A Note: The CSCE Cheddar Cheese Cash and Futures Price Long-Term Equilibrium Relationship Revisited

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In the early 1990s, after four decades of relying on government mandated minimum price supports and public stockholding to achieve price risk management, the United States dairy industry is undertaking a shift to a market clearing equilibrium system. A potentially important component of this new structure is the development of an operational futures market for selected milk and dairy products. In June of 1993 the Coffee, Sugar, & Cocoa Exchange introduced a contract on Cheddar Cheese. As the production of cheese represents over one third of the use of raw milk in the United States, this contract has the potential of serving as an important price risk management tool. Using unit root and cointegration techniques, Fortenbery and Zapata studied the cheese cash-futures relationship over the period June 1993–July 1995. They reach the conclusion that the cash and futures markets, during the period of their analysis, had not established an economic equilibrium relationship. F&Z raise the important question as to whether the cheddar cheese market is in some sense "slow" to develop or whether there something fundamentally amiss. The work of F&Z provides an important initial step toward understanding the cash–futures relationship. This research revisits

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the existence of a cointegrating relation using a much longer time period and additional time-series statistical tests. The results of this study suggest that the data support the establishment of an equilibrium relationship in the cheese markets and therefore provide support for the use of the futures market as a price risk management tool by the dairy industry. © 1999 John Wiley & Sons, Inc. Jrl Fut Mark 19: 233–244, 1999

INTRODUCTION

In an article published in this Journal, Fortenbery and Zapata (1997) investigate the cointegration of the cheddar cheese futures and cash markets. F&Z raise four important questions. First, are the cheese spot and cheese future prices nonstationary? Second, if they are nonstationairy, do they share a single cointegrating relation? Third, does the relationship between the cash and futures market prices include an interest rate variable to reflect a carrying charge which would affect the temporal dynamics between cash and futures prices?[1] Fourth, given evidence that other new markets achieve this equilibrium more quickly, is there something amiss with the cheese and/or cash market institutions that would prevent the establishment of a long-term equilibrium.

F&Z investigate the presence of a cointegrating relation in the cheese market using cash and futures price data over the period June 1993 through July 1995.[2] The cash market price is represented by the Friday close price as reported on the National Cheese Exchange.[3] F&Z test for nonstationarity of each individual series using the non-parametric Phillips-Perron test. F&Z find that cash market and futures price series are nonstationary and can be represented as I(1) processes. After applying the Johansen Maximum Likelihood method for the null of no-cointegration they conclude that given the data there is no empirical support for the existence of a long-term equilibrium relationship between the cash-futures price. They reach this conclusion with and without the specifi-

[1]In an efficiently functioning futures market, the basis, i.e., the difference at any time period t between the cash and the futures price, should be relatively stable with the futures and the spot price moving closely together as the contract approaches its expiration. The basis series created by rolling-over at the expiration of one futures contract to the next nearby contract so as to keep the expiration date at a fixed time, should be a stationary series. If this were not true there will be an arbitrage opportunity with positive expected profits. In order for the market participants to be able to effectively hedge against price risk, it is essential that they be able to predict the basis with a reasonable degree of accuracy, that is, able to estimate its conditional mean and variance.

[2]Although F&Z do not explicitly state the number of weeks of trading this span represents, if they utilized all of the available data during this period this would be about 111 trading weeks.

[3]Using an argument of the timing of market information, F&Z explore alternative futures price series, i.e., the Thursday close, Friday close, and the Monday close price series. Their conclusions are not affected by these alternative specifications.

cation of an interest rate in the hypothesized model (Fortenbery and Zapata, 1997, page 291). With the finding of no cointegration F&Z suggest that the cheese futures may not offer a viable tool for price risk management tool over the time period that they studied. They are careful to point out that their conclusion is dependent on the short length of time that the cheese contract was trading. They conclude, "Given the relative infancy of the cheddar cheese futures market, it may be that sufficient time has not passed for the two markets to have established a long-run equilibrium." F&Z examine this market infancy issue by applying their analysis to two new contracts trading on the Chicago Board of Trade, anhydrous ammonia (NH3) and diammonium phosphate (DAP).[4] From this analysis they conclude that, at least for HN3 and DAP, cash-futures prices can develop a long-term relationship in a short period of time. In their summary conclusion, F&Z state "Until and unless the cash and futures markets for cheddar cheese exhibit an identifiable long-run equilibrium relationship, hedging opportunities using the cheddar cheese futures contract appear limited" (Fortenbery and Zapata, 1997, page 296).

The issues raised and addressed by F&Z are very important to the U.S. dairy industry as it begins a transition from price stabilization to open markets. Whereas F&Z are careful not to explicitly state that something is amiss with the pricing institutions, they do address this as a distinct possibility. They state, "If a strong price relationship between cash and futures markets does not emerge, it would be appropriate to question whether the institutional structure of either cash or futures markets for cheddar cheese restricts efficient pricing behavior." The purpose of this note is to reexamine the empirical evidence of a long-run relationship in the cheddar cheese futures and cash or spot markets. This is accomplished by using a much longer time period over which such a relationship could be established. In addition to the cointegration tests specified by F&Z the null of stationarity in the disequilibrium error is tested with a variant of the KPSS test as suggested by Harris and Inder (1994) and by Shin (1994). Finally, the evolution of the estimated cointegrating parameters over the sample period is examined. In doing so it is shown that during the time period which F&Z base their conclusions the parameter estimates are highly unstable. These estimates damp down to reasonable values in late 1996. The final section considers the implications of this research for further work in this area. Anticipating the conclusion section there is strong empirical evidence in favor of cointegration and the establishment of a long-term equilibrium. Considering the vector of cash

[4]NH3 closely matched the trading period for the cheese contract and DAP exhibited an additional eighteen months of trading over the cheese contract.

price, futures price, and interest rate there is at most a single cointegrating relation.[5] Therefore it can be concluded that there exists a fundamental long-term equilibrium such that shocks can cause the cash market and the futures market to diverge but they return rather quickly back into equilibrium with each other.

EMPIRICAL ANALYSIS

The data used in this analysis consist of the weekly cheese spot price, the Friday futures price and a weekly interest rate series. The time period is July 1993 through October 1997.[6] In the cheddar cheese market the cash prices are represented by the National Cheese Exchange (NCE) series as reported by Dairy Market News Service of the United States Department of Agriculture.[7] The cheddar cheese futures price used is the Friday settle price as reported on the CSCE. The interest rate is represented by the 3-month Treasury Bill secondary market averages of daily figures as reported by the Federal Reserve Bank of St. Louis. All data are converted to natural logarithms.

Non-Stationarity and Unit Roots

As with F&Z the first step is to provide empirical evidence that each of the price variables are non-stationary and possess a unit root, i.e., the series are I(1). This accomplished with three alternative tests put forth in the literature: (i) Augmented Dickey-Fuller (ADF), (ii) the non-parametric Phillips-Perron (PP), and (iii) the stationarity test developed by Kwaitkowski, et. al. (KPSS).[8] The results of these tests are listed in Table I. The conclusion from these tests is that each of the data series is I(1):

[5]The interest rate is included in this analysis for the same reasons as put forth by F&Z in their paper. Cheddar cheese can be delivered on the contract up to 60 days old, which implies that an equilibrium relationship between cash and futures prices should account for carrying charges in the two markets. See Zapata and Fortenberry, 1996 for a discussion and empirical analysis of the importance of interest rates in commodity markets.

[6]Trading in cheddar cheese futures has continued on beyond the October 1997 time period. However, on October 3, 1997 the Chicago Merchantile Exchange introduced a cheddar cheese contract and at that point most trading in the CSCE contract ceased, even though the contract was not delisted. Because there are no meaningful trades taking place in the CSCE contract after October 1997 this analysis considers the time period from July 1993 through October 1997.

[7]Cash cheddar cheese prices for the period July 1993–April 1997 are from the National Cheese Exchange and from May 1997 through October 1997 are from the Chicago Merchantile Exchange cash cheese market.

[8]Because the form of the null may have a material effect on the finding of a unit root the stationarity test KPSS is also applied to the data series.

TABLE I

Augmented Dickey-Fuller, Philips-Perron, KPSS Unit Root Tests.

			Constant / No Trend Specification		Constant and Trend Specification	
	TEST	LAGS	a(1)=0	a(1)=0	a(1)=0	a(1)=0
			z -test	t- test	z test	t test
	CV (ADF)			-2.87		-3.42
	CV (PP)		-13.8	-2.87	-21.12	-3.42
	CV (KPSS)			0.46		0.15
			Cheese Market Price Series - Levels			
csce-Friday	ADF	3		-2.18		-2.10 A / Unit root
	PP	3	-9.98	-2.20	-10.12	-2.10 A / Unit root
	KPSS	3		0.6958		Reject Stationarity
nce-cash	ADF	3		-2.67		-2.59 A / Unit root
	PP	3	-7.74	-1.85	-7.26	-1.62 A / Unit root
	KPSS	3		0.8025		Reject Stationarity
tbill90	ADF	3		-1.91		-0.87 A / Unit root
	PP	3	-2.27	-1.87	-1.18	-0.70 A / Unit root
	KPSS	3		2.053		0.7643 Reject Stationarity
			Cheese Market Price Series - Differences			
Δcsce-fr.	ADF	3		-6.36		-6.37 R / Unit root
	PP	3	-200	-13.9	-201.	-13.9 R / Unit root
	KPSS	3		0.0867		Accept Stationarity
Δnce-cash	ADF	3		-5.85		-5.90 R / Unit root
	PP	3	-128	-9.76	-129	-9.81 R / Unit root
	KPSS	3		0.1158		Accept Stationarity
Δtbill90	ADF	3		-6.02		-6.34 R / Unit root
	PP	3	-156	-11.27	-159	-11.5 R / Unit root
	KPSS	3		0.5611		0.1551

ADF=Augmented Dickey-Fuller Unit Root Test; PP =Phillips-Perron Unit Root Test; KPSS = Kwaitkowski, Phillips, Perron, Shin test; csce-fr = futures price, Friday close on the CSCE; nce-cash = National Cheese Exchange; tbill90 = 90 day treasury bill rate
CV.=Critical values at 95% significance level; Δ = first difference operator

their levels possess unit roots and their first differences were stationary, i.e, their first differences did not have unit roots.[9]

Cash and Futures Cointegration

After verifying the nonstationarity of the basic price series, the Johansen method is used to test for the presence of a cointegrating relationship between the logarithms of cash, futures, and interest rates. The JJ-MLE results for the cheese price series are presented in Table II. The original Johansen and a small-sample bias corrected Johansen test statistics are provided for the VAR(3) model.[10] In the cheese cash and futures markets there is strong empirical evidence in favor of cointegration and the establishment of a long-term equilibrium. Considering the vector of cash price, futures price, and interest rate, there is a most a single cointegrating relation. Therefore it can be concluded that there exists a fundamental long-term equilibrium such that shocks can cause the cash market and the futures market to diverge but they return rather quickly back into equilibrium with each other.

Figures 1 and 2 show the behavior of the Johansen test statisitics computed at various lengths in the dataset. These figures show the Johansen Maximum Eigenvalue (J-me) test statistic for the null of no cointegrating vector, Figure 1, and at most one cointegrating vector, Figure 2, respectively. Over the entire trading period there is substantial empirical support to reject the hypothesis that there are no cointegrating vectors in favor of the alternative hypothesis. From Figure 2 one can see that in the early part of the trading period the null of $r = 1$ can be rejected in favor of $r = 2$. After approximately 124 weeks of trading both of the J-me statistics are clearly below the 95% critical value.

The findings of this research raise an interesting question concerning the learning process and what is required for a new market to reach equilibrium with the underlying cash market. To investigate this question the JJ-MLE cointegrating vectors, estimated sequentially over the time period, are graphed. Figure 3 shows the evolving time pattern for the estimated cointegration parameters beginning with the 103 week of trading.[11] As can be clearly seen in Figure 3, the estimated cointegrating

[9]The unit root tests and cointegration tests were constructed using the COINT (Version 2.0) by Ouliaris and Phillips and run with the GAUSS 3.2.25 Programming Software by Aptech Systems, Inc.

[10]Reinsel and Ahn suggest that a small sample bias correction can be made to the Johansen test statistics which corrects for the finite sample bias toward over rejection of the no cointegration hypothesis.

[11]This initial trading week is approximately 10 weeks prior to the end of the data series used by F&Z.

TABLE II

Results of the cointegration Analysis based on the Johansen MLE Method

Cheddar Cheese Cash Price Series[a]				
Estimated Cointegration Vector				
	Lag (p)	nce	cscef	r
	3	1.000	-1.0516	-0.01747
	adj-ratio*	1.2:1		
Hypothesis		Statistic[c]	Critical Values[b]	

Null	Alt.	Max EV	Trace / Modified Trace	95% CV EV	95% CV Trace	Decision
r=0	r = 1	29.23 / 28.06	44.73	22.00	34.91	Reject r = 0
r<=1	r = 2	9.16 / 8.79	15.49	15.67	19.96	Accept r <= 1
r<=2	r = 3	6.33 / 6.08	6.33	9.24	9.24	Accept r <=2

a: Data transformed to natural logarithms and the ECM contains a drift term without trend.

b: The critical values are for the 95% level and are taken from Table 1* in Osterwald-Lenum.

c: The modified eigenvalue statistic is calculated as [Max EV-statistic * (T-pk) / T)] where T is the number of observations, p is the lag order and k is the number of time series vectors.

*: adj-ratio: The ratio of the adjustment coefficient on the cash price to the futures price. Indicates the relative speed with which the cash vs. Futures price returns to equilibrium after being driven from equilibrium.

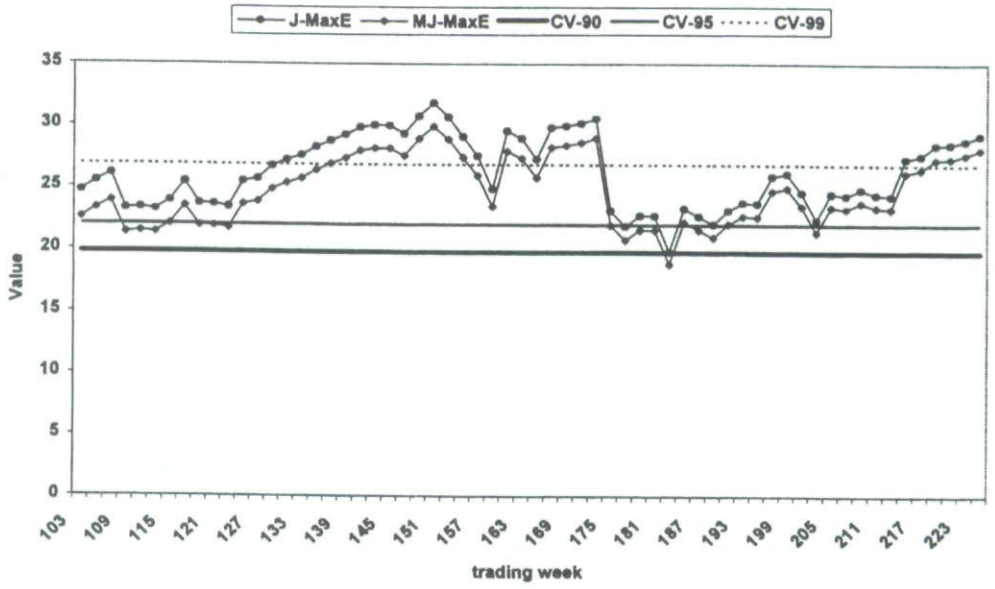

FIGURE 1
Johansen maximum eigenvalue statistic HO: no cointegrating vector

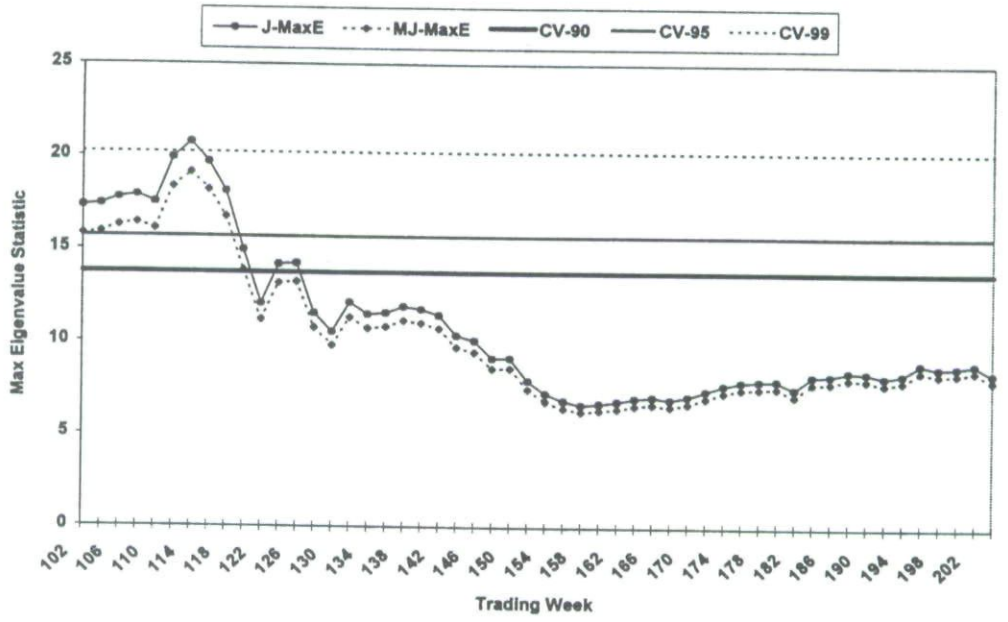

FIGURE 2
Johansen maximum eigenvalue statistic HO: at most 1 cointegrating vector

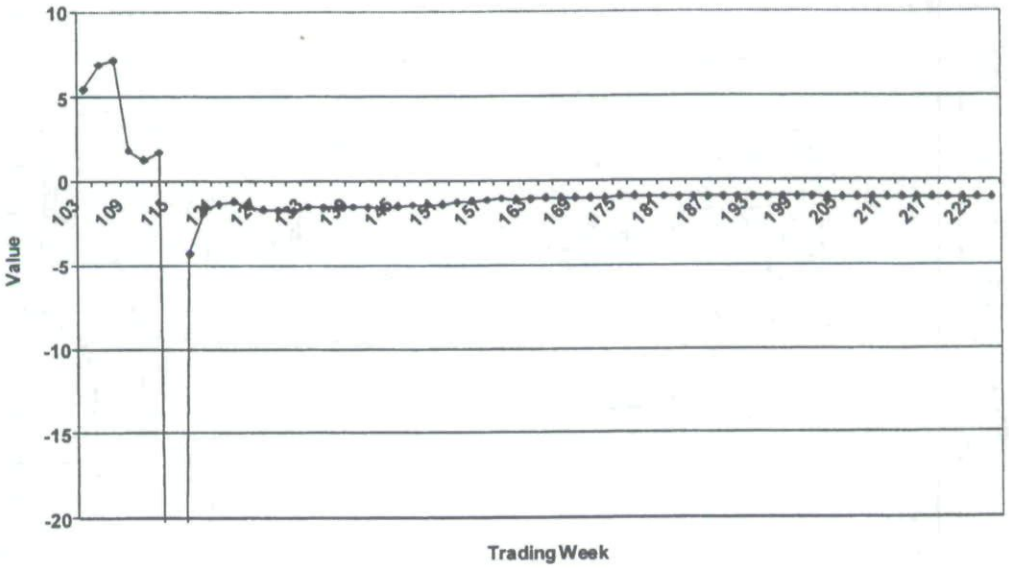

FIGURE 3
Behavior of the estimated parameter on futures price in the cointegration vector

parameters are highly unstable during this early time period. Examination of the time pattern reveals that the cointegration parameters converge toward a stable state after approximately 126 weeks of trading. This suggests that the equilibrium relationship between the cheese cash and futures markets had not yet developed over the time period studied by F&Z but had emerged relatively shortly thereafter.

Figure 4 depicts the disequilibrium error process generated by the cointegration vector for the cheddar cheese spot -futures price series over the full dataset, i.e., coint $=\{1, -1.0516, -0.01747\}$. Inspection of Figure 4 shows that the disequilibrium error process possesses a finite variance, does not trend, and is bounded. While visual inspection suggests that the disequlibrium error may be stationary it remains to be tested as a null hypothesis. This hypothesis is tested with the natural null of stationarity and therefore the KPSS method is used to test the null of stationarity versus the alternative of nonstationarity in the disequilibrium series (Harris and Inder, 1994; Shin, 1994).[12] The test statistic indicates that the data do not reject the null hypothesis of stationarity for this series. The disquilibrium error process is stationary and as this represents

[12]F&Z provide a visual inspection of their estimated disequilibrium error but do not provide a direct statistical test of the null of stationarity in the series.

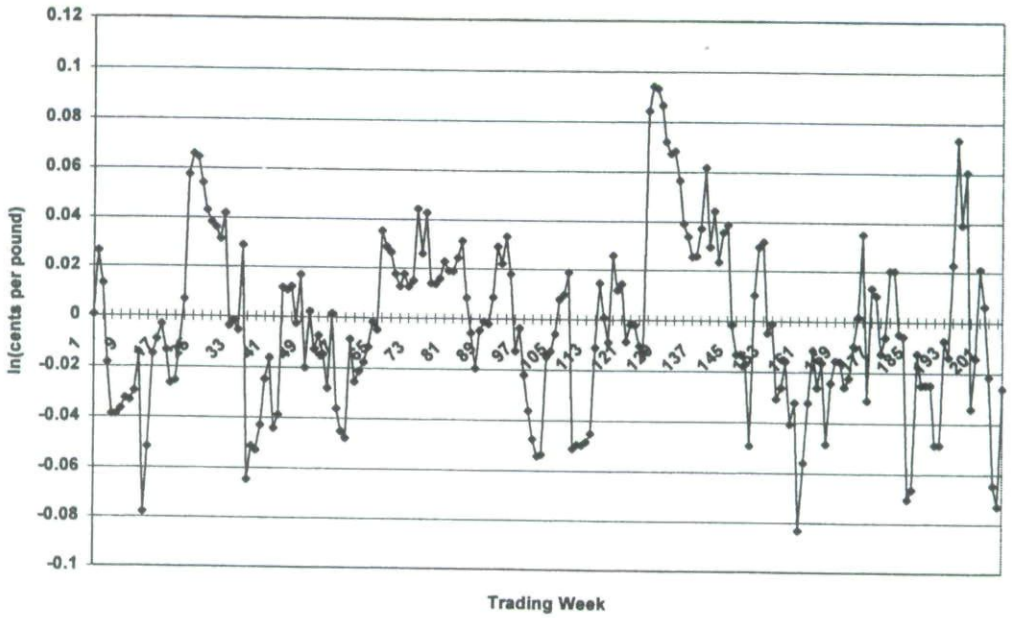

FIGURE 4
Cointegrating error process—cheddar cheese (cash, futures, interest rate)

the nearby basis for the cheddar cheese market it can be concluded that the basis is a stationary series.[13]

IMPLICATIONS FOR EFFICIENT MARKETS AND PRICE RISK MANAGEMENT

The conclusion of this paper is that cheddar cheese market exhibits a cointegrating relation among the futures and spot markets. This long-term equilibrium indicates that there is a flow of information between the two markets. This research finding is important because this process reflects the basis for nearby contracts and as such suggests that market participants can use the cheese futures price discovery mechanism as an effective price risk management tool. The results of this research suggest that there is nothing amiss with the institutional structure in either the cash or the futures market that would prohibit efficient pricing. This conclusion is reinforced when we consider the recent trading activity in the cheddar cheese contract on the CME. The trading volume and open interest have increased steadily in this contract since its introduction in

[13]Application of the Harris and Inder, and Y. Shin modified versions of the KPSS test to the null of stationarity in the cointegration error and support the conclusions set forth in this paper.

October of 1997. Monthly trading volume is now at the 200 contracts level daily and open interest exceeds 200 contracts.

Although this research has presented evidence to support the position of pricing efficiency in the cheddar cheese cash and futures markets there are a number of questions that remain to be addressed. The question raised by F&Z as to why some markets could achieve a long-term equilibrium in a shorter time span than the cheddar cheese market has yet to be resolved. Perhaps it has to do with rational adaptive learning and the fact that market participants in the cheese market had little prior experience in cash market activities relative to participants in other markets. While the cash cheese market has existed for long periods of time, the greatest proportion of commercial transactions have been conducted by direct contract. Whether or not this learned behavior represented an early barrier to efficient spot -futures market relationship is difficult to determine. This is an intriguing question but one that is not answered in this paper.

Given the evidence of cointegration between futures and cash in the cheese market, what importance does this have for practical price risk management? How can this knowledge of the cointegrating relation improve market participants' ability to form optimal hedge ratios? Can knowledge of the cointegrating relationship improve forecasting models for the cheese market? These are questions that are vitally important and remain to be addressed for the newly developing futures markets for milk and dairy products.

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