Efficiency of Hedging Against Fluctuating Prices of Dairy Products

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This paper investigates hedging and cross-hedging internationally traded milk derivative products with internationally traded commodities, recently launched New Zealand dairy futures, New Zealand agricultural products, and mature United States dairy market futures. The contribution of the paper is twofold. First, we show that international dairy commodities are a distinct commodities subgroup, as changes in prices of dairy products are uncorrelated with other worldwide traded commodities. Second, we show that New Zealand Stock Exchange dairy futures are an effective tool for hedging exposure to smaller size trades and may not necessarily be of large positions as required by cooperatives and multinationals.

Keywords: Agricultural commodities, CME dairy futures, Cross-hedging, Dairy, Error Correction Model, New Zealand Stock Exchange dairy futures

1. Introduction

Hedging is particularly challenging in the case of assets for which a fully developed derivative market does not exist or when there is insufficient market size to execute hedging trades. In this situation, cross-hedging using futures on other highly correlated assets is the main risk management tool (see Rahman et al. 2001 for cotton-seed meal, Franken and Parcell 2003 for ethanol, Adams and Gerner 2012 for jet fuel). Despite the strong increase in agricultural commodity price volatility and the food crises of 2008 and 2010–2011, there is relatively little academic research in the area of commodity cross-hedging (for a review of agricultural markets see Garcia and Leuthold 2004). Other risk management tools applicable to agricultural products include diversification of exposures on the portfolio level or production level (Paul and Nehring 2005). The recent study by Bellemare (2014) has shown that increases of food prices lead to social unrest. Therefore, hedging of food prices has political as well as economic importance. In this paper, we analyze the hedging of internationally traded commodity products produced from milk. These products, including milk powders, cheese, and butter, are refined from fluid milk to counteract milk's perishability.

In recent years food prices have become significantly more volatile (Roache 2010, Wright 2011); thus finding an effective method of hedging has become very important for market participants, including farmers, milk processors, cooperatives, wholesalers, and retailers. Cross-hedging of exposure to milk-derived products is important in the context of the New Zealand economy. A dollar change in the milk-solids price results in an approximate NZD 100,000 gain or loss for dairy owner-operators and sharemilkers (see Dairy NZ Economic Surveys). For example, from 2007/2008 to 2008/2009, the milk-solids price dropped from NZD 7.37 to NZD 5.21. In aggregate, this amounted to over a billion dollar loss for the NZ economy (see NZIER 2010). Our paper considers hedging from the perspective of a farmer resident in a milk-product exporting nation.

The contribution of this paper is twofold. First, we show that internationally traded milk products are a distinct commodity group with low correlation to all tradable commodities. Second, NZX whole milk powder (WMP) futures are effective in hedging exposure to WMP spot prices for smaller trades. The effectiveness of hedging is on the level of 71%—indicating the proportion of variance reduced by hedging. The smaller size of the NZ dairy futures market makes hedging effective for individual farmers but makes hedging of large positions unfeasible for cooperatives and multinationals.

The remainder of this paper is organized as follows. Section two describes the salient features of the global dairy product market. Section three discusses the econometric methodology utilized. Section four describes the data utilized for analysis. Section five reports results and section six concludes the paper with suggestions for future research.

2. The International Milk Product Market

Crude oil ("black gold") is refined into gasoline, heating oil, gasoil, lubricants, kerosene, and other products. Fluid cow's milk ("white gold") is refined into cheese, butter, whole milk powder, skim milk powder, whey, and numerous other shorter-shelf-life specialty products like ice cream and yogurt. However, unlike crude oil, milk is perishable. Unless refrigerated carefully, milk will not last and must be processed into longer-life products.[1] The vast majority of fluid milk is collected from farmers by large cooperatives that process the milk directly into other products.

The international trade in milk products is dominated by six commodities: WMP, SMP, butter, anhydrous milk fat (AMF, a refined butter or butterfat), cheddar cheese, and whey powder. There is also significant trade in specialized products like infant formula. WMP is the largest in trade volume and the most important export for New Zealand. Non-fat dry milk, or SMP, is the largest dairy export for the United States and is also important for New Zealand and the European Union.

The growth in importance of the international dairy market has resulted in an increase in the number of exchanges offering dairy futures. The market for dairy futures characterized by the highest open interest is offered by the CME in the US. The other market with sufficient open interest for hedging is the New Zealand Stock Exchange Dairy Futures.

3. Methodology

The first order estimate of the optimal hedge ratio is estimated by a regression of spot returns on futures returns.

$$\Delta \log S_t = c + h\Delta \log F_t + \varepsilon_t \tag{1}$$

where S_t and F_t are the spot and futures price of the underlying, c is the intercept, h is the hedge ratio and $\varepsilon_t \sim N(0,\sigma^2)$. The hedge ratio depends on the correlation between the change of the spot price and the change of the futures price on different underlying assets (Cechetti et al. 1988).

$$h = \rho_{SF}\frac{\sigma_S}{\sigma_F} = \frac{\sigma_{SF}}{\sigma_F^2} \tag{2}$$

where σ_S is the spot return standard deviation, σ_F is the futures return standard deviation, and ρ_{SF} is the coefficient of correlation between spot and future returns.

Equation (2) implies that the search for an effective cross-hedge can utilize the correlation between changes in spot prices as search criteria. If a high correlation is found between spot prices on two commodities and one of those commodities has a liquid futures market, one can assume that a correlation between the asset being hedged and the futures contract on the different underlying will also be high.

The regression in Equation (1) above is estimated using the OLS method. In order to detect serial correlation in the residuals, we apply the Ljung-Box test (Ljung and Box 1978). We test for the presence of heteroskedasticity in the residuals using the Engle ARCH test (Engle 1982).

Lien (2004) illustrates that the optimal hedge ratio will be underestimated if a cointegrating relationship between futures and spot prices is present and not taken into account. Cointegration is verified using the Engle-Granger methodology (Engle and Granger 1987). First, the futures and spot prices are tested both in levels and first differences for stationary behavior. If the levels are non-stationary, but the returns are stationary, then a regression is performed of log spot prices on log future prices, and the residuals are tested for stationary behavior using the augmented Dickey-Fuller test (Dickey and Fuller 1986). If the residuals are stationary, an error correction model (ECM) (Ghosh 1993) can be estimated using OLS with the parameters from the first regression:

$$\Delta logS_t = c + \beta \Delta logF_t + \sum_k \gamma_k \Delta logF_{t-k} + \sum_l \delta_l \Delta logS_{t-l} + \lambda e_{t-1} + \varepsilon_t \quad (3)$$

where $\Delta \log S_t, \Delta \log F_t$ are the change in log spot and futures prices; $\Delta \log F_{t-k}$ are the lagged log future price changes from the same contract; $\Delta \log S_{t-l}$ are the lagged spot price changes; γ_k, δ_l are the short-term autocorrelation coefficients; λ, e_{t-1} are the error correction coefficient and term; and ε_t are the innovations. The error correction term is calculated as:

$$e_t = logS_t - a - b \cdot logF_t \quad (4)$$

where a and b are the coefficients from the original cointegration test regression between the log(spot) and log(future) price level series. Note that the ECM also includes several lags of both the spot and future returns, thus allowing for short-term serial correlation in future and spot return series.

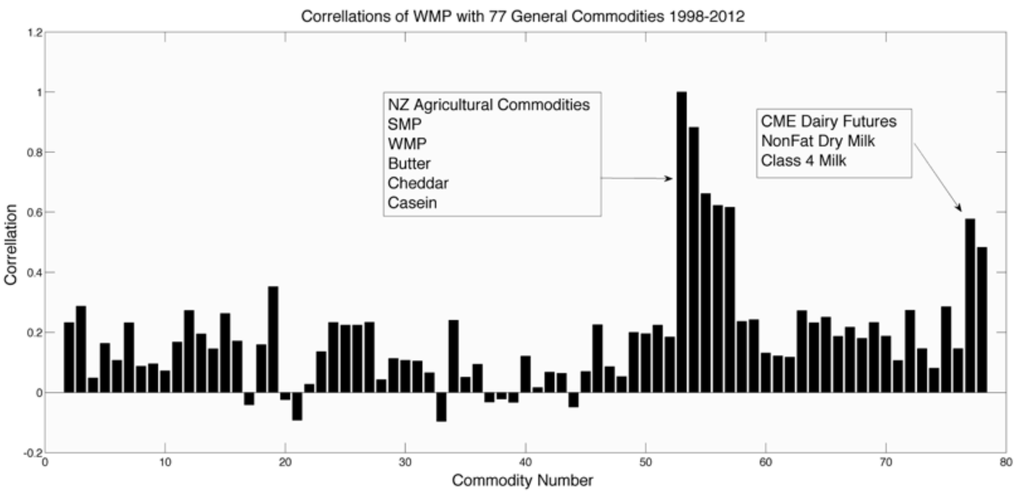
4. Data

In order to examine the most effective way to hedge exposure to the fluctuation of international dairy product prices such as WMP and SMP, four different approaches to hedging are investigated. As the best proxy for the international trade, we analyze the hedging of New Zealand WMP USD-denominated spot prices[2]. New Zealand is the dominant exporter of WMP with 61% of the international trade.

First, we examine the quality of hedging with NZX WMP futures constructed explicitly for the international trade of WMP. Second, we look at New Zealand agricultural commodities, as they share several of the same economic inputs or factors (land, silage, energy, weather). Thus, they may exhibit similar price behavior as WMP. Third, to ensure a comprehensive search for possible hedging instruments, internationally traded agricultural and non-agricultural commodities compiled by the International Monetary Fund are examined that include the major inputs to dairy in the United States (corn, soybeans, energy, etc.) and commodities that may be either economic complements (coffee) or substitutes (orange juice). Finally, we test the effectiveness of hedging with the most mature dairy derivatives in the world—CME dairy futures.

The NZX launched a futures contract on WMP in October 2010. This contract is cash-settled in USD to Global Dairy Trade second month contract auction prices[3]. The WMP contract was explicitly designed for hedging on the international WMP market. Contracts expiring monthly are available for 18 months.[4] It is a young market characterized by low open interest and volume. As a result, the NZX hedging results are principally of interest to individual farmers or speculators resident in major milk-product exporting nations – in particular NZ, the US, and the EU.

Figure 1. Correlations of 77 commodity assets with WMP from 1998-2013



Notes: This figure illustrates the correlations between monthly returns on 77 commodities with New Zealand (NZ) whole milk powder (WMP). The right center peak consists of the New Zealand dairy products – WMP, SMP, butter, cheddar, and casein. The perfect correlation of WMP with itself is shown for reference. The peak on the far right of the graph consists of two USA dairy products – class 4 milk and nonfat dry milk

The above makes the international dairy product group an excellent commodity portfolio diversifier. On the other hand, the uniqueness of dairy production makes finding assets for cross-hedging very difficult.

Next, we focus on finding the best cross-hedging instrument using regression and error correction model methodology. Table 1 reports the results of hedging WMP spot contracts with near-month NZX WMP futures. Column 1 contains the results from the simple regression (see Equation 1) and column 2 illustrates the error correction model results (see Equation 3).

Table 1. Comparison of cross-hedging models for WMP futures

Model	Regression	Error Correction
	$\Delta \log S_t = a + \beta \Delta \log F_t + \varepsilon_t$	$\Delta \log S_t = c + \beta \Delta \log F_t + \sum_k \gamma_k \Delta \log F_{t-k} + \sum_l \delta_l \Delta \log S_{t-l} + \lambda e_{t-1} + \varepsilon_t$
	(1)	(2)
Spot Variable	WMP (Agrifax)	WMP (Agrifax)
Futures Variable	WMP (NZX)	WMP (NZX)
Start Week	18-Oct-10	18-Oct-10
End Week	1-Apr-13	1-Apr-13
Constant	0.0006	0.0007
β	**0.5645**	**0.5984**
	[0.4941, 0.6349]	[0.5283, 0.6685]
e_{t-1}		**-0.2195**
Adj. R-Squared	0.67	0.7051
LBQ	15.3444	
Engle-ARCH	0.002	

Bold numbers indicate statistical significance at the 5% level or lower

Notes: This table illustrates the model fit parameters of hedging WMP with WMP futures. Column 1 reports the simple regression results and column 2 depicts the coefficients from an error correction model.

Column 1 reports the results from hedging WMP spot contracts with NZX near-month WMP futures contracts from October 2010 to March 2013. The LBQ and ARCH statistics are not significant, indicating that neither autocorrelation nor conditional volatility is present in the residuals.

In order to test for cointegration, the spot and futures variables must be non-stationary in levels but stationary in first differences or returns. WMP spot and WMP futures have non-stationary level series (ADF Stats Spot:-1.161, Futures: -1.249) but stationary return series (ADF Stats Spot-:-3.3784, Futures: -5.2948). The WMP spot/WMP futures residuals have a highly significant ADF statistic: -5.8615, indicating that the combination is cointegrated. The cointegration model results for WMP spot/WMP futures are illustrated in column 2 of Table 1. As expected, allowing for the long-term cointegration increases the R2 from 0.67 to 0.70. The near-month WMP futures contract is an effective hedge.

6. Conclusions

Two main conclusions can be drawn from the empirical analysis in this paper. First, international milk products are a distinct commodity group with low correlation to all tradable commodities, presenting excellent diversification opportunities for commodity portfolios but making hedging difficult.

Second, NZX WMP futures are effective at hedging whole milk powder (WMP). At this stage, the market is characterized with low open interest and liquidity and principally of interest to farmers in milk-exporting nations or speculators. The success of NZX dairy futures highlights the need for explicitly tailored futures contracts.

There are several directions in which our research could be extended. Since international dairy products form an uncorrelated commodity group, the diversification potential for a commodity portfolio could be investigated. Third, the standard method of hedging involves minimizing the variance of the combined portfolio, but several market participants may be more interested in hedging the down-side risk (see Mello and Parsons 2000). An alternate measure of hedging effectiveness that analyzed the covariance of asset returns during crisis times could be formulated and tested.

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Note

1. In particular, this means that there are no futures contracts on raw milk, which would be the natural hedge for derived products. The Chicago Mercantile Exchange does have futures on milk used for cheese production (class 3 milk) and milk used for powder production (class 4 milk).
2. New Zealand milk-powder products are priced in USD, rather than NZD, as 95% of NZ production is exported to the world market.
3. See NZX WMP contract specifications - http://www.nzxfutures.com/dairy/contract_specifications/wmp
4. We are grateful to the NZX which provided the futures contract data free of charge.

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