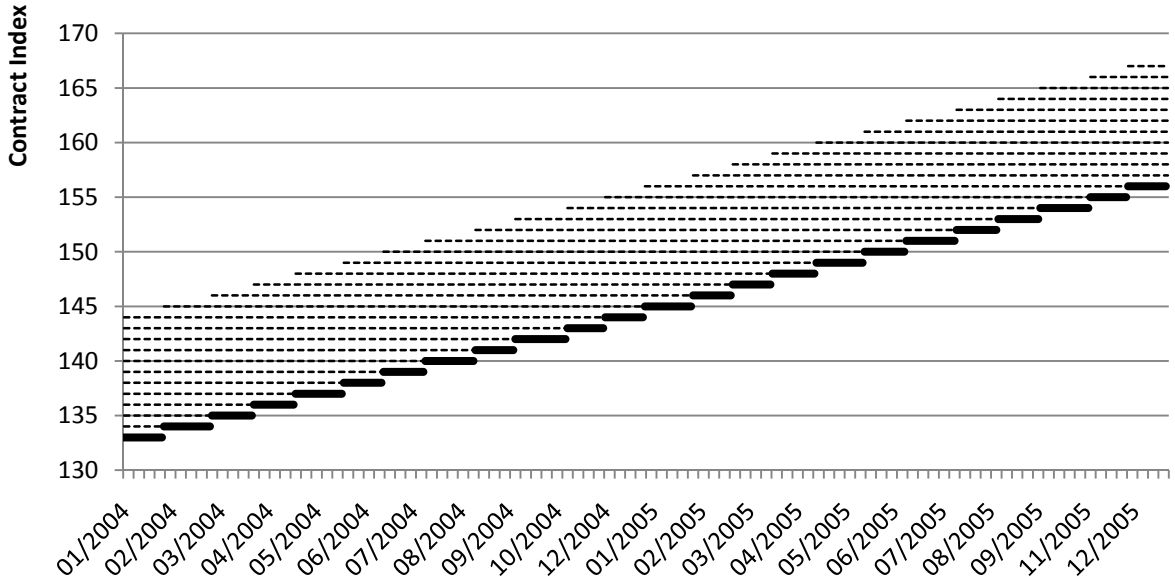
5. Econometric Model

A most common approach to studying volatility in futures markets is to construct a so called "nearby" series, where only data from contracts closest to expiry are used. In such an approach, when the nearby contract expires, or time-to-maturity falls below certain predetermined number of trading days, data used for the "nearby" series are drawn from the next-to-nearby contract. Such aggregation creates a single time series which is subsequently used in econometric estimation. Problems with such an approach abound. In deciding to use information from only a single contract on any given trading day, information from all other contracts is discarded. Furthermore, the "rollover" procedure for patching consecutive contracts may introduce complex non-linear dynamics.

In this paper, we employ partially overlapping time series (POTS) model similar to Smith (2005) and Suenaga, Smith and Williams (2008). The POTS model utilizes information from all contracts trading concurrently. The difference between a "nearby" and POTS approach is illustrated in Figure 5 that shows trading periods for Class III Milk Futures. In the POTS approach, each line

from this figure represents a new variable, while in the "nearby" series approach only bolded segments of each contract trading period are used, patched together consecutively to create a continuous time series. In this sense, the POTS model can be interpreted as unbalanced panel approach, as each contract constitutes a separate time series that originates on the first day that contract is traded, and terminates at its' last trading day.

Figure 5. Partially Overlapping Time Series vs. "Nearby" Series



In explaining the POTS model, we closely follow the terminology and notation of Smith (2005). Let F denote the price of a futures contract, d the number of trading days until maturity for a particular contract, and t the date of the observation. Then subscripting $F_{d,t}$ suffices to uniquely identify any point in a partially overlapping panel data set. Smith models sources of volatility in futures prices as originating from a latent common factor ε_t, influencing all currently trading contracts, and idiosyncratic errors, specific to each contract $u_{d,t}$. Here we employ a single-factor model:

$$\Delta F_{d,t} = \theta_{d,t}\varepsilon_t + \lambda_{d,t}u_{d,t}$$

The coefficients $\theta_{d,t}$ and $\lambda_{d,t}$ are factor loading and innovations standard deviation. For identification of model parameters, $E(\varepsilon_t) = 0, E(\varepsilon_t^2) = 1, E(u_{d,t}) = 0, \quad E(u_{d,t}^2) = 0,$ $E(u_{d,t}u_{d',t}) = 0$ for $d \neq d'$, and $E(\varepsilon_s u_{d,t}) = 0, \forall s,d,t$ is imposed. We assume no risk premium, i.e. $E(\Delta F_{d,t} \mid \Im^{t-1}) = 0$ where $\Im^{t-1}$ denotes the information set as of $t-1$.

Factor loading and innovation standard deviations are modeled using cubic splines with three nodes. As Smith explains, spline functions capture deterministic seasonal and time-to-delivery effects. Separate splines are estimated for each delivery month. For a specific delivery month, factor loadings and innovation standard deviation splines have the following functional form:

$$\theta_{d,t} = \sum_{j=1}^{3}\left(\phi_{0j} + \phi_{1j}\left(d_t - k_{j-1}\right) + \phi_{2j}\left(d_t + k_{j-1}\right)^2 + \phi_{3j}\left(d_t - k_{j-1}\right)^3\right)I_{jt}$$

$$\lambda_{d,t} = \sum_{j=1}^{3}\left(\gamma_{0j} + \gamma_{1j}\left(d_t - k_{j-1}\right) + \gamma_{2j}\left(d_t + k_{j-1}\right)^2 + \gamma_{3j}\left(d_t - k_{j-1}\right)^3\right)I_{jt}$$

$$I_{jt} = 1\left(k_{j-1} \le d_t \le k_j\right)$$

where I_{jt} is indicator function, ϕ_{ij} and γ_{ij} are parameters estimated by the model, d_t is the number of trading days to maturity on date t for a particular contract, and nodes k_1, k_2, k_3 are chosen a priori to be 30, 120 and 210 trading days to maturity. Splines are constrained to equalize the value and slope of consecutive cubic functions at the nodes, and additional constraint is imposed to force slope of the spline equal to zero at the end points.

We follow Smith's specification of time-varying conditional volatility in the common factor modeled using a GARCH approach. In estimating the POTS model we maximize the Gaussian likelihood function using the approximate EM algorithm of Dempster et al. (1977). Estimation is

done using modifications of the Gauss code developed by Smith and made available on his website. For details, we refer the reader to Smith (2005).

6. Data used in estimation

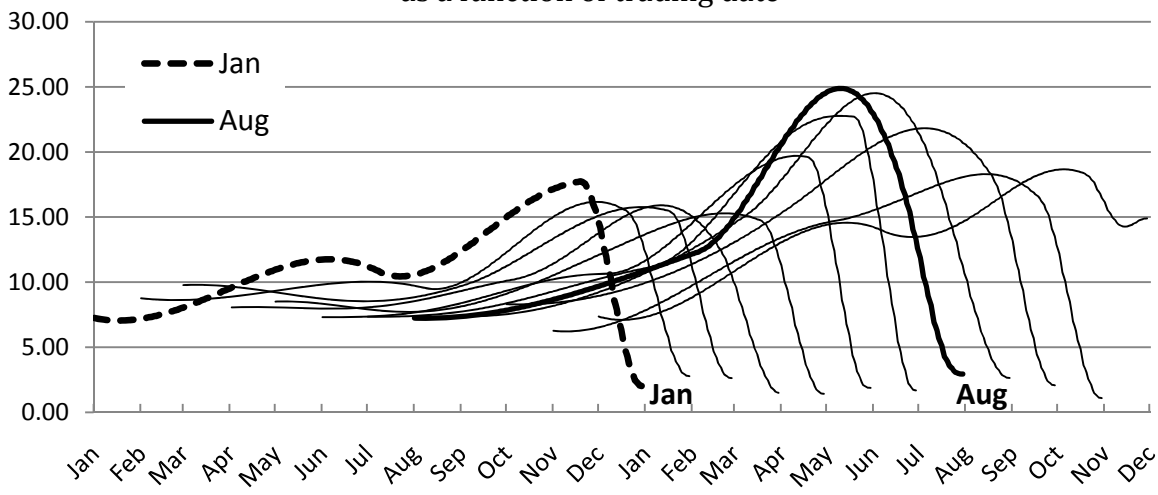
To estimate the POTS model for dairy futures we have used the Class III futures contracts because they exhibit the highest open interest and daily volume of all 7 dairy futures trading at the Chicago Mercantile Exchange. Estimation period is January 2000 to October 2009. Trading in class III contracts was originally allowed for up to 12 months prior to maturity. That was later expanded out to 18, and then to 24 months. However, there is very little volume for contracts more than 1 year out so we restrict our dataset to the daily close prices for the 12 nearby contracts. That gives us 28,268 data points over 118 contracts, classified in 12 categories based on the contract delivery month.

7. Results

Key issues we seek to understand are seasonal and time-to-maturity effects on volatility of futures prices and proportion of unconditional variance explained by common factor. Figure XX below plots unconditional standard deviation as a function of trading date for each delivery month contract. To illustrate the interpretation while avoiding the clutter, only January and August contracts are emphasized in the figure 6. We notice three systematic patterns. First, there is evidence of seasonal variation in volatility, with summer months having higher volatility than winter period. Second, from the time a contract is first traded to about two months left to maturity, there is evidence of increasing volatility as time-to-maturity decreases. In commodity economics, this phenomenon is well known under name Samuelson effect, which postulates

that shocks to production are going to influence nearby contracts more strongly than contracts far from maturity. However, in each contract analyzed, there a is strong *decline* in volatility over the last eight trading weeks. This pattern stands in sharp contrast to grain futures contracts (i.e. corn, as analyzed by Smith) where the Samuelson effect extends all the way to the last trading day. The reason behind this decline, which we call "Inverse Samuelson effect", may lie in the design of milk futures contract. The Class III contract is cash settled against a known formula calculated using a set of prices that is partially revealed weeks before contract maturity, much of the cash price uncertainty is resolved in the last several weeks of trading.

Figure 6. Class III Dairy Futures - Unconditional standard deviation as a function of trading date



We further seek to understand what common factor explains the variation in futures prices. For a storable commodity, inter-temporal arbitrage implies that a common factor should explain nearly all the observed price variation. While fluid milk is itself not storable, some dairy products are. Cheese can be stored for several months, and butter and dry milk much longer. However, product composition changes through thed processing, and overall storability is much

lower for dairy products than for grains. Hence, we would expect that a common factor explains less of total variance price variance for milk. From the model and assumptions listed above, it follows that the unconditional variance of changes in futures price can be written as

$$E\left(\Delta F_{d,t}^2\right) = \theta_{d,t}^2 + \lambda_{d,t}^2$$

Based on this, the proportion of unconditional variance explained by a common factor is therefore $\frac{\theta_{d,t}^2}{\theta_{d,t}^2 + \lambda_{d,t}^2}$. Table 3 lists the average proportion of unconditional variance explained by a common factor for each Class III contract.

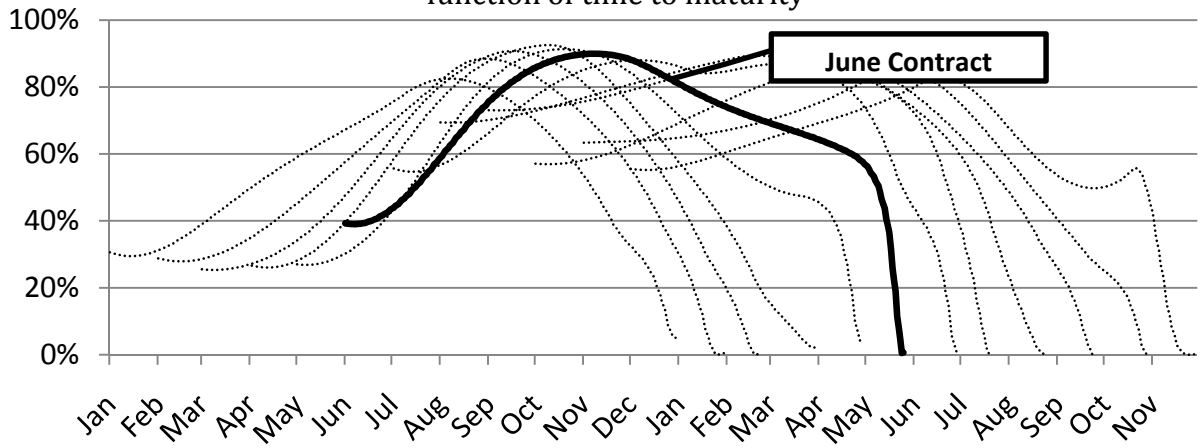
Table 3. Proportion of variance explained by common factor

January	53.5%
February	56.4%
March	57.7%
April	58.7%
May	63.2%
Jun	65.2%
July	71.8%
August	74.7%
September	72.3%
October	65.6%
November	60.2%
December	56.0%

These averages hide the fact that for each contract, the common factor at some point in time explains over 80% of variance. More insight can be gained from figure 7, where we plot the proportion of variance explained by a common factor as a function of time to maturity, for each contract separately. We find two principal regularities. First, as overall variance collapses near maturity, the share of variance explained by the common factor declines even faster. Second,

the common factor explains the highest share of variance six to nine months prior to expiration. For example, for the July contract, the common factor explains 88% of variance 207 trading days to maturity, or for approximately 289 calendar days.

Figure 7. Proportion of variance explained by common factor as a function of time to maturity

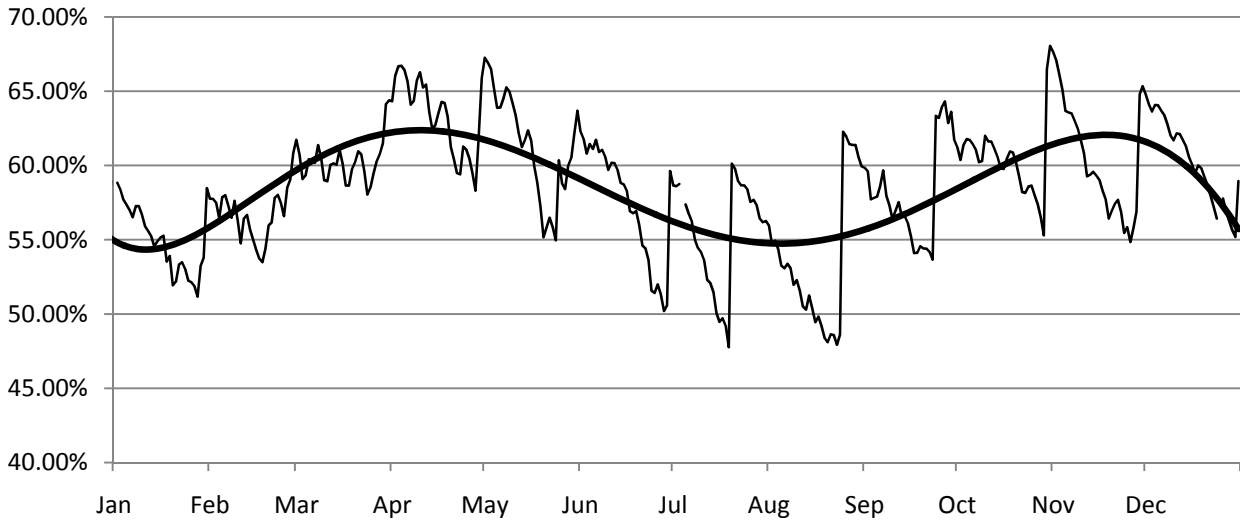


Smith puts forward inter-temporal arbitrage through storage as explanation for a very high proportion of variance in corn contracts explained by a common factor. However, any change in the economic environment or production that influences supply or demand across all delivery months will reveal itself as an information innovation appearing in the common factor. For dairy production, the most important influence to prices in the medium run appears to be exit and cow replacement decisions made by farmers. If more farmers decide to exit the industry because they deem prices to be below their shutdown point, then in the following period we would expect to see higher prices for all delivery months. Vice versa, if a majority of farmers decide to reduce culling and increase their herds, prices will soon fall. In fact, for the June contract illustrated in Figure 7, the common factor explains the highest fraction of variance 289 calendar days prior to maturity. That corresponds to the average cow gestation period of 285

days. While traders cannot observe entry/exit and replacement decisions directly, they can observe dairy cow slaughter data.

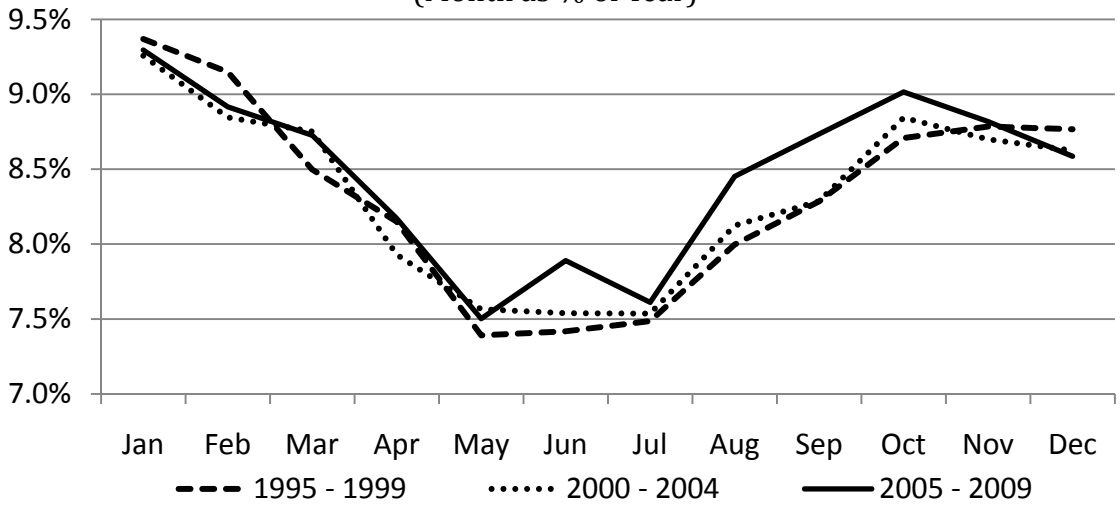
In the following figure we weight the proportion of variance explained for each contract at a particular day of the year by the open interest of that contract and obtain a scalar measure of proportion of overall volatility explained by the common factor, as a function of the day in a year. To further illustrate any potential seasonality, we fit a polynomial trend-line (bold line).

Figure 8. Proportion of market variance explained by common factor



We observe that the common factor explains more variance in spring and fall, and less in summer and winter. Seasonality is not extreme, though, as differences between the seasonal maximum and minimum is about 15 percentage points. The serrated shape of the un-trended line comes from the fact that the variance of expiring contracts is due mostly to idiosyncratic shocks. Compare that graph with the seasonal variations in dairy cow slaughter in figure 9.

Figure 9. U.S. Commercial Dairy Cow Slaughter
(Month as % of Year)



The seasonal shape in slaughter exhibits approximately the same cycle as the proportion of market variance explained by common factor. This, in conjunction with the observation that for each contract, the common factor explains the most 6-9 months away from maturity,and indicates that the principal driving force behind the common factor is not the storage of dairy products, but investment decisions regarding dairy herd, where herd can be thought of as capital input to production, and structural changes in the demand for dairy products.

8. Conclusions

In this paper we have analyzed the dynamics of milk prices in the U.S., and the performance of futures contracts as a tool to hedge price risk. We found that lowering support prices in the early 1990s has resulted in a 3-year business cycle with rising amplitude. We analyze correlations of dairy prices and find that the current set of active dairy futures contracts may contain several redundant contracts. We utilize a new tool to visualize risk premiums in futures prices to examine whether Class III futures prices are unbiased predictors of the announced

USDA Class III price, and find no substantial evidence of bias. Employing the partially overlapping time series model of Smith (2005) we analyze seasonality and sources of volatility in futures prices. Model results indicate that futures prices volatility is higher in summer months, increases as time-to-maturity decreases up to eight weeks to maturity when settlement price starts to become increasingly predictable and uncertainty is quickly resolved. We name this decline in volatility in the last two trading months the *Inverse Samuelson effect*. Further results reveal that a common factor explains 50-60% of milk futures contract variance, with the highest fraction of variance explained by a common factor being 80+% about six to nine months prior to expiry. This is when information regarding the upper bound of dairy herd size expected at the time of maturity is revealed. The Importance of the common factor itself reveals pronounced seasonality that corresponds to the seasonal cycles in dairy cow culling.

Future research will focus on a deeper analysis of relationships between trader composition and bias and variance in futures prices. Possible trade-offs between higher liquidity and a larger number of dairy futures contracts will be examined. We will further seek to build a theoretical model that looks at the possible role of futures markets in amplifying (or mitigating) a 3-year business cycle in the US dairy industry.

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