Cross-hedging on the International Milk-derived Product Market [Δ]

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Abstract

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 threefold. 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, New Zealand Stock Exchange dairy futures are an effective tool for hedging exposure to international dairy commodities. Third, Chicago Mercantile Exchange dairy futures are ineffective both for hedging international dairy commodities and for hedging US dairy commodities. Our findings have important implications for understanding effective methods of hedging with futures contracts on highly regulated markets with government agency interventions.

JEL classification: G11; G32; Q14; Q17

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

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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.

Hedging exchanges price risk—the risk that the price will fall or rise—with basis risk—the risk of unanticipated changes in the differential between the spot and futures price (Figlewiski 1984). The basis risk for cross-hedging is higher in comparison with direct hedging due to the application of futures contracts on similar but different underlying instruments.

Assuming highly risk-averse participants or unbiased futures markets, the optimal variance-minimizing hedge ratio depends on the correlation between the futures price used to hedge exposure to a particular spot price and the spot instrument price as well as the respective variances (Chen et al. 2003). Historically, the optimal hedge ratio was derived from a regression of futures on spot prices (Ederington 1979, Lien 2005b). Since Nelson and Plosser (1982) reported the likelihood of spurious results when using non-stationary level data, changes or log returns have been utilized instead of prices. In addition, advanced time series modeling techniques have been incorporated that account for autocorrelation, heteroskedasticity, return distributions other than the Gaussian, and co-integration (Baillie and Myers 1991, Ghosh 1993, Lien and Tse 2002). Recent studies have investigated multiplicative basis risk (Adam-Müller and Nolte 2011), volatility spillover effects (Wu et al. 2011), and jump diffusion models (Schmitz et al. 2013).

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. The dairy market has several unusual features of theoretical interest. The international milk product market is segmented, exposed to foreign currency fluctuations, and driven to a large extent by producer supply and consumer demand rather than investor speculation[a]. In addition, several of the futures markets are either new or illiquid. For example, the New Zealand Stock Exchange (NZX) dairy futures market was launched in 2008. It is characterized by insufficient liquidity to hedge exposure to milk powders and other milk derivatives. Therefore, cross-hedging might be the preferred technique for managing price risk.

The existing literature on commodity cross-hedging to a large extent has focused on jet fuel (see Carter et al. 2006, Adam-Müller 2011, Adams and Gerner

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[a] The recent study by Vercammen and Doroudian (2014) has shown that speculation, rather than destabilizing commodity prices as is commonly believed, actually reduces price volatility.

2012, Ankirchner and Imkeller 2012), grains (Brinker et al. 2007), and electricity (Woo et al. 2001, 2011). Less attention has been paid to cross-hedging for agricultural products (for a review, see Garcia and Leuthold 2004), and in particular there is little research on cross-hedging milk-derived products (see Deng 2007, Newton and Thraen 2013).

The analysis of cross-hedging of exposure to milk-derived products is important for at least two reasons.[b] First, 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 from the perspective of market participants, including farmers, milk processors, cooperatives, wholesalers, and retailers. Second, the international milk-derived product market is segmented; dairy policy in the United States and the European Union creates pricing distortions in the futures and spot markets within those key regions[c]. Previous studies on the effectiveness of cross-hedging, with the exception of Newton and Thraen (2013), have analyzed global non-segmented agricultural commodities markets.

The contribution of this paper is threefold. 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.

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[b] Cross-hedging of exposure to milk-derived products would be important in the context of the New Zealand economy. A dollar change in the milk-solids price results in an approximate $NZ 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).

[c] Recent policy changes may lead to a less segmented global milk market. Thirty-year-old milk production quotas in the EU were abolished on April 1st 2015 (see European Commission 2015), and the United States has discontinued the Dairy Product Price Support Program in the Agricultural Act of 2014(see USGPO 2014).

The effectiveness of hedging is on the level of 71%—indicating the proportion of variance reduced by hedging. Unfortunately, the insufficient size of the NZ dairy futures market (just 6,000 tons open interest versus over 2 million tons annual trade volume worldwide) makes hedging of large positions unfeasible.

Last, we establish that US non-fat dry milk futures (NFDM) are ineffective at hedging both international skim milk powder (SMP) and US NFDM, despite virtually identical commodity specifications.[d] Over the time period analyzed, the hedging effectiveness is measured as 18% and 30% for NFDM and SMP, respectively. The low effectiveness of hedging can be partly attributed to market segmentation caused by US government direct intervention in the market. The US government purchases milk powders at or below set floor prices and sells accumulated inventory when prices rise.

The remainder of this paper is organized as follows. Section two describes the salient features of the global dairy product market. Section three presents a short review of the relevant literature. Section four discusses the econometric methodology utilized. Section five describes the data utilized for analysis. Section six reports results, and robustness checks are enumerated in section seven. Section eight 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

[d] NFDM future contracts are also reported as ineffective at hedging NFDM spot prices within the United States.

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.[e] The vast majority of fluid milk is collected from farmers by large cooperatives that process the milk directly into other products. Typically, a few cooperatives dominate the process in a country and set the farmgate milk price for farmers on an infrequent basis. For example, Fonterra of New Zealand processes 89% of the milk produced in New Zealand and sets the farmgate milk price twice annually. Cooperatives have approximately a 57% market share in the European dairy industry (Hanisch et al. 2012). In the United States in 2012, the five largest cooperatives processed 42% and the top 50 processed 79% of all cows milk generated (Johnson 2012). The cooperatives are effectively a market maker for the spot market for fluid milk (Cakir and Balagtas 2012).

There are three main production streams for processed milk. The following long-shelf-life products can be produced from approximately 100 liters of fluid milk: 13 kg of WMP or 9 kg of SMP and 4 kg of butter[f] or 13 kg of cheddar cheese and 6 kg of whey powder (Lucey 1994). A typical milk tanker carries approximately 24,000 liters of fluid milk[g] which, for example, could be refined into 2 tons of WMP.

The international trade in milk products is dominated by six commodities: WMP, SMP, butter, anhydrous milk fat (AMF, a refined butter or

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[e] 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).

[f] Pearce C., "Milk Powder", New Zealand Institute of Chemistry, *nzic.org.nz/ChemProcesses/dairy/3C.pdf*, Retrieved January 12, 2014.

[g] Fonterra Edendale Factsheet, http://www.fonterra.com//global/en/about/our+locations/newzealand/edendale, Retrieved January 12, 2014.

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 major exporters of whole milk powder are New Zealand (61%), the European Union (18%), Argentina (12%), and Australia (5%) (IndexMundi 2013a). New Zealand exports 95% of all milk produced via the cooperatives Fonterra (93%), Synlait, Tatua, and Westland. The European Union only exports surplus WMP, and there are government market intervention policies in place. The major importers of WMP are China (49%), Algeria (22%), Indonesia (7%), and Brazil (7%) (IndexMundi 2013b).

Figure 1 illustrates the WMP prices in Germany and Oceania over the period January 8, 2004 to November 21, 2013. Though the products are identical, there is significant variation in the WMP prices. This segmentation arises from the dairy policy of the European Union. New Zealand has no restrictions on dairy production or export, but both the European Union and the United States have tariffs,[h] tariff quotas, and export subsidies.[i] In addition, there is direct market intervention[j] at pre-set floor prices.[k] The inventory is then

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[h] The European Union has tariffs and tariff quotas on cheese and butter, and grants export refunds on WMP. The United States has import tariffs and tariff quotas on cheese, butter, SMP, WMP, and whey (USDA Foreign Agricultural Service 2008).

[i] The European Union pays exporters a refund to allow them to sell WMP at the international market price.

[j] In the United States, "Through its support price program, the U.S. government agrees to buy dairy commodities at a minimum level (cwt basis)—$1.13 for block cheese, $1.10 for barrel cheese, $1.05 for butter, $.80 for non-fortified non-fat dry milk and $.81 for fortified non-fat dry milk ", CME Group, An Introduction to Trading Dairy Futures and Options.

[k] In the European Union, butter and SMP are available for intervention from March 1st to August 31st of each year. From 2008, these prices have been set at 246.39 euros for butter and 169.8 euros for SMP. Purchasing will take place at a guaranteed 90% of the support price for 20,000

stored until market prices recover, at which point the stored inventory is released into the market.

[insert Figure 1 here]

The major exporters of skim milk powder are the United States (31%), the European Union (27%), New Zealand (24%), and Australia (1%) (IndexMundi 2013c). The major importers of SMP are China (21%), Indonesia (19%), Mexico (17%), the Russian Federation (11%), Algeria (10%), and the Philippines (10%) (IndexMundi 2013d). Figure 2 depicts SMP prices from the major production regions. The SMP price for Oceania is significantly more volatile than the European Union or United States prices. Again, the difference may be attributed to government policy.

[insert Figure 2 here]

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. It is not only the largest dairy futures market, but also the market in which the price discovery process must accommodate government direct intervention. Table 1 enumerates the 2013 dairy futures contracts available around the world. The United States government classifies milk into different categories, depending on the ultimate end use. Class 3 milk is milk allocated for making cheese. Class 4 milk is milk allocated for making milk powders and butter.

[insert Table 1 here]

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tons of butter and 109,000 tons of SMP. After this threshold, additional quantities may be bought by tender. (Jongneel et al. 2011)

Most of time, the CME dairy futures market is in contango–that is, futures prices are greater than current spot prices. However, this situation occasionally inverts, as in late 2013, into a backwardation market due to high demand for futures or lower expected spot prices in the months to come. It is worth noting that the second market in terms of open interest—NZX dairy futures market—tends to be in mild backwardation most of the time.

In contrast to other commodities like corn, the CME dairy futures market does not attract speculative interest from the hedge fund industry (Commodity Futures Trading Commission [CFTC] Disaggregated Commitment of Traders Report 2013). For example, as of December 31, 2013, hedge funds held only 2% of outstanding long positions and no short positions in class 3 milk futures, while in corn futures they held 19% of the outstanding long positions and 30% of the outstanding short positions.

The dairy market provides an interesting contrast to the oil market. The dairy market is segmented due to government regulations/interventions, has immature futures markets, and lacks a market in the primary source commodity. The problems induced in the derivative pricing process and the low liquidity of new dairy futures markets lead naturally to the question of whether it is possible to find a commodity with similar price behavior that can effectively reduce basis risk and allow for effective hedging.

3. Literature Review

The analysis of hedging has a long history in academic studies. Johnson (1960) and Stein (1961) outline the theory of minimizing the variance of the combined futures/spot position. Ederington (1979) suggests a measure of hedging effectiveness—the proportion of the variance reduced after adding position in futures. His gauge is still utilized in empirical studies. Anderson and Dathine (1981) apply mean-variance analysis to the futures/spot portfolio, and provide the starting point for empirical studies. Those studies assume extremely risk-averse investors or efficient futures markets. Benninga et al. (1984) have shown that if futures markets are unbiased, and future changes in price are a linear function of spot changes in price, then the variance-minimizing position maximizes expected utility irrespective of the hedger's utility function (also see Myers and Thompson 1989).

In order to take into account the long-term co-integration of spot and futures prices and short-term serial correlation in spot and future returns, an error correction model was applied (see Ghosh 1993). Next heteroskedasticity in futures and spot return series was incorporated into the estimation of the optimal hedge ratio by using a GARCH framework (Baillie and Myers 1991, Lien and Tse 2002). Finally, studies such as Kroner and Sultan (1993) and Adams and Gerner (2012) consider the error correction model with a GARCH error framework.

The Ederington measure of hedging effectiveness—the reduction in unconditional variance—will always favor the ordinary least squares (OLS) regression of future returns on spot returns (Kroner and Sultan 1993, Lien 2005a, Lien 2009). By construction, the simple regression of futures on spot returns produces a constant hedge ratio that minimizes the unconditional variance. Any other estimator of a constant hedge ratio—for example, from an error correction model—will not improve on the simple OLS estimate. However, the more complex models that allow the hedge ratio to vary over time will minimize the conditional variance (Lien 2009, Alexander and Barbosa 2007).

This requires that the statistical model is correctly specified, or the residual variance will not correspond to the conditional variance and be economically meaningful. Thus, the R-Square from an error correction model for an in-sample estimate may provide an indication of the superiority of the model over a simple regression, but this must be ultimately be verified. One method is backtesting over rolling periods and allowing the hedge ratio to vary (Adams and Gerner 2012).

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Cross-hedging is hedging using a futures contract on a different underlying. The primary academic focus of cross-hedging has been on the stock index and foreign exchange markets (see Benet 1982, Ghosh 1993, Chang and Wong 2003). In the case of commodities, research on cross-hedging has been mainly focused on jet fuel. The hedging of exposure to this commodity has served as a test bed for many theoretical improvements in cross-hedging methodology (see Adam-Müller and Nolte 2011, Adams and Gerner 2012, Brooks et al. 2012, Schmitz 2013).

Other commodities than jet fuel have received less focus. Rahman (2001) investigates cross-hedging cottonseed meal with soybean meal. Woo et al. (2011) study cross-hedging electricity with NYMEX natural gas futures. Franken and Parcell (2002) report on hedging ethanol with unleaded gasoline. Brinker et al. (2007) examine hedging distillers dried grains with corn and soybean meal. Newton and Thraen (2013) investigate cross-hedging Class 1 fluid milk with class 3 fluid milk futures. The majority of these studies (with the exception of

Woo (2011)) disregard co-integration and heteroskedasticity, and some studies utilize price levels rather than changes or returns. This paper uses a comprehensive econometric modeling technique on a less studied, illiquid commodity market—the dairy market.

4. Methodology

In hedging, the basis is the difference between the spot price and the futures price. In the case of cross-hedging, the basis is higher as it is the sum of two components. The first component is the basis when direct hedging with the same underlying, and the second component is due to the mismatch between the underlyings.

Basis risk is the risk of unanticipated changes in the spot and futures price differential between the time that the hedge is placed and the hedge is lifted. The total risk of a hedged position is minimized by constructing a combined portfolio of spot and futures contracts and minimizing the portfolio variance. Note that in cross-hedging, the portfolio consists of spot contracts on the hedged commodity and futures contracts on a different commodity. The problem of minimizing that portfolio is solved by finding the optimal hedge ratio, which defines the number of contracts per unit of exposure to spot prices.

The first order estimate of the optimal hedge ratio is constructed by a regression of spot returns on futures returns.[1]

[1] Before the seminal study by Nelson and Plosser (1982) that illustrated spurious results with non-stationary price data, several studies utilized price-level regressions. In this paper, we follow the recommendation by Benninga (1983) to use price differences or log price differences (continuous financial returns).

$$\Delta \log S_t = c + h\Delta \log F_t + \varepsilon_t \qquad (1)$$

where S_t and F_t are the spot and futures price of the underlying, c is the intercept, *h* is the slope and $\varepsilon_t \sim N(0,\sigma^2)$.

This ratio depends on the correlation between the change of the spot price and the change of the futures price on different underlyings (Cechetti et al. 1988).

$$h = \rho_{SF} \frac{\sigma_S}{\sigma_F} = \frac{\sigma_{SF}}{\sigma_F^2} \qquad (2)$$

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. However, there are at least four imperfections in the time series data that violate OLS assumptions—serial correlation, heteroskedasticity, return distributions other than the normal,[m] and co-integration. Following other studies (Baillie and Myers 1991, Ghosh 1993, Lien 2004), we argue that ignoring the above

[m] In general, empirical studies that have investigated the use of alternative return distributions have found negligible effects (Baillie and Myers 1993, Adams and Gerner 2012). Given the minor importance, this imperfection is not modeled in this paper.

imperfections may lead to the incorrect selection of the size of the optimal hedging position.

In order to detect serial correlation in the residuals, we apply the Ljung-Box test (Ljung and Box 1978). If present, the model fit can be improved by adding several lags of both the future and spot returns to Equation (3) (Herbst et al. 1989, Ghosh 1993, Lien 2002, Adams and Gerner 2012). We test for the presence of heteroskedasticity in the residuals using the Engle ARCH test (Engle 1982). Standard econometric methodology deals with heteroskedasticity using a model from the GARCH family. As an example, Baillie and Myers (1991) investigate direct hedging of six commodities—beef, coffee, corn, cotton, gold, and soybeans—using a GARCH(1,1) model. Newton and Thraen (2013) utilize a GARCH(1,1) model to accommodate volatility clustering in the class 3 and class 4 milk basis.

Lien (2004) has illustrated 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:

$$\Delta \log S_t = c + \beta \Delta \log F_t + \sum_k \gamma_k \Delta \log F_{t-k} + \sum_l \delta_l \Delta \log S_{t-l} + \lambda e_{t-1} + \varepsilon_t \quad (3)$$

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:

$$e_t = \log S_t - a - b \log F_t \quad (4)$$

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.

The ECM can be augmented to accommodate GARCH errors in the residuals (Kenourgious et al. 2008, Adams and Gerner 2012). In this case, the system of equations is jointly estimated using maximum likelihood. It is also possible to include multiple regressors in the model, giving rise to composite hedging. Chen and Sutliffe (2007) report that composite hedging of the Amex Oil Index using S&P 500 and New York Mercantile Exchange crude oil futures is more effective than either alone. However, Lien (2008) has illustrated that the proposed composite hedging effectiveness estimator is biased and therefore unreliable.

5. Data

In order to examine the most effective way to hedge exposure to the fluctuation of dairy product prices such as WMP and SMP, four different approaches to hedging are investigated. First, we examine the quality of hedging with NZX WMP and SMP futures constructed explicitly for the international trade of WMP and SMP. 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 and SMP products. Third, 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 and SMP and AMF futures in December 2010. These contracts are cash-settled in USD to Global Dairy Trade second month contract auction prices[n]. The WMP contract was explicitly designed for hedging on the international WMP market. Contracts expiring monthly are available for 18 months.[o] It is a young market characterized by low liquidity and volume. As a result, it cannot meet the needs of all market

[n] See NZX WMP contract specifications - http://www.nzxfutures.com/dairy/contract_specifications/wmp

[o] We are grateful to the NZX which provided the futures contract data free of charge.

participants. The open interest was only 6,375 tons as of December 2013.[p] This is in comparison to over 2 million tons exported annually.[q] The NZX SMP futures market is even smaller, with 2,510 metric tons open interest as of December 2013.

New Zealand agricultural product data consist of weekly time series for all key New Zealand agricultural products, including lamb, mutton, beef, venison, dairy, wool, grain, and forestry and fish products.[r] The majority of these time series extend from 1980 to 2013. The diary products are quoted in USD, and the other series are converted from NZD to USD for comparison. Several of these products compete for production inputs with dairy. For instance, when milk prices are high, sheep or venison farms may undergo conversion to dairy. The high milk price in 2008 engendered the conversion of 300 sheep farms to dairy production.[s] In addition, climate variations will affect several of these products simultaneously.

The IMF provides monthly time series from 1980 to 2013 on virtually all internationally traded commodities.[t] These commodities include energy (oil, coal, natural gas), agricultural products (corn, soybeans, sugar, rice, hides, ground nuts, fishmeal), metals (copper, aluminum, tin, zinc), forestry products, and more exotic products like fishmeal and bananas. All commodities are quoted in USD. A full list is provided in the appendix. Many of these commodities are

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[p] NZX Dairy Futures, http://www.nzxfutures.com/dairy/quotes/wmp, retrieved December 9 2012.
[q] USDA via IndexMundi, http://www.indexmundi.com/agriculture/?commodity=powdered-whole-milk&graph=exports, retrieved December 9, 2012.
[r] These data were kindly provided by Agrifax at minimum cost.
[s] Otago Daily Times, June 7, 2008, *No end in sight to dairy conversions*, ,http://www.odt.co.nz/news/business/8748/no-end-sight-dairy-conversions, retrieved September 17, 2014.
[t] IMF, http://www.imf.org/external/np/res/commod/index.aspx, retrieved December 9, 2012.

used indirectly or directly in the production process for dairy (grains, energy), or are economic complements (coffee, tea).

The CME is the most mature and liquid market for dairy futures. USD Futures are available on butter, cheddar cheese, class 3 milk, class 4 milk, non-fat dry milk, and dry whey. Class 3 milk is used to produce cream cheese and hard manufactured cheese. Class 4 milk is used to produce butter and any milk in dried form. SMP is virtually the same as Non-fat dry milk (NFDM), but has a minimum protein content of 34% whereas NFDM has an average protein content of 38%. The non-fat dry milk futures data analyzed consist of near-month daily prices from April 2003 to June 2013. The class 4 milk futures run from October 2000 to June 2013.

USD spot prices for US dairy commodities were downloaded from the website of the University of Wisconsin Dairy Marketing and Risk Management Program.[u] The following time series are available for non-fat dry milk, class 4 milk, CME cheddar cheese, CME butter, whey powder, lactose, and rennet casein. The time series are available with weekly and monthly granularity.

In the search for assets that are highly correlated with WMP and SMP, all spot price time series are converted to monthly frequency by averaging the weekly prices within each month. In addition, the start month for all spot price time series was set to October 1998, as several time series do not extend backwards before this month. The correlations between the series are calculated based on log price changes.

[u] University of Wisconsin Dairy Marketing and Risk Management Program, http://future.aae.wisc.edu/index.html

For the analysis of hedging Agrifax weekly spot prices with WMP futures, the futures price for the near-month contract on the closest date to the Agrifax survey date is used. As an alternative method, WMP futures prices could be averaged over each week, but this was found to diminish the correlation with the Agrifax weekly time series. The futures price level time series is constructed of weekly observations of the near-month futures contract.

For the analysis of cross-hedging Agrifax WMP and SMP spot prices, and US NFDM spot prices with US dairy futures, the near-month CME time series for NFDM and class 4 milk are averaged over each week before log returns were calculated.[v] For the study of hedging NFDM spot prices with NFDM futures, the prices are matched on a weekly basis.

6. Results and Interpretation

This section is divided into two parts. In first part, we discuss the hedging effectiveness of all commodities, and in the second part, we focus on the two best hedging instruments—NZX WMP futures and CME NFDM futures for hedging WMP, SMP, and NFDM.

To identify a commodity that minimizes basis risk, all commodity time series in the dataset are converted to monthly returns to match the IMF granularity, and the correlations with WMP are investigated. Figure 3 illustrates the correlations of 77 different commodities with WMP over the time period October 1998–March 2013.

[insert Figure 3 here]

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[v] Matching based on the closest futures date to the Agrifax series was also investigated, and resulted in marginally lower correlations..

The right-center peak corresponds with the New Zealand dairy products—WMP, SMP, butter, cheddar, and casein. The perfect correlation of WMP with itself is shown for reference (see Figure 3). The peak on the far right of the graph consists of two US dairy products—class 4 milk and NFDM. Table 2 reports assets with the highest correlation to WMP and SMP products. As expected, US dairy futures on NFDM and class 4 milk have the highest correlation with NZ dairy products. The second-largest correlation after US dairy futures is reported for lead traded on the London Metal Exchange (LME). Table 2 reports correlations for the full sample and its second half.

[insert Table 2 here]

The correlations increase marginally over the second half of the sample, but no commodity has a sufficiently high correlation with dairy products to act as a hedge. This result can be explained by the fact that New Zealand essentially sets the price for internationally traded WMP with a 64% market share. Moreover, New Zealand production conditions are such that no commodity is of overriding importance as an input. That is in contrast to the United States, where the milk cow diet is supplemented with a significant amount of corn and other high-energy supplements. Dairy products in New Zealand are produced from free-range cows—in other words, cows are only fed grass and a small of amount of supplemental silage. Thus, the main drivers of the milk production process are the number of cows and the amount of grass growth, which is driven to a large extent by rainfall.

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

To examine the stability of the correlations over time, a rolling one-year intensity map is illustrated in Figure 4. The year is shown on the x-axis and the commodity number on the y-axis. The NZ dairy product group is numbered from 52 to 56. The white line at 53 is WMP, with a perfect correlation. Stable correlations are marked by a consistent shade horizontal line. The only stable correlations are again in the dairy product group. Though on an annual basis there are frequently high-magnitude correlations (positive and negative), these correlations are unstable and often switch sign from year to year. The increase in positive correlations since 2008 has been noted in academic papers (see Tang and Xeong 2010) , but the effect appears to be attenuating over time.

[insert Figure 4 here]

Next, we focus on finding the best cross-hedging instruments using regression and error correction model methodology. Table 3 reports the results of three separate regressions: hedging WMP spot contracts with near-month NZX WMP futures, cross-hedging SMP spot contracts with near-month CME NFDM futures, and hedging NFDM spot contracts with near-month CME NFDM futures. Columns 1–3 are the results from the simple regression (see Equation (1)) and columns 4–6 are the error correction model results (see Equation (3)).

[insert Table 3 here]

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. Panel A in

Table 4 reports the stationarity tests for WMP spot, SMP spot, NFDM spot, WMP futures, and NFDM futures prices. All variables have non-stationary level series but stationary return series. Panel B reports the ADF statistics from cointegration tests that inspect the residuals of the regression of log(spot) on log(futures) levels for unit roots. Each pair—WMP spot/WMP futures, SMP spot/NFDM futures, and NFDM spot/NFDM futures—have highly significant ADF statistics, indicating that each combination is cointegrated.

[insert Table 4 here]

The cointegration model results for WMP spot/WMP futures are illustrated in column 4 of Table 3. As expected, allowing for the long-term cointegration increases the optimal hedge ratio from 0.67 to 0.70. The near-month WMP futures contract is an effective hedge, but as discussed previously the market size is minimal and not sufficient to execute hedging trades.

Class 4 milk and NFDM have the highest correlation with WMP and SMP, and also have liquid futures markets in the United States.[w] Table 4, column 2, reports the results from hedging SMP with CME NFDM futures. The residuals display autocorrelation, with a significant LBQ statistic, but there is no evidence of conditional volatility. The R-squared is only 0.07, which is insufficient for hedging purposes. It is possible to extend the hedging horizon, defined as the time interval between observations, to two weeks, one month, or more. This approach increases the R-squared of the regression, argue Juhl, Kawaller & Koch 2012, However, increasing the time interval should not be necessary given the effectiveness of the weekly time period used in the NZX analysis,

[w] CME NFDM futures have 59,780 tons open interest as compared with 6,000 tons open interest in NZX WMP futures (http://www.cmegroup.com/trading/agricultural/dairy/nonfat-dry-milk_quotes_volume_voi.html, last retrieved December 9, 2013.).

In Table 4, column 5, we present the cointegration model of SMP and near-month CME NFDM futures. There is significant autocorrelation at futures lag one and spot lags one and two. The cointegration coefficient is significant and of the correct sign. However, the R-squared of the full model is only 18%, which is still far from sufficient for hedging.[x] This mismatch most likely arises from the dairy policy of the United States, which has a price floor of $0.80 for non-fortified non-fat dry milk and $0.81 for fortified non-fat dry milk (CME Group 2013). The government will buy and store non-fat dry milk and then later sell the product when prices increase. This policy has the effect of truncating the price distribution by setting floor and ceiling prices on non-fat dry milk. The truncation appears to distort the correlation with international SMP prices, although the products are virtually identical in content.

This distortion of the correlations is also visible in the results reported for hedging USA NFDM prices with near-month CME NFDM futures contracts. Simple regression results are reported in Table 3 (see column 3). Both autocorrelation and heteroskedasticity are present in the residuals from the simple model, indicating violations of the OLS assumptions.

The error correction model results for NFDM spot/NFDM futures are reported in column 6 of Table 3. There are significant autocorrelation coefficients for futures lag one and spot lags one–five. There is no evidence of remaining residual heteroskedasticity or autocorrelation. In a similar vein to hedging international SMP, the CME futures contracts are also ineffective at hedging the NFDM spot prices within the United States with an R-squared of

[x] Finnerty and Grant (2003) recommend an adjusted R-squared of 80% for a hedge to qualify for hedge accounting treatment.

30%[y]. The pronounced autocorrelation is indicative of feedback effects from government dairy policy. It should be noted that the poor hedging effectiveness of CME NFDM futures is in stark contrast to the excellent hedging effectiveness of NZX WMP futures. The NZX dairy futures market is much newer and smaller in relative size to the CME dairy futures market, but the contracts are far more effective at hedging.

7. Robustness Checks

In the search for a commodity that minimizes basis risk with WMP and SMP, lagged correlations were investigated up to four lags ahead and behind, with the highest correlations at lag zero. In addition, quarterly correlations were calculated and compared at several forward and backward lags and found to be higher than monthly correlations but with greater instability. The increase in correlation over longer intervals indicates long-term relationships among the time series and supports the use of a cointegration model.

8. Conclusions

Three main conclusions can be drawn from the empirical analysis in this paper. First, New Zealand milk products are a distinct commodity group with low correlation to all tradable commodities, presenting excellent diversification opportunities for commodity portfolios. New Zealand milk is produced from grass-fed cows and production depends mainly on rainfall and cow numbers,

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[y] The U.S. agriculture futures contract exhibit usual patterns. Garcia et al. (2014) reported that agriculture futures contracts for corn, wheat, and soybeans traded at Chicago Board of Trade (CBOT) failed to converge to the price of the underlying commodity on the expiration date.

which ultimately will depend on the quantity and quality of agricultural land rather than commodity inputs.[z]

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. The success of NZX dairy futures highlights the need for explicitly tailored futures contracts.

Third, US dairy futures traded at CME are ineffective at hedging skim milk powder (SMP) and non-fat dry milk (NFDM). This is in stark contrast to the newer NZX Futures and most likely due to market segmentation caused by US government intervention policies. Interestingly, the return distributions for US dairy futures are markedly different from the return distributions for international WMP and SMP.[aa]

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. The relationship between the futures and forward markets for international milk products could be analyzed, as the data on both are readily available. 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

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[z] To take a long position in WMP or SMP, a portfolio manager could invest directly in NZX futures, purchase shares of dairy processors, buy into a dairy farming syndicate, or purchase agricultural land that could undergo dairy conversion. Directly purchasing dairy farming operations is also possible, as it is common for the operations to be outsourced to sharemilkers.

[aa] The analysis and contrast of the statistical properties of return series in regulated versus non-regulated markets shows promise for further research in the effects of government intervention on the operation of futures markets.

effectiveness that analyzed the covariance of asset returns during crisis times could be formulated and tested.

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Appendix:

The list of 77 commodities tracked by the International Monetary Fund (IMF), New Zealand Stock Exchange Agrifax, and the University of Wisconsin Dairy Risk Marketing and Management Program.

#	Description
1	YearMonth descriptor
2	Crude Oil (petroleum), Price index, 2005 = 100, simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh
3	Aluminum, 99.5% minimum purity, LME spot price, CIF UK ports, US$ per metric ton
4	Bananas, Central American and Ecuador, FOB U.S. Ports, US$ per metric ton
5	Barley, Canadian no.1 Western Barley, spot price, US$ per metric ton
6	Beef, Australian and New Zealand 85% lean fores, CIF U.S. import price, US cents per pound
7	Coal, Australian thermal coal, 12,000- btu/pound, less than 1% sulfur, 14% ash, FOB Newcastle/Port Kembla, US$ per metric ton
8	Cocoa beans, International Cocoa Organization cash price, CIF US and European ports, US$ per metric ton
9	Coffee, Other Mild Arabicas, International Coffee Organization New York cash price, ex-dock New York, US cents per pound
10	Coffee, Robusta, International Coffee Organization New York cash price, ex-dock New York, US cents per pound
11	Rapeseed oil, crude, fob Rotterdam, US$ per metric ton
12	Copper, grade A cathode, LME spot price, CIF European ports, US$ per metric ton
13	Cotton, Cotton Outlook 'A Index', Middling 1-3/32 inch staple, CIF Liverpool, US cents per pound
14	Fishmeal, Peru Fish meal/pellets 65% protein, CIF, US$ per metric ton
15	Groundnuts (peanuts), 40/50 (40 to 50 count per ounce), cif Argentina, US$ per metric ton
16	Hides, Heavy native steers, over 53 pounds, wholesale dealer's price, US, Chicago, fob Shipping Point, US cents per pound
17	China import Iron Ore Fines 62% FE spot (CFR Tianjin port), US dollars per metric ton
18	Lamb, frozen carcass Smithfield London, US cents per pound
19	Lead, 99.97% pure, LME spot price, CIF European Ports, US$ per metric ton
20	Soft Logs, Average Export price from the U.S. for Douglas Fir, US$ per cubic meter
21	Hard Logs, Best quality Malaysian meranti, import price Japan, US$ per cubic meter
22	Maize (corn), U.S. No.2 Yellow, FOB Gulf of Mexico, U.S. price, US$ per metric ton
23	Nickel, melting grade, LME spot price, CIF European ports, US$ per metric ton
24	Crude Oil (petroleum), Price index, 2005 = 100, simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh
25	Crude Oil (petroleum), Dated Brent, light blend 38 API, fob U.K., US$ per barrel

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26	Oil; Dubai, medium, Fateh 32 API, fob Dubai Crude Oil (petroleum), Dubai Fateh Fateh 32 API, US$ per barrel
27	Crude Oil (petroleum), West Texas Intermediate 40 API, Midland Texas, US$ per barrel
28	Olive Oil, extra virgin less than 1% free fatty acid, ex-tanker price U.K., US$ per metric ton
29	Oranges, miscellaneous oranges CIF French import price, US$ per metric ton
30	Palm oil, Malaysia Palm Oil Futures (first contract forward) 4-5 percent FFA, US$ per metric ton
31	Swine (pork), 51-52% lean Hogs, U.S. price, US cents per pound.
32	Poultry (chicken), Whole bird spot price, Ready-to-cook, whole, iced, Georgia docks, US cents per pound
33	Rice, 5 percent broken milled white rice, Thailand nominal price quote, US$ per metric ton
34	Rubber, Singapore Commodity Exchange, No. 3 Rubber Smoked Sheets, 1st contract, US cents per pound
35	Fish (salmon), Farm Bred Norwegian Salmon, export price, US$ per kilogram
36	Hard Sawnwood, Dark Red Meranti, select and better quality, C&F U.K port, US$ per cubic meter
37	Soft Sawnwood, average export price of Douglas Fir, U.S. Price, US$ per cubic meter
38	Shrimp, No.1 shell-on headless, 26-30 count per pound, Mexican origin, New York port, US cents per pound
39	Soybean Meal, Chicago Soybean Meal Futures (first contract forward) Minimum 48 percent protein, US$ per metric ton
40	Soybean Oil, Chicago Soybean Oil Futures (first contract forward) exchange approved grades, US$ per metric ton
41	Soybeans, U.S. soybeans, Chicago Soybean futures contract (first contract forward) No. 2 yellow and par, US$ per metric ton
42	Sugar, Free Market, Coffee Sugar and Cocoa Exchange (CSCE) contract no.11 nearest future position, US cents per pound
43	Sugar, U.S. import price, contract no.14 nearest futures position, US cents per pound (Footnote: No. 14 revised to No. 16)
44	Sunflower oil, Sunflower Oil, US export price from Gulf of Mexico, US$ per metric ton
45	Tea, Mombasa, Kenya, Auction Price, US cents per kilogram, From July 1998,Kenya auctions, Best Pekoe Fannings. Prior, London auctions, c.i.f. U.K. warehouses
46	Tin, standard grade, LME spot price, US$ per metric ton
47	Uranium, NUEXCO, Restricted Price, Nuexco exchange spot, US$ per pound
48	Wheat, No.1 Hard Red Winter, ordinary protein, FOB Gulf of Mexico, US$ per metric ton
49	Wool, coarse, 23 micron, Australian Wool Exchange spot quote, US cents per kilogram
50	Wool, fine, 19 micron, Australian Wool Exchange spot quote, US cents per kilogram

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51	Zinc, high grade 98% pure, US$ per metric ton
52	Milk Class 3
53	SMP (USD/t)
54	WMP (USD/t)
55	Butter (USD/t)
56	Chedder (USD/t)
57	Casein (USD/t)
58	NZD/USD
59	Non-Fuel Price Index, 2005 = 100, includes Food and Beverages and Industrial Inputs Price Indices
60	Food and Beverage Price Index, 2005 = 100, includes Food and Beverage Price Indices
61	Food Price Index, 2005 = 100, includes Cereal, Vegetable Oils, Meat, Seafood, Sugar, Bananas, and Oranges Price Indices
62	Beverage Price Index, 2005 = 100, includes Coffee, Tea, and Cocoa
63	Industrial Inputs Price Index, 2005 = 100, includes Agricultural Raw Materials and Metals Price Indices
64	Agricultural Raw Materials Index, 2005 = 100, includes Timber, Cotton, Wool, Rubber, and Hides Price Indices
65	Metals Price Index, 2005 = 100, includes Copper, Aluminum, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices
66	CME Cheddar
67	CME Butter
68	US Whey Powder
69	US Lactose
70	US Rennet Casein
71	NZ weighted average mutton
72	NZ weighted average P2 300 kg steer
73	US imported bull 95CL (USc/lb)
74	NZ weighted average AP 60kg stag
75	Wool 35 micron
76	AU ASW wheat
77	NonFat Dry Milk (USA)

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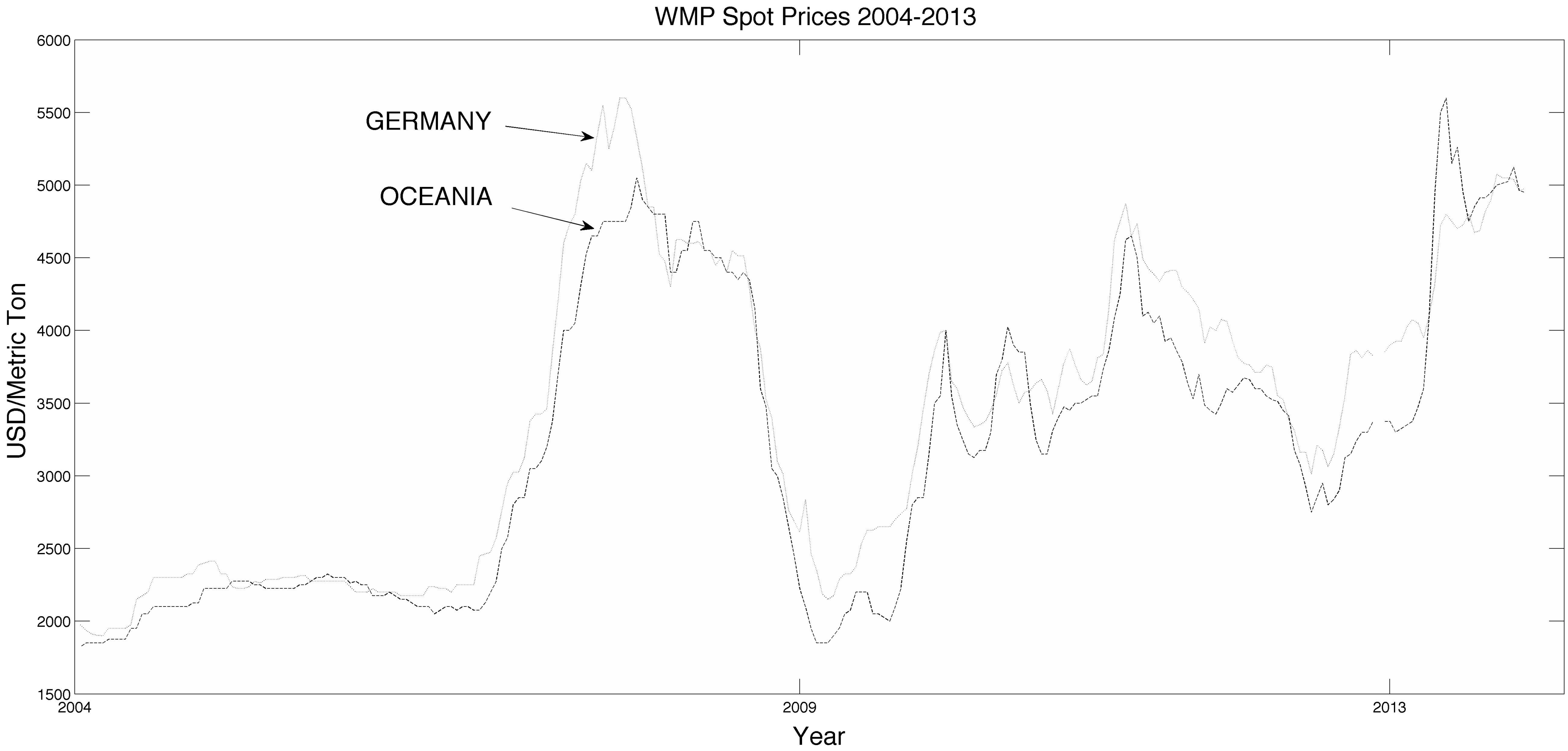
78	Class 4 Milk (USA)

Figure 1 – Oceania and Germany WMP Prices Over the Period January 8, 2004 to November 21, 2013 .



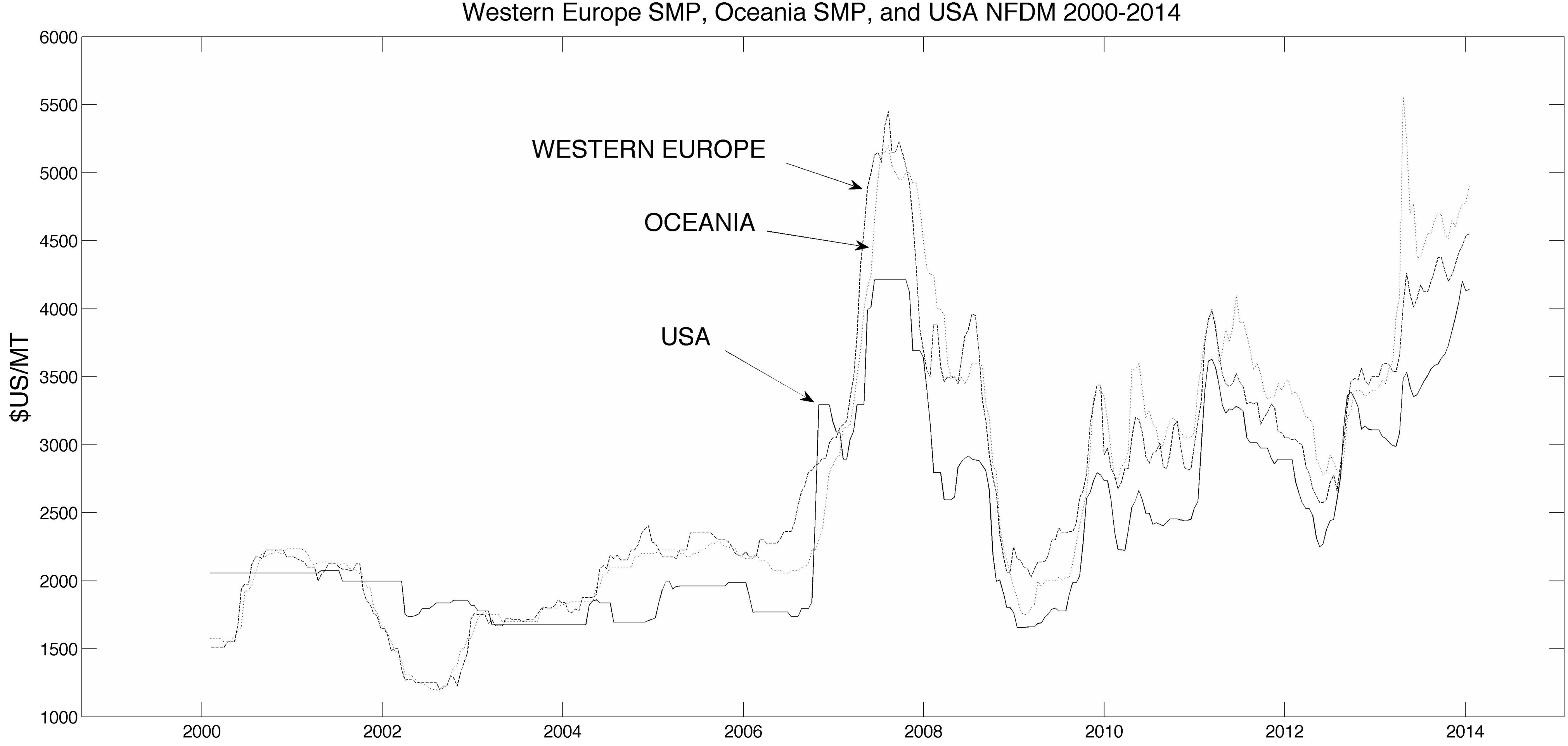
This figure illustrates the whole milk powder (WMP) prices in Germany and Oceania from January 8, 2004 to November 21, 2013 at weekly frequency in USD/metric ton (Bloomberg). Although the products are identical, there is significant variation in the prices.

Table 1 – Dairy Futures Contracts Around the World (2013)

Exchange	Description	Open Interest Dec 2013
Chicago Mercantile Exchange (CME)	Class III Milk	26,574 X 90 MT
CME	Class IV Milk	8,758 X 90 MT
CME	Cheese	8,888 X 9 MT
CME	Nonfat Dry Milk	3715 X 20 MT
CME	Dry Whey	2376 X 20 MT
CME	Butter	5308 X 9 MT
Eurex	Butter	464 X 5 MT
Eurex	SMP	172 X 5 MT
Eurex	Whey Powder	14 X 5 MT
NZX	WMP	6045 X 1 MT
NZX	SMP	2510 X 1 MT
NZX	Anhydrous Milk Fat (AMF)	600 X 1 MT

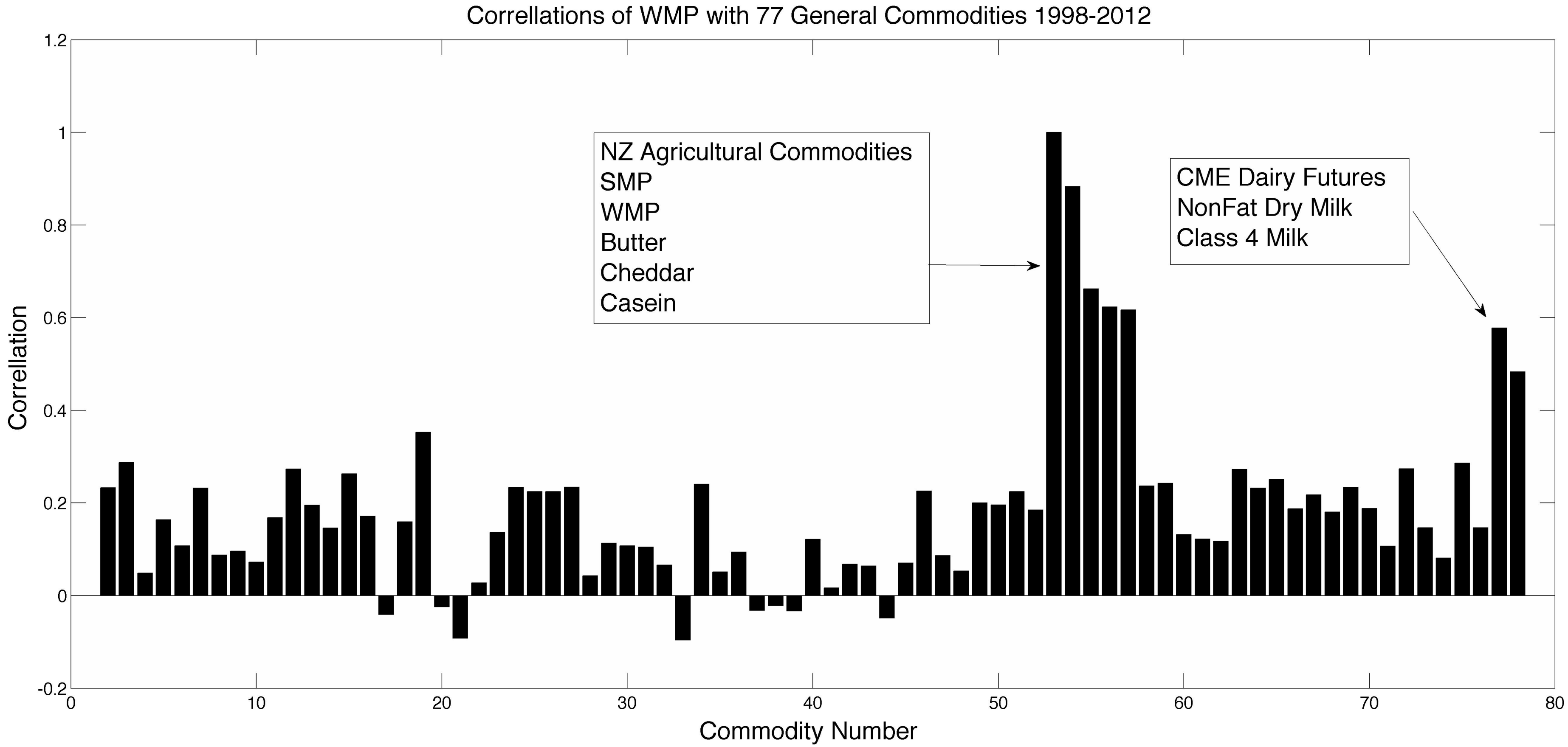
This table lists the dairy futures contracts available around the world in December, 2013 and the associated open interest, a proxy for the market size. The open interest is formatted as
(number of contracts) X (size in metric tons (MT)).

Figure 2 – Worldwide SMP Prices 2000-2014.



This figure illustrates the skim milk powder (SMP) prices in the USA, Oceania and the EU from 2000 to 2014 at bi-weekly frequency in USD/metric ton.

Figure 3 – Correlations of 77 Commodity Assets with WMP from 1998-2013



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

Table 2 – Commodity Spot Prices with Highest Correlation to WMP and SMP Spot Prices 1999-2013.

Commodity	WMP Full Sample 1999-2013	WMP 2nd Half	SMP Full Sample	SMP 2nd Half
SMP (USD/t) NZ Dairy	0.88**	0.88**	1**	1**
WMP (USD/t) NZ Dairy	1**	1**	0.88**	0.88**
Butter (USD/t) NZ Dairy	0.68**	0.68**	0.66**	0.69**
Chedder (USD/t) NZ Dairy	0.59**	0.6**	0.62**	0.67**
Casein (USD/t) NZ Dairy	0.61**	0.6**	0.62**	0.67**
NonFat Dry Milk (USA)	0.53**	0.6**	0.58**	0.65**
Class 4 Milk (USA)	0.46**	0.59**	0.48**	0.62**
Lead, 99.97% pure, LME spot price	0.31**	0.36**	0.35**	0.41**

This table reports the commodity spot prices with the highest correlation to WMP and SMP spot prices over the period 1999-2013. The first five commodities are NZ dairy commodities, followed by two USA dairy commodities. Columns three and five show the correlations over the second half of the sample. ** indicates significance at the 1% level

Table 3 – Comparison of cross-hedging models for WMP, SMP, and NFDM 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)	(3)	(4)	(5)	(6)
Spot Variable	WMP (Agrifax)	SMP(Agrifax)	NFDM(USA)	WMP (Agrifax)	SMP(Agrifax)	NFDM(USA)
Futures Variable	WMP (NZX)	NFDM (CME)	NFDM(CME)	WMP (NZX)	NFDM (CME)	NFDM(CME)
Time Period (YYYYWW)	201042 to 201314	200315 to 201311	200315 to 201310	201042 to 201314	200315 to 201311	200315 to 201310
Constant	0.0006	0.0011	0.0008	0.0007	0.0006	-0.0002
β	**0.5645**	**0.326**	**0.3681**	**0.5984**	**0.2262**	**0.2585**
	[0.4941, 0.6349]	[0.2273, 0.4246]	[0.281, 0.4552]	[0.5283, 0.6685]	[0.125, 0.328]	[0.1511 ,0.3660]
$\Delta \log F_{t-1}$					**0.1605**	**0.1999**
$\Delta \log F_{t-2}$					0.0531	-0.0072
$\Delta \log F_{t-3}$						0.0162
$\Delta \log F_{t-4}$						-0.045
$\Delta \log F_{t-5}$						-0.1854
$\Delta \log S_{t-1}$					**0.1204**	**-0.2288**
$\Delta \log S_{t-2}$					**0.188**	**0.3197**
$\Delta \log S_{t-3}$						**0.3074**
$\Delta \log S_{t-4}$						**0.2768**
$\Delta \log S_{t-5}$						**0.2212**
e_{t-1}				**-0.2195**	**-0.038**	**-0.2129**
Adj. R-Squared	0.67	0.0753	0.1178	0.7051	0.1808	0.3048
LBQ	15.3444	**50.5809**	**97.4956**		15.8769	22.4914
Engle-ARCH	0.002	0.0247	**12.7945**		0.4454	1.9329

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

This table illustrates the model fit parameters of hedging WMP with WMP futures, SMP with NFDM futures, and NFDM with NFDM futures. Columns 1-3 report the simple regression results whereas columns 4-6 depict the coefficients from an error correction model.

Table 4 – Stationarity and Cointegration Tests For Dairy Products.

Panel A

Stationarity Tests	Levels	Returns
	ADF-Stat	ADF-Stat
WMP Spot (Agrifax)	-1.161	**-3.3784**
SMP Spot (Agrifax)	-1.69	**-8.8333**
NFDM Spot (CME)	-1.542	**-7.627**
WMP Futures (NZX)	-1.249	**-5.2948**
NFDM Futures (CME)	-1.3497	**-9.5262**

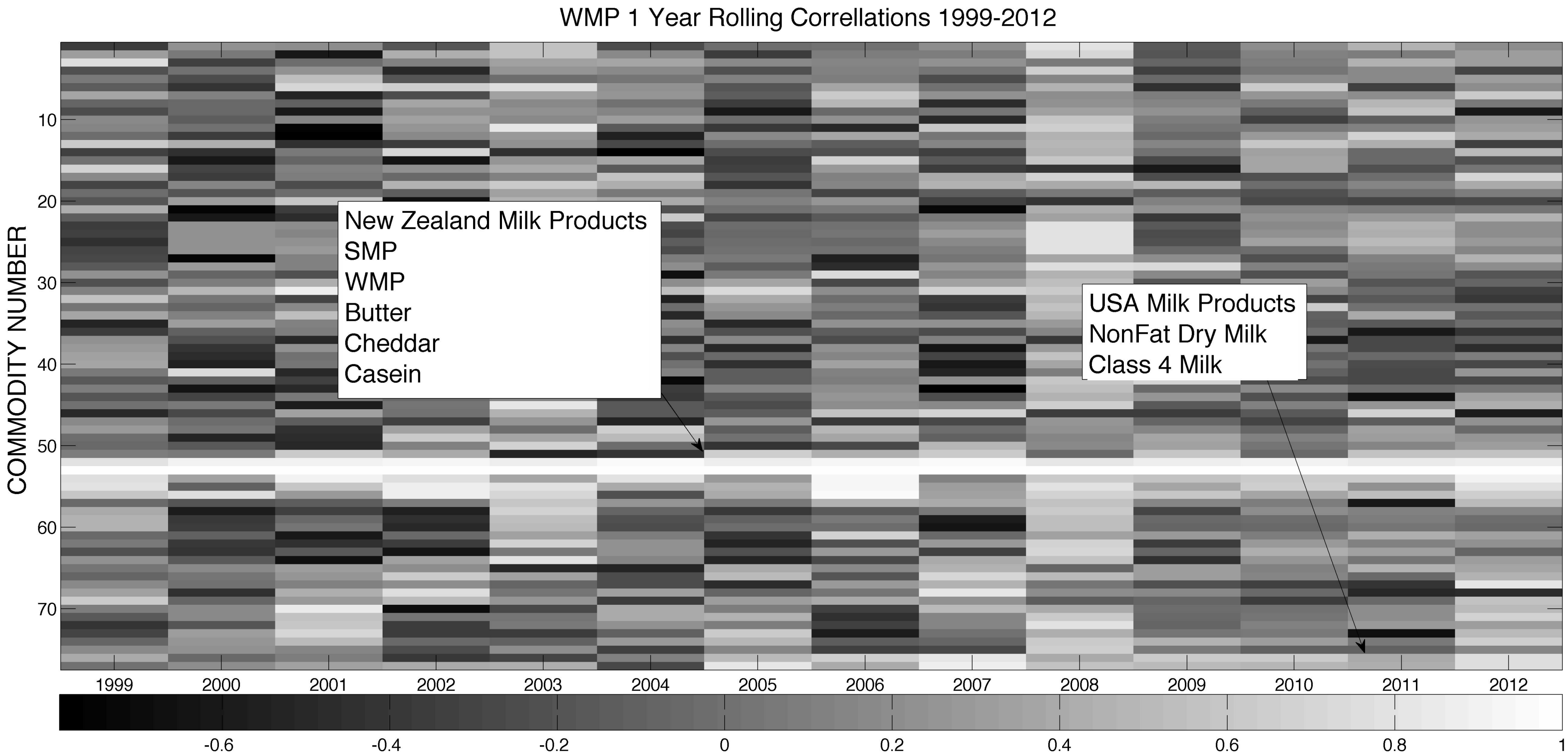
Panel B

Cointegration Tests

Spot Variable	Futures Variable	ADF-Stat
WMP (Agrifax)	WMP (NZX)	**-5.8615**
SMP (Agrifax)	NFDM (CME)	**-4.2881**
NFDM (CME)	NFDM (CME)	**-7.8833**

This table reports the stationarity and cointegration test statistics for the WMP, SMP, and NFDM spot time series. WMP futures and NFDM futures time series are also included. Bold values indicate significance at the 5% level or less. Panel A illustrates that each of the time series is non-stationary in price level but stationary in returns. Panel B indicates that each of the spot/futures combinations are cointegrated.

Figure 4 – WMP Correlation Stability Intensity Map



This figure depicts the rolling one-year monthly correlations of 77 commodities with WMP using an greyscale intensity map. The year is shown on the x-axis and the commodity number on the y-axis. The NZ dairy product group is numbered from 52 to 56. The white line at 53 is WMP, with a perfect correlation. Stable correlations are marked by a consistent shade horizontal line