DEPARTMENT OF ECONOMICS AND FINANCE

SCHOOL OF BUSINESS

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

**Does the Design of Spot Markets Matter for the Success of Futures
Markets? Evidence from Dairy Futures**

**Jędrzej Białkowski
Jan Koeman**

WORKING PAPER

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**Department of Economics and Finance
School of Business
University of Canterbury
Private Bag 4800, Christchurch
New Zealand**

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Does the Design of Spot Markets Matter for the Success of Futures Markets? Evidence from Dairy Futures

Jędrzej Białkowski^{1†}
Jan Koeman¹

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Abstract: This study provides evidence of the importance of a well-defined and functioning spot market for the success of the associated futures market. The United States (US) spot market for nonfat dry milk has several distinct pricing indices, whereas the New Zealand (NZ) market has a single spot reference price. Our analysis of hedging effectiveness and hedge ratio persistence shows that none of the US spot market indices may be hedged effectively with the Chicago Mercantile Exchange nonfat dry milk futures at short hedging horizons, whereas the NZ Stock Exchange whole milk powder futures contract is an effective hedge for the Global Dairy Trade spot pricing benchmark. Four important dimensions of spot market design are identified – timeliness, market-based measurement, forward-spot separation, and inclusiveness.

Keywords: Agricultural Commodities, Hedging; Futures Market Effectiveness; Spot Market Design, Dairy, CME NFDM Futures, NZX WMP Futures, Settlement to Average Spot Price

JEL Classifications: G13; G14; Q14; Q17

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¹ Department of Economics and Finance, University of Canterbury, NEW ZEALAND

† The corresponding author is Jędrzej Białkowski. Email:
jedrzej.bialkowski@canterbury.ac.nz

1. Introduction

A number of newly introduced futures contracts have failed to attract substantial interest from market participants and their trading is characterized by low volume (Carlton, 1984; Black, 1986; Brorsen & Fofana, 2001). Several studies investigate the possible reasons behind the success or failure of exchange traded derivatives and in particular futures contracts (see Johnston and McConnell, 1989; Bialkowski and Jakubowski, 2012; Garcia et al., 2015; Till, 2014; Webb, 2015). Although past studies point out several features of futures and related cash markets that increase the chance of success, the topic is the subject of debate, and Bhardwaj, Gorton, and Rouwenhorst (2015) argue that more research into the success and failure of futures contracts is needed. In this paper, we provide evidence that a previously unstudied aspect of futures markets – the underlying spot market index design – is a strong determinant of the hedging effectiveness of futures contracts and hedge ratio persistence over short to long hedging horizons.

Gray (1966) outlines three broad classes of reasons for the failure of futures contracts: poor design of the futures contract that favors either the buyer or the seller, the motivation to boycott a futures market because of the loss of pre-existing market power by either the buyer or seller, and the failure to attract speculation. In addition, Gray argues that the futures markets must serve a hedging function for commercial traders. Till (2014) and Webb (2015)¹ reinforce these considerations.

The majority of studies focus on the characteristics of the commodity, the salient features of the cash and futures market, and the aspects of the futures contract that are associated with success or failure. There is the implicit assumption that the cash market is structured to produce a single benchmark price to serve as the futures' underlying. Only a few studies, primarily in the shipping and freight markets, examine the characteristics of the cash market's underlying

¹ Professor Robert Webb's keynote speech during the 2015 Derivatives Markets Conference in Auckland enumerated 10 characteristics that are related to the successful introduction of a futures contract: 1) price volatility in the cash market, 2) the need to hedge for commercial participants, 3) public order flow of genuine commercial (i.e. hedging) trades, 4) good contract design that does not favor the long or short side, 5) first mover advantage, 6) actively traded related futures that facilitate spread trading, 7) liquidity in comparison with existing cross-hedges, 8) low explicit trading costs (e.g. brokerage commissions), 9) speculator interest to take the long side of hedger trades, and 10) timing of the introduction of the contract.

price index that promote success. In the case of these markets, the construction of price indices is necessary due to the wide range of product or service grades.

The contribution of this paper is threefold. First, it highlights the importance of the proper institutional design of the spot market to produce a benchmark with the necessary features to serve as the underlying for a successful futures contract. Second, the paper illustrates the trade-off between the settlement of futures contracts to a historical average and settlement to the spot price of the underlying. Third, this paper aims to serve as a source of information on the United States (US) and New Zealand (NZ) dairy futures and spot markets, a commodity market that has not received significant academic attention despite its importance and size. The analysis of the US and NZ futures contracts and their underlying spot markets illustrates that the design of spot markets strongly impacts the functioning of futures markets. In particular, the design of the spot market affects the hedging efficiency and hedge ratio persistence from short to long hedging horizons.

The remainder of this paper is organized as follows. Section 2 enumerates the important dimensions of spot market design. Section 3 illustrates how the selection and design of the spot market influences the riskiness of arbitrage, hedging, and speculative activity. Section 4 provides an overview of the US and NZ dairy spot market indices, and formulates our research hypotheses. Section 5 presents the data examined in this study. Section 6 reports our methodology. Section 7 reports results, and section 8 concludes.

2. Spot Market Design Dimensions

Little academic research focuses on spot market design as a factor affecting the performance of futures markets; all studies make an implicit assumption that the spot market is structured in a competitive manner so as to produce a single cash price.² This assumption is valid in the case of highly liquid underlyings with well-established mechanisms for single-price determination. The situation is different with less liquid assets traded in several locations with multiple price indices. Good examples of such assets are dairy products. In their case, the spot market was often designed shortly before a futures market was launched. In addition, government regulation has resulted in global market segmentation.

² Appendix 1 contains a detailed review of the factors that have been related to the success and failure of futures contracts.

A few studies in the shipping, trucking, fishing, and forestry markets examine the design of the underlying cash market. These markets exhibit a wide range of product grades and quality, requiring the explicit construction of a single-price index. Kavussanos and Visvikis (2006) examine the maritime shipping industry and enumerate 10 characteristics that a cash market price index should exhibit – accuracy, absence of bias, familiar units, broad coverage, frequent publication, auditability, low access cost, and the participation of major market participants. Bignell (2013) adds the ability to break down the index into separate sub-indices and the ability to update the index structure as market conditions change.

We identify four important dimensions of spot market design for producing a single-price index that can serve as an effective underlying for a futures contract: timeliness, market-based measurement, inclusiveness, and forward-spot separation. Timeliness measures the extent to which the information is current for price formation. Timeliness will be lower for indices that incorporate a range of historical information into the spot price or for indices that induce a delay between the price measurement and publication date. Hedging effectiveness is ultimately determined by the correlation between spot and futures price changes. At a point in time, the correlation between a single futures price and a range of spot prices will be lower than that between two single prices. Indices that use more current information are superior. The market-based characteristic indicates the extent to which the measure is determined by markets rather than surveys among market participants. Prices generated by financial and commodity markets are more accurate than survey prices and mandatory surveys are more accurate than voluntary surveys. Forward-spot separation indicates the separation of spot and forward market sales. A price index that mixes forward and spot sales, or that only provides spot or forward sales, will be less effective than a structure that provides both spot and forward price information. In markets for perishable commodities, it is often advantageous to have forward rather than immediate delivery. Inclusiveness assures that a significant representative portion of trades are included in the spot market index. A price index that accurately reflects the breadth of trading activity is superior for price formation to a thinly traded index. A secondary advantage of an inclusive price index is resistance to price manipulation.

The corn spot markets provide an illustrative example of effective spot market design. At any particular moment in time, it is possible to ascertain the price of corn at the nearest country elevator. The website <http://www.agweb.com/markets/cash-grain-bids/> allows the entry of a

zip code to immediately see the cash bids and basis levels for the closest five elevators. In addition, the daily settlement price is available from several resources, including IndexMundi.³ Finally, at a moment in time, it is possible to see the geographic corn basis for the entire United States.⁴ The hedging effectiveness of the corn futures markets has been reported from 74% to 80% (Sanders et al., 2003; Lien, 2008).

In our study of the US and NZ dairy markets, we provide evidence that the spot market design matters for the functioning of the associated futures market. In particular, we report higher hedging effectiveness and superior hedge ratio persistence for futures contracts with spot market indices that incorporate the above dimensions.

3. Implications of Settlement to the Average Spot Price

The setup of a spot market and method in which futures contracts are settled make hedging, speculation, and arbitrage more risky and complicated. The introduction of averaging across time into the settlement mechanism introduces distortions for speculators or participants arbitraging physical versus financial through to settlement. In addition, settlement averaging makes hedging more risky due to uncertainty about the basis.

Both US and NZ dairy futures use an average price for settlement. The average price is chosen to increase the validity of the settlement price.⁵ More data points provide a more representative price for commodities that are thinly traded. A secondary possible reason for adopting an average price is an attempt to avoid manipulation of the spot price to gain from the futures settlement (Tashjian, 1995; Pirrong, 2001).

The Chicago Mercantile Exchange (CME) futures nonfat dry milk contract settles to the United States Department of Agriculture (USDA) Agriculture Marketing Service (AMS) National Dairy Product Sales Report (NDPSR) monthly announced price – a historical moving average, with sales included from up to 60 days prior to settlement.⁶ In New Zealand, the settlement calculation is also to the average of two biweekly auctions within the settlement month, but the

³ Index Mundi, Commodity price for Maize, <http://www.indexmundi.com/commodities/?commodity=corn>

⁴ AG Manager, Corn basis map 6th of January 2016, <http://www.agmanager.info/marketing/basis/maps/archives/2016/January/1/basismaps.asp?image=Basiscorn201601.jpg>

⁵ From a discussion with commercial traders.

⁶ Appendix 2 contains a list of dairy market acronyms

convergence problem is partly mitigated by the second auction being the day before settlement and the single source of price from the Global Dairy Trade (GDT) auction platform.

Settling to a historical average increases the basis risk for hedgers, introduces risk into arbitrage trades, and requires speculators to consider the relative movement of both futures and spot prices during the hedge lifetime. First, we show that in the case of futures contracts settled to a historical average instead of the spot price at expiration, the basis is different than zero. Assume that a trade was initiated at time 0, the price of the underlying is S_0 , and the price of the underlying on the spot market at time 1 is S_1 . When settling to a historical average of the prices at time 0 and 1, the settlement price is equal to $(S_0 + S_1)/2$. In this case, the basis is not 0 but $S_1 - (S_0 + S_1)/2 = (S_1 - S_0)/2$. In this model, the basis at settlement in the case of a futures contract with settlement to a historical average is equal to half the change in the spot price – a substantial difference from zero.

In the actual nonfat dry milk (NFDm) markets, the average is a volume-weighted average price, not a simple arithmetic average as in the above example. The average is calculated from four or five separate weekly numbers. As with the above example, one would expect a non-zero basis at expiration. Cohen and Gorham (1985) note that with the feeder cattle contract, the basis risk at settlement will be non-zero, as the cash settlement price is an average over time, space, and grade (also see Kenyon et al., 1991). The non-zero basis at maturity leads to greater uncertainty in basis changes, and lower hedging effectiveness. Perversi, Feuz, and Umberger (2002) identify an unpredictable basis as the major cause of failure of the cattle stocker contract. Paul et al. (1981) argue that the failure of the Maine potato contract was attributable to a lack of convergence of the potato spot and futures prices at contract maturity.

A non-zero basis at the maturity of a contract directly affects arbitrageurs and speculators. In the case of arbitrage implied by the cost-of-carry formula, an investor is expected to make a profit equal to the absolute value of the difference between the futures price and the theoretical price if the position is kept open until maturity. Past studies show that such arbitrage is not risk free (see Kawaller, 1987; McMillan and Ülkü, 2009; Nam et al., 2010). Nevertheless, settlement to an average price increases the risk. The profit from arbitrage is equal to the difference between the futures price and the theoretical price plus the basis at contract expiration. From the perspective of a futures market speculator who bets on the direction of price movements between opening the position and the contract maturity, settlement to an

average price makes the trade more complex. The potential profit or loss depends not only on the ability to predict the price at contract maturity, as with settlement to a point-in-time spot price, but also on the ability to predict prices at points taken as input for the average. For example, in the case of a simple arithmetic average calculated from the price at time 0 and 1 and a speculative short position open at time 0, the profit from speculation is higher when the spot price at time 1 is less than the spot price at 0. The speculator needs to predict the price path of the commodity rather than only the prices at contract settlement.

Hedging using futures with settlement to a historical average is more risky due to a higher basis risk. The cost of the asset or sale price for a hedged position is equal to the futures price at time 0, F_0 , plus the *basis*, where the *basis* is measured at the time of closing the hedging position. As a result of the non-zero basis at maturity for futures with settlement to the average of past prices, the basis will be higher if the hedging position is closed near expiration.

To summarize, there are costs associated with settlement to the historical mean of past spot prices. Arbitrage is more risky, hedging is less certain, and speculation requires prediction of the price path rather than only the price at closing. In the US and NZ dairy markets, average value settlement results in less than optimal hedging, but due to the single source of price in the NZ spot market, the reduction in overall hedging effectiveness is expected to be substantially smaller.

4. Dairy Markets in the United States and New Zealand

In this section, we outline the structure of and highlight the differences between the dairy spot and futures markets in the United States and New Zealand. Dairy market futures are used to illustrate the importance of proper spot market design for the functioning of associated futures markets. In particular, we provide the detailed structure of each of the possible spot price indices in the context of the relevant dimensions of spot market design.

4.1. The Global Production and Processing of Milk

Over 735 billion liters of cow's milk are produced annually worldwide. The global dairy sector is a \$330 billion market and significantly larger than the \$100 billion worldwide coffee market. Coffee is traditionally considered the second largest commodity after oil. The \$30 billion

export market for dairy ingredients⁷ is approximately the same size as the coffee export market. Dairy products made from cow's milk are a dietary staple in advanced western economies, and consumption is rising quickly in China and other rapidly developing nations. The United States produces approximately 26% and New Zealand 6% of raw milk globally. NZ exports exceed 90% of milk in the form of dairy ingredients, while the US exports approximately 14%.⁸

Raw milk is produced by individual farmers, and then either marketed as beverage milk or processed into a variety of longer-shelf-life commodity dairy ingredients. The processing of raw milk into beverage milk or dairy commodities is accomplished by large farmer cooperatives or independent milk processors and handlers. The beverage milk and dairy ingredients are then purchased and marketed by large multinational companies or retail chains. The main dairy ingredients produced in the United States are nonfat dry milk, cheese, whey, and butter. In New Zealand, whole milk powder is also produced in significant quantities. Approximately 70% of US and 90% of NZ raw milk production is manufactured into dairy commodities.⁹

An important problem in dairy markets is the compensation of individual farmers for raw milk production by the processors and handlers of raw milk. This problem arises from the perishability of raw milk – large tanker trucks collect and process milk in an industrial scale process, and the farmers are paid from the sales of manufactured products. The United States and New Zealand have taken different approaches to the problem; in the former, there is substantial government involvement, while the latter favors a free market approach.

4.2. The New Zealand Market

4.2.1. NZ Government Regulation

In contrast to the United States, the NZ government does not intervene significantly in the dairy marketplace. The largest dairy cooperative – Fonterra – has approximately a 90% market share in purchasing milk from farmers, and uses reference prices from the Global Dairy Trade auction

⁷ The Global Dairy Industry, Fonterra, <http://www2.fonterra.com/our-financials/the-global-dairy-industry>

⁸ US Dairy Export Council, US Export Data 2015, <http://www.usdec.org/research-and-data/market-data/us-export-data>

⁹ USDA, Fluid milk sales by product, 1975–2014 (millions of pounds), <http://www.ers.usda.gov/data-products/dairy-data.aspx>

platform.¹⁰ The NZ Commerce Commission conducts an annual review of the methodology utilized by Fonterra to calculate the farmgate milk price ultimately paid to farmer producers. Unlike in the United States, the NZ government is not involved in the publication of reference commodity prices.

4.2.2. NZ Spot and Futures Markets

Virtually all milk collected in New Zealand is processed for export into whole milk powder, skim milk powder, cheese, butter, whey, and a few other minor dairy ingredients. The bulk of forward ingredient sales is done in the over-the-counter market, directly with Fonterra and other cooperatives. However, approximately 30% of Fonterra's output is auctioned biweekly on Global Dairy Trade,¹¹ an auction platform explicitly designed for the forward selling of dairy ingredients to the worldwide marketplace.¹² GDT also sells ingredients from several other large dairy processors, including Dairy Foods of the United States, and ARLA of Sweden. GDT was formed in 2010, and holds auctions every two weeks for six different forward contracts. Contract 1 is for delivery in the next calendar month, Contract 2 for delivery in the second calendar month, and so on. The most liquid of these contracts is the second forward delivery month (Contract 2). Contract 1 is often thinly traded. A sufficiently large volume of dairy ingredients is sold on GDT to make it the key source of benchmark prices for internationally traded dairy ingredients. Prices in a weekly survey by Agrifax of producers in New Zealand closely follow the GDT prices.

The farmgate milk price paid to farmers by Fonterra is determined from the sales of dairy ingredients on GDT, less reasonable costs. Note that the calculation of the farmgate milk price is not connected in any way with the current spot pricing of dairy ingredients – it is calculated post sales.

In contrast to the United States, the GDT spot market benchmark is a two-month forward-looking price. The GDT prices are an accurate reflection of the price of dairy ingredients in the

¹⁰ Fonterra, Milk Price – The Facts, <https://www2.fonterra.com/files/financial-docs/milk-price-methodology/Milk+Price+Questions+and+Answers+1+Aug+2011.pdf>

¹¹ Global Dairy Trade Profile, Fonterra, <https://www.globaldairytrade.info/assets/Uploads/resources/GDT-Profile-2016.pdf>

¹² Fonterra, Submission on the Base Milk Price Calculation, <https://www2.fonterra.com/files/financial-docs/industry-regulations/commerce-commission/Fonterra+Submission+on+Key+Issues+-+Review+of+Milk+Price+Calc+2012-13.pdf>

marketplace. It is important to note that only a marketplace can give current pricing information – collecting an average of forward sales induces a delay in the spot price determination process.

The New Zealand Stock Exchange (NZX) launched whole milk powder (WMP), skim milk powder, and anhydrous milk fat (a clarified butter) futures in 2010. Open interest in whole milk powder has grown at a rate of 50% per year from 2012 to 2016, the hallmark of a successful futures contract introduction. The NZX dairy futures started trading shortly after GDT became operational. The whole milk powder and skim milk powder futures settle to an average of the last two GDT Contract 2 auctions, with the last futures trading day falling on the day before the second GDT auction.

4.3. The US Market

Before discussing the US dairy market in detail, we would like to highlight one of the important features of both dairy spot and futures markets. By convention, the underlying asset for a futures contract is a price series in the spot or cash market for immediate delivery of a commodity. However, in the case of the United States, the primary spot benchmark – the AMS National Dairy Product Sales Report of nonfat dry milk survey data – includes historical information from up to two months prior and is backwards looking. In contrast, the primary NZ spot benchmark – the Global Dairy Trade Whole Milk Powder Auction Contract 2 – has elements of a forward contract.

4.3.1. US Legislation

The US milk pricing regulations are intricate in nature and arose from a perceived historical need to increase the production of beverage milk relative to manufactured milk products and to support dairy prices (Erba and Novakovic, 1995). The legislation accomplishes this objective by surveying the prices of four basis commodities – nonfat dry milk, cheese, butter, and whey on a weekly basis. The surveyed prices are then used to stipulate the ultimate payment to farmers for raw milk according to usage. There are several laws that regulate the dairy industry

in the United States. The most important are the Federal Milk Marketing Orders, the Dairy Product Price Support Program,¹³ and the Dairy Import Tariff Rate Quotas.¹⁴

The milk marketing orders¹⁵ govern 10 separate geographic regions – Pacific Northwest, Arizona, Upper Midwest, Central, Southwest, Southeast, Mideast, Appalachian, Northeast, and Florida. The orders regulate dairy processors and handlers, and establish the price which farmers will be paid for raw milk. California has separate rules but functions essentially like another geographical marketing region.¹⁶

According to the USDA, the marketing orders have the following objectives: “(1) assure consumers of an adequate supply of wholesome (fluid) milk at a reasonable price; (2) promote greater producer price stability and orderly marketing; and (3) provide adequate producer prices to ensure an adequate current and future Grade A milk supply” (Jesse and Cropp, 2008).

Each of the 11 marketing orders classifies milk into four different categories depending on utilization: Class I – beverage milk; Class II – milk used for soft manufactured products, including yogurt, cream, and cottage cheese; Class III – milk used for hard cheeses and cream cheese; and Class IV – milk used for dry milk products and butter.

The prices for the four classes of milk are calculated from formulas based on the surveyed prices for four commodity products manufactured from milk: nonfat dry milk, cheese, whey, and butter. The class formulas establish minimum prices for the four classes of milk¹⁷ based on the surveyed prices of the four commodities, and are weighted to increase the production of beverage milk. Milk handlers and processors must pay these minimum prices into a pool that is used to compensate farmers. Farmers within a marketing order region receive uniform raw milk component prices funded by the pool payments.

¹³ The DPPSP was repealed in the 2014 Farm Bill, and replaced with the Margin Protection Program (MPP), a voluntary participation program which offers insurance against low milk-feed margins.

¹⁴ Randy Schnepf, Dairy Provisions in the 2014 Farm Bill, <https://www.hSDL.org/?view&did=752261>

¹⁵ USDA, Federal Milk Marketing Orders, <https://www.ams.usda.gov/rules-regulations/moa/dairy> , <http://www.fmmone.com/>

¹⁶ California Department of Food and Agriculture, Milk Pricing in California, https://www.cdffa.ca.gov/dairy/pdf/Milk_Pricing_in_CA.pdf

¹⁷ International Dairy Foods Association, How Raw Milk Is Priced, <http://www.idfa.org/news-views/media-kits/milk/how-farm-milk-is-priced>

Before being discontinued in 2014, the price support program set market floor prices for nonfat dry milk, butter, and cheese. The Commodity Credit Corporation bought and placed stock into inventory when prices fell before the floor levels. For example, before 2014, “through its support price program, the U.S. government agreed 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 nonfat dry milk and \$.81 for fortified nonfat dry milk.”¹⁸ The Dairy Import Tariffs made the import of competitive foreign milk powder products more difficult. One effect of these combined regulations before 1990 was to cause over-production and government storage of dairy products (Erba and Novakovic, 1995). Since 1990, the market price of commodities has, in general, been greater than the minimum prices.

Shipments of the four basic commodities are surveyed weekly by the Agriculture Marketing Service, and the price average is published in the National Dairy Product Sales Report on the following Wednesday. The shipments include sales in the prior 30 days. Thus, the weekly announced price for nonfat dry milk is a backward-looking price for milk powder sold in the previous month for delivery. The class prices are based on volume-weighted averages of the weekly commodity surveys. For example, the Class IV price for May 2016, published before the 5th of June 2016, is based on the volume-weighted weekly commodity averages for May.

The purpose of the government survey and publication of weekly prices for the four basic dairy commodities is to construct class prices and ultimately determine the price that farmers will get paid for raw milk components. However, an unintended consequence of the government publication of reference settlement prices and the price support program may be to discourage the formation of suitable spot market price indices for nonfat dry milk, cheese, butter, and dry whey. Milk processors, in the absence of a timely, inclusive, and market-based index for nonfat dry milk, use the weekly backward-looking surveys as the starting point for pricing current spot sales.¹⁹ This is despite the presence of a spot market on the CME.

4.3.2. US Spot Market Price Indices

¹⁸ CME Group, An Introduction to Trading Dairy Futures and Options, http://www.hedgebroker.com/documents/education/CME_IntroTradingDairyFuturesAndOptions.pdf

¹⁹ MCT Dairies, Intricacies of NFDM Pricing and California Dairy Information Bulletin November 2003

Processors and handlers of milk can choose from several pricing indices for the four base products. Table 1 lists the four possible spot price indices for nonfat dry milk.

[INSERT TABLE 1 ABOUT HERE]

The vast majority of current sales, other than in California, appear to be priced as a differential to the weekly National Dairy Product Sales Report survey prices. This causes prices to incorporate historical price movements from up to two months prior. The CME spot index is thinly traded, with only about 6% of market volume. The California index is similar in construction to the NDPSR survey.

The Dairy Market News (DMN) Surveys²⁰ are a weekly average of voluntarily provided spot sales for three geographical regions:²¹ East, Central, and West. Dairy Market News provides a range of prices for low-, medium-, and high-heat nonfat dry milk, as well as the “mostly” price range.²² The mostly price range includes “most” commercial transactions. These indices are more timely than the NDPSR index, as the information is only one week old. However, the information is a week old, based on voluntary participation, from different geographical regions, and comes in a range with significant variance rather than a single price. Furthermore, the Dairy Market News weekly reports are descriptive in character rather than a market-based measurement of the prevailing nonfat dry milk price. By the mid-2000s, many sellers of nonfat dry milk discontinued using the midpoint of the “mostly” ranges for their pricing index in favor of the NASS²³ price. Both buyers and sellers of nonfat dry milk appreciated the transparency in the NASS prices and associated volume.²⁴ The advantage of the NDPSR commodity price is the standardized reporting mechanism – all processors with production above 1 million pounds per year are required to report. However, this transparency comes with the cost of

²⁰ The Dairy Market News is published by the USDA Agricultural Marketing Service.

<https://www.ams.usda.gov/market-news/dairy>

²¹ USDA AMS, Dairy Market News, Agricultural Marketing Service, Dairy Market News Guidelines, <https://www.ams.usda.gov/sites/default/files/media/DMN%20Working%20Guidelines.pdf>

²² USDA AMS, Dairy Market News, Nonfat Dry Milk – Central and East https://www.ams.usda.gov/mnreports/md_da650.txt

²³ Until April 2012, weekly survey prices were published by the National Agricultural Statistics Service. Since April 2012, the weekly survey prices for NFDM milk have been published by the USDA Agricultural Marketing Service, Market Information Branch in the National Dairy Product Sales Report.

²⁴ MCT Dairies, Intricacies of NFDM Pricing, <http://www.mctdairies.com/Compass/2015/MCT-Dairies-Compass-2015-02.pdf>

extensive historical price information being included in the definition of the nonfat dry milk price.

The NDPSR and California weekly survey averages include forward sales up to 30 days prior, and the Dairy Market News surveys and CME prices are based on spot sales. The forward contracting order flow is opaque in the US market. In contrast, NZ-based GDT provides public timely order flow up to six months in advance.

Figure 1 depicts the monthly production, stocks, and shipment of nonfat dry milk from April 2012 to May 2017. In some time periods, there is a clear lag from production maximums to stock maximums to shipment maximums, which suggests that a significant percentage of sales are taking place several months before shipment. An example of a lag from March 2016 to May 2016 is highlighted in the figure. For comparison, the main spot market survey in New Zealand of whole milk powder prices is for delivery in two months. In order to get timely price establishment, it may be necessary to make these forward sales into public order flow.

[INSERT FIGURE 1 ABOUT HERE]

The following cash-settled futures contracts are traded on the CME in 2017: Class III Milk Futures, Class IV Milk Futures, Nonfat Dry Milk Futures, Dry Whey Futures, Butter Futures, and Cheese Futures. All of the CME futures contracts are settled to the monthly announced class or commodity prices published by the USDA Agricultural Marketing Service.

Table 2 shows the extent to which timeliness, market-based measurement, inclusiveness, and forward-spot separation are present in the US and NZ spot indices for dairy products. From the table, it is clear that only GDT available on the NZ market has the required properties of a representative spot market. Given the nature of the spot market indices in the United States and New Zealand and considering the implication of average price settlement, we formulate the following research hypotheses. One, the hedging effectiveness of NZX dairy futures will be higher than CME nonfat dry milk futures. Two, spot market indices that are correctly designed across several dimensions will have higher hedging effectiveness and better hedge ratio persistence from short to long hedge horizons than indices with few correct dimensions. These hypotheses are examined in section 7.

[INSERT TABLE 2 ABOUT HERE]

5. Data

In this section, we present the sources of data for hedging efficiency. For the NZ market, we examine the hedging of three separate spot price indices with NZX whole milk powder futures: Agrifax whole milk powder survey prices, Global Dairy Trade biweekly auctions, and a modified GDT price series. Agrifax surveys large milk processors in New Zealand on a weekly basis. The reported survey prices are weekly averages of whole milk powder and skim milk powder contract sales for delivery in two months; the time period covers June 2013 to May 2017. Global Dairy Trade auctions are biweekly auctions for six forward contracts. The time period covers June 2013 to May 2017.

NZX dairy futures for whole milk powder and skim milk powder trade daily with 18 monthly expiration dates. We construct a near-month series changing contracts on the last contract trading day. The Agrifax survey and GDT auction prices are compared with the NZX futures prices on the same date. A synthetic GDT series – GDT-Modified – is also constructed. The GDT-Modified time series is modified by replacing each second monthly auction price with the mean of the two auction prices within the month. The GDT-Modified series tracks the average price of whole milk powder to match the underlying implied in the settlement calculation in the futures contract. In addition, the GDT-Modified series starts in June 2013, when the NZX settlement calculation was changed to the average of the two within-month auctions. Prior to that date, the settlement average was constructed from the last auction of the settlement month and the first auction of the succeeding month.

For the US market, we examine the hedging of four separate nonfat dry milk spot indices with CME nonfat dry milk futures: NDPSR survey prices, California survey prices, Dairy Market News survey prices, and CME spot prices. CME nonfat dry milk futures trade daily for contract expirations up to 24 months. We use the near-month series from Bloomberg. CME Spot nonfat dry milk trades daily with delivery in six days. The CME spot series runs from April 2012 to May 2017.

The NDPSR weekly survey prices are compiled by the Agricultural Marketing Service of the USDA, and include all nonfat dry milk sales shipped in the previous week. The NDPSR weekly

prices are announced the following Wednesday. The data series starts in April 2012, when announcements were shifted to Wednesday from Friday,²⁵ and ends in May 2017. California weekly survey prices are compiled by the California Department of Food and Agriculture. The California prices are announced the following Friday. The series runs from April 2012 to May 2017. The Dairy Market News survey prices are also gathered by the Agricultural Marketing Service, and include spot sales for the current week. The Dairy Market News prices are published on the Thursday of the relevant week. The series runs from April 2012 to May 2017.

6. Methodology

In order to test our hypothesis, we examine the efficiency of hedging using methodology applied by Adams and Gerner (2012) and developed by Herbst et al. (1989), Ghosh (1993), and Lien (2002). 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:

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

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

$$e_t = \log S_t - a - b \log F_t, \quad (2)$$

²⁵ In April 2012, the reporting organization was changed from the National Agricultural Statistics Service to the USDA Agricultural Marketing Service, Market Information Branch.

where a and b are the coefficients from the original cointegration test regression between the $\log(S_t)$ and $\log(F_t)$ price-level series. The ECM also includes several lags of both the spot and future returns, thus allowing for short-term serial correlation in the future and spot return series. Hedging effectiveness is determined by the adjusted R^2 of the statistical model. In addition, hedge ratios closer to unity indicate strong co-movement between spot and futures prices.

7. Results

In this section, we examine futures hedging efficiency in the NZ and US markets. In the NZ market, the Agrifax, GDT, and modified GDT whole milk powder indices are hedged with NZX dairy futures contracts. In the US market, the NDPSR, California, Dairy Market News, and CME spot nonfat dry milk indices are hedged using CME nonfat dry milk futures contracts.

As the hedging horizon lengthens, hedge effectiveness increases for both OLS and cointegration models (Juhl et al., 2012). However, liquidity is generally highest in the near-month contract, resulting in a stack and roll hedge implementation. A stack and roll implementation is exposed to shorter contracts at the beginning and end of the hedge. For example, a hedge implemented from March 15th to April 25th would be exposed to a short-term contract from March 15th to the rollover date, and from the rollover date to April 25th. This may result in price risk if the short-term hedge correlations are low. In addition, if the shorter horizon hedge ratio estimates are substantially different from the longer horizon hedge ratio estimates, the stack and roll strategy may be less than optimal. Finally, futures markets' participants will utilize a variety of hedge intervals, and hedges should be effective both at short- and longer-term horizons.

Table 3 reports the hedging effectiveness as a function of the hedge horizon using an OLS regression model. All spot market indices show an increase in hedging effectiveness as the horizon increases. The Agrifax time series reports the best effectiveness for hedging up to three weeks, and the Global Dairy Trade Modified benchmark is the most effective for time scales from four to eight weeks. The superiority of the NZ indices is reduced as the time horizon is increased.

[INSERT TABLE 3 ABOUT HERE]

Table 4 reports the hedging effectiveness as a function of the hedge horizon using the cointegration regression model. All spot market indices show an increase in hedging effectiveness as the horizon increases. The Agrifax time series reports the best effectiveness for hedging at a one-week horizon (70%). In the US market, the highest hedging effectiveness at a one-week horizon is 52% for NDPSR survey prices. Only hog (13%), cotton (32%), and silver (54%) futures have reported lower hedging effectiveness in the past (see Lien, 2008). CME futures offer an ineffective hedge for any of the price series at a one-week horizon, in contrast to the NZX futures which effectively hedge the Agrifax index. At two-week and longer horizon, the hedging effectiveness of the Agrifax, GDT-Modified, and NDPSR indices are similar (77–78%). However, the only index that provides both high hedging effectiveness and a stable estimate of the hedge ratio for both short and long horizons is the GDT-Modified benchmark.

[INSERT TABLE 4 ABOUT HERE]

The GDT-Modified time series incorporates all the relevant dimensions of spot market design, and tracks the underlying average price implied by the settlement calculation in the futures contract. The hedging effectiveness ranges from 77% at a two-week horizon to 98% at an eight-week horizon. The hedge ratios are close to 1.0 across all hedge horizons. However, short-term hedging performance would improve if the settlement calculation in the NZX futures contract were amended to settle to only the second GDT auction price. Settling to an average of the two prices distorts the incentives for both arbitrageurs and speculators. The short-term hedging effectiveness of the NZX whole milk powder futures compares favorably with that for corn (74% to 80%) (see Sanders et al., 2003; Lien, 2008).

The Agrifax hedge effectiveness ranges from 70% at a one-week horizon to 93% at an eight-week horizon, and the hedge ratio varies from .58 to .80. Although the Agrifax prices have a similar hedging effectiveness to the GDT benchmark at horizons of two-weeks or greater, the hedge ratio is not stable as the hedge horizon changes. This results from the index being survey based, and incorporating week-old information. The hedging effectiveness is still relatively high because the GDT auctions provide an effective single-source price indicator, and the Agrifax prices closely follow the GDT auctions.

The NDPSR hedge effectiveness ranges from 51% at a one-week horizon to 96% at an eight-week horizon, and the hedge ratio varies from .42 to .97. The NDPSR weekly surveys are not timely, as they incorporate historical information from up to two months prior. This results in a low hedging effectiveness at a one-week horizon and a significant change in the hedge ratio as the horizon lengthens. In addition, the forward and spot sales are mixed, as the index is based on product shipping in the prior week, not on market sales. The higher effectiveness, relative to the other US price indices, stems from its inclusiveness – the NDPSR surveys contain all shipments from large nonfat dry milk processors. In addition, the NDPSR survey benefits from alignment with the settlement calculation in the CME futures contract. The California surveys are similar in nature, but less inclusive and are not directly related to the settlement calculation. Thus, the California survey hedging effectiveness range is slightly lower and ranges from 51% at one week to 95% at eight weeks, and the hedge ratio varies from .37 to .78.

The Dairy Market News surveys are more timely than the NDPSR surveys, as historical information is only one week old. In addition, they provide some forward-spot separation in the form of only spot sales. However, they are not market-based or inclusive due to voluntary reporting and have separate series for geographical regions and the type of nonfat dry milk. The representative series chosen was East and Central Low and Medium Heat. Thus, the hedging effectiveness ranges from 28% at one week to 77% at eight weeks.

The lowest hedging effectiveness range of 10% at one week to 79% at eight weeks is reported for the CME spot market. This series is market based and timely. The problem stems from the lack of inclusiveness and the absence of forward pricing information. Only 6% of spot market volume is sold on the CME. It is worthwhile noting that the CME recognizes the defectiveness of their own spot market index in preferring the NDPSR historical average benchmark for the CME futures contract settlement calculation.

The analysis of hedging effectiveness reveals that the NZX dairy futures contract is a better tool to use than CME nonfat dry milk futures at shorter hedge horizons and provides persistent estimates of hedge ratios. We argue that the design of the spot market contributes to the success of futures contracts as a hedging tool. Our results show that in the case of a spot market missing one or more of the elements of timeliness, market-based measurement, inclusiveness, and forward-spot separation, one would expect underperformance of the futures market at shorter

hedge horizons in terms of hedging effectiveness²⁶ and a large variation between short- and long-horizon hedge ratios.

8. Conclusion

High hedging effectiveness is an indicator of the successful introduction of a futures contract. Prior studies on hedging effectiveness have focused on the design of the futures contract and other aspects of the futures and cash markets, but have neglected the underlying spot market benchmark design. This study illustrates that the design of the spot market to produce a timely, market-based, inclusive underlying with forward-spot separation is necessary for effective hedging.

In the United States, the majority of the spot pricing of dairy ingredients is published on a historical basis, leading to a multitude of different spot pricing indicators. In addition, the US forward price curve information is not published. In New Zealand, the Global Dairy Trade auction system provides all of the correct dimensions of a spot price benchmark.

Both the Chicago Mercantile Exchange and New Zealand Stock Exchange have chosen to settle dairy futures contracts to historical price averages. We illustrate that the settlement of a futures contract to a historical average introduces basis risk for hedgers and arbitrageurs, and requires speculators to predict the price path rather than only the price at maturity, making speculative trading more complex. Our results show that the New Zealand Stock Exchange dairy futures contract is a better tool for hedging at short hedge horizons, as the Global Dairy Trade spot market benchmark has all the required properties. In addition, the GDT benchmark provides persistent estimates hedge ratios from short- to long-term hedge horizons. Furthermore, the relative hedging effectiveness of each spot index is strongly related to the extent to which the particular index reflects the correct spot market design dimensions.

²⁶ Significant volume may be necessary to avoid price manipulation. Industry observers have raised a concern about the thin trading volume on the CME cheese spot market, in light of the CME cheese spot price being used as a reference price for cheese contracts in the industry at large. This concern was validated by a CFTC fine for the Dairy Farmers of America executives for manipulating the Class III milk futures price by trading cheese spot contracts (see US GAO, Spot Cheese Market: Market Oversight Has Increased, but Concerns Remain about Potential Manipulation, <http://www.gao.gov/products/GAO-07-707>).

The above results permit us to formulate the following recommendations. First, we believe that the US nonfat dry milk spot market needs to be re-designed to provide a timely, market-based, and inclusive spot and forward price indicator. A design similar to the US corn market or the NZ Global Dairy Trade may be considered. Once a single spot benchmark has been established for the US market, the Chicago Mercantile futures contract should be changed to use the new benchmark for settlement. Finally, our results show that there would be a benefit to adjusting the settlement calculation in New Zealand to reflect only the spot price at expiration.

Appendix 1 – Success and Failure Criteria for Futures Contracts

This appendix presents a review of the academic literature on the determinants of the success or failure of futures contracts. The characteristics associated with the success or failure of futures can be broadly categorized into the properties of the underlying, the features of the cash market, the attributes of the futures contract, and the institutional setup of the futures market. Table A.1 offers a survey of relevant studies grouped by category. Criteria common to several studies are identified.

[INSERT TABLE A.1 ABOUT HERE]

Black (1986) reports that cash market size, the risk-reduction ability of the contract relative to other cross hedges, cash price volatility, and liquidity costs of a new contract in comparison with existing instruments are associated with the success or failure of futures contracts. Brorsen and Fofana (2001) consider product homogeneity (uniformity), vertical integration of the cash market, buyer concentration, and activeness of the cash market and report that an active cash market is the single characteristic that predicts whether a commodity may have a successful futures market. The study by Bekkerman and Tejeda (2013) examines the failure of the Distillers Dried Grains (DDG) contract on the Chicago Mercantile Exchange (CME). The authors identify the following factors which contribute to the success of new futures contracts:

- *Cash price variability:* A volatile cash market with substantial price uncertainty is more likely to develop a futures market than a market with little variability.
- *Size of the cash market:* The size of the cash market is an indicator of the potential revenue loss due to price volatility. Larger markets are more likely to develop futures markets to manage price risk.
- *Activeness of the cash market:* High activity and participation by different types of investors contribute to a potential higher demand for an organized futures market. In addition, a larger, more active cash market is more likely to have available and credible price information (Fortenberry and Zapata, 1997).
- *Product homogeneity:* Individual futures contracts can only hedge a single grade or quality of a commodity. If the commodity is not homogenous and interchangeable or suffers from quality variation, the hedging effectiveness will be lower for each market

segment. The lack of hedging effectiveness contributes to the failure of a futures contract.

- *Product storability*: Bergfjord (2007) argues that ineffective storage may cause quality degradation and inhomogeneity. In addition, good storage infrastructure can facilitate the year-round trading of a commodity.
- *Degree of vertical integration in the market*: Vertical integration measures the extent to which the system of entities responsible for moving the product or service from producer to consumer (the supply chain) is owned by a single company. In a market with a high degree of vertical integration, most price hedging will occur within firms' structure. Consequently, activeness of the cash market and price volatility are likely to be lower.
- *Degree of market power concentration and number of market participants*: In cash markets with a high degree of concentration with only a few participants, futures markets are not expected to be successful due to the ability of firms to control the price.
- *Risk reduction through futures cross-hedging*: When effective price risk cross-hedging tools already exist, significant demand for another tool is unlikely (Black, 1986).
- *Liquidity of cross-hedge futures contracts*: Traders will compare the liquidity costs of an own-hedge futures contract to that of a competing cross-hedge product. The advantage in lower bid-ask spreads for a cross-hedge may outweigh a superior risk-reduction own-hedge capability. For example, jet fuel is a classic example of a market which is cross-hedged by a variety of oil-derived products.

Bekkerman and Tejeda (2013) conclude that the activeness of the cash market, underlying cash market volatility, product homogeneity, industry vertical integration and market power concentration, and the activeness of the futures market with which cross-hedging opportunities exist are important factors in predicting a futures market's success. Their findings are in contrast to Brorsen and Fofana (2001), who report that homogeneity, vertical integration, and buyer concentration were not significantly correlated with success or failure. Furthermore, the study by Brorsen and Fofana (2001) finds that substantial hedging activity in closely related markets is a critical determinant of a futures contract's success. For example, in the case of the DDG futures contract, low hedging activity in the related ethanol futures contract may have caused a failure of the DDG contract.

Perversi, Feuz, and Umberger (2002) provide evidence that futures markets characterized by high basis variability are less attractive for hedgers. They examine basis variability in the cattle stocker versus the cattle feeder market and conclude that one of key reasons behind the stocker contract failure was high basis risk, which discouraged producers from using the contract to hedge calves.

Recently, Till (2014) and Webb (2015) have extended the list of necessary conditions for the successful introduction of a futures contract. Both scholars highlight the importance of a commercial need for hedging and sufficient speculator interest to take the long side of hedger trades. In addition, Webb (2015) points out that the time of introduction, cost of trading, and contract design contribute to the ultimate success/failure of a new contract. Finally, public policy should not be too adverse to futures trading (see Till, 2014), otherwise futures trading is negatively affected. For example, in 1979, the Commodity Futures and Trading Commission (CFTC) banned trading in the March wheat futures contract, and in 1980, the CFTC also considered suspension of trading in silver futures to avoid price manipulation (Till, 2014).

Appendix 2 – Dairy Market Acronyms

Acronym	Description
AMS	Agriculture Marketing Service of the United States Department of Agriculture
CME	Chicago Mercantile Exchange
DMN	Dairy Market News
GDT	Global Dairy Trade
NASS	National Agricultural Statistics Survey
NPDSR	National Dairy Product Sales Report
NFDM	Nonfat Dry Milk
USDA	United States Department of Agriculture
WMP	Whole Milk Powder

References

- Adams, Z., & Gerner, M. (2012). Cross hedging jet-fuel price exposure. *Energy Economics*, 34(5), 1301-1309.
- Bekkerman, A., & Tejeda, H. A. (2013). Revisiting the determinants of futures contracts: The curious case of distillers' dried grains. Available at SSRN 2274912.
- Bergfjord, O. J. (2007). Is there a future for salmon futures? An analysis of the prospects of a potential futures market for salmon. *Aquaculture Economics & Management*, 11(2), 113-132.
- Bhardwaj, Geetesh, Gorton, Gary B., & Rouwenhorst, K. Geert. Facts and fantasies about commodity futures ten years later (June 2015). NBER Working Paper No. w21243. Available at SSRN: <http://ssrn.com/abstract=2615649>
- Białkowski, J., & Jakubowski, J. (2012). Determinants of trading activity on the single-stock futures market: Evidence from the Eurex exchange. *Journal of Derivatives*, 19(2), 29-47.
- Bignell, A. A. S. (2013). *Characteristics of spot-market rate indexes for truckload transportation*. Doctoral dissertation, Massachusetts Institute of Technology.
- Black, G. D., 1986. Success and failure of futures contracts: Theory and empirical evidence. Monograph 1986-1, Salomon Brothers Center for the Study of Financial Institutions, New York.
- Brorsen, B. W., & Fofana, N. F. (2001). Success and failure of agricultural futures contracts. *Journal of Agribusiness*, 19(2), 129-146.
- Carlton, D. W. (1984). Futures markets: Their purpose, their history, their growth, their successes and failures. *Journal of Futures Markets*, 4(3), 237-271.
- Cohen, L., & Gorham, M. (1985). The projected impact of cash-settled commodity contracts on cash/futures price relationships. In *Conference on Applied Commodity Price Analysis, Forecasting and Market Risk Management* (Vol. 2).
- Dickey, David A., and Wayne A. Fuller. "Distribution of the estimators for autoregressive time series with a unit root." *Journal of the American statistical association* 74.366a (1979): 427-431.
- Erba, E., & Novakovic, A. M. (1995). *The Evolution of Milk Pricing and Government Intervention in Dairy Markets* (Vol. 95, No. 5). Department of Agricultural, Resource, and Managerial Economics, College of Agriculture and Life Sciences, Cornell University.
- Fortenbery, T. R., & Zapata, H. O. (1997). An evaluation of price linkages between futures and cash markets for cheddar cheese. *Journal of Futures Markets*, 17(3), 279-301.
- Garcia, P., Irwin, S. H., & Smith, A. (2015). Futures market failure?. *American Journal of Agricultural Economics*, 97(1), 40-64.

- Ghosh, A. (1993). Hedging with stock index futures: Estimation and forecasting with error correction model. *Journal of Futures Markets*, 13, 743-743.
- Gray, Roger W. (1966). Why does futures trading succeed or fail: An analysis of selected commodities. Futures Trading Seminar
http://www.farmdoc.illinois.edu/irwin/archive/books/Views_From_the_Trade/Section6_4.pdf
- Herbst, A. F., Kare, D. D., & Caples, S. C. (1989). Hedging effectiveness and minimum risk hedge ratios in the presence of autocorrelation: Foreign currency futures. *Journal of Futures Markets*, 9(3), 185-197.
- Jesse, E., & Cropp, B. (2008). Basic milk pricing concepts for dairy farmers. *Economic Research*, 180, 200.
- Johnston, E. T., & McConnell, J. J. (1989). Requiem for a market: An analysis of the rise and fall of a financial futures contract. *Review of Financial Studies*, 2(1), 1-23.
- Juhl, T., Kawaller, I. G., & Koch, P. D. (2012). The effect of the hedge horizon on optimal hedge size and effectiveness when prices are cointegrated. *Journal of Futures Markets*, 32(9), 837-876.
- Kavussanos, M. G., & Visvikis, I. D. (2006). Shipping freight derivatives: A survey of recent evidence. *Maritime Policy & Management*, 33(3), 233-255.
- Kawaller, I. G. (1987). A note: Debunking the myth of the risk-free return. *Journal of Futures Markets*, 7, 327-331.
- Kenyon, D., Bainbridge, B., & Ernst, R. (1991). Impact of cash settlement on feeder cattle basis. *Western Journal of Agricultural Economics*, 1991, 93-105.
- Lee, Y., Ward, C. E., & Brorsen, B. W. (2012). Procurement price relationships for fed cattle and hogs: Importance of the cash market in price discovery. *Agribusiness*, 28(2), 135-147.
- Lien, Donald, and Yiu Kuen Tse. "Some recent developments in futures hedging." *Journal of Economic Surveys* 16.3 (2002): 357-396.
- Lien, D. (2008). A note on estimating the benefit of a composite hedge. *Journal of Futures Markets*, 28(7), 711-716.
- McMillan, D. G., & Ülkü, N. (2009). Persistent mispricing in a recently opened emerging index futures market: Arbitrageurs invited. *Journal of Futures Markets*, 29(3), 218-243.
- Nam, S. O., Kim, B. C., & Kim, H. K. (2010). An alternative approach to evaluating the agreement between financial markets. *Journal of International Financial Markets, Institutions & Money*, 20(1), 13-35.
- Paul, A., Kahl, K., & Tomek, W. (1981). Performance of futures markets: The case of potatoes. U.S. Department of Agriculture, National Economics Division: Economics and Statistics Service, Technical Bulletin, No.1636, January.

Perversi, S., Feuz, D. M., & Umberger, W. J. (2002, December). Basis variability on the feeder cattle contract versus the failed stocker contract. In *2002 Western Agricultural Economics Association Annual Meetings (July 28–31, 2002: Long Beach, California)*. Western Agricultural Economics Association.

Pirrong, C. (2001). Manipulation of cash-settled futures contracts. *The Journal of Business*, 74(2), 221-244.

Sanders, D. R., Manfredo, M. R., & Greer, T. D. (2003). Hedging spot corn: An examination of the Minneapolis Grain Exchange's cash settled corn contract. *Journal of Agribusiness*, 21(1), 65-82.

Tashjian, E. (1995). Optimal futures contract design. *The Quarterly Review of Economics and Finance*, 35(2), 153-162.

Till, H. F. (2014). Why some commodity (and financial) futures contracts succeed and others fail: A survey of relevant research. Available at SSRN 2573894.

Webb, R. (2015) What drives success in futures markets. Keynote speech, 2015 Derivative Markets Conference.

Figure 1: Nonfat dry milk production, stock, and shipments 2012–2017

This table illustrates the nonfat dry milk production, inventory, and shipments from April 2012 to May 2017. Source: United States Department of Agriculture National Agricultural Statistical Service Quick Stats Database, <https://quickstats.nass.usda.gov/>. In 2016, a lag from production to shipment is highlighted.

Table 1: Nonfat dry milk spot market price indices for the US market

Price Index	Description	Estimated percentage of sales volume included in index
USDA Agricultural Marketing Service National Dairy Product Sales Report weekly surveys	Published on Wednesday for sales shipped in the prior week. Sales occur up to 30 days before	40%
Chicago Mercantile Exchange spot market	Current prices for nonfat dry milk to be shipped within six days	6%
California weekly surveys	Published on Friday for sales shipped in the prior week. Sales occur up to 30 days before	40%
Dairy Market News surveys	Weekly average of spot sales	5%

This table lists the four major dairy spot price indices for nonfat dry milk in the United States, and the estimated percentage of sales included in each index. California produces approximately 40% of the US nonfat dry milk. Further information can be found in MCT Dairies, Intricacies of NFDM Pricing and California Dairy Information Bulletin, November 2003.

Table 2: Characteristics of the nonfat dry milk spot market price indices for the US and NZ markets

Index	Timeliness	Market-Based	Forward-Spot Separation	Inclusiveness
USDA Agricultural Marketing Service National Dairy Product Sales Report	Includes historical trades up to two months old.	No	Forward and Spot are mixed	Yes
Dairy Market News weekly	Includes historical trades from last week.	No	Only Spot	Voluntary reporting
Chicago Mercantile Exchange spot	Current	Yes	Spot	No – only 6% of market volume
AgriFax weekly	Includes historical trades from last week.	No	Only Forward	Based on survey responses
Global Dairy Trade auctions	Current	Yes	Spot and up to six months delivery visible	Yes

This table illustrates the characteristics of the existing milk powder spot market price index characteristics in the United States and New Zealand. Timeliness measures the extent to which the information is current. Market-based indicates the extent to which the measure is based on markets rather than surveys. Market-based pricing indexes allow for arbitrage in the spot market. Forward-spot separation measures the separation of the spot and forward market sales. Inclusiveness assures that a significant representative fraction of trades are included in the index..

Table 3: Hedge effectiveness as a function of horizon – OLS regression

		<i>Model Specifications</i>						
<i>Spot market (S_t)</i>		<i>WMP</i> <i>(Agrifax)</i>	<i>GDT</i> <i>Contract 2</i>	<i>GDT</i> <i>modified</i>	<i>NDPSR</i> <i>NFDM</i>	<i>CME</i> <i>NFDM</i>	<i>DMN NFDM</i>	<i>Cal NFDM</i>
<i>Futures market(F_t)</i>		<i>WMP</i> <i>(NZX)</i>	<i>WMP(NZX)</i>	<i>WMP(NZX)</i> <i>)</i>	<i>CME</i> <i>NFDM</i>	<i>CME</i> <i>NFDM</i>	<i>CME NFDM</i>	<i>CME NFDM</i>
<i>Period</i>		<i>Jun 2013-</i> <i>May 2017</i>	<i>Jun 2013-</i> <i>May 2017</i>	<i>Jun 2013-</i> <i>May 2017</i>	<i>Apr 2012-</i> <i>May 2017</i>	<i>Apr 2012-</i> <i>May 2017</i>	<i>Apr 2012-</i> <i>May 2017</i>	<i>Apr 2012-</i> <i>May 2017</i>
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>Horizon</i>								
<i>1 week</i>	β	0.621** (15.38)			0.338** (7.37)	0.281** (4.04)	0.155** (3.04)	0.350** (5.16)
	<i>Adj R²</i>	0.542			0.173	0.059	0.034	0.091
<i>2 weeks</i>	β	0.648** (18.78)	0.496** (6.40)	0.627** (9.57)	0.512** (12.23)	0.403** (5.66)	0.421** (8.44)	0.506** (9.38)
	<i>Adj R²</i>	0.639	0.310	0.502	0.366	0.110	0.216	0.251
<i>3 weeks</i>	β	0.686** (21.23)			0.711** (18.88)	0.604** (8.48)	0.672** (15.13)	0.685** (15.02)
	<i>Adj R²</i>	0.695			0.580	0.218	0.470	0.463
<i>4 weeks</i>	β	0.730** (23.66)	0.807** (15.53)	0.855** (23.66)	0.851** (25.78)	0.719** (10.06)	0.802** (20.17)	0.821** (20.41)
	<i>Adj R²</i>	0.740	0.728	0.862	0.721	0.283	0.613	0.615
<i>5 weeks</i>	β	0.749** (26.88)			0.901** (30.10)	0.762** (10.94)	0.862** (24.08)	0.852** (23.87)
	<i>Adj R²</i>	0.787			0.780	0.319	0.694	0.687
<i>6 weeks</i>	β	0.766** (28.77)	0.841** (16.98)	0.866** (22.79)	0.926** (32.43)	0.792** (11.87)	0.865** (25.36)	0.853** (24.80)
	<i>Adj R²</i>	0.809	0.764	0.854	0.805	0.356	0.716	0.704
<i>7 weeks</i>	β	0.781** (30.50)			0.944** (36.71)	0.817** (13.00)	0.886** (28.56)	0.858** (26.74)
	<i>Adj R²</i>	0.827			0.841	0.399	0.763	0.735
<i>8 weeks</i>	β	0.801** (32.12)	0.884** (22.29)	0.918** (34.03)	0.974** (42.72)	0.848** (14.05)	0.902** (30.26)	0.879** (28.58)
	<i>Adj R²</i>	0.842	0.850	0.929	0.878	0.438	0.783	0.761

This table reports Ordinary Least Squares (OLS) regression results as a function of hedging horizon. Columns (1) to (3) are the Agrifax whole milk powder (WMP), and Global Dairy Trade (GDT) whole milk powder Auctions with New Zealand Stock Exchange whole milk powder Futures. The *GDT modified* series replaces the second auction with settlement calculation of monthly auction average. Columns (4) to (8) are the USDA AMS National Dairy Product Sales Report (NDPSR) Survey, Chicago Mercantile Exchange (CME), Dairy Market News (DMN), and California Survey prices with CME nonfat dry milk (NFDM) futures. The specifications (1)–(8) are using model

$$\Delta \log S_t = a + \beta \Delta \log F_t + \varepsilon_t$$

**, * denote statistical significance at the 5% and 10% level, respectively.

Table 4: Hedge effectiveness as a function of horizon – cointegration model

		Model Specifications						
Spot market (S_t)		WMP (Agrifax)	GDT Contract 2	GDT modified	NDPSR NFD	CME NFD	DMN NFD	Cal NFD
Futures market(F_t)		WMP (NZX)	WMP(NZX)	WMP(NZX)	CME NFD	CME NFD	CME NFD	CME NFD
Period		Jun 2013- May 2017	Jun 2013- May 2017	Jun 2013- May 2017	Apr 2012- May 2017	Apr 2012- May 2017	Apr 2012- May 2017	Apr 2012- May 2017
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Horizon								
1 week	β	0.582** (16.14)			0.424** (10.66)	0.219** (2.54)	0.167** (3.06)	0.365** (6.94)
	Adj R^2	0.697			0.516	0.105	0.282	0.515
2 weeks	β	0.573** (12.10)	1.159** (8.85)	1.021** (14.61)	0.584** (13.69)	0.482** (3.57)	0.445** (5.53)	0.361** (5.86)
	Adj R^2	0.776	0.610	0.773	0.769	0.296	0.450	0.651
3 weeks	β	0.616** (14.03)			0.767** (15.66)	0.782** (4.20)	0.764** (9.84)	0.470** (7.60)
	Adj R^2	0.841			0.842	0.348	0.648	0.748
4 weeks	β	0.722** (12.64)	1.062** (15.18)	1.062** (15.18)	0.746** (16.53)	1.353** (7.83)	0.793** (7.34)	0.691** (10.16)
	Adj R^2	0.896	0.906	0.906	0.908	0.623	0.609	0.844
5 weeks	β	0.811** (12.90)			0.818** (11.96)	1.472** (9.69)	0.962** (11.37)	0.809** (13.84)
	Adj R^2	0.906			0.866	0.762	0.853	0.924
6 weeks	β	0.744** (9.44)	1.058** (15.67)	1.019** (22.81)	0.933** (24.85)	1.387** (5.46)	1.101** (9.31)	0.552** (7.72)
	Adj R^2	0.888	0.941	0.967	0.962	0.571	0.765	0.864
7 weeks	β	0.744** (13.08)			0.996** (10.92)	1.579** (7.40)	0.994** (8.97)	0.681** (12.18)
	Adj R^2	0.959			0.939	0.754	0.838	0.924
8 weeks	β	0.796** (8.30)	1.112** (20.83)	1.112** (20.83)	0.973** (12.65)	1.500** (7.55)	1.106** (7.50)	0.767** (13.17)
	Adj R^2	0.934	0.983	0.983	0.961	0.786	0.765	0.945

This table reports cointegration regression results as a function of hedging horizon. Columns (1) to (3) are the Agrifax whole milk powder (WMP), and Global Dairy Trade (GDT) whole milk powder Auctions with New Zealand Stock Exchange whole milk powder Futures. The *GDT modified* series replaces the second auction with settlement calculation of monthly auction average. Columns (4) to (8) are the National Dairy Product Sales Report (*NDPSR*) Survey, Chicago Mercantile Exchange (CME), Dairy Market News (DMN), and California Survey prices with CME nonfat dry milk (NFD) futures. The specifications (1)–(8) are using model

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

**, * denote statistical significance at the 5% and 10% level, respectively.

Table A.1: Characteristics of futures markets and futures contracts associated with the success and failure of futures contracts

Category	Characteristic	Studies
Futures Market	Hedging need for commercial market participants.	Black (1986) Gray (1978) Webb (2015)
Futures Market	The attraction of speculative interest to the futures market.	Gray (1978) Till (2014) Webb (2015)
Futures Market	Favorable disposition towards the futures contract introduction by existing market power holders	Gray (1978)
Futures Market	Favorable public policy towards the contract (for example not prohibiting trading in a particular contract)	Till (2014)
Futures Contract	Good contract design that does not favor the buyer or seller.	Gray (1978) Webb (2015) Garcia, Irwin and Smith (2015)
Futures Contract	The risk reduction ability of the contract in comparison to existing futures cross-hedging contracts.	Black (1986)
Cash Market	Size and activeness of the cash market	Black (1986) Brorsen and Fofana 2001 Bekkerman and Tejada 2013 Fortenberry and Zapata (2002)
Cash Market	Volatility of the cash price	Black 1985 Bekkerman and Tejada 2013 Webb (2015)
Commodity	Homogeneity or uniformity of the commodity.	Bekkerman and Tejada 2013
Cash Market	The extent of existing vertical market integration	Bekkerman and Tejada 2013
Cash Market	Buyer concentration within the cash market.	Bekkerman and Tejada 2013
Commodity	The storability of the commodity.	Bekkerman and Tejada 2013
Futures Market	Superior liquidity of existing cross-hedges discourages a new own-hedge contract.	Black 1986 Brorsen and Fofana (2001) Bekkerman and Tejada 2013 Webb (2015)
Futures Market	Significant hedger activity in closely related markets.	Bekkerman and Tejada 2013
Futures Market	Basis Risk impedes a futures contract.	Perversi, Feuz, and Umberger (2002)
Futures Market	Public genuine commercial order flow	Webb (2015)
Futures Market	First mover advantage in the introduction of the contract.	Webb (2015)
Futures Market	Low explicit trading costs, for example broker commissions	Webb (2015)
Futures Market	Timing of the introduction of the contract	Webb (2015)

This table reports the characteristics identified in the literature that are associated with the success or failure of futures contracts. The *Category* column indicates the general area of the market the attribute refers to – the commodity, the cash market, the futures market, or the futures contract. The *Characteristic* column lists the particular characteristic of the market, contract, or commodity. The *Studies* column lists the studies in which the relevant characteristic was found to have a significant statistical relationship.